THE EFFECTS OF SUBLIMINAL STIMULATION: SEMANTIC PRIMING AND THE AROUSAL OF ANXIETY

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CONTENTS

CONTENTS CONTINUED

ABSTRACT

This thesis investigates semantic priming without conscious awareness of prime stimuli. It also investigates the hypothesis that anxiety responses may be made to emotionally aversive stimuli presented subliminally.

Following a review of literature on semantic priming without awareness it is concluded that the phenomenon has not been adequately investigated. It is argued that an adequate investigation requires presentation of primes below objective detection threshold and that satisfactory criteria for the definition of objective threshold are lacking. Three criteria are proposed. Using these an initial experiment found semantic priming effects below objective threshold when stimuli were presented binocularly in a backward pattern masking paradigm. Experiments 2 and 3 replicated this finding with different samples of stimuli and participants. Experiment 4 replicated the finding with dichoptic stimulus presentation and found the magnitude of priming effect was independent of the method of stimulus presentation (binocular or dichoptic).

A new variant of the semantic priming effect, an "emotional priming" effect is proposed. This hypothesises that priming effects can be obtained when primes and targets are related solely in terms of their emotional quality. Experiment 5 supported this hypothesis when primes were presented below objective detection threshold, though the effect was not replicated in two further experiments. Experiment 9 replicated both the "emotional" and conventional semantic priming effects with emotionally aversive targets when primes were presented below subjective detection threshold.

Experimant 10 showed that emotionally threatening stimuli

presented subliminally can generate certain psychological components of an anxiety response including some having somatic referents (increased feelings of sweating, muscular tension and shaking).

The final chapter of the thesis draws together the findings into a model of anxiety (panic) attacks, arguing that the early somatic features are produced by subliminally perceived stimuli possibly acting in conjunction with semantic and/or emotional priming effects.

PART I

INTRODUCTION AND REVIEW OF LITERATURE ON SEMANTIC PRIMING

CHAPTER 1

THE AIMS OF THE THESIS

An elderly American psychologist of my acquaintance tells the story of how, when he was a young man, the first question asked of a new academic colleague was "Are you an experimental or clinical psychologist?" The implication that one could not be both is now no longer (so) true as evidenced by the attempts of experimental psychologists to deal with clinical topics such as emotional states (Posner & Snyder 1975; Bower 1981) and dynamic unconscious processes (Shevrin & Dickman 1980; Silverman 1985).

This thesis grew out of an interest in a particular clinical problem and the conviction that its solution might well lie in the application of research findings and techniques in current experimental cognitive psychology. The problem is simply this: How are free floating anxiety (panic) attacks generated without apparent precipitants. The important word here is, of course, 'apparent'. The onset of panic attacks might well be understood, in principle, to result from non-apparent, that is, non-consciously perceived stimuli capable of inducing threat. Such a speculation at once raises the old controversy of whether perception without awareness can occur. Recent reviews of hard experimental evidence by Shevrin and Dickman (1980) and Dixon (1981) clearly suggest that stimuli can indeed be perceived without awareness though no one reading the paper by Holender (1986) could think that the pool of sceptics has been drained dry.

The thesis is divided into four parts, the first of which re-examines the perception without awareness issue from the standpoint of one particular experimental paradigm; semantic priming.

Following a literature review in Chapter 2, which discusses the nature of semantic priming with and without awareness of primes, the first aim of the thesis is announced in Chapter 3 and explored experimentally in Chapters 4 to 6. The first aim was to determine whether perception without awareness could occur by investigating whether semantic priming effects could be obtained with emotionally neutral targets when primes were presented below objective detection threshold. Subsidary aims in Part I were to clarify certain methodological issues associated with subliminal semantic priming.

The second part of the thesis had two aims. First, to establish whether emotionally aversive target stimuli can be primed by emotionally neutral prime stimuli presented subliminally. Here the concept of an 'emotional priming' effect as a variant of the conventional semantic priming effect is introduced. Experimental work on these two points is reported in Chapters 7 to 12.

The third part of the thesis explores the hypothesis that psychological and psychophysiological components of anxiety can be generated by subliminal perception of emotionally threatening stimuli (Chapters 13 & 14).

In Part IV an attempt is made to draw together the experimental findings of the first three parts and a 'model' is presented which, it is argued, may go some way towards explaining the generation of free floating anxiety attacks.

CHAPTER 2

SEMANTIC PRIMING WITH AND WITHOUT AWARENESS: A REVIEW OF LITERATURE

The effect of subliminal stimulation can be assessed directly or indirectly. Direct assessment has a number of disadvantages associated with it. Firstly, while a subliminal stimulus may affect behaviour it may not be processed in such a way that an intentional discriminative response can be made directly to it and a direct assessment of subliminal stimulation cannot take this into account. Secondly, participants see little point in responding to a stimulus which they cannot detect and some have refused to complete the task assigned them (see Marcel 1983a, Experiment 1). Assessing the effects of subliminal stimulation by indirect means is thus appealing. Over the last fifteen years an upsurge of interest in non-conscious perception has coincided with the development of three experimental paradigms which enable an indirect assessment of the effect of subliminal stimulation. The first two, dichotic listening and parafoveal vision, have been discussed by Holender (1986) and will not be discussed here. The third, subliminal semantic priming, will be discussed in some detail because it is the paradigm used in the experimental work reported in Chapters 3 to 12.

Studies of subliminal semantic priming can be seen as an extension of supraliminal studies in this field. For this reason, before the subliminal research literature is reviewed a brief, non-exhaustive review of the findings from supraliminal semantic priming experiments will be given.

In a typical semantic priming experiment participants are shown two consecutive letter strings. The first is generally referred to as the prime and the second as the target. Prime and target letter strings may each spell a real word or a nonword. It is usually the participants task to read the prime and then make a lexical decision about the target, that is, to decide whether the target spells a real word or a nonword, although in some experiments participants also make a lexical decision to the prime. Using one of these experimental paradigms it has been found that targets are recognised as real words significantly more quickly when they are preceded by semantically related primes (e.g. nurse-doctor, bread-butter) than when they are preceded by semantically unrelated primes (e.g. nurse-butter, bread-doctor). This finding is known as the semantic priming effect. (Meyer & Schvaneveldt 1971; Meyer, Schvaneveldt & Ruddy 1975; Fischler 1977; Neely 1976, 1977; Dannenbring & Briand 1982; Balota 1983).

Semantic priming and type of prime-target relationship

Whilst there are many different types of semantic relationship (Chaffin & Herman 1984) few have been investigated in semantic priming experiments. Nevertheless, priming has been found to occur when primes are category names and targets are examples of the category (e.g. bird-robin; Neely 1977), when primes are antonyms or synonyms of the target (e.g. dry-wet; Becker 1980) and when primes and targets are semantically similar (e.g. nurse-wife; Fischler 1977) or strongly associated (e.g. bread-butter; Meyer et al. 1975). Prime-target pairs are considered to be strongly associated if large numbers of people give the target word in response to the prime in a free association test. Normative data from tests of free association are published (e.g. Postman & Keppel 1970; Palermo & Jenkins 1964; Bousfield, Cohen, Whitmarsh & Kincaid 1961) and the semantically related (SR) prime-target word pairs used in many semantic priming experiments have been taken from these sources (e.g. Warren 1977). However, tests of free association have also been used with individual participants to establish personal associations which have subsequently formed SR prime-target pairs in a semantic priming experiment. Using this technique Franklin and Okada (1982) found a significant semantic priming effect which did not differ significantly in magnitude from that in which the SR word pairs comprised normative associates. Moreover, the facilitation effect based on personal associations was evident not only immediately after the prime-target pairings had been established but also 1-2 weeks later. Mckoon and Ratcliff (1979) found that semantic priming also occurred when primes and targets were neither personal nor normative associates but had been studied in their pairings just prior to the experiment. Of particular interest in Mckoon and Ratcliff's study was the finding that the facilitation in lexical decision time was not significantly different in magnitude to that which occurred with SR stimuli whose association was pre-experimentally acquired and normative. Meyer and Ruddy (1974) found that bilingual subjects were facilitated in their recognition of a target stimulus when it was preceded by a semantically related prime in another language and that the facilitation for mixed language pairs was comparable to that for same language pairs. Thus the semantic priming effect appears to be robust in the sense that it can be replicated when primes and targets are related in a variety of ways.

Semantic priming with different experimental paradigms

Although many semantic priming experiments conform to the description of a typical experiment given above semantic priming has been investigated in many diverse ways. Carroll and Slowcaczek (1986) for example, investigated the influence of primes on the speed of target processing when both words were embedded within a sentence. Taking the amount of time that the eye fixates the target as a measure of processing speed they found that the target was processed significantly more quickly when it was preceded by a semantically related prime rather than a neutral prime and that the priming effect was influenced by the syntactic structure of the sentence.

Semantic priming effects have also been found using non-verbal stimuli. For example, in an experiment with children McCauley, Weil and Sperber (1976) found that the time taken to name a picture was facilitated by the presentation of a picture prime which was semantically related to the target. Moreover, responses were made significantly more quickly when there was a high, rather than low, degree of association between the primes and targets.

Bruce and Valentine (1986) asked their subjects to decide if target pictures were of a familiar or unfamiliar face and found that seeing an associated face prior to the target significantly facilitated decision time in comparison to seeing an unassociated face. Stimuli used in this experiment included the pairings Prince Charles and Lady Diana; Eric Morecambe and Ernie Wise.

Semantic priming has been demonstrated in the auditory modality too. Radeau (1983) for example, conducted an experiment in the French language in which subjects heard prime-target pairs and responded by pushing a lever one way to indicate that both stimuli were real words and the other way to indicate that the prime or the target, or both, were nonwords. 'Real' responses were significantly faster when the prime and target were semantically related than when they were unrelated and the priming effect did not differ significantly between adults and children of 6-7 years. It seems clear from the studies discussed so far that the semantic priming effect is not modality or language specific. It is probably not merely a verbal phenomenon either although of course this needs to be investigated with stimuli which cannot be encoded verbally.

Semantic and repetition priming effects

Not all studies of priming have involved the use of different primes and targets. Priming by repetition of the target has also been investigated and in some studies compared with conventional semantic priming. Jackson and Morton (1984) investigated repetition effects in a study in which participants guessed the identity of words heard against a background of auditory noise. Results showed that correct responses were made significantly more often when subjects had previously read the words or heard them spoken in either a male or female voice. Scarborough, Gerard and Cortese (1984) found that lexical decision time was significantly shorter for words which had been included in a previous lexical decision task than for 'novel' words, although this finding was not evident when bilingual subjects performed the two different lexical decision tasks in different languages. Dannenbring and Briand (1982) used a lexical decision task to compare semantic priming effects with those of repetition. In their study letter strings were presented one after the other and the number of letter strings between the prime and target were systematically varied. Results showed that semantic priming occurred only when the target was immediately preceded by the prime. However, repetition effects were significant not only when the prime and target were separated by up to 17 stimuli within one session but also when they were presented two days apart! Dannenbring and Briand (1982) also found that with a prime-target lag of zero repetition effects were significantly greater than those of semantic priming.

Some support for these findings come from a study of event related potentials (ERPs) by Rugg (1987). Rugg found that repetition had a considerably more profound effect on ERPs in terms of magnitude and duration of response than did semantic priming. But it is not clear whether semantic and repetition effects are due to different processes or whether the repetition effect is simply a particularly powerful form of semantic priming.

Factors affecting the magnitude of semantic priming effects

Semantic priming has been found to aid recognition most when the target is particularly difficult to recognise. Meyer et al. (1975) found that facilitation was greater when the targets were degraded, by superimposing 'noise' in the form of a grid of dots, than when they were left intact. Becker and Killion (1977) found that a semantically related prime aided the recognition of the target more when the target was shown with reduced luminance than when it was clearly visible. Bruce and Valentine (1986) found that a prime consisting of a familiar face aided recognition of the target face to a greater extent when the targets were blurred images than when they were sharply focused. This finding is supported by Sperber, McCauley, Ragain and Weil (1979) who, in a series of naming tasks, also found that semantic priming aided the recognition of pictures and words to a greater extent when the images were blurred.

Some studies indicate that semantic priming is influenced by the level at which the prime is processed. Henik, Friedrich and Kellogg (1983) found that when the prime was named their results supported previous research which found a facilitation in target lexical decision time and an inhibition in colour naming (Stroop effect). But, both these effects disappeared when the prime was searched for a letter and thus presumably processed non-semantically. However, Kaye and Brown (1985) found that semantic priming did occur when participants were asked to search the prime for a letter although not when they were asked to decide whether the prime was printed in capital or lower case letters. They argue that it is probably not depth of processing (semantic versus non-semantic) that matters but the speed at which the prime is processed, though of course speed and depth of processing are not necessarily unrelated. Certainly time available for processing appears to be an important factor. On the basis of data gathered after their experiment Fischler and Goodman (1978) divided their primes into those which had fast naming latencies and those which had slow naming latencies. Ex post facto analyses revealed that targets which had been primed with 'fast' primes showed a large significant semantic priming effect while the semantic priming effect associated with 'slow' primes was small and non-significant. Moreover, when targets were divided into those associated with fast lexical decision times and those associated with slow lexical decision times semantic priming was significant for 'slow' targets and non-significant for 'fast' targets. Fischler and Goodman believe their findings demonstrate that semantic priming is in part dependent upon the time available for processing. They interpret the significant facilitation associated with 'slow' targets as indicating that processing of the prime does not necessarily end with presentation of the target but that the two stimuli can be processed in parallel. Support for this interpretation comes from the work of Kiger and Glass (1983) who found that semantic priming occurred even when the prime was presented after the target.

Semantic priming and semantic memory

Many researchers have attempted to fit the results of semantic priming experiments into a model or theory of semantic memory and word recognition. Schvaneveldt and Meyer (1973) explained their findings in terms of a spreading activation theory. This theory was originally developed by Quillian (1967, 1969) as a programme for a digital computer simulation of memory search. It has subsequently been extended by Collins and Loftus (1975). According to spreading activation theory concepts are stored at nodes in a semantic network. The distance between nodes represents the degree of association between concepts; related concepts are located close together (see Figure 1).

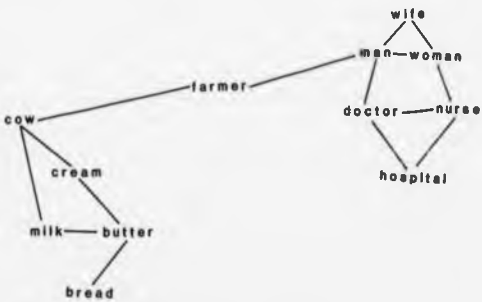

Figure 1. A Semantic representation of concept relatedness in a stereotypical fragment of human memory. (Based on Figure 1 in Collins and Loftus 1975).

When a stimulus activates a node the theory proposes that the node is energised and that this energy spreads out along the paths of the network in a decreasing gradient. As a result nodes which are located near to the source of the energy are also partially energised while those more distant remain unaffected if the energy has dissipated before reaching them. Thus semantically related primes are thought to partially energize the target while unrelated primes are thought to leave it unaffected. It is assumed that it is easier to recognise (and therefore make a lexical decision to) a target which has been partially energised and thus relative to unrelated primes semantically related primes facilitate recognition.

Whilst spreading activation enables the basic semantic priming effect to be conceptualised the theory is unable to accommodate more recent findings. In particular it is unable to account for the patterns of facilitation and inhibition which occur when the effect of semantically related and unrelated primes are compared with a neutral 'baseline' condition in which the prime comprises a series of X's. Facilitation is said to occur when in comparison to neutral (X) primes semantically related primes decrease the time taken to respond to the target. Inhibition is said to occur when in comparison to X primes unrelated primes hinder speed of response. Some studies have found a facilitation dominant pattern of results in which large significant facilitation and small non-significant inhibition effects occur (e.g. Neely 1976; Schuberth & Eimas 1977) while others have found their results dominated by inhibition (e.g. Neely 1977; Fischler & Bloom 1979).

Becker (1980) found that facilitation dominance occurred when prime-target pairs were strongly related (antonyms) and inhibition dominance occurred when the strength of association between prime-target pairs was relatively weak but variable. He explained these findings with reference to his verification model of word recognition. In Becker's model words are first stored in sensory memory and undergo a feature extraction process. This process does not lead directly to identification but, through the operation of word detectors which recognise relational qualities among features detected, a set of possible alternative words is generated. Each alternative is in turn compared with the information in sensory memory and when a match occurs the word is recognised. Once a word is recognised the semantic features of the word are used to identify a semantically related set of words which in turn become available for comparison with the sensory memory representation of a subsequent word in a verification process akin to that which occurs with the sensory set. Becker's model explains semantic priming as occurring when the prime has been recognised through the operation of feature and word detectors and has generated a semantically related set of words. When the target is represented in sensory memory it is compared directly with the semantic set generated by the prime. If no match is found the target is processed through feature and word detectors to the point where it is recognised. Facilitation is dominant when prime-target pairs are strongly related and therefore give rise to the creation of a small semantic set. Targets in the semantically related condition will be members of this small set and thus verification can occur very quickly before the sensory set for the target has even been created. Targets in the unrelated condition will not be contained in the semantic set but because the set is small comparison of its members with the sensory memory occurs quickly and there is only a short delay before the sensory set can be considered. In the X priming condition no semantic set is created so the verification process has to be performed on the sensory set. Thus when prime and target are strongly related response time in the semantically unrelated condition and X prime condition are comparable and quite slow in comparison to the semantically related condition.

In contrast when the relationship between prime and target is weak and variable primes give rise to a large semantic set. Verification of the target word in the semantically related condition will eventually occur with a member of the semantic set but this is likely to be quite a slow process because of the size of the set. Thus verification may occur only just before a match is made with a member of the sensory set in the X prime condition. In the unrelated condition however verification with the sensory set is considerably delayed because every member of the large semantic set has to be considered first. Thus when prime-target pairs are weakly related and give rise to the creation of a large semantic set inhibition effects dominate.

In Becker's (1980) model facilitation and inhibition effects are entirely dependent upon the strength of relationship within prime-target word pairs and the model is unable to account for the finding that these effects are also influenced by the time available for processing. In some studies of semantic priming the amount of time between presentation of the prime and presentation of the target has been systematically varied. This time period is known as the stimulus onset asynchrony (SOA). In one study den Heyer, Briand and Smith (1985) manipulated SOA and characteristics of the stimulus list which Becker proposed to account for facilitation/inhibition effects. Their research replicated Becker's results at a long SOA (1000 msec) but when the SOA was short (200 msec) there was a facilitation dominant pattern of results regardless of stimulus characteristics. Other studies too have shown that at short SOAs semantic priming is dominated by facilitation effects (large significant facilitation; small non-significant inhibition) while at long SOA facilitation and inhibition are both prominent (e.g. Neely 1977). These findings have been explained with reference to the Posner and Snyder (1975) two process model of word recognition. This model combines the fast automatic spreading activation theory of semantic priming with a slower attention driven mechanism dominated by strategic effects. Posner and Snyder's (1975) model is based on Morton's (1970) view of verbal long term memory which is somewhat similar to that of Collins and Loftus (1975) described above. Morton's view is that information about familiar events is stored as logogens and the logogens of semantically related words are assumed to be located close together. When stimuli are perceived they are analysed by banks of visual and/or auditory feature detectors which feed into long term memory. A logogen is activated whenever the number of features feeding into it exceeds some critical threshold.

Posner and Snyder (1975) propose a two process model of word recognition. Firstly, they propose that a stimulus automatically activates its logogen and that this activation automatically spreads to adjacent semantically related logogens. This automatic spreading activation process is assumed to be fast acting, to occur without intention or conscious awareness and assumed not to affect the retrieval of information stored in semantically unrelated logogens to which activation has not spread. Semantic priming is assumed to occur, in part, because of a facilitation in target recognition due to the targets partial (automatic) activation by a semantically related prime. However, Posner and Snyder (1975) also propose that semantic priming is based, in part, upon the operation of a second mechanism: the limited capacity conscious attention (LCCA) mechanism. This mechanism is thought to be slow acting and unable to operate without attention and conscious awareness. Unlike spreading activation the LCCA mechanism inhibits the retrieval of information stored in semantically unrelated logogens upon which it is not focused. This is because before the information stored at the unattended logogen can be analysed prior to making a response, the conscious attention readout mechanism has to be 'shifted' to that logogen. Thus a semantically related prime facilitates lexical decisions because it requires attention to be shifted a shorter distance than would an unrelated prime.

The role of the limited capacity attentional mechanism in semantic priming was investigated by Neely (1976) who found that in comparison to a neutral prime (series of X's) a semantically unrelated word prime produced inhibition. This finding implicates the role of attention but other aspects of Neely's results were difficult to interpret. For example, although Posner and Snyder's (1975) theory predicts that inhibition will build up as SOA increases Neely found that it remained constant over three SOA's (360, 600, and 2000 msec). Moreover, he found that the processing of nonword targets was facilitated by the word primes - a finding which argues against the role of limited capacity attention in inhibition. Neely (1976) argued that his results may have been affected by the highly stereotyped association between primes and targets in the semantically related condition (e.g. cat-dog). Specifically, he postulates that participants may have tried to guess the target and adopted a strategy of trying to match each 'guess' with the target when it appeared. If the participants then responded 'word' when there was a match there would be a tendency to respond 'nonword' when the two items differed. Thus lexical decision time to semantically unrelated words would have slowed while lexical decision time to nonwords would have speeded up. In a further study Neely (1977) investigated the effect of expectancy by presenting participants with a category name as a prime followed by a target which was an example from another category (e.g. body-door, body-sparrow). When participants were told from which category the target would come lexical decisions were facilitated when targets were expected and inhibited when they were unexpected. But both these effects disappeared when the SOA between prime and target was short. In the condition where primes were category names and targets were either exemplars of the category (semantically related: SR condition) or not (semantically unrelated: UR condition) facilitation and inhibition effects were apparent at an SOA of 2000 msec. However, as the SOA decreased facilitation remained constant and the inhibition effect decreased and disappeared altogether at an SOA of 250 msec. Neely's (1977) study clearly supports Posner and Snyder's (1975) two process theory of word recognition and semantic priming.

Further support for a slow limited capacity conscious attention mechanism comes from finding that the magnitude of the semantic priming effect increases as the proportion of related trials increases. (Tweedy & Lapinski 1981; den Heyer, Briand & Dannenbring 1983; de Groot 1984). Furthermore, when the SOA between prime and target is short, thus preventing the operation of a slow conscious mechanism, the proportion effect disappears (den Heyer et al. 1983).

Semantic priming effects and the identifiability of primes

Whilst many semantic priming experiments have presented both the prime and target supraliminally semantic priming has also been investigated in studies in which the prime could not be identified (McCauley, Parmelee, Sperber & Carr 1980; Carr, McCauley, Sperber & Parmelee 1982) or detected (Spence 1981; Fowler, Wolford, Slade & Tassinary 1981, Experiments 5 & 6; Marcel 1983a, Experiment 4; Balota 1983). It has been thought that the minimal condition for priming would be the identification of the prime and Fischler and Goodman (1978) thought they were investigating this in a study in which participants tried to recall the prime after making a lexical decision to the target. The authors expected to find that only when the prime could be recalled would there be a significant semantic priming effect, but they found just the opposite. That is, they found that prime recall was associated with a non-significant semantic priming effect, and inability to recall the prime with a highly significant priming effect! Fischler and Goodman (1978) explained the non-significant result as due to interference which occurred when the prime was kept in mind whilst making a lexical decision. Priming without prime recall was interpreted as a 'subthreshold effect'. However, in Fischler and Goodman's experiment no attempt was made to present the primes below identification threshold and it does not seem reasonable to assume that primes which could not be recalled after each trial were not identified at the time of presentation. A better investigation of priming below identification threshold was conducted by McCauley et al. (1980). In the McCauley et al. study picture primes were followed in temporal and spatial succession by a pattern mask made up of letters and letter pieces. Pattern masking can be used to prevent conscious detection of the prime (see below) or, as in this case, to prevent identification. In McCauley et al.'s study participants attended a preliminary session during which they tried to identify 10 picture primes each succeeded by a pattern mask exposed for 50 msec. Primes were initially displayed for a duration at which they could easily be identified but this duration was gradually reduced using the method of descending limits. Zero identification threshold (zero IT) was defined as the duration at which 6 attempts at identification were unsuccessful and to ensure that a particularly conservative estimate of zero IT was made 5 msec was then deducted. Taking zero IT as the baseline an ascending method of limits was then used to find 1/3 threshold, 2/3 threshold and full identification threshold. These thresholds were defined as the duration at which the prime was successively identified on 2/6, 4/6 and 6/6 occasions respectively. In a subsequent session the influence of semantically related and unrelated pictures on the time taken to name a picture target was investigated. Significant semantic priming was found to occur not only when the prime was presented at full identification threshold (IT) but also when it was presented at zero IT, 1/3 and 2/3 IT. Moreover, the magnitude of priming did not differ significantly between any of these conditions. In a second experiment McCauley et al. (1980) extended the range of prime durations to include a supraliminal condition in which the prime was presented for full IT plus 250 msec, and a 1/3 and 2/3 zero identification threshold (defined as zero IT multiplied by 0.33 and 0.67 respectively). Priming was again significant and comparable across a range of prime durations (supraliminal, full IT, zero IT and 2/3 zero IT) and only dropped to insignificance at the shortest duration of 1/3 zero IT. Results thus supported McCauley et al.'s previous findings and their conclusion that semantic priming can occur when primes are presented below identification threshold.

Following Fischler and Goodman (1978) McCauley et al. (1980) asked participants to recall each prime after responding to the target in both Experiments 1 and 2. In general prime recall was poor; even at full identification threshold it only reached 13% in Experiment 1. McCauley et al. interpret these findings in the same way as Fischler and Goodman (1978), in that they suggest that response to the target and some aspect of identifying and remembering the prime interfere with one another.

Carr et al. (1982) extended the research of McCauley et al. (1980) in a study of semantic priming with all combinations of picture and word prime and target. When primes and targets were both pictures they replicated the earlier finding of McCauley et al. (1980) in showing that priming occurred below identification threshold. However, the effect of cross modal priming (prime-target combinations of word-picture, or picture-word), designed to investigate whether words and pictures are encoded in the same amodal system, was non-significant at zero identification threshold. With word stimuli as primes and targets Carr et al. (1982) also found a non-significant priming effect below identification threshold. This finding is of particular interest and is given fuller consideration below.

Whilst the research of McCauley et al. (1980) and Carr et al. (1982) appears to show that semantic priming can occur when primes are presented below identification threshold some researchers consider the findings of these studies to be spurious. Holender (1986), for example, argued that in these experiments there was much more light involved in the priming phase than in the threshold determination phase and therefore participants were probably more light adapted during priming than during detection. As a result, he believes that primes were more clearly visible in the second phase of the experiment and that it was identification of the primes which led to semantic priming. Because Holender (1986) also makes this criticism of some of the experiments which purport to show semantic priming below detection threshold a fuller discussion of his views will follow after the studies of semantic priming below detection threshold have been presented.

Semantic priming when primes are presented below detection threshold

Although semantic priming without awareness has been investigated in a number of ways (e.g. Lewis 1972) only 4 studies have required lexical decisions about visually presented targets preceded by subliminal verbal primes (i.e. the type of task used in the present research). One of the first studies was undertaken by Spence (1981). Spence conducted a semantic priming experiment in which primes were presented for 10, 20 and 40 msec. After the experiment participants were shown an additional 30 trials at each prime duration and asked to discriminate trials (N = 15) in which the prime was a word from those in which the prime was replaced by a blank card (N = 15). When discrimination was at, or below, chance level the primes were assumed to have been presented subliminally and ex post facto analyses of priming below and above detection threshold were therefore possible. Results showed that when primes were presented subliminally lexical decisions made to the targets were significantly faster in the semantically related condition than in the unrelated. Surprisingly however, this effect was non-significant when primes were presented above detection threshold. Spence concluded that semantic priming without awareness is possible but that when primes are presented just above detection threshold they are partially recognised and this interferes with processing of the target in such a way that it cancels out the facilitation afforded by semantically related primes.

In the studies of semantic priming conducted by Marcel (1983a, Experiment 4), Fowler et al. (1981, Experiments 5 & 6) and Balota (1983) a dichoptic backward pattern masking technique was used. This entailed presentation of the prime to one eye, followed by presentation of a pattern mask to the other eye and finally presentation of the target binocularly. This technique was adopted to ensure that central rather than peripheral masking occurred (Turvey 1973). Peripheral masking occurs in the peripheral nervous system at the level of the retina, the lateral geniculate nucleus and possibly the striate cortex whilst central masking occurs more centrally at the striate cortex and beyond. Marcel (1983b) claimed that whilst both central and peripheral masking prevented conscious awareness of the masked stimulus only central masking enabled unconscious perception and analysis of the prime to take place. Thus semantic priming effects are associated with central, but not peripheral, masking. The type of masking which predominates is determined by the energy relationship between the prime and the mask and also the length of time which elapses between them. It has also been found that dichoptic presentation cannot result in peripheral masking and that central masking can only occur with a pattern mask (i.e. with a mask which comprises a random structure whose individual elements are similar to the elements of the prime; Turvey 1973). Thus besides taking into account energy and time factors researchers wanting to ensure central masking use a backward pattern masking technique involving dichoptic presentation of prime and mask. Using this technique Balota (1983), Fowler et al. (1981, Experiments 5 & 6) and Marcel (1983a, Experiment 4) appeared to demonstrate semantic priming without awareness. All three studies began with the assessment of detection threshold (DT) during which participants tried to discriminate blank cards from cards on which a word was printed. Each trial consisted of a blank or stimulus card followed by a dark interstimulus interval (ISI) and then the pattern mask. In a descending method of limits the ISI was reduced until participants were unable to discriminate blanks from stimulus cards at better than chance level. Chance level responding was defined as being less than 60% correct. Balota, Fowler et al. and Marcel found that primes presented below detection threshold gave rise to semantic priming effects when the SOA between the prime and target was long (2000 msec) but not short (200 msec, Fowler et al. 1981; 350 msec, Balota 1983). Moreover, in two of the three experiments semantic priming without awareness at the long SOA was not significantly different in magnitude from semantic priming above detection threshold.

As noted above Holender (1986) has criticised the studies of semantic priming below identification (McCauley et al. 1980; Carr et al. 1982) and detection threshold (Fowler et al. 1981; Marcel 1983a; Balota 1983) on the grounds of differential light adaptation between the threshold determination and priming phases of each experiment. Holender (1986) argued that when participants are dark adapted and see the prime-mask sequence during threshold assessment against a dark background the prime is relatively difficult to identify or detect. However, in the priming sequence (prime-mask-target) more light is available because an extra stimulus - the target - is presented for a few hundred milliseconds. This, it is claimed, may lead to increased light adaptation during priming and therefore an improvement in detection and identification of the prime. Holender cites Purcell, Stewart and Stanovich (1983) in support of his argument. Purcell et al. (Experiment 2) assessed zero picture identification threshold in a similar manner to Carr et al. (1982) and McCauley et al. (1980). They then recorded how many pictures were correctly recognised in a mock priming procedure in which the prime was succeeded by a mask and then a white card exposed for 800 msec. Instead of getting 20% correct recognition (as expected by chance) Purcell et al. found that 70% of the pictures were correctly identified. Moreover, when in Experiment 3, they equalised levels of light adaptation between the threshold and priming phases of the experiment, at zero identification threshold the semantic priming effect was non-significant.

Holender's contention that significant semantic priming below identification and detection threshold are spurious finding has been challenged. Balota (1986) for example, argued that the studies of

McCauley et al. (1980) and Carr et al. (1982) differ in crucial ways from those of Fowler et al. (1981) and Balota (1983), and because of this the same criticism applied to them all is difficult to sustain. Balota (1986) recognises that a different level of light adaptation may be responsible for the findings of McCauley et al. (1980) and Carr et al. (1982) but he defends his own study and that of Fowler et al. (1981) on two grounds. Firstly, he points out that whilst a dark field was shown during the intertrial interval in the experiments of McCauley et al. (1980) and Carr et al. (1982) there was a return to the dimly lit fixation field between trials in the Fowler et al. (1981) and Balota (1983) experiments. As a result participants would have been more light adapted throughout the whole of Fowler and Balota's experiments and thus the additional stimulus (the target) seen during priming trials would be less likely to have a substantial effect. Secondly, Balota (1986) points out that the contrast between stimuli was far less in the studies of Balota (1983) and Fowler at al. (1981) than in those of McCauley et al. (1980) and Carr et al. (1982). This was partially due to stimuli being presented at lower levels of luminance in the Balota and Fowler et al. study and partly because they presented their stimuli dichoptically rather than binocularly as McCauley et al. and Carr et al. chose to do. Thus Balota (1986) claims that although luminance levels were not equated across the threshold and priming phases of the experiments of Fowler et al. (1981) and Balota (1983) the potential for light adaptation occurring in the priming trials was relatively minimal compared to that in the McCauley et al. study. Holender (1986) suggested that one way of assessing whether light adaptation has led to improved identification or detection in the priming phase of an experiment is to include such trials within the priming experiment itself. In fact Marcel (1983a, Experiment 5) had already done this in 1983 when he randomly mixed detection trials with a lexical decision task. In a procedure where light adaptation could not have differed for the two types of trials and where participants could not detect primes (as assessed by the procedure advocated by Holender) there was a significant priming effect. Moreover, when Carr and Dagenbach (1986) equalised the lighting conditions between the threshold assessment and priming phases of their experiments there was still a significant semantic priming effect when primes were presented below detection threshold.

Whilst Holender's belief that light adaptation may have improved between the threshold determination and priming phases in some investigations of priming without identification or detection, and Purcell et al.'s (1983) results support this point of view, other studies (Marcel 1983a; Carr & Dagenbach 1986) suggest that priming without identification or detection is unlikely to have been due entirely, if at all, to an increase in light adaptation.

Holender (1986) criticised the studies of priming without awareness not only on the grounds discussed above but also on the more substantial point that primes were probably presented above detection threshold because detection thresholds were inadequately assessed. In expressing this criticism Holender (1986) was voicing his support for the views of Merikle (1982). Merikle's (1982) criticism of the assessment of detection threshold was directed at the studies of Marcel (described in a conference paper and unpublished manuscript and reported in 1983a) and Fowler et al. (1981) but can be applied equally well to the work of Spence (1981) and Balota (1983). In all these studies detection threshold was assumed to have been reached when participants were unable to discriminate word stimuli from blank cards at better than chance level. To ensure this technique accurately assesses detection threshold Merikle (1982) stated that two criteria must be met. First, it must be demonstrated that participants used both available responses (i.e. 'yes' - a stimulus was present and 'no' - no stimulus was present). Merikle argued, quite correctly in principle, that if this criterion were not met it would be possible to get chance level responding quite spuriously as a result of the same response ('yes' or 'no') being given all the time; that is, on all trials where the stimulus was present and on all blank card trials. Second, Merikle (1982) argued that a reasonable number of trials must be given in order to assess whether responses follow chance distributions. He condemned the procedures used by Marcel and Fowler et al. because response distributions were not considered and Fowler et al. (1981) assessed detection thresholds using blocks of only five trials. Marcel (1983a, Experiment 4) assessed detection thresholds with a reasonable number of trials (40); 30 trials were given by Spence (1981) but only 20 by Balota (1983). Balota (1983) claimed that both 'yes' and 'no' responses were used by his participants though he gave no quantative data to allow one to judge the extent to which this occurred and Spence (1981) failed to consider response distributions at all.

Henley (1984) argued that Merikle's (1982) methodological criticisms of the subliminal priming experiments were irrelevant because the forced choice procedure used to assess detection thresholds was inappropriate. Henley cited the finding by Rollman and Nachmias (1972) that recognition performance had exceeded chance level at detection threshold in an experiment where participants were presented either with no stimulus or with weak red or green flashes. Henley suggested this finding indicated that information available for discriminative report was still available at detection threshold and so above chance level responding may be expected if participants are not firmly required to report only what is consciously seen (i.e. if they are allowed to report whether they think a stimulus was present or not).

Henley's insistence on threshold determination procedures which emphasise subjective awareness was taken further by Cheesman and Merikle (1984) who proposed the idea of 'subjective' and 'objective' detection thresholds. Subjective threshold is determined with reference to participants' reports of failure to detect the presence of a stimulus while objective threshold is defined with reference to the occurrence of chance level (i.e. non-discriminative) responding and the latter is of course lower than the former (Carr & Dagenbach 1986). Cheesman and Merikle (1984) claim that semantic priming can occur below subjective threshold but not below objective threshold and they cite findings from their own research to support their claim. On the basis of their results Cheesman and Merikle (1984) argue that the priming effects obtained by Fowler et al. (1981) and Marcel (1983a) resulted from an inadvertent measurement of subjective rather than objective detection thresholds.

The distinction between objective and subjective detection thresholds is both potentially useful and important. Acceptance of it lessens the force of Henley's (1984) objection to the use of forced choice threshold assessment techniques because, in principle, the Rollman and Nachmias (1972) finding upon which Henley relies could be explained as due to the assessment of subjective rather than objective detection thresholds. However, Marcel (1983a), Fowler et al. (1981), Spence (1981) and Balota (1983) presumably intended to assess objective thresholds and their findings were intended to demonstrate that semantic priming effects could occur at, or below, objective detection threshold. But Cheesman and Merikle's (1984) results do not necessarily disconfirm this hypothesis because objective detection threshold was assessed in their study not using the two choice discrimination procedure but using a four choice identification procedure in which participants were required to say which of four pattern masked colour words had been presented. Thus while maintaining that objective detection thresholds were being assessed Cheesman and Merikle (1984) actually assessed objective identification thresholds. Although it is somewhat of an enigma, a number of studies have failed to find significant semantic priming effects just below, or at, identification threshold and Cheesman and Merikle's findings are consistent with this.

Further difficulties with Cheesman and Merikle's work arise from the use of colour names as priming stimuli. It is known that colour preferences exist and that these are somewhat different for men and women (Choungourian 1968; McManus, Jones & Cottrell 1981). It is also known that strong preferences exist for colour names. For example, when asked to state a colour name in a free response situation, Simon (1971) found 52% of a large sample of college men gave "Blue", 11% gave "Red", 10% "Green", 8.5% "Brown", 5.5% "Purple" and 3% "Yellow". These six colour names accounted for 90% of the responses. A similar order of preference was found by Trueman (1979). Thus there is a very strong preference for the colour name "blue" and a very weak preference for "Yellow", both of which were used by Cheesman and Merikle (1984). In the first experiment reported by Cheesman and Merikle (1984) the same stimulus onset asynchrony (SOA) between prime and mask was used for all colour names (Blue, Green, Orange and Yellow) during threshold detection. Below subjective threshold participants were clearly attempting to discriminate colour names under conditions of great uncertainty and so response bias resulting from colour preferences seems very likely to have been produced. In attempting to assess objective threshold

Cheesman and Merikle reduced SOA when, in a block of 24 trials, participants failed to show non-discriminative responding which was defined as occurring when the probability of a correct response, taken over the set of four colour names, fell below 0.3. As a result of response bias due to colour name preferences this procedure could have resulted in the situation where the overall probability of a correct response indicated discriminative responding though non-discriminative responding occurred for three of the four colour names. In such a case Cheesman and Merikle's procedure would falsely require SOA to be lowered. Thus in their Experiment 1 it may well have been the case that, as a result of response bias, estimates of objective threshold were made appreciably below actual objective threshold, and this may explain the failure to obtain semantic priming effects. Some suggestion that substantial response bias may have occurred can be seen in Cheesman and Merikle's discussion of the procedure in Experiment 2 (p. 393) where they state that "occasionally there was a relatively large discrepancy in detection performance across individual words". To eliminate this disbalance thresholds were individually assessed for each colour word prime in Experiment 2. However, this cannot be considered to have resolved the difficulty because, although Cheesman and Merikle informed participants that each colour name would occur with equal probability, Trueman (1979) found that informing participants of colour name preferences did not result in chance level responding in a free response task. Thus response bias in colour naming appears difficult to overcome and it seems likely that to attain chance level responding Cheesman and Merikle may have had to lower SOA below 'true' objective threshold. That is, lower SOA to a level appreciably below that at which an observer without colour preferences would have yielded chance level responding. If this happened it might well account for the failure to find semantic priming effects.

However, there is another alternative explanation of Cheesman and Merikle's (1984) findings. Carr and Dagenbach (1986) suggest that it is probably not only the stringency of threshold assessment that determines whether semantic activation (and therefore priming and Stroop interference effects) will or will not occur, but the type of task that is used. They consider the threshold-setting task to be "an experience that affects the perceivers' strategies for attempting to gain information from the prime" (p. 26). Carr and Dagenbach believe that only particular types of threshold assessment procedures lead to the adoption of strategies for acquiring information which subsequently enables the occurrence of priming or Stroop interference effects. Carr and Dagenbach (1986) found that semantic priming occurred when detection threshold was assessed using the unrestricted presence-absence procedure of Marcel (1983a), Fowler et al. (1981), Balota (1983) and Spence (1981), but disappeared when primes were presented at detection thresholds assessed by a forced choice recognition procedure. This is a particularly interesting finding because the same participants took part in both experiments and the threshold assessed by the forced choice procedure was less stringent (longer) than that assessed by the two-choice detection task.

The finding that priming effects occur using detection but not recognition threshold procedures is difficult to explain as the latter are less stringent than the former. However, the finding may be explicable in terms of partial but misleading information being available to awareness with recognition procedures with the result that primes are misidentified to some extent and therefore activate targets other than those later presented.

Conclusions on semantic priming without awareness

Two major points emerge from the literature reviewed in the last section. First, in the light of the criticisms made by Merikle (1982), Cheesman and Merikle (1984) and Holender (1986) it may be argued that detection thresholds were not satisfactorily assessed in the studies by Spence (1981), Fowler et al. (1981), Marcel (1983a) and Balota (1983). Second, thresholds assessed by forced choice recognition procedures are not equivalent to those assessed by forced choice detection procedures and the issue of whether subliminal priming effects can occur must be resolved with respect to detection, not recognition, thresholds if sceptics are to be convinced of the phenomenon. The most convincing procedure would obviously involve presentation of primes below objective detection threshold because in this case there would be a clear demonstration that truly non-discriminative responding occurred at threshold. To the best of the author's knowledge no study has been carried out in which priming effects at, or below, objective detection threshold have been investigated. Thus it may be claimed that an adequate test has not yet been made of the hypothesis that semantic priming can occur without awareness.

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PART II

SEMANTIC PRIMING EFFECTS BELOW OBJECTIVE DETECTION THRESHOLD

CHAPTER 3

SEMANTIC PRIMING WITHOUT AWARENESS: QUESTIONS FOR INVESTIGATION

From a review of the subliminal semantic priming literature in Chapter 2 it was concluded that semantic priming without awareness has not been adequately investigated. It was also concluded that an adequate test of the subliminal priming hypothesis requires primes to be presented below objective detection threshold. A major obstacle to doing this lies in the fact that objective detection threshold has not been satisfactorily defined in operational terms. Merikle (1982) proposed that the assessment of objective detection threshold should meet two criteria. Firstly, when discriminating between stimuli and blank cards participants must use both responses and secondly assessment of detection threshold must be carried out using a reasonable number of trials so that an adequate assessment of response distributions can be made. Neither of these criteria have been defined operationally. However, as noted in Chapter 2 it seems not unreasonable to assume that 40 trials (20 blank cards and 20 stimuli) will ensure an adequate measurement of response distributions at detection threshold. This corresponds to the number of trials used by Marcel (1983a, Experiment 4).

To demonstrate that participants cannot discriminate blank cards from stimuli at better than chance level three criteria for non-discriminative responding are now proposed: firstly that the probability of a correct response [P(C)] must lie within the 95% confidence limits of the chance expectancy of 0.5; secondly, that the probability of a hit (correct response when a stimulus is presented) must lie within the 95% confidence limits of the chance expectancy of 0.5 and thirdly, that the probability of a false alarm (incorrect response when a blank card is presented) must also lie within the 95% confidence limits of the value 0.5 which is expected by chance. These specific criteria take account of Merikle's (1982) argument that both response categories must be used and that the observed response distributions should be compared with those expected on the basis of chance. The criteria conform to usual experimental practice by assuming that stimulus and blank card trials occur with equal probability and that participants are aware of this.

It might be argued that the signal detection theory measure of sensitivity d' could be used in place of the proposed criteria. In this case non-discriminative responding might be defined as occurring when d' = 0 (Macmillan 1986). This view is not favoured because d' is equal to zero when the probability of a hit is equal to the probability of a false alarm irrespective of the value of the probability. As participants are typically told (as in Marcel 1983a; Fowler et al. 1981) that stimuli and blank cards will be presented with equal frequency some account should be taken of participants' knowledge of this fact in defining and assessing chance level performance. However, as the proposed criteria require that d' approximates zero, obtained values of d' may be used as assessments of detection performance. If participants are unable to discriminate blank cards from stimuli at detection threshold then an assessment of detection performance should not correlate significantly with the magnitude of priming effect and this would be a further check on the adequacy of the detection assessment procedure. Some support for this view comes from the findings of Cheesman and Merikle (1984). Cheesman and Merikle (1984) used the percentage of correctly identified colour names as a measure of identification performance (IP), and found that IP correlated significantly with the magnitude of priming effect at subjective, but not objective, threshold.

Merikle has claimed that:

> "as long as it is assumed that the boundary between conscious and unconscious processes is defined by the threshold for discriminative responding, no evidence for unconscious perceptual processes will be found when precautions are taken to ensure accurate measurement of discriminative responding" (Merikle 1986, p. 42).

The first question posed in the present research was concerned with whether semantic priming effects occur when primes are presented below objective detection threshold assessed in accordance with the three criteria proposed above.

Leaving aside the criticisms of threshold assessment techniques made by Merikle (1982) and Cheesman and Merikle (1984), the validity of the conclusions drawn about subliminal semantic priming by Spence (1981), Fowler et al. (1981), Balota (1983) and Marcel (1983a) may be questioned on other grounds. Clark (1973) argued that in experiments where stimuli are words chosen at random it is inappropriate to use statistical models which assume fixed effects. According to Clark (1973), statistical analyses making such an assumption can only reveal whether the results are likely to generalise to other samples of participants and cannot determine whether generalisation to other samples of words is likely. Clark (1973) advocated the use of a quasi F ratio (F') in ANOVAs testing hypotheses about the generalisability of findings in experiments using verbal stimuli. However, Wike and Church (1976) presented some powerful arguments against Clark's view. They contended that Clark's definition of a 'random effect' is different from that conventionally accepted, that there is a lack of clarity regarding how F' should be computed and that in any event it is deficient in power. Wike and Church suggested that replication with different verbal stimuli and different subjects is preferable to the use of F' for determining whether results are likely to generalise. However, the subliminal priming investigations by Spence (1981), Marcel (1983a) Fowler et al. (1981) and Balota (1983) used neither F' nor replication. The second question posed by the research reported in Chapters 4 and 5 was therefore concerned with the value of quasi F (F') for predicting the generalisability of findings from experiments using verbal stimuli: Is F' a useful statistic or is replication a preferable procedure?

In their discussion of the problem of demonstrating generalisability of results Wike and Church (1976) suggested that replication, not only with different samples of words and subjects, but with different experimental techniques is advisable. Marcel (1983a, Experiment 4), Balota (1983) and Fowler et al. (1981, Experiments 5 & 6) used a dichoptic backward pattern masking technique to ensure central rather than peripheral masking. Spence (1981) used binocular presentation of both primes and targets but did not use a pattern mask. Theoretically, under certain conditions it should be possible to achieve central masking by using a pattern mask with binocular presentation of both prime and mask. Turvey (1973, Experiments 10 and 11) found monoptic presentation produced peripheral masking with stimulus and mask durations up to 10 msec, but that beyond this critical duration a transition to central masking occurred, especially with mask durations of 50 msec or longer. Presumably this should also hold true for binocular presentation. Breitmeyer (1984) indicated that binocular presentation of stimulus and structure mask (especially pattern mask) can produce the same type of masking (i.e. central) as dichoptic presentation provided the energy ratio of target:mask is greater than unity. Thus it seems reasonable to suppose that central masking should be obtained with binocular presentation if; (a) the stimulus is presented for more than 10 msec, (b) the pattern mask has a duration of at least 50 msec and (c) the mask has lower energy than the stimulus.

In priming experiments the use of both dichoptic and binocular presentation of prime and mask (under the appropriate conditions) would have the advantage of conforming to Wike and Church's (1976) suggestion that replication with alternative techniques should be sought. The third question investigated in Chapters 4 and 5 was therfore concerned with whether binocular presentation of stimuli and pattern mask is a viable alternative to the dichoptic procedure much used in subliminal semantic priming experiments (e.g. Fowler et al. 1981; Marcel 1983a; Balota 1983).

CHAPTER 4

A SUBLIMINAL SEMANTIC PRIMING EXPERIMENT AND TWO REPLICATIONS EXPERIMENTS 1, 2 AND 3.

The experiments reported in this chapter had three aims:

1. To determine whether subliminal semantic priming effects occur when primes are presented below objective detection threshold as assessed by the three criteria proposed in Chapter 3.

2. To investigate the value of quasi F (F') for predicting whether the results of subliminal semantic priming studies will generalise to experiments using new participants and different stimuli.

3. To explore binocular presentation of stimuli and pattern mask as an alternative to dichoptic presentation in research into subliminal semantic priming.

EXPERIMENT 1

METHOD

Participants

Twelve undergraduate students took part in the experiment. They had a mean age of 19.6 years (SD 1.75) and 6 were men. None were aware of the nature of the research, or had taken part in similar studies. Each was paid £1.50 for participating.

Apparatus

The Stimuli were presented in an Electronic Developments 3-field tachistoscope fitted with fast rising ED3 lamps. Illumination of the mask field was set to 1.90 lg cd/M^2 while prime and target stimuli were presented at a luminance of 2.35 lg cd/M^2. These luminances, measured with blank cards in the respective fields, were chosen because pilot trials had indicated they were very likely to produce detection thresholds in excess of 10 msecs. Such thresholds were required because binocular presentation of primes for less than 10 msecs followed immediately by a mask is likely to result in peripheral masking. Lexical decision times were measured by a Colne Instruments Tyer C4 digital timer interfaced with the tachistoscope. The experiment was conducted in a sound attenuating room lit by a 40 watt bulb in a small desk lamp.

Stimuli

Ten prime-target letter strings in each of 4 conditions were used in the experiment (see Appendix A). Two examples from each condition appear in Table 4.1. All primes were real words. Of the 40 targets half were real words and half were nonwords. Nonwords were pronounceable and represented high level approximations to English words. Half of the real word targets were preceded by semantically related primes (SR condition) and these word pairs were first associates from the Minnesota norms for the Kent-Rosanoff word association test (Postman and Keppel 1970). The remainder of the real word targets were preceded by semantically unrelated primes (UR condition). Two prime-target lists of 10 word-nonword pairs ($W\bar{W}_1$; $W\bar{W}_2$) were chosen so that the primes matched those in the SR and UR conditions for frequency and length, and the targets were of a comparable length to those in the SR and UR conditions. Whenever the word 'length' is used to describe stimuli in this thesis it refers to number of letters. For presentation the stimuli in all 4 conditions were combined and randomised.

Table 4.1 Examples of prime-target letter strings in Experiment 1.

		Condition			
		SR	UR	$WN̊_1$	$WN̊_2$
Type of letter String	Prime Target	Real Real	Real Real	Real Nonword	Real Nonword
Example I	Prime Target	BREAD BUTTER	REPLY BIRTH	TEACH WENTAL	LOAD MIGLON
Example II	Prime Target	DOCTOR NURSE	EMPEROR FROZEN	FIFTY LERT	SUPPLY ESPET

The frequency with which primes and targets occur in everyday usage was determined by reference to the Kucera and Francis (1967) word norms. Mean frequency and word length, is shown in Table 4.2 for the SR, UR and WN̊ conditions. The primes did not differ between conditions in length ($F = 0.0152$; df 3,36; $P > 0.05$) or frequency ($F = 0.0004$; df 3,36; $P > 0.05$). Targets did not differ significantly between conditions in length ($F = 0.1406$; df 3,36; $P > 0.05$) or between the SR and UR conditions in frequency ($t = 0.0114$; df 18; $P > 0.05$). It was considered important to ensure that the frequency of targets in the SR and UR conditions were matched because frequency has been found to significantly affect lexical decision time (Rubenstein, Garfield & Millikan 1970; Scarborough, Cortese & Scarborough 1977; Gardner, Rothkopt, Lapan & Lafferty 1987). For practice 12 additional pairs of letter strings were constructed in the same proportions as the experimental stimuli, that is three SR, three UR and six WΩ prime-target word pairs. The practice stimuli are shown in Appendix A.

Table 4.2 Mean length, and frequency, of prime and target stimuli in Experiment 1.

	Condition			
	SR	UR	$WΩ_1$	$WΩ_2$
Primes:				
Length	5.2 (1.25)*	5.2 (1.25)	5.2 (1.25)	5.3 (1.10)
Frequency	67.8 (56.81)	68.1 (57.13)	67.3 (56.84)	67.4 (56.09)
Targets:				
Length	5.0 (0.78)	5.0 (0.78)	5.0 (0.78)	5.2 (0.87)
Frequency	46.3 (56.03)	46.0 (55.44)	- -	- -

* Standard deviations are shown in parentheses

For the assessment of detection thresholds ten test words were selected (see Appendix A). Each had a frequency of occurrence equal to, or greater than, the most frequently occurring prime, and each was equal in length to the longest prime. Thus test stimuli were chosen to give conservative estimates of detection thresholds.

All stimuli comprised capital letters printed on self-adhesive transparent tape using wheel size 10 of the KROY 80 lettering system. This gave a letter height of 2.5 mm. Stimuli were centred on white cards 101 x 152 mm which were viewed at a distance of approximately 508 mm. Primes and targets subtended horizontal visual angles of 1.13 to 3.38 and 1.35 to 2.37 degrees respectively. The pattern mask comprised parts of letters which had been printed in an identical manner to the prime and target stimuli but had then been cut up and fixed on a blank card at random orientations in an area measuring 20 x 50 mm. The mask subtended visual angles of 5.63 degrees in width and 2.26 degrees in height. It is shown in Appendix A.

Procedure

After the tachistoscope had been adjusted for height the main overhead light was switched off so that the room was lit by a small desk lamp only. Participants were then told that two separate experiments were to be carried out, the first on visual acuity and the second on word recognition.

Each experimental session began with the assessment of detection threshold. Participants were told that they would be shown either a blank card or a card on which a word was printed, followed immediately by another card on which there was a random pattern (the mask). The experimenter said that a warning bleep would precede this sequence by one second and that the participant's task was to look at the sequence, from the bleep, and decide whether, prior to the random pattern, a word or blank card had been presented. Participants were told that the sequence would be shown in sets of 10, and that in each set 5 blank cards and 5 stimulus cards would be presented in random order. The sequence was initiated by the experimenter and comprised a dark field, prime, mask, dark field. The mask was exposed for 500 msec. Initially test words and blank cards were presented supraliminally for 100 msec to familiarise participants with the task and to indicate the appropriate region to fixate. A marked fixation point was not used because in the semantic priming experiment all three available fields were required to present the prime, mask and target. When participants understood the procedure the duration for which the test stimuli/blank cards was presented was reduced to 80 msec and then further reduced by 10, 5 or 1 msec whenever in a block of 10 trials stimuli were distinguished from blanks at greater than 60% accuracy. When 60% or fewer responses were correct in a block of 10 trials another 3 sets of 10 trials were shown at the same duration. If the probability of a correct response fell within the 95% confidence limits of the chance expectancy of 0.5 (0.35 to 0.65) when assessed over the 4 sets of trials, detection threshold was assumed to have been reached. Threshold assessment took between 30 and 45 minutes.

For the semantic priming experiment participants held a small trigger in each hand. Half the men and half the women were instructed to press the trigger in their dominant hand when the target stimulus was a real word and to press the other trigger when the target was a nonword. This procedure was reversed for the other half of the sample. Participants were instructed to respond as quickly and as accurately as possible.

The practice stimuli were presented three times before the experiment proper began. Each experimental trial was initiated by the experimenter while the participant fixated the centre of a dark field. A trial consisted of a warning 'bleep' followed one second later by the prime which was exposed at a duration 10% below the participant's detection threshold. This procedure was adopted to ensure that stimuli were truly subliminal. 500 msec of mask followed immediately after the offset of the prime and the target followed immediately after the offset of the mask. Target exposure was terminated by a trigger response from the participant and the target was followed by a dark field. Thus participants were presented with the sequence dark field, prime, mask, target and dark field.

There was no conversation between the participant and experimenter during the semantic priming experiment although participants would often comment spontaneously when they had made a mistake.

Lexical decision time was recorded by the experimenter who also changed the stimulus cards manually between trials. At no time did the experimenter know which stimuli were being presented as she saw only the back of each card while loading it into the machine. This was also the case in all subsequent experiments. The timer automatically reset itself and there was an inter-trial interval of approximately 12 seconds.

At the end of the experiment participants were questioned about the second experiment and in particular about what they might have seen prior to the mask on priming trials. Firstly, they were reminded that they had been told that the first experiment was designed to assess visual acuity but that they had not been told why the second experiment was conducted. They were then asked to guess the purpose of the second experiment and to give a reason for the presentation of the patterned stimulus (mask). Finally they were asked whether it ever seemed as if a stimulus had been presented prior to the pattern (mask) in the second experiment.

RESULTS

Over the final 40 trials of threshold assessment all 12 participants gave a response distribution in which the probability of making a correct response, P(C), fell within the upper and lower 95% confidence limits (0.35 and 0.65) about the chance expectation of 0.5. However, three participants had response distributions in which the probability of a hit P(H) and/or a false alarm P(FA) was outside the computed confidence limits of 0.3 and 0.7. The nine participants whose response distributions conformed to all three criteria proposed in Chapter 3 for non-discriminative responding had the following mean response probabilities: P(C) = 0.527 (SD 0.061), P(H) = 0.540 (SD 0.100) and P(FA) = 0.480 (SD 0.080). Their mean detection threshold (DT) was 56.7 msec (SD 9.68) and mean d' at DT was 0.136 (SD 0.342). The results reported for the priming experiment are only those for the nine participants who showed non-discriminative responding and only lexical decision times in the SR and UR conditions will be discussed.

The results of the semantic priming experiment show that no incorrect lexical decisions were made in either the SR or UR conditions. Following the procedure used by Fischler and Goodman (1978) 'outliers', that is, lexical decision times further than two standard deviations from a participant's mean time in each experimental condition were set at values equal to 2SDs in the appropriate direction. In the SR and UR conditions 'outliers' represented 6.7% and 8.9% of all responses.

The mean decision time for the UR condition was 698 msec (SD 125.3) while that for the SR condition was 635 msec (SD 114.2). Thus on average lexical decisions were faster by 63 msec when targets were preceded by semantically related primes. The magnitude of the priming effect due to the semantic relatedness of primes and targets was calculated as 8.86%. All nine participants showed quicker mean lexical decision times in the SR condition. Three way hierarchical analysis of variance showed that according to the conventional F_1 ratio lexical decisions were significantly faster in the SR condition than in the UR ($F_1 = 17.47$; df 1,8; $P = 0.003$). However, the quasi F ratio was not significant ($F' = 2.82$; df 1,23; $P > 0.05$). The product moment correlation between detection performance at threshold (d') and the magnitude of priming effect was -0.170 ($P > 0.05$).

When questioned at the end of the session most participants said they had no idea of the purpose of the second experiment, although some students thought that handedness (dominant versus non-dominant), speed of response and type of letter string (real versus nonword) were the important variables. Most participants thought that the patterned stimulus (mask) was shown as an aid to focussing and/or to the location of the subsequent letter string. No participant thought that a stimulus had been presented prior to the mask.

DISCUSSION

The results of Experiment 1 indicate that 9 of the 12 participants showed non-discriminative responding at detection threshold according to the criteria proposed in Chapter 3. It therefore seems likely that estimates of objective threshold were obtained for these participants and this belief is strengthened by the lack of a significant correlation between the magnitude of priming effect and detection performance as assessed by d'. The significant F_1 ratio for the priming data shows that a subliminal semantic priming effect was obtained when primes were presented 10% below objective threshold, though the non-significant value of F' suggests that this finding may not be replicated when new participants and different prime-target word pairs are used. Experiment 2 was carried out to investigate this possibility.

EXPERIMENT 2

Experiment 2 was a replication of Experiment 1 in a different sample of subjects and with different stimuli. Owing to the quasi F analysis of Experiment 1 it was hypothesised that the significant subliminal priming effect found in that experiment would not be replicated in Experiment 2.

METHOD

<u>Participants</u>

Twelve undergraduate students, 7 men and 5 women, took part in the experiment. Their mean age was 20 years (SD 1.73). None knew the nature or purpose of the research and none had taken part in Experiment 1. All were paid £1.50.

<u>Stimuli</u>

Using identical procedures to those described in Experiment 1 a new set of experimental stimuli was constructed. The stimuli are shown in Appendix B. The mean frequency and length of primes and targets in the semantically related (SR), unrelated (UR), and word-nonword (WN) conditions are shown in Table 4.3.

Table 4.3 Mean length and frequency of prime and target stimuli in Experiment 2.

	Condition			
	SR	UR	WR_1	WR_2
Primes:				
Length	5.0 (1.18)*	5.0 (1.18)	5.1 (1.14)	5.1 (1.30)
Frequency	55.0 (47.42)	54.8 (47.29)	55.2 (47.82)	55.1 (47.05)
Targets:				
Length	4.6 (1.02)	4.7 (1.05)	4.6 (1.02)	4.6 (1.02)
Frequency	56.4 (56.31)	57.2 (57.49)	- -	- -

* Standard deviations are shown in parentheses.

Primes did not differ significantly between conditions in terms of length ($F = 0.0207$; df 3,36; $P > 0.05$) or frequency ($F = 0.00001$; df 3,36; $P > 0.05$). Targets did not differ significantly between conditions in length ($F = 0.0217$; df 3,36; $P > 0.05$) nor between the SR and UR condition in terms of frequency ($t = 0.0298$; df 18; $P > 0.05$). Primes and targets subtended horizontal angles of 1.01 to 3.38 degrees and 1.02 to 2.59 degrees respectively.

The mask used in Experiment 1 was used again in Experiment 2. The practice stimuli were the same as in Experiment 1 except that the words bath, clean, oboe, load, and ivory replaced the words slow, fast, shoe, oboe and apple respectively. New test stimuli for the assessment of detection threshold were chosen on the same basis as in Experiment 1. They are shown in Appendix B.

Apparatus and Procedure

These were identical to those used in Experiment 1.

RESULTS

Ten of the 12 participants gave response distributions in the final 40 detection trials which conformed to all three criteria for non-discriminative responding proposed in Chapter 3. Only the results for these 10 participants will be presented and only lexical decision times for the SR and UR conditions will be discussed. For the 10 participants who responded non-discriminatively the mean probabilities of correct response, hit and false alarm were 0.525 (SD 0.041), 0.505 (SD 0.079) and 0.455 (SD 0.093) respectively. Mean detection threshold was 41 msec (SD 15.42) and mean d' at threshold was 0.128 (SD 0.021).

For the non-discriminative responders incorrect lexical decisions comprised 1% and 2% of the total responses in the SR and UR conditions respectively. In order to compute F' the participant's mean decision time for the appropriate experimental condition was substituted for the actual decision time in the case of incorrect decisions. For the SR and UR conditions respectively 2% and 7% of all lexical decisions were 'outliers'. Outliers were dealt with as in Experiment 1.

The mean lexical decision time for the SR condition was 540 msec (SD 28.8) and that for the UR condition was 593 msec (SD 60.9). Therefore, on average lexical decisions in the SR condition were quicker by 53 msec and the magnitude of the priming effect was 8.61% (SD 6.15). Nine of the 10 participants who showed non-discriminative responding at threshold showed quicker mean lexical decision times in the SR condition. Analysis of variance showed that lexical decisions in the SR condition were significantly quicker than in the UR condition both in terms of the F_1 ratio (F_1 = 16.61; df 1,9; P = 0.0027) and quasi F ratio (F' = 8.40; df 1,25; P < 0.01). The product moment correlation between magnitude of priming effect and d' was 0.599 (P > 0.05). When questioned after the priming experiment all participants claimed not to have seen anything prior to the mask on priming trials.

DISCUSSION

Ten of the 12 participants showed non-discriminative responding in terms of the three criteria proposed in Chapter 3. It therefore seems reasonable to conclude that objective thresholds were assessed for these participants and this conclusion is supported by the lack of a significant correlation between detection performance (d') and the magnitude of priming effect.

The pessimistic hypothesis drawn from the value of F' in Experiment 1 was that the subliminal semantic priming effect would be unlikely to replicate in research which used new participants and different stimuli. But this effect was replicated in Experiment 2.

However, the correlation between d' and the magnitude of priming effect was rather high, albeit non-significant. Cheesman and Merikle (1984) found a significant correlation between performance at threshold and the magnitude of priming effect when subjective thresholds were assessed though, as one would expect, this correlation was non-significant when objective thresholds were assessed. would expect. Because objective detection threshold was thought to have been assessed in the current experiment the rather high correlation between d' and the magnitude of priming effect is worrying. It was therefore decided that a futher replication, with different stimuli and different participants, was warranted.

EXPERIMENT 3

Experiment 3 was a second replication of Experiment 1 using new participants and different prime-target word pairs.

METHOD

Participants

Twelve undergraduate students took part in the experiment. They had a mean age of 21.7 years (SD 2.82) and 4 were men. All were blind to the nature and purpose of the experiment and none had participated in similar research. All were paid £1.50.

Stimuli

The stimuli were constructed in the same way as for Experiments 1 and 2 and a full list appears in Appendix C. The mean frequency (derived from the Kucera and Francis 1967 norms) and length of primes and targets in the SR, UR and WŴ conditions is shown in Table 4.4.

Table 4.4 Mean length and frequency of prime and target stimuli in Experiment 3.

	Condition			
	SR	UR	WR_1	WR_2
Primes:				
Length	4.9 (0.94)*	4.9 (0.94)	4.9 (0.94)	5.0 (1.10)
Frequency	29.6 (15.45)	29.6 (15.45)	29.6 (15.45)	29.6 (15.45)
Targets:				
Length	4.8 (0.75)	4.8 (0.75)	4.8 (0.75)	4.8 (0.75)
Frequency	157.9 (148.27)	158.3 (149.99)	- -	- -

* Standard deviations are shown in parentheses.

Primes did not differ significantly between conditions in frequency ($F = 0.0000$; df 3,36; $P > 0.05$) or length ($F = 0.0000$; df 3,36; $P > 0.05$). Targets did not differ significantly between conditions in length or between the SR and UR condition in frequency of occurrence ($t = 0.0057$; df 18; $P > 0.05$). The primes and targets subtended horizontal visual angles in the range 1.47 to 2.59 degrees. The mask was that used in Experiments 1 and 2. Test stimuli for the assessment of detection threshold and practice stimuli were chosen on the same basis as for previous experiments and are shown in Appendix C.

Apparatus and Procedure

Both were identical to those used in Experiments 1 and 2.

RESULTS

Nine of the 12 participants showed non-discriminative responding according to the three criteria proposed in Chapter 3. For these 9 participants the following mean values were obtained: P(C) = 0.517 (SD 0.035), P(H) = 0.511 (SD 0.124) and P(FA) = 0.477 (SD 0.120). These participants' mean detection threshold was 26.67 msec (SD 10.0) and at threshold mean d' was 0.086 (SD 0.170). The proportion of incorrect lexical decisions for non-discriminative responders was zero in the SR condition and 7.8% in the UR. Outliers occurred in 5.6% of the SR decisions and 4.4% of the UR. Errors and outliers were dealt with as in Experiments 1 and 2. The results presented below are only those for the 9 non-discriminative responders and only lexical decision times in the SR and UR conditions are discussed.

The mean lexical decision times for the SR and UR conditions were 628 msec (SD 100.6) and 723 msec (SD 85.8) respectively. On average lexical decisions were quicker in the SR condition by 95 msec and the mean magnitude of priming effect was 13.44% (SD 6.14). Analysis of variance showed lexical decisions were significantly quicker in the SR condition both in terms of the conventional F_1 ratio (F_1 = 27.64; df 1,8; $P = 0.0008$) and in terms of quasi F ($F' = 6.04$; df 1,25; $P < 0.05$). The product moment correlation between d' and the magnitude of priming effect was 0.266 ($P > 0.10$). Upon questioning none of the participants reported having seen anything prior to the mask on priming trials.

DISCUSSION

Non-discriminative responding over the final 40 detection trials was obtained for 9 of the 12 participants and no significant correlation was found between detection performance (d') and the magnitude of the priming effect. Thus for 9 participants objective thresholds appeared to have been satisfactorily determined. The results of Experiment 3 confirmed those of Experiments 1 and 2 in again finding a significant subliminal semantic priming effect. Experiments 1, 2 and 3 used binocular presentation of primes, targets and mask, and it seems clear that semantic priming effects can be obtained below objective threshold with this technique. However before concluding that binocular presentation offers an acceptable alternative to the dichoptic technique used by Marcel (1983a, Experiment 4), Balota (1983) and Fowler et al. (1981, Experiments 5 & 6) it was considered necessary to compare the two procedures when applied to the same prime and target stimuli. It was evident from the significant values of F_1 in all three experiments that subliminal priming effects will replicate over different samples of participants and therefore it was not considered necessary to apply both dichoptic and binocular techniques to the same sample of people, but merely to the same sample of stimuli. Accordingly Experiment 4 was carried out to test the hypothesis that dichoptic and binocular pattern masking procedures would give comparable results when applied to the same prime-target stimuli. Experiment 4 is reported in the next chapter.

CHAPTER 5

EXPERIMENT 4: A REPLICATION OF EXPERIMENT 3 WITH DICHOPTIC STIMULUS PRESENTATION

The subliminal semantic priming experiments reported in Chapter 4 appear to show that binocular presentation is an acceptable alternative to the dichoptic technique used by Fowler et al. (1981), Balota (1983) and Marcel (1983a). If this is the case then the semantic priming effect found using binocular presentation in Experiment 3 should be replicable in a further study using the same stimuli presented dichoptically. Furthermore, if binocular presentation is an acceptable alternative to dichoptic, it may be hypothesised that the two methods of presentation would yield the same magnitude of semantic priming effect when used with the same stimuli. Experiment 4 set out to investigate these hypotheses.

METHOD

Participants

Twelve undergraduate students, with mean age 19.7 years (SD 2.56), took part in the experiment. Five were men. None had previously taken part in similar research and all were paid £1.50.

Apparatus

The 3-field tachistoscope used in Experiments 1 - 3 was modified by fitting polarising filters to the mask and prime fields. These two filters were fitted at 90^{0} to each other. Two pairs of spectacles were constructed with two polarised filters, one in each eye piece, at 90^{0} to each other. The mask was seen by the right eye and the prime by the left eye of the wearer of one pair of spectacles and vice-versa by the wearer of the other pair. Thus it was possible to present the mask to the participant's dominant eye which ever eye this was. In all other respects the apparatus was the same as in Experiments 1 - 3.

Stimuli and Procedure

The test, practice, and experimental stimuli were those used in Experiment 3. Eye dominance was assessed by means of the finger alignment procedure used by Marcel (1983a). Following Marcel (1983a, Experiment 4), Balota (1983), Fowler et al. (1981, Experiments 5 & 6) and Turvey (1973) the mask was presented to the dominant eye and primes were presented to the non-dominant eye. Targets were presented to both eyes. To ensure that the mask fully covered the prime for participants with right or left eye dominance the size of the mask was extended to 20 x 70 mm. Except for these differences the procedure followed was identical to that used in Experiments 1 - 3.

RESULTS

In the final 40 detection trials 9 out of 12 participants showed non-discriminative responding according to the three criteria proposed in Chapter 3. The 9 participants had a response distribution in which the mean probability of a correct response, a hit, and a false alarm was 0.528 (SD 0.036), 0.510 (SD 0.133) and 0.458 (SD 0.143) respectively. The mean threshold for the non-discriminative responders was 18.11 msec (SD 9.60) and the mean value of d' was 0.148 (SD 0.194). The discussion of results includes only those for the non-discriminative responders and only lexical decision times in the SR and UR conditions are presented.

In the priming experiment 1.1% of lexical decisions in the SR condition were incorrect while the error rate in the UR condition was 3.3%. Outliers represented 7.8% of the SR responses and 4.4% of the UR. Errors and outliers were treated in the same manner as in the three previous experiments.

The mean lexical decision times in SR and UR conditions were 670 msec (SD 116.4) and 810 msec (SD 167.7) respectively. Thus lexical decisions were, on average, 140 msec faster in the SR condition and the mean magnitude of priming effect was 16.67%. Analysis of variance showed that lexical decisions were significantly quicker in the SR condition (F_1 = 30.74; df 1,8; $P = 0.0005$ and $F' = 8.11$; df 1,26; $P < 0.01$). The product moment correlation between detection performance (d') and the magnitude of priming effect was 0.370 ($P > 0.05$). A comparison of the mean magnitude of priming effect in Experiments 3 and 4 showed that there was no significant difference between them ($t = 1.07$, df 16, $P > 0.1$).

As in the previous three experiments, despite extensive questioning, no participant reported seeing any stimulus prior to the mask on priming trials.

DISCUSSION

At detection threshold (DT) 9 out of 12 participants had response distributions which obeyed the three criteria proposed in Chapter 3 for non-discriminative responding. Moreover, the correlation between percentage priming effect and d' at DT was not significant and it seems reasonable to conclude therefore that primes, presented as they were at 90% DT, were presented below objective threshold.

As in Experiments 1 - 3 lexical decisions in Experiment 4 were made significantly more quickly, on average, when the target was preceded by a semantically related, rather than unrelated, prime. The significant quasi F (F') in Experiment 4 suggests that the results are likely to replicate in further studies using new participants and different word pairs.

The results of Experiment 4 replicate the findings of Experiment 3 and the hypothesis that the magnitude of priming effect would not differ significantly as between binocular (Experiment 3) and dichoptic (Experiment 4) presentation of primes was supported. This suggests that the binocular method of presentation adopted for Experiment 3 is an acceptable alternative to the dichoptic presentation used in Experiment 4. A further discussion of this experiment, and Experiments 1 - 3, follows in the next chapter.

CHAPTER 6

THE SUBLIMINAL SEMANTIC PRIMING OF NEUTRAL TARGETS: AN OVERALL DISCUSSION OF EXPERIMENTS 1 - 4

In Experiments 1 - 4 all participants gave a response distribution at threshold in which the probability of a correct response did not deviate significantly from the chance expectancy of 0.5. Thus all participants satisfied the criterion for non-discriminative responding used by Marcel (1983a), Fowler et al. (1981), Balota (1983) and Spence (1981). However, in each of the experiments some participants failed to meet the additional criteria proposed in Chapter 3. This suggests that it is unwise to specify objective detection thresholds in terms of the probability of correct response alone, and that Merikle's (1982) insistence upon the need to examine response distributions was well founded. But, in Experiments 1 - 4 it seems reasonable to conclude that adequate assessments of objective threshold were made for those participants who showed non-discriminative responding in terms of all three of the criteria proposed in Chapter 3. This conclusion is strengthened by the finding in each experiment that the magnitude of priming effect was not significantly related to detection performance at threshold. As objective thresholds appear to have been satisfactorily assessed, and as primes were presented 10% below threshold, it seems not unreasonable to assume that Experiments 1 - 4 provided a satisfactory test of the hypothesis that semantic priming effects can be obtained below objective threshold. However, to be as certain as possible of this conclusion several additional analyses were carried out by pooling data across the four experiments for those participants

(N = 37) who showed non-discriminative responding at detection threshold. This was considered appropriate because some of these participants showed quite substantial values for d' at estimated detection threshold. In fact 8 of the 37 participants had values for d' between 0.28 and 0.53. A sceptic might argue that participants included in the data analyses of Experiments 1 - 4 who had values of d' in excess of zero might, despite the stringent criteria employed in assessing detection threshold and the non-significant correlation between d' and the magnitude of priming effect in each experiment, have been showing discriminative responding. This, it could be argued, was responsible for the priming effects obtained. To examine this point participants were divided into two groups. The first group (N = 14) contained participants for whom d' was less than, or equal to, zero (mean d' = -0.102, SD = 0.15; mean percentage priming effect = 10.73, SD = 6.51). The second group (N = 23) contained participants for whom d' was greater than zero (mean d' = 0.261, SD = 0.143; mean percentage priming effect = 12.45, SD = 6.88). The correlation between d' and percentage priming effect for the group for which d' was ≤ 0 was found to be 0.164 ($P > 0.05$) and the correlation for the group for which d' was > 0 was 0.132 ($P > 0.05$). Thus no significant relationship between detection performance (d') and magnitude of priming effect was found for either group and the sizes of the correlations are very comparable. A second analysis showed that the magnitude of priming effect did not differ significantly between the d' ≤ 0 and d' > 0 groups ($t = 0.753$; df 35; $P > 0.1$).

It is clearly very difficult to believe that where d' was ≤ 0 priming effects were due to conscious awareness of the primes or discriminative performance at threshold. As the d' > 0 group showed priming effects of the same magnitude as the d' ≤ 0 group, and showed the same (null) relationship between d' and percentage priming effect as the d' $\leqslant$ 0, it cannot be maintained that high values of d' produced the results found. Thus the additional analyses strongly support the conclusion that Experiments 1 - 4 demonstrated that semantic priming effects can occur below objective detection threshold. Thus the first aim of the research was fulfilled and it may be concluded that semantic priming can occur without awareness of the primes.

As regards the second aim of the investigation use of the quasi F ratio advocated by Clark (1973) suggested that the priming effect obtained in Experiment 1 would be unlikely to be replicated with different samples of prime and target words. However, the effect was replicated in Experiments 2 and 3 which used different word samples with the same stimulus presentation technique. The priming effect was again replicated in Experiment 4 using a different (dichoptic) presentation technique but the same primes and targets as Experiment 3. These findings offer substantial support to Wike and Church's (1976) argument that replication of experimental results with different verbal stimuli and different experimental techniques is preferable to the use of quasi F ratios. In fairness to Clark's (1973) position it should be pointed out that in Experiments 2, 3 and 4 the quasi F ratio suggested that the obtained priming effect would generalise to other samples of prime-target stimuli even though this was not the case in Experiment 1. But it should also be noted that had a conclusion been drawn from the value of F' in a single experiment (i.e. Experiment 1) it would have been that the significant subliminal semantic priming effect was a chance finding. Thus there is little doubt that replication is preferable to the use of F' applied to a single investigation.

The results of Experiment 4 are interesting on two grounds.

First, as already mentioned, they replicated the results of the first three experiments. Second, the magnitude of the priming effect in Experiment 4 was not significantly different from that found in Experiment 3 which used the same stimuli but a different method of presentation. This relates to the third aim of the investigation and indicates that the binocular presentation technique used in the first three experiments was a satisfactory alternative to the dichoptic technique used in the fourth.

One of the criticisms made of previous subliminal semantic priming experiments was that differences in lighting conditions between the priming and detection phases of the experiments may have rendered the primes more visible during priming than during detection (Holender 1986). This point was discussed in some detail in Chapter 2 where it was also noted that when Carr and Dagenbach (1986) equalised lighting conditions between the two phases of their experiment significant subliminal semantic priming effects were still evident below detection threshold. The present experiments were carried out before this criticism had been made and so Carr and Dagenbach's (1986) procedure was not followed. They presented a bright field after the mask on detection trials to compensate for the bright target field during priming trials. However, in the experiments reported here participants were not dark adapted as the room was moderately well lighted. It therefore seems extremely unlikely that changes in dark adaptation could account for the results. A further point which adds some support to this conclusion comes from the finding that in Experiment 4 where polarising filters reduced luminance levels, and thus reduced the contrast between stimulus fields and the dark inter-trial field, the magnitude of priming effect was not significantly different from that in Experiment 3 where the same stimuli were used but where luminance levels were appreciably higher relative to the dark inter-trial field. If dark adaptation changes were responsible for the results it would be expected that participants would benefit more in Experiment 3 than in Experiment 4 and therefore the priming effect in Experiment 3 should have been significantly larger than that in Experiment 4 (which it wasn't).

In considering the discrepancy between the results of Experiments 1 - 4 and those of Cheesman and Merikle (1984) a return will be made to the point made in Chapter 2 that the identity discrimination procedures, as used by Cheesman and Merikle, do not assess detection thresholds. As noted in Chapter 2 evidence supporting this point comes from Carr and Dagenbach (1986). Using a pattern masking procedure Carr and Dagenbach assessed conventional detection thresholds, forced choice recognition thresholds and thresholds for making semantic similarity judgements. Forced choice recognition threshold required participants to answer such questions as "Was 'doctor' or a blank field presented before the mask?" While semantic similarity judgements were assessed by asking participants to respond to questions of the sort: "Was the word before the mask more similar in meaning to 'nurse' or to 'bread'?" Detection thresholds were found to be more stringent (i.e. lower) than the other types of threshold and significant semantic priming effects were found <u>only</u> at detection threshold. These findings indicate that identity discrimination procedures do not yield satisfactory estimates of detection thresholds and the failure by Cheesman and Merikle (1984) to find semantic priming effects may therefore be considered as possibly resulting from inappropriate threshold assessment. It is particularly interesting to note that both Cheesman and Merikle, and Carr and Dagenbach, failed to find priming effects with thresholds assessed by identity discrimination while

Carr and Dagenbach and Experiments 1 - 4 reported here found such effects below detection threshold.

PART III

PRIMING EFFECTS WITH 'EMOTIONAL' TARGETS

CHAPTER 7

THE CONCEPT OF EMOTIONAL PRIMING

Studies of semantic priming have been designed primarily to enhance understanding of word and picture recognition and the features of semantic memory. To this end many factors have been manipulated, for example; type of stimulus, mode of presentation, stimulus onset asynchrony, prime-target relationship and target quality. One factor whose investigation has not been reported in published studies of semantic priming is the emotional quality of the target stimulus, although emotional quality has been investigated in research on unprimed word recognition where it was found that emotional words (positive and negative) do not differ significantly from neutral words in terms of lexical decision time (Clark, Teasdale, Broadbent & Martin 1983). One reason for conducting priming experiments with emotional target stimuli is that they might lead to a better understanding of the way in which the emotional connotations of stimuli are perceived and stored and may also have explanatory value in abnormal/clinical psychology.

One clinical problem which might be explained by a semantic priming effect is the onset of anxiety attacks which occur without the conscious perception of threat. It has been thought that such attacks arise because of the activation of non-conscious emotional stimuli (Tyrer 1985) but the mechanism by which these stimuli are activated is not well understood, though evidence has been found that non-conscious concepts associated with conflict can be activated (Silverman 1985). Priming effects are thought to occur because the prime activates a representation of the target in semantic memory and various models of semantic memory and word recognition assume this (e.g. Morton 1970; Collins & Loftus 1975; Becker 1980). In principle non-conscious emotional stimuli present in memory could be activated by this mechanism but of course the explanation relies on two assumptions. First that the emotional information associated with a stimulus is activated when the representation of the stimulus is activated in semantic memory. Second that this emotional information, once activated, is capable of giving rise to an emotional response. The first of these assumptions is supported by the work of Posner and Snyder (1975). They carried out two experiments the first of which involved participants in making a decision about the presence/absence of emotional probe words in a sentence. The second involved decisions about whether the emotional quality of a probe was congruent with the emotional quality of the sentence. From the results of the two experiments Posner and Snyder (1975) concluded that emotional information is stored as a high level and habitual associate to a given word and that the presentation of the word automatically activates related emotional responses. On the basis of Posner and Snyder's work it may be hypothesised that if a neutral prime can activate an emotional target through a semantic priming effect it should also activate the emotional information associated with the target. This may in turn may give rise to the emotional response which patients with free floating anxiety report comes 'out of the blue'.

The first aim of the work reported in Chapters 8 - 12 was to investigate whether emotional targets, that is, targets with (aversive) emotional connotations can be primed by emotionally neutral primes to which they are semantically related, when the primes are presented below objective detection threshold.

A second aim of the work was to determine whether a priming effect can be obtained with emotional targets when the primes have a similar emotional quality to the targets but are not in other ways semantically related. The possibility that an 'emotional priming effect' exists is not as unlikely as it seems at first sight and has been demonstrated supraliminally by Hill and Kemp-Wheeler (1987). Most semantic priming experiments have used primes and targets related through common semantic principles, for example, primes and targets as antonyms (dry-wet, Becker 1980) or strong normative associates (bread-butter, Meyer et al. 1975). However, Franklin and Okada (1982) showed that personal idiosyncratic associations can give rise to priming effects and Mckoon and Ratcliff (1979) demonstrated priming with unrelated word pairs which had been studied in their pairings prior to the semantic priming experiment. Thus a variety of different kinds of semantic relationship appear capable of yielding priming effects and it seems clear that the priming effect depends upon primes and targets sharing at least one of quite a large set of possible semantic attributes.

In their analysis of 'meaning' Osgood, Suci and Tannenbaum (1955) found that the meaning of a concept could be specified in terms of three dimensions; activity, potency and evaluation. It is the last of these which is relevant to the present argument. If two verbal stimuli (words) are evaluated in the same way they must, according to Osgood et al.'s analysis, share a semantic attribute or set of attributes and must therefore be semantically related. Consequently if two words are evaluated as both having unpleasant emotional connotations they should be capable of acting as prime and target to produce an 'emotional' priming effect. This argument is supported, and indeed derivable from, Bower's (1981) network theory which postulates that emotions no less than concepts are represented in a semantic memory network.

Bower's (1981) theory also predicts that words which have emotional connotations congruent with a persons mood state should be recognised more readily and with greater accuracy. But the findings from research designed to investigate these predictions have been somewhat inconsistent. For example, Teasdale and Russell (1983) and Clark and Teasdale (1985) found significantly better recall for mood-congruent than mood-incongruent words. This is what would be expected if mood congruent words are more easily recognised because such words would presumably be subject to strong early-processing effects in terms of receiving selective attention and preferentially deeper encoding. But Gerrig and Bower (1982) found that briefly presented mood-congruent words were not more accurately identified than neutral or incongruent words in a two-choice forced recognition task. Moreover, Clark, Teasdale, Broadbent and Martin (1983) found not only that lexical decision time for mood-congruent words was not significantly faster than for word-incongruent words but in a subsequent surprise recall task mood-incongruent words were those best recalled. Whilst previous research findings are rather contradictory it remains a possibility that in tasks requiring participants to process words with emotional connotations personality traits and mood states may influence performance. To investigate the possibility that the semantic and emotional priming of emotionally aversive targets may be influenced by emotional state the first emotional priming experiment (Experiment 5) was conducted with participants who scored at the two extremes of the neuroticism dimension of the Eysenck Personality Inventory.

CHAPTER 8

PRIMING EFFECTS WITH EMOTIONAL TARGETS: EXPERIMENT 5

The experiment reported in this chapter was designed to investigate priming effects with emotionally aversive targets. There were three hypotheses:

1. Lexical decisions will be made significantly more quickly when emotional targets are preceded by a semantically related neutral prime than by a semantically unrelated neutral prime presented below objective detection threshold. That is, there will be a significant semantic priming effect with emotional targets.

2. Lexical decisions will be made significantly more quickly when emotional targets are preceded by emotional (but otherwise unrelated) primes than by semantically unrelated neutral primes presented below objective detection threshold. That is, there will be a significant 'emotional priming effect' with emotional targets.

3. Lexical decision times for primed emotionally aversive targets will differ significantly between groups of high and low scorers on the Neuroticism scale of the Eysenck Personality Inventory. No prediction is made regarding direction of the difference.

METHOD

Participants

Following administration of the Eysenck Personality Inventory (EPI; Eysenck & Eysenck 1964) to large groups of first year undergraduates in the University of Keele, two groups of students were chosen to participate in the experiment. One group comprised 7 women and 3 men who scored 18 or more on the Neuroticism (N) scale of the EPI (High N group). A second group (Low N group) comprised 6 women and 4 men who scored 8 or less on the EPI N scale. Mean Neuroticism scores for the High and Low N groups were 18.20 (SD 1.077) and 5.20 (SD 2.135) respectively. The two groups did not differ significantly in extraversion [High N mean 10.60 (SD 4.758), Low N mean 10.60 (SD 3.412); $t = 0$, df 18, $P > 0.05$] or age [High N mean 20.1 years (SD 2.548), Low N mean 23.4 years (SD 6.726); $t = 1.376$, df 18, $P > 0.05$]. None of the students was aware of the nature of the research and all were paid £2.00 for participating.

Apparatus

The apparatus was identical to that used in Experiments 1 - 3. As before luminance levels were set at 2.35 lg cd/m^2 for the presentation of prime and target stimuli and at 1.90 lg cd/m^2 for the presentation of the mask. The experiment was conducted in a sound deadened room which was lit by a 40 watt bulb in a small desk lamp.

Stimuli

20 prime-target letter strings in each of 6 conditions were used in the experiment. Two examples from each condition appear in Table 8.1 and the full list is shown in Appendix D.

Table 8.1 Examples of Prime-Target letter strings in Experiment 5

		Condition					
		SR	ER	UR	$\bar{W}W_1$	$\bar{W}W_2$	$\bar{W}W_3$
Type of letter string	Prime	Neutral	Emotional	Neutral	Neutral	Emotional	Neutral
	Target	Emotional	Emotional	Emotional	Nonword	Nonword	Nonword
Example I	Prime	FUSE	RIDICULE	PILOT	SIGN	BULL	PARK
	Target	BOMB	MURDER	RATS	GOGGET	FIRT	WENTAL
Example II	Prime	POLITICS	CRIMINAL	TOWEL	SLEEP	KILLER	COINS
	Target	FASCISM	SHARKS	DEVIL	PRENTAGES	BARTING	MELK

Of the 120 targets half were real words and half were nonwords. The real word targets were chosen to be associated with unpleasant emotions. One third of these targets were preceded by semantically related neutral words (semantically related; SR condition). Another third were preceded by unpleasant emotional words to which they were not semantically related (emotionally related; ER condition). The remainder were preceded by semantically unrelated neutral words (unrelated; UR condition). The nonword targets were preceded by real word primes (word-nonword; WN conditions). In one condition the primes were emotional words but in the other two conditions they were neutral. This matched the 2:1 ratio of neutral to emotional primes in the three conditions which had real word targets. The emotional tone of the words was decided by the Experimenter and her Supervisor. Tables of norms could not be used because many words were required and frequency of occurrence had to be matched across conditions thus restricting choice. In later experiments (e.g. Experiment 6) stimuli were chosen after the completion of an 'emotionality' rating exercise. All nonword stimuli were pronounceable and represented high level approximations to English words. The prime-target stimulus pairs in all 6 experimental conditions were combined and randomised. They were then divided into 4 packs of 30 for presentation. This made the large set of stimuli (240 cards altogether) easier to handle and gave participants a brief rest when the packs of cards were changed. For practice 12 further prime-target letter strings were constructed; 2 of each type of prime-target pair used in the experiment (see Appendix D).

The average length of prime stimuli was matched across all conditions, as was the average length of target stimuli. The average frequency of occurrence was calculated for each set of primes using the Kucera and Francis (1967) norms and matched across conditions.

The average frequency of occurrence of target stimuli was matched across the SR, ER, and UR conditions. Mean length and frequency of primes and targets in the SR, ER, UR and WR conditions are shown in Table 8.2. One way ANOVA for independent groups showed that the primes did not differ significantly between conditions in length ($F = 0.8012$; df 5,114; $P > 0.05$) or frequency ($F = 0.0043$; df 5,114; $p > 0.05$). The length of target stimuli did not differ significantly between conditions either ($F = 0.0089$; df 5,114; $P > 0.05$) and there was no significant difference in the frequency of targets in the SR, ER and UR conditions ($F = 0.0089$; df 2,57; $p > 0.1$).

For the assessment of detection threshold 6 test words were selected (see Appendix D). These had the same number of letters as the longest prime and a frequency which was equal to, or greater than, the most frequently occurring prime. Thus, test stimuli were chosen to give conservative estimates of detection threshold. As in Experiments 1 - 4 all stimuli were printed on self-adhesive transparent tape using wheel size 10 of the KROY 80 lettering system. This gave a letter height of 2.5 mm. Stimuli were centred on white cards 101 x 152 mm which were viewed at a distance of approximately 508 mm. Primes and targets subtended horizontal visual angles in the range 0.90 to 3.72 degrees and 1.24 to 3.33 degrees respectively. The pattern mask from Experiments 1 - 3 was also used in Experiment 5. It measured 20 x 50 mm and subtended visual angles of 5.63 degrees in width and 2.26 degrees in height.

PAGINATION
ERROR

Table 8.2 Mean length, and frequency, of prime and target stimuli in Experiment 5

	Condition					
	SR	ER	UR	$\bar{W}_1$	$\bar{W}_2$	$\bar{W}_3$
Prime stimuli						
length	6.10 (1.546)*	6.70 (1.418)	6.50 (1.466)	7.00 (1.949)	7.00 (1.949)	6.35 (1.314)
frequency	28.95 (23.913)	29.80 (27.802)	29.30 (28.473)	29.35 (27.897)	28.55 (29.009)	29.15 (27.975)
Target stimuli						
length	5.60 (1.241)	5.60 (1.241)	5.60 (1.241)	5.55 (1.284)	5.55 (1.284)	5.55 (1.284)
frequency	14.85 (15.583)	14.35 (17.746)	14.10 (19.222)	- -	- -	- -

* standard deviations are shown in parentheses

Procedure

After the tachistoscope had been adjusted for height the main overhead light was switched off so that the room was lit by a small desk lamp only. Participants were then told that two entirely separate experiments were to be carried out, the first on detection threshold (DT) and the second on word recognition. To give a plausible rational for the assessment of DT participants were told that the first experiment was one of a series designed to investigate how detection varied with type of stimuli - numbers, shapes and words - and the influence of distractors. The Experimenter said that in this research the distractor looked similar to the tiles which lined the room and from then on the distractor (mask) was referred to as 'the wallpaper card' (WPC). This was because it was thought that participants would be less likely to think that its function was to mask stimuli if it was never referred to as a distractor or mask.

Participants were told that in the first experiment they would be shown either a blank card or a card on which a which a word was printed followed by the WPC exposed for half a second. The experimenter said that a warning bleep would precede the stimulus/blank card sequence by one second, and that the participants' task was to look at the whole sequence, from the bleep, and then decide whether a blank card or a stimulus card had preceded the WPC. It was stressed that the task was not difficult at first as the participant would probably be able to read the stimulus when it was present. However, participants were also told that after each set of trials the amount of time for which the first card of the sequence was shown would be reduced and gradually the letters would just look like a black smudge. Then as exposure time was further reduced even the smudge itself would become very difficult to distinguish from a blank card. Participants were told that the sequence would be shown in sets of 10, and that in each set 5 blank cards and 5 stimulus cards would be presented in random order. They were asked to say 'yes' if they thought a stimulus card had been shown and 'no' if they thought a blank card had been presented. Participants were encouraged to remember how many 'yes' and 'no' responses they made in each set of trials and as far as possible to say 5 of each. In trying to prevent response bias in this way it was hoped that cases would not have to be dropped from the final analyses as in Experiments 1 - 4.

Stimuli and blank cards were first shown at a duration which enabled participants to distinguish between them with perfect accuracy in one block of trials. For most people this was 100 msec. Presentation time was then reduced by 20, 15, 10 or 5 msec until participants were responding at approximately chance level (i.e. 6/10 or less correct). At this point four sets of 10 trials were begun. If performance exceeded 60% accuracy during any of these sets presentation time was further reduced. Detection threshold (DT) was assumed to have been reached when four sets of trials had been completed with an overall accuracy within the 95% confidence limits of the chance expectancy of 0.5 (0.35 - 0.65). Threshold assessment took 30 to 45 minutes.

The Experimenter then rewired the tachistoscope, set the time for presentation of primes to 90% of DT, and gave an explanation of the 'next experiment'. Participants were told they would see a sequence in which the WPC (mask) appeared one second after the warning bleep with a letter string appearing immediately after the WPC. They were asked to decide whether the letter string spelt an English word or a nonword. Participants terminated the display of letters by pressing a small handheld trigger in their dominant (writing) hand when they thought the letters spelt a real word and by pressing a small handheld trigger in their non-dominant hand when they thought the letters spelt a nonword. They were told to respond as quickly and accurately as possible.

Prior to the onset of the prime, which immediately preceded the mask, and following the offset of the target a dark field was exposed. Thus, the sequence presented was dark field, prime, mask, target, dark field. The mask was displayed for 500 msec as in threshold assessment. There was an intertrial interval of about 12 seconds during which the Experimenter recorded lexical decision time and correctness of response. The stimulus cards were then changed manually whilst the timer automatically reset itself. There was no conversation between the experimenter and participant during the four parts of the experiment, in each of which 30 prime-target pairs were presented, although participants would often comment spontaneously when they had made a mistake. Between the presentation of stimulus sets 1 and 2, 2 and 3, and 3 and 4 participants rested for approximately two minutes.

At the end of the experiment participants were asked to describe what they thought the second experiment was designed to investigate and in particular about the role of the WPC (mask). They were also asked if they thought the two experiments were related and whether it seemed as if a stimulus word had ever been presented prior to the WPC in the second study.

RESULTS

Over the final 40 trials of threshold assessment all participants gave a response distribution in which the probability of making a correct response [P(C)], a hit [P(H)] and a false alarm [P(FA)] fell within the upper and lower 95% confidence limits about the chance expectation of 0.5. These probabilities are shown for the high and low N groups in Table 8.3, together with mean detection threshold (in msec) and d'. As can be seen from Table 8.3 independent sample 't' tests revealed that the high and low N groups did not differ significantly on any of these measures.

Table 8.3 Mean detection threshold (DT), d', P(C), P(H) and P(FA) at DT for high and low N groups in Experiment 8.

	High N	Low N	t	Sig.
Detection Threshold (msec)	33.50 (11.630)*	35.50 (13.500)	0.337	$P > 0.05$
d'	0.077 (0.106)	0.013 (0.148)	1.056	$P > 0.05$
P(C)	0.523 (0.021)	0.505 (0.033)	1.342	$P > 0.05$
P(H)	0.516 (0.100)	0.495 (0.065)	0.503	$P > 0.05$
P(FA)	0.480 (0.078)	0.480 (0.056)	0.000	$P > 0.05$

* Standard deviations are shown in parentheses.

Lexical decisions made about real word targets only are presented below. The percentage of incorrect responses made by the high and low N groups in the SR, ER and UR conditions are shown in Table 8.4. As in Experiments 1 - 4 'outliers', that is, lexical decision times further than 2 standard deviations from a participant's mean time in each condition, were set at values equal to 2SDs in the appropriate direction. The percentage of outliers made by the two groups in the SR, ER and UR conditions is also shown in Table 8.4.

Table 8.4 Percentage of incorrect responses and outliers made by the high and low N groups in the SR, ER and UR conditions of Experiment 5.

		Condition		
		SR	ER	UR
Percentage of incorrect responses	High N	1.5	0.5	0.5
	Low N	3.0	4.0	2.0
Outliers	High N	6.0	5.0	6.0
	Low N	5.5	6.0	4.0

Mean lexical decision time in the SR, ER and UR conditions for the high and low N groups is shown in Table 8.5. Lexical decision times were analysed using a two way (3 x 2; condition x group) ANOVA with repeated measures on one factor (condition) and a summary of the results appears in Table 8.6.

Table 8.5 Mean lexical decision time for high and low N groups in the SR, ER and UR conditions of Experiment 5.

	Condition			
Group	SR	ER	UR	SR, ER and UR combined
High N	615.8 (66.86)*	602.3 (70.57)	643.4 (92.01)	620.4 (74.07)
Low N	618.0 (105.06)	608.9 (88.43)	629.8 (91.08)	619.0 (92.51)
High and Low N Combined	616.9 (88.06)	606.0 (80.07)	636.6 (91.80)	

* Standard deviations are shown in parentheses.

Table 8.6 Summary table from two way ANOVA (condition x group) of lexical decision times in Experiment 5.

Source of Variation	df	MS	F	Sig.
Group (G)	1	38.38	0.002	P > 0.05
Error: G x S	18	23412.53		
Condition (C)	2	4922.60	6.056	P = 0.054
Group x condition	2	564.20	0.694	P > 0.05
Error: G x C x S	36	812.81		

From Table 8.6 it can be seen that the difference between conditions (SR/ER/UR) was on the margin of significance at the 5% level, although the high and low N groups did not differ significantly and there was no significant interaction effect. The Tukey test showed that for high and low N groups combined mean lexical decision time was significantly faster in the ER condition than in the UR ($P < 0.01$). The difference between the SR and UR condition just failed to reach significance at the 5% level, while a correlated 't' test revealed that the difference was just not significant at $P = 0.07$. Mean lexical decision times in the SR and ER conditions did not differ significantly ($P > 0.05$).

Overall, the magnitude of the priming effect due to emotional and semantic relatedness of prime and target stimuli was 4.45% (SD 7.00), and 2.82% (SD 6.71) respectively. The product moment correlation between detection performance at threshold (d') and magnitude of semantic and emotional priming effect was 0.276 ($P > 0.05$) and 0.432 ($P > 0.05$) respectively.

When participants were questioned at the end of the session it became clear that none of them had any suspicion that letters had been presented prior to the mask in the priming experiment.

Participants said that they thought that the WPC (mask) had been presented in the 'second' experiment as a fixation point; an aid to focusing or to clear their mind of the previous letter string. None of the participants thought that 'experiments 1 and 2' were connected.

DISCUSSION

In Experiment 5 all participants showed non-discriminative responding at objective detection threshold (DT), which was assessed in accordance with the criteria proposed in Chapter 3. Detection performance at threshold (d') and percentage semantic priming effect did not correlate significantly and thus it seems reasonable to believe that primes, presented at 90% of DT, were indeed presented below objective threshold.

The first experimental hypothesis, which predicted a significant priming effect when emotional targets were paired with emotionally neutral semantically related primes, was weakly supported by the findings. Although lexical decisions were made more quickly in the semantically related condition than in the unrelated condition the difference just failed to reach statistical significance at the conventionally accepted level. However, lexical decisions were made significantly faster when emotional targets were preceded by semantically unrelated emotional primes than by semantically unrelated neutral primes and thus the second experimental hypothesis which predicted a statistically significant emotional priming effect was supported. The third experimental hypothesis predicted that overall lexical decision times and the magnitude of semantic and emotional priming effects would differ significantly between the high and low N groups. Tables 8.5 and 8.6 show that neither of these predictions were supported. Although the influence of personality traits and emotional states on recognition and response to mood congruent stimuli has been the focus of much research it will not be discussed in detail here. Note should be taken however that the non-significant effect of neuroticism in this experiment appears to add to the growing body of research which has failed to support Bower's (1981) semantic network model of emotion (e.g. Gerrig & Bower 1982; Clark et al. 1983; Bower & Meyer 1985; Garcia & Beck 1985).

The results of this study suggest that emotional stimuli can be activated by primes which are presented below objective detection threshold when the prime and target are both evaluated in the same way (i.e. both evaluated as having emotionally unpleasant connotations) even though the two stimuli are semantically unrelated in terms of conventional meaning. However, it is less certain whether emotional stimuli can be activated by semantically related neutral primes presented below objective detection threshold (the conventional semantic priming effect). To investigate how reliable these effects are it was decided that a second experiment should be undertaken particularly because in the analysis of variance the effect of condition was only marginally significant which would suggest that the semantic and emotional priming effects should be interpreted with caution. Replication was chosen in preference to the Quasi F analysis because of the conservative nature of the latter (see Chapter 4).

One criticism which can be made of Experiment 5 is that the stimuli were not rated for emotionality but were chosen because they were thought to be either emotionally unpleasant or emotionally neutral by the Experimenter and her Supervisor. Clearly it would have been preferable to have chosen words which had been rated as having these qualities by members of the population from which the sample of participants were drawn. It was therefore decided that a rating exercise should be undertaken before stimuli were chosen for the replication attempt.

Although word length and number of syllables has been found not to influence lexical decision time significantly (Frederiksen & Kroll 1976), frequency of occurrence does have a significant effect (Rubenstein, Garfield & Millikan 1970; Scarborough, Cortese & Scarborough 1977; Gardner, Rothkopt, Lapan & Lafferty 1987) and it is therefore very important that frequency is matched across conditions in a priming experiment. Using the Kucera and Francis (1967) word norms target stimuli were matched for frequency of occurrence in the SR, ER and UR conditions of Experiment 5 and they did not differ significantly in this respect. However, the accuracy with which words can be rated for frequency of occurrence from norms which are based on American English nearly twenty years out of date must be questioned. An alternative way to ensure that target stimuli do not differ in frequency of occurrence is to repeat the targets, that is, use the same set of targets in each experimental condition. Using this design a further subliminal semantic, and emotional, priming experiment was undertaken. It is reported, together with a supraliminal study, in Chapter 9.

CHAPTER 9

A FURTHER INVESTIGATION OF SEMANTIC AND EMOTIONAL PRIMING: EXPERIMENTS 6 AND 7

In Experiment 5 it was found that lexical decisions were made more quickly when emotional target words were preceded by primes which were semantically, or emotionally, related to them. The emotional priming effect was significant at the 1% level but the semantic priming effect only at the 7% level. Experiment 6 was designed to investigate whether significant semantic and emotional priming effects would occur in a replication with new words and different participants.

The importance of matching target stimuli across conditions for frequency of occurrence was stressed in Experiment 5 and it was argued that a 'perfect' match could be achieved by repeating targets in each experimental condition. This was done in Experiment 6 in which one set of targets were chosen and repeated with different primes in the semantically related, emotionally related and unrelated conditions.

EXPERIMENT 6

METHOD

Participants

The participants were 18 undergraduate students with mean age 20.9 years (SD 2.58). Twelve were men. None of the students had previously taken part in subliminal research or in semantic priming experiments. All were paid £2.00 for participating in this study.

Apparatus

The apparatus was identical to that used in Experiment 5.

Stimuli

To establish a word pool of neutral and emotional words a rating exercise was undertaken by 50 undergraduate students [15 men, 35 women; mean age 20.5 years (SD 3.57)]. Each student rated the quality and strength of emotion they associated with a series of words on a seven point scale. Each scale point was described verbally although numbers were subsequently assigned for the purpose of scoring. The scale points were 'A very strong unpleasant emotion' (score = 1); 'A fairly strong unpleasant emotion' (score = 2); 'A mild unpleasant emotion' (score = 3); 'No emotion' (score = 4); 'A mild pleasant emotion' (score = 5); 'A fairly strong pleasant emotion' (score = 6) and 'A very strong pleasant emotion (score = 7). The instructions were printed at the top of a questionnaire and are shown in Appendix E.

Median ratings of emotionality were computed for each word and words which scored less than 3.49 were considered 'emotional' (i.e. emotionally unpleasant). Words which had a median rating of 3.50 to 4.49 were considered 'neutral' but in order to increase the choice of non-emotional primes (in particular for the semantically related condition for which prime-target word pairs were difficult to find) 13 words which had median ratings greater than 4.49 were also considered neutral. Thus all 'emotional' words had median ratings which fell into the emotionally unpleasant categories but some 'neutral' words had median ratings which fell into the emotionally pleasant categories.

From the pool of rated words 18 emotional words were chosen as targets and each target was paired with one of three primes. One prime was a neutral word semantically related to the target (SR condition), one prime was an emotional word not semantically related to the target (ER condition) and one prime was a neutral word not semantically related to the target (UR condition). Some of the prime-target pairs in the SR condition of Experiment 5 were used again in the SR condition of Experiment 6. However, in Experiment 6 mean lexical decision time for the SR condition was compared with mean lexical decision time for prime-target word pairs in the UR and ER conditions which were unique to Experiment 6.

Eighteen nonword targets were chosen from the WW̊ stimuli used in Experiment 5. Each WW̊ target was paired with 3 primes; two neutral and one emotional. Thus primes paired with the WW̊ targets matched the 2:1 ratio of neutral to emotional primes paired with the real word targets. Two prime-target letter strings in each of the experimental conditions are shown in Table 9.1 and a full list appears in Appendix F.

Mean length, frequency of occurrence and emotionality rating for the primes and targets used in Experiment 6 are shown in Table 9.2. The primes did not differ significantly between conditions in length ($F = 0.1546$; df 5,102; $P > 0.05$) or frequency ($F = 0.0246$; df 5,102; $P > 0.05$).

The word pairs were presented in three blocks of 36, each containing one complete set of real and nonword targets. In every block one third of the real word targets were paired with primes in the SR condition; one third with primes in the ER condition and one third with primes in the UR condition. Similarly, in every block, one third of the WW̊ targets were paired with emotional primes and two thirds with neutral primes. After 3 blocks of trials prime-target

Table 9.1 Examples of Prime-Target letter strings in Experiment 6

		Condition					
		UR	ER	UR	$\bar{W}_1$	$\bar{W}_2$	$\bar{W}_3$
Type of	Prime	Neutr: l	Emotional	Neutral	Neutral	Emotional	Neutral
letter string	Target	Emotional	Emotional	Emotional	Nonword	Nonword	Nonword
Example I	Prime	POLITICS	CANCER	TO.EL	FIXTURES	COFFIN	CAPSULE
	Target	FASCISM	FASCISM	FASCISM	ESPET	ESPET	ESPET
Example II	Prime	FUSE	RAPE	MEASURE	SLEEP	SUICIDE	TEACH
	Target	BOMB	BOMB	BO:B	ESTONE	ESTONE	ESTONE

Table 9.2 Mean length, frequency, and emotionality rating for primes and targets in Experiment 6

	Target		Primes					
	Real	Nonword	SR	ER	UR	$W\bar{W}_1$ (Neutral)	$W\bar{W}_2$ (Emotional)	$\bar{WW}_3$ (Neutral)
length	5.78 (1.27)*	5.89 (1.24)	6.06 (1.84)	6.00 (1.12)	6.06 (1.22)	6.06 (1.22)	6.00 (1.37)	5.72 (1.33)
frequency	15.78 (17.72)	- -	34.33 (27.04)	31.44 (30.77)	32.56 (24.47)	31.83 (29.32)	32.44 (29.26)	32.94 (24.72)
emotionality	2.33 (0.53)	- -	4.25 (0.57)	2.01 (0.54)	4.06 (0.09)	4.23 (0.42)	2.40 (0.44)	4.15 (0.37)

* standard deviations are shown in parentheses

pairs in all 6 experimental conditions had been presented and the two sets of target stimuli (real and nonword) had been seen three times. To control for order effects a fully crossed design with 6 different orders of presentation was used. Within blocks presentation order was randomised.

For practice 12 prime-target letter strings were constructed: two from each type of experimental condition. They are shown in Appendix F. For threshold assessment 6 test stimuli were chosen equal in length to the longest experimental prime and occurring with greater frequency than the most frequently occurring prime. This was to ensure that conservative estimates of detection threshold were assessed. These test stimuli were the same as those used in Experiment 5.

As in Experiments 1 - 5 all stimuli were printed on the KROY 80 lettering system, wheel size 10, and fixed to the centre of white cards measuring 101 x 152 mm. The cards were viewed at a distance of approximately 508 mm. The visual angle subtended horizontally for prime and target stimuli ranged from 0.90 to 3.60 degrees and 1.24 to 3.55 degrees respectively. The mask used in Experiments 1 - 3, and 5, was used again for this experiment.

Procedure

The procedure was the same as in Experiment 5 except that three blocks of 36 trials were given in the priming experiment instead of four blocks of 30. Participants were not told that targets would be repeated.

RESULTS

Over the final 40 trials of threshold assessment all 18 participants gave a response distribution in which the probability of making a correct response P(C), a hit P(H) and a false alarm P(FA) fell within the upper and lower 95% confidence limits about the chance expectation of 0.5. Averaged across participants the mean value of P(C), P(H) and P(FA) was 0.464 (SD 0.037), 0.442 (SD 0.069) and 0.514 (SD 0.078) respectively. Mean detection threshold (DT) was 37.22 msec (SD 12.38) and mean d' at DT was - 0.186 (SD 0.198).

The percentage of incorrect responses in the SR, ER and UR conditions was 1.5%, 2.5% and 1.2% respectively. Outliers were dealt with as in previous experiments and comprised 5.9%, 4.9% and 4.0% of the total responses in the SR, ER and UR conditions respectively.

Mean lexical decision time for the SR, ER and UR conditions in blocks I, II and III are shown in Table 9.3. They were analysed using a two way repeated measures analysis of variance and a summary of the results appears in Table 9.4.

Table 9.3 Mean lexical decision time for the SR, ER and UR condition in block I, II and III of Experiment 6.

		BLOCK			
		I	II	III	I, II and III combined+
CONDITION	SR	644.28 (110.80)*	595.78 (78.59)	577.61 (81.03)	607.78 (83.44)
	ER	639.67 (102.31)	598.11 (74.98)	575.06 (69.33)	602.55 (73.19)
	UR	628.61 (96.17)	593.22 (69.23)	569.00 (64.16)	597.00 (69.99)
	SR, ER and UR combined+	637.52 (97.19)	595.70 (66.63)	573.89 (68.38)	

* Standard deviations are shown in parentheses.
\+ Means for the combined groups do not tally exactly with means for the groups combined because of errors in rounding up.

Table 9.4 Summary table from two way ANOVA (condition x block) of lexical decision times in Experiment 6.

Source of variation	df	MS	F	Sig.
Condition (C)	2	1227.39	0.91	$P > 0.05$
Block (B)	2	56457.85	19.56	$P < 0.01$
Subjects (S)	17	53232.74		
C x B	4	199.54	0.13	$P > 0.05$
Error: C x S	34	1349.28		
Error: B x S	34	2886.30		
Error: C x B x S	68	1535.30		

As can be seen from Table 9.4, although experimental condition (SR/ER/UR) did not have a significant effect on lexical decision time, block (I/II/III) was significant at the 1% level. There was no significant interaction effect (condition x block). A Tukey test carried out on the block means in Table 9.3 revealed that the significant effect of block was due to lexical decisions being made significantly faster in block III than in block I ($P < 0.01$). Lexical decisions were also made considerably faster in block II than in block I but the difference just failed to reach statistical significance (critical mean difference at $P = 0.05$ was 44; calculated mean difference was 42).

The percentage semantic, and emotional, priming effect was -1.35% (SD 4.73) and -0.96% (SD 4.73) respectively. The product moment correlation between d' and the percentage priming effect for the semantically and emotionally related conditions was - 0.0145 ($P > 0.05$) and - 0.013 ($P > 0.05$) respectively.

DISCUSSION

Once again each participant's detection performance at threshold obeyed the criteria for non-discriminative responding proposed in Chapter 3. Moreover, the correlation between detection performance and percentage semantic and emotional priming effect was non-significant and one may therefore be reasonably confident that primes were presented not only subliminally but below objective detection threshold. Also, none of the participants guessed correctly why the WPC (mask) was used in the priming experiment and no one thought there was a connection between the assessment of DT and the subsequent lexical decision task.

Contrary to expectations mean lexical decision time was not significantly faster in the SR and ER conditions than in the UR. Indeed the percentage semantic, and emotional, facilitation effect was negative because on average lexical decisions were made very slightly faster in the UR condition. The absence of significant priming effects may be due to the repetition of target stimuli for, even though a fully crossed experimental design was used to control for the presentation order of the primes, the effect of target repetition (block) was highly significant. Relevant to this argument are the findings from supraliminal studies in which participants made lexical decisions about a series of letter strings presented one after the other. Using this experimental paradigm Dannenbring and Briand (1982) found that lexical decisions were facilitated more when the target word was immediately preceded by itself than when it was immediately preceded by a semantically related word. Furthermore, while semantic priming effects lasted for only a few seconds (Dannenbring & Briand 1982; Meyer et al. 1975) the effect of target repetition was long lasting (Forbach, Stanners & Hochaus 1974;

Dannenbring & Briand 1982; Ratcliff, Hockley & McKoon 1985). Indeed Scarborough et al. (1977) found that repetition effects were evident even when the interval between repetitions of the target was as long as two days! Such studies suggest that target repetition has a long lasting facilitative effect on lexical decision time while the effects of conventional semantic priming are considerably weaker and more transient. This conclusion is supported by Rugg's (1987) study of Event Related Potentials (ERP's) which showed that while both semantic priming and word repetition modulated ERP's, repetition had a considerably more profound effect in terms of magnitude and duration. In Experiment 6 lexical decisions were made more quickly with each subsequent presentation of the target stimuli and it may be that this repetition effect was so strong that it prevented the occurrence of priming effects due to semantic and emotional relatedness.

Although there is not a great deal of evidence in support of subliminal semantic priming effects, the literature review of Chapter 2 indicated that activation of target stimuli by supraliminally presented semantically related primes is well established. However, if target repetition effects are stronger then semantic priming effects, with the consequence that when the two are investigated together the effect of semantic priming is masked or overriden, the results of Experiment 6 should occur in a supraliminal study using the same experimental design. Experiment 7 was undertaken to investigate this possibility.

EXPERIMENT 7

Experiment 7 was a supraliminal replication of Experiment 6. It was hypothesised that:

1. There would be no significant difference between average lexical decision time in the SR, ER and UR conditions.

2. Lexical decision time would decrease significantly with each repetition of the target stimuli.

METHOD

Participants

Twenty four undergraduate students took part in the experiment. They had a mean age of 22.5 years (SD 3.84) and fourteen were men. As in previous experiments none of the students had participated in similar research and all had English as their first or only language. The students were not paid for participating in this experiment because it was not considered an arduous task and took less than thirty minutes to complete.

Apparatus and Details of Stimulus Presentation

The stimuli were presented on the screen monitor of an Apple II compatible micro computer. The computer was programmed to ensure that primes always appeared in the centre of the screen between two figure 1's placed approximately 5 cms apart. Targets appeared just below the prime between two figure 2's. The numbers acted as fixation points and remained on the screen throughout the experiment.

The prime was displayed for approximately 500 msec and there was a delay of approximately 50 msec between the offset of the prime and the onset of the target. The target display was terminated by a trigger response from the participant. Approximately 3 seconds elapsed between the offset of the target and the onset of the next prime. To warn participants of the beginning of a new prime-target sequence a bleep sounded one second before the onset of the prime. The computer automatically recorded lexical decision time and the correctness of each response. The experiment was conducted with each participant individually in a sound deadened room, lit by natural lighting. It took approximately 30 minutes.

Stimuli

The stimuli were exactly the same as in Experiment 6.

Procedure

Participants were told to read the first letter string which appeared on the screen, and then to read the second letter string and to decide whether this second letter string spelt a real English word or a nonword. Half of them were instructed to press a small hand held trigger in their dominant hand to give the response 'real word' and to press the trigger in their non-dominant hand to give the response 'nonword'. For the remaining participants this order was reversed.

Participants were asked to respond as quickly and as accurately as possible. As in Experiment 6 they were not told that the targets were to be repeated, although they were told that there were three parts to the experiment and that a break of two to three minutes would be taken between each one. Before the experiment proper began the practice stimuli were presented twice.

RESULTS

The percentage of incorrect responses in the SR, ER and UR conditions was 2.3%, 2.1% and 2.8% respectively. Outliers were dealt with as in previous experiments and comprised 5.1%, 4.9% and 4.9% of the total responses in the SR, ER and UR conditions respectively.

Mean lexical decision times for the SR, ER and UR conditions in blocks I, II and III are shown in Table 9.5.

Table 9.5 Mean lexical decision time for the SR, ER and UR conditions in block I, II and III of Experiment 7.

		BLOCK			
		I	II	III	I, II and III combined+
CONDITION	SR	718.50 (196.37)*	713.25 (302.25)	668.58 (266.90)	697.46 (230.02)
	ER	736.54 (209.38)	650.29 (226.42)	655.54 (191.28)	686.71 (190.54)
	UR	724.17 (230.46)	706.25 (268.45)	647.42 (198.74)	691.00 (220.70)
	SR, ER and UR combined+	727.83 (206.92)	690.42 (255.03)	656.46 (210.70)	

* Standard deviations are shown in parentheses.
\+ Mean for the combined groups do not tally exactly with means for the groups combined because of errors in rounding up.

Table 9.6 Summary table from two way ANOVA (condition x block) on lexical decision times in Experiment 7.

Source of variation	df	MS	F	Sig.
Condition (C)	2	6945.00	0.8653	P > 0.05
Block (B)	2	88152.70	2.7925	P = 0.07
Subjects (S)	23	410617.39		
C x B	4	12514.59	1.7061	P > 0.05
Error: C x S	46	31567.29		
Error: B x S	46	8025.31		
Error: C x B x S	92	7334.78		

Lexical decision times were analysed using a two way repeated measures ANOVA and the results appear in Table 9.6. As can be seen from Table 9.6 the main effect for condition (SR/ER/UR) was not significant, while block (I/II/III) had a significant effect at P = 0.07. There was no significant interaction effect (condition x block). Although not significant at the conventionally accepted 5% level of significance, the effect of block was in the hypothesised direction as can be seen from Table 9.5 which shows that lexical decisions were made more quickly with each subsequent presentation of the target stimuli.

The facilitation effect due to the semantic, and emotional, relatedness of primes and targets was - 0.82% (SD 7.54) and - 0.12% (SD 6.90) respectively.

DISCUSSION

As predicted in the first hypothesis, the priming effect due to emotional relatedness, and indeed the semantic priming effect which has been demonstrated so often in supraliminal research, failed to occur in Experiment 7. In fact, on average lexical decisions were made slightly faster in the unrelated (UR) condition than in the semantically related (SR) condition. The findings from Experiment 7 also support hypothesis 2 in that lexical decisions were made more quickly with each subsequent repetition of the target stimuli, although the effect of repetition (block) was significant at only the 7% level.

The results of Experiment 7 are similar to those of Experiment 6 and they offer some support for the hypothesis expressed in the discussion section of Experiment 6 that priming effects due to target repetition can prevent the occurrence of semantic and emotional priming. To replicate the findings of Experiment 5, and so confirm the existence of subliminal semantic and emotional priming effects with emotional targets, a return to the design used in Experiment 5 was therefore considered necessary.

CHAPTER 10

SUBLIMINAL SEMANTIC AND EMOTIONAL PRIMING: A FURTHER ATTEMPT AT REPLICATION

Semantic and emotional priming effects failed to occur subliminally in Experiment 6 and supraliminally in Experiment 7 where an experimental design involving target repetition was used. Some support was found in these experiments for the hypothesis that repetition of targets creates a strong priming effect in its own right and it is plausible to argue that this repetition effect overrides conventional priming effects due to semantic and emotional relatedness of primes and targets. The experiment reported in this chapter (Experiment 8) was undertaken to investigate whether significant semantic and emotional priming effects would occur when a return was made to the experimental design of Experiment 5 which avoided repetition effects. Experiment 8 was a replication of Experiment 5 using new stimuli and different participants.

METHOD

Participants

Fifteen undergraduate students with mean age 22.7 years (SD 4.64) took part in the experiment. Ten were men. None of the students knew of the nature of the experiment or had previously taken part in similar research. All were paid £2.00 for participating.

Apparatus

The apparatus was identical to that used in Experiments 5 and 6.

Stimuli

Words which had been rated 'emotional' (median rating less than 3.50) or 'neutral' (median rating 3.50 to 4.49) in the rating exercise completed for Experiment 6 formed part of the word pool from which prime-target word pairs were chosen for Experiment 8. To increase the size of this word pool another 100 words were rated. Thirty five students, with mean age 20.5 years (SD 4.14), completed the additional rating exercise. There were 12 men and 23 women and all were native English speakers. The same questionnaire was used as in the previous rating exercise (see Appendix E) but, of course, new words were substituted for those previously rated. As before, words with a median rating which fell into the categories 'A very/fairly/mildly strong unpleasant emotion' were considered 'emotional', while 'neutral' words were defined as having a median rating which fell into the category 'no emotion'. In Experiment 6 some words were considered neutral because they had been rated not emotionally unpleasant (i.e. they were considered neutral even though they had been rated emotionally pleasant). In Experiment 8 it was decided that all neutral words must have a neutral median rating and only words which conformed to this strict definition of neutral were taken from Experiment 6 for use in Experiment 8. Into this word pool of emotional and neutral words the nonword stimuli from Experiment 6 were added. Seventeen prime-target word pairs were then chosen for 6 experimental conditions. These conditions, the same as in Experiments 5, 6 and 7, were semantically related (SR), emotionally related (ER), unrelated (UR), neutral prime - nonword target ($W\bar{W}_1$), emotional prime - nonword target ($W\bar{W}_2$) and neutral prime - nonword target ($W\bar{W}_3$).

To ensure that prime-target word pairs in the SR condition were semantically related, and those in the ER and UR conditions were not semantically related a further rating exercise was undertaken. Thirty five undergraduate students with mean age 20.3 years (SD 3.11) took part. Some of these students had also taken part in the previous rating exercise described in Chapter 9. Semantic relatedness was assessed by giving students a list of prime-target word pairs and asking them to decide how likely it was that the target word would be given in response to the prime in a test of free association in which five responses to each prime were required. Students indicated their response by ticking one of five categories each of which was verbally labelled and assigned a number for the purpose of scoring. The categories were 'extremely likely' (score = 1), 'very likely' (score = 2), 'fairly likely' (score = 3), 'fairly unlikely' (score = 4), 'very unlikely' (score = 5), and 'extremely unlikely' (score = 6). The instructions, which were printed at the top of the questionnaire, are shown in Appendix G. Semantically related prime-target word pairs were defined as having a median rating of 3.49 or below. Semantically unrelated word pairs had a median rating of 3.50 and above.

The primes in all 6 conditions were matched for average word length and for average frequency of occurrence using the Kucera and Francis (1967) word count. The 6 sets of targets were also matched for average length. Targets in the SR, ER and UR conditions were matched for average frequency of occurrence and they did not differ significantly in this respect ($F = 0.0049$; df 2,48; $P > 0.05$). The mean length, frequency of occurrence, emotionality rating and degree of semantic relatedness between primes and targets are shown in Table 10.1. All stimuli appear in Appendix H, together with their individual ratings of emotionality and relatedness. For presentation prime-target pairs from all 6 conditions were combined, randomised and divided into 4 packs (3 of 25 and 1 of 27).

PAGINATION
ERROR

Table 10.1 Mean length, frequency, emotionality rating and degree of relatedness between prime and target stimuli in Experiment 8

		Condition					
		SR	ER	UR	$W\bar{W}_1$	$W\bar{W}_2$	$W\bar{W}_3$
Type of word	Prime Target	Neutral Emotional	Emotional Emotional	Neutral Emotional	Neutral Nonword	Emotional Nonword	Neutral Nonword
Length	Prime	5.294 (1.225)*	5.353 (1.369)	5.118 (1.131)	6.000 (1.085)	5.471 (1.194)	6.000 (1.372)
	Target	5.529 (1.242)	6.647 (1.185)	6.706 (1.562)	5.176 (0.856)	5.412 (1.032)	5.294 (1.225)
Frequency	Prime	44.588 (43.265)	41.823 (43.279)	43.118 (44.455)	43.000 (33.026)	40.647 (40.240)	41.235 (31.339)
	Target	24.941 (27.511)	25.706 (31.137)	25.941 (30.317)	- -	- -	- -
Emotionality	Prime	3.972 (0.302)	2.289 (0.483)	4.018 (0.046)	4.050 (0.075)	2.322 (0.511)	4.023 (0.100)
	Target	2.276 (0.492)	2.167 (0.451)	2.463 (0.433)	- -	- -	- -
Degree of semantic relatedness		2.534 (0.656)	5.012 (0.695)	5.829 (0.245)	- -	- -	- -

* standard deviations are given in parentheses

Twelve additional prime-target word pairs were chosen for practice; two from each type of experimental condition. The practice stimuli are shown in Appendix H. For threshold assessment, 8 stimuli were chosen. Each was equal in length to the longest prime and had a frequency of occurrence greater than the most frequently occurring prime. Thus, as in previous experiments, conservative estimates of detection threshold (DT) were attempted. The stimuli used for the assessment of DT are shown in Appendix H.

All stimuli were constructed as in previous experiments. Prime and target stimuli subtended visual angles of 0.9023 to 3.1000 degrees and 1.2400 to 3.9500 degrees respectively. The mask used in Experiment 6 was used again in Experiment 8.

Procedure

The procedure was the same as in Experiment 5.

RESULTS

At detection threshold (DT) all participants showed non-discriminative responding as defined by the objective criteria proposed in Chapter 3. At DT the mean probability of making a correct response, a hit and a false alarm was 0.505 (SD 0.036), 0.503 (SD 0.059) and 0.493 (SD 0.048) respectively. Mean d' at DT was 0.025 (SD 0.183) and mean DT was 36.67 msec (SD 17.480).

Errors comprised 1.18%, 1.96% and 2.35% of the total number of responses in the SR, ER and UR conditions respectively. Outliers were dealt with as in previous experiments and comprised 4.70%, 3.14% and 5.88% of the total responses in the SR, ER and UR conditions.

Mean lexical decision time in the SR, ER and UR conditions was 546.33 msec (SD 39.43), 567.80 msec (SD 60.25) and 578.73 msec (SD 46.14) respectively. Thus lexical decisions were made on average 32 msec faster in the SR condition than in the UR condition and on average 11 msec faster in the ER condition than in the UR. Lexical decision times were analysed using a one way repeated measures ANOVA and a summary of the results appears in Table 10.2.

Table 10.2 Summary table from one way ANOVA of lexical decision times in Experiment 8.

Source of Variance	df	MS	F	Sig.
Condition (SR/ER/UR)	2	4075.29	10.75	P < 0.001
Subjects	14	7077.71		
Residual	28	379.17		

As can be seen from Table 10.2 the effect of experimental condition was significant at P < 0.001. Subsequent Tukey tests revealed that lexical decisions were made significantly faster in the SR condition than in the UR (P < 0.01) or the ER (P < 0.05) while lexical decision times in the ER and UR condition did not differ significantly from each other (P > 0.05).

The facilitation effect due to semantic relatedness was 5.45% (SD 4.35) and all but one participant showed a facilitation effect. Although 13 of the 15 participants also made lexical decisions faster in the ER condition than in the UR the average emotional facilitation effect was only 2.04% (SD 3.42). The product moment correlation between d' at threshold and percentage semantic and emotional priming effect was 0.116 ($P > 0.05$) and 0.472 ($P > 0.05$) respectively.

After careful questioning it became clear that none of the participants had any suspicion that words were presented prior to the mask in the priming experiment and neither had any participant thought that the two experiments (threshold detection and priming) were part of a single study.

DISCUSSION

Once again detection threshold (DT) was assessed in accordance with the objective criteria proposed in Chapter 3 and all participants showed non-discriminative responding at threshold. Further support for the belief that primes were presented below objective, rather than subjective threshold comes from the non-significant correlation between percentage semantic priming effect and d' at DT. Moreover, primes were presented not at DT but at the more conservative duration of 90% DT. It was therefore hardly surprising that no participant had any conscious awareness that stimuli were presented prior to the mask in the priming experiment.

The semantic priming effect, significant at the 7% level of confidence in Experiment 5, was highly significant in Experiment 8. Unfortunately though the emotional priming effect, highly significant in Experiment 5, failed to reach statistical significance in the current experiment. Nevertheless emotionally related primes facilitated responses (lexical decision time) to semantically unrelated emotional targets and, although not significant, the results were in the expected direction.

The contradictory findings of Experiment 5 and 8 suggest that while semantic and emotional priming of emotional targets may occur below objective detection threshold, they are not effects which can be relied upon. Whether they occur at all probably depends, at least in part, upon properties of the stimuli such as degree of relatedness between prime-target word pairs. For example, Fischler and Goodman (1978) found that highly associated prime-target words pairs showed significantly more facilitation than words pairs which were less strongly related and this difference was particularly pronounced when the stimulus onset asynchrony was short. McCauley et al. (1976) also found a similar effect in an experiment in which target pictures were preceded by picture primes sharing either high or low category relatedness. McCauley et al. found that the time taken to name the target was significantly shorter when the prime-target stimuli were highly related than when the relationship was weak, although this effect did not emerge significantly when the participants were kindergarteners of about 6 years old. While it may appear that prime-target word pairs in the semantically related (SR) condition of Experiment 8 were less related in meaning than those in the SR condition of Experiment 5 this was not borne out by student ratings. Thirty one undergraduate students [mean age 20.6 years (SD 3.51)] rated the stimuli in the SR condition of Experiment 5 using the same rating scale as that used to assess degree of relatedness between primes and targets in Experiment 8 (see Appendix G). A comparison was then made between ratings for the two sets of SR stimuli and the difference was found to be non-significant ($t = 0.7306$; df 35; $P > 0.05$). Presumably though, it is not just the degree of relatedness, whether semantic or emotional, within one set of prime-target stimuli that matters, but this degree of relatedness in comparison to the degree of unrelatedness in the set of stimuli used for comparison purposes (UR condition).

A possible explanation of the apparent unreliability of the priming of emotional targets by semantically unrelated emotional primes may lie in the stringent conditions for subliminality enforced in Experiments 5 and 8. In both these investigations primes were presented below objective detection threshold. If it is assumed that the emotional priming effect is merely a variant of the conventional semantic priming effect, that is, that emotional relatedness is merely one form of semantic relatedness, then it may be that it is a relatively weak form of relatedness and for that reason the emotional priming effect may not be reliable below the rather stringent objective detection threshold. However, it is also possible that both semantic and emotional priming effects occur more reliably below the less stringent subjective detection threshold. Priming effects have been found to occur less strongly below detection threshold than supraliminally (Balota 1983) though in some studies this trend did not reach statistical significance (Marcel 1983a, Experiment 4; Fowler et al. 1981, Experiment 5). Cheesman and Merikle (1984) found that priming effects were significantly weaker below objective threshold than below subjective threshold in a colour naming Stroop task. However, in the Cheesman and Merikle study identification rather than detection thresholds were assessed. There appears to be no report in the literature of a comparison between priming effects below subjective and objective detection threshold in a priming experiment using a lexical decision task. Yet the results of the experiments discussed above (i.e. Balota 1983; Fowler et al. 1981; Marcel 1983a; Cheesman & Merikle 1984) suggest that if a less stringent level of detection threshold had been assessed in the current experiments (Experiments 5 & 8) the semantic and emotional priming effects may have occurred more strongly and reliably. To investigate this possibility Experiment 5 was replicated with the prime stimuli presented below subjective, rather than objective, detection threshold and this experiment (Experiment 9) is reported in the next chapter. The differential effects of priming below objective and subjective detection threshold were then investigated by comparing the results of Experiment 9 with those of Experiment 5.

CHAPTER 11

EMOTIONAL PRIMING BELOW SUBJECTIVE DETECTION THRESHOLD: EXPERIMENT 9

Experiment 9 was designed to investigate the priming of emotional target stimuli by primes presented below subjective detection threshold. Cheesman and Merikle (1984) defined subjective threshold as the level at which participants claim not to be able to discriminate the stimuli and objective threshold as the level at which non-discriminative responding can be demonstrated. In their own research Cheesman and Merikle assessed subjective threshold by asking participants to guess the accuracy of their responses at the end of each block of discrimination trials. In one experiment (Cheesman & Merikle 1984, Experiment 2) in which four-choice identification thresholds were assessed participants estimated that they were responding at chance level (i.e. 25% correct) when objective assessment revealed that on average 66% of their responses were correct. Facilitation and inhibition in a subsequent Stroop task was significant when the primes were presented at the level at which participants estimated that they were responding at chance level but not when primes were presented at the level at which discrimination was actually at chance. Holender (1986) criticised Cheesman and Merikle's (1984) procedure for assessing subjective threshold. He argued that the discrepancy between estimated and actual performance may have occurred because of the inaccuracy associated with asking participants to rate their global performance retrospectively after a large number of trials (48 in Cheesman & Merikle 1984, Experiment 2). Holender (1986) advocates a procedure in which a response is given after every trial. But what response should be required of the subject and how should the responses be combined across trials? Marcel (1983a, Experiment 4), Balota (1983) and Fowler et al. (1981, Experiments 5 & 6) assessed detection threshold by ensuring that in a two-choice detection procedure the probability of making a correct response did not deviate significantly from that expected by chance. Merikle (1982) claimed that subjective rather than objective detection thresholds may have been assessed in these experiments because even when the overall probability of making a correct response was at chance level participants may have been able to respond discriminatively. Experiments 1 - 4 (Chapters 4 & 5) show that sometimes this is the case. In each of these experiments some participants were dropped from the final analysis because their response distributions at detection threshold showed discriminative responding even though their overall probability of making a correct response was at chance level. One might therefore define subjective threshold as the level at which participants show discriminative responding while at the same time having a probability of making a correct response within the boundaries of chance expectation. Operationally this may be defined as occurring when two criteria are met:

1. The probability of a correct response lies within the 95% confidence limits about the chance expectancy of 0.5.

   and

2. The probability of a hit and/or a false alarm lies outside the 95% confidence limits about the chance expectancy of 0.5.

In the experiment reported below (Experiment 9) subjective detection threshold was assessed according to the criteria specified above. The stimuli chosen for Experiment 5 were used again for Experiment 9 so that a direct comparison could than be made of semantic and emotional priming effects below objective (Experiment 5) and below subjective (Experiment 9) detection threshold.

METHOD

Participants

Nine undergraduate students took part in the experiment for which they were paid £2.00. They had a mean age of 20.0 years (SD 1.25) and 8 were women. None of them had previously taken part in subliminal research.

Apparatus

The apparatus was identical to that used for Experiments 1 - 3. Tachistoscopic luminance levels were at the settings previously used and the experiment was conducted under exactly the same conditions as in Experiment 5.

Stimuli

All prime-target word pairs, practice stimuli, mask, and test stimuli for the assessment of detection threshold were the same as in Experiment 5 (Chapter 8).

Procedure

The procedure was identical to that of Experiment 5 with the following exceptions. First, as in Experiment 5, during detection threshold assessment participants were asked to indicate 'yes' when they thought that they could detect a stimulus and 'no' when they could not detect a stimulus. But unlike in Experiment 5 they were not encouraged to give approximately 5 'yes' and 5 'no' responses per block of 10 trials, although as before they were told that an equal number of stimuli and blank cards would be presented in each block of trials. During threshold assessment some participants commented that they were giving a disproportionate number of 'no' responses and must therefore be making many incorrect decisions. In response to this comment the Experimenter reaffirmed that the participants task was to report which stimulus they thought had been presented even if this meant giving the same response on every trial.

A second difference between Experiment 5 and the current experiment was that objective detection thresholds were assessed in Experiment 5 and subjective detection thresholds were assessed in Experiment 9. Subjective detection threshold (DT) was assumed to have been assessed when, averaged across 4 sets of 10 trials, the probability of making a correct response P(C) fell within the 95% confidence limits about the chance expectancy of 0.5 and the probability of a hit and/or a false alarm fell outside the 95% confidence limits of the chance expectancy of 0.5. Participants who showed non-discriminative responding when P(C) did not differ significantly from chance were not asked to take part in the priming experiment.

RESULTS

The results given below for threshold assessment are only those for the participants who subsequently took part in the priming experiment.

At detection threshold (DT) all participants had a probability of making a correct response P(C) within the 95% confidence limits about the chance expectancy of 0.5. The mean value of P(C) was 0.54 (SD 0.052). Eight participants had a probability of a hit which was below the lower boundary of the 95% confidence limits about the chance expectancy of 0.5 [i.e. P(H) < 0.3] and all participants' probability for false alarm also fell below this lower boundary of 0.3. The mean probability for a hit and a false alarm was 0.16 (SD 0.123) and 0.08 (SD 0.094) respectively. Mean d' at DT was 0.230 (SD 0.420) but this was based on only 5 observations because in 4 cases response distributions were so extreme [P(H) and/or P(FA) = 0] that d' could not be calculated. Mean DT was 26.11 msec (SD 7.74).

As in previous studies only responses to real words were analysed. The percentage of incorrect responses in the SR, ER and UR conditions was 3.9%, 1.7% and 3.3% respectively. Outliers were dealt with as in previous experiments and comprised 5.0%, 4.4% and 3.9% of the responses in the SR, ER and UR conditions.

On average, lexical decision time was 706 msec (SD 131.57) in the SR condition; 717 msec (SD 152.73) in the ER condition and 759 msec (SD 125.10) in the UR condition. Thus there was a 53 msec mean facilitation effect due to semantic relatedness between prime and target and a 42 msec mean facilitation effect due to emotional relatedness. The average percentage semantic and emotional facilitation effect was 6.18% (SD 4.88) and 7.15% (SD 4.80) respectively. Lexical decision times were analysed using a one way repeated measures ANOVA and a summary of the results appear in Table 11.1.

Table 11.1 Summary table from one way ANOVA of lexical decision times in Experiment 9.

Source of Variation	df	MS	F	Sig.
Condition (SR/ER/UR)	2	6956.59	9.5529	P = 0.0018
Subjects	8	61865.45		
Residual	16	728.22		

As can be seen from Table 11.1 experimental condition (SR/ER/UR) had a significant effect on lexical decision time well beyond the 1% level of confidence. Tukey tests revealed that this was due to lexical decisions being made significantly more slowly in the UR condition than in either the SR ($P < 0.01$) or ER ($P < 0.05$) conditions, while lexical decision times in the SR and ER conditions did not differ significantly ($P > 0.05$).

As noted above four participants had a response distribution at DT in which the probability of a hit and/or the probability of a false alarm was equal to zero. Thus in some cases d' - the measure of detection performance used in previous experiments - could not be calculated. Cheesman and Merikle (1984) found a significant correlation between percentage priming effect and identification performance at threshold when identification performance was defined as the percentage of correct responses in a four-choice recognition task. Following Cheesman and Merikle's (1984) procedure detection performance was defined in the current experiment as the percentage of correct responses in the two choice discrimination task. The product moment correlation between percentage correct responses and percentage semantic and emotional priming effect was -0.280 and 0.095

respectively. Neither corrlation was significant at the 5% level of confidence.

All participants were very carefully questioned at the end of the session to determine whether they had seen any stimuli prior to the mask on priming trials. All students reported in the negative and none thought that the assessment procedure was related in any way to the priming experiment.

The results of Experiments 5 and 9 compared.

For comparison purposes the mean lexical decision time for the semantically related (SR), emotionally related (ER) and unrelated (UR) conditions of Experiments 5 and 9 are shown in Table 11.2. Because the high and low Neuroticism groups of Experiment 5 were found not to differ significantly on any dependent measure the results for the two groups were combined.

Mean lexical decision times in the SR, ER and UR conditions of Experiments 5 and 9 were analysed using a two way analysis of variance with replication on one factor (condition). The results of this analysis are shown in Table 11.3.

Table 11.2 Mean lexical decision time in the SR, ER and UR conditions of Experiments 5 and 9.

	CONDITION			
	SR	ER	UR	SR, ER and UR combined+
Experiment 5	617 (88.06)*	606 (80.07)	637 (91.80)	620 (87.72)
Experiment 9	706 (131.57)	717 (152.73)	759 (125.10)	728 (138.84)
Experiments 5 and 9 combined+	645 (111.52)	640 (119.72)	674 (117.82)	

* Standard deviations are shown in parentheses.
\+ Means for the combined groups do not tally exactly with means for the groups combined because of errors in rounding up.

Table 11.3 Summary table from a two way ANOVA of lexical decision times in Experiments 5 and 9.

Source of variation	df	MS	F	Sig.
Experiment (E)	1	216903.1	6.39	$P < 0.05$
Error: E x S	27	33940.3		
Condition (C)	2	10893.1	14.00	$P < 0.01$
E x C	2	1756.6	2.26	$P > 0.05$
Error: E x C x S	54	778.2		

From Table 11.3 it can be seen that there was a significant main effect for Experiment (5 & 9) and for Condition (SR, ER & UR) but a non-significant interaction effect. It can be seen from Table 11.2 that lexical decisions were made significantly faster in Experiment 5 than in Experiment 9. Tukey tests revealed that when the results of the two experiments were combined lexical decisions were made significantly more slowly in the UR condition than in either the SR or ER conditions ($P < 0.01$) while average lexical decision time in the SR and UR condition did not differ significantly ($P > 0.05$).

For comparison purposes the percentage semantic and emotional priming effects in Experiments 5 and 9 are shown in Table 11.4. These priming effects were analysed using a two way (Experiment x Priming effect) analysis of variance with repeated measures on one factor and a summary of the results is shown in Table 11.5.

Table 11.4 Percentage semantic and emotional priming effects in Experiments 5 and 9.

	Priming effect	
	Semantic	Emotional
Experiment 5	2.82 * (6.71)	4.45 (7.00)
Experiment 9	6.18 (4.88)	7.15 (4.80)

* Standard deviations are shown in parentheses.

Table 11.5 Summary table from a two way ANOVA of percentage priming effects in Experiments 5 and 9.

Source of variance	df	MS	F	Sig.
Experiment (E)	1	114.29	1.517	P > 0.05
Error: E x S	27	75.36		
Priming effect (P)	1	1.38	0.139	P > 0.05
E x P	1	20.99	2.118	P > 0.05
Error: E x P x S	27	9.91		

As can be seen from Table 11.5 there was no significance overall difference in priming between Experiments 5 and 9. When the results of Experiments 5 and 9 were combined there was no significant difference between the emotional and semantic priming effect and the interaction effect (Experiment x Priming effect) was not significant at the 5% level of confidence.

DISCUSSION

Merikle's (1982) claim that non-discriminative chance level responding cannot be adequately assessed by ensuring only that the probability of making a correct response at threshold does not differ significantly from that expected by chance is supported by the results of detection threshold assessment in Experiment 9. All 9 participants in this experiment had an overall probability for making a correct response at chance level but nevertheless were responding discriminatively in that their probability of a hit and/or a false alarm lay outside the boundaries of chance expectation.

As in previous experiments participants were familiarised with the threshold assessment procedure by supraliminal presentation of the stimuli and stimulus duration was not reduced until each participant detected blank cards and word stimuli with 100% accuracy in one block of 10 trials. Thus initially 'yes' (stimulus present) and 'no' (stimulus absent) responses were made with equal frequency. However, as prime duration was reduced participants began to use the 'yes' response less frequently. Many participants spontaneously commented that if it really was the case that an equal number of each type of stimuli was presented, and some students were quite sceptical of this, then they must be failing to detect the word stimuli on many occasions when they were presented. For all participants the probability of making a correct response reached chance level when there was a considerable over-representation of 'no' responses and thus high accuracy for detecting blank cards and low accuracy for detecting word stimuli. Indeed, at detection threshold blank cards were correctly identified on average 92% of the time while on average stimuli were detected on only 16% of the occasions on which they were presented.

Although Cheesman and Merikle's (1984) method for assessing subjective threshold was not adopted in Experiment 9 subjective threshold appears to have been assessed in accordance with their criteria. However, Cheesman and Merikle (1984) found a significant correlation between percentage priming effects and performance at detection threshold in a Stroop colour naming task when the primes (colour names) were presented at subjective threshold. But the correlation between percentage correct detection trials at threshold and percentage semantic and emotional priming effects were non-significant in Experiment 9. This discrepancy in findings may have arisen because primes were presented below subjective detection threshold in Experiment 9 but at subjective identification threshold in the experiment by Cheesman and Merikle and the latter is likely to be higher than the former. It may also be the case that had participants been asked to estimate the accuracy of their responses during threshold assessment they may have indicated that they thought they were responding at chance level before their probability of making a correct response actually fell within the boundaries of chance expectation. Thus subjective threshold may have been assessed more stringently in Experiment 9 than in Cheesman and Merikle's (1984) experiment and this may account for the fact that in Experiment 9 a non-significant correlation between detection performance and semantic and emotional priming was found.

The results of Experiment 9 show that emotional stimuli can be primed by semantically and emotionally related primes presented below subjective detection threshold. Thus further support was found for the concept of priming through a common emotional evaluation of prime and target and for priming of emotional target stimuli below detection threshold.

By considering the results of Experiments 5 and 9 together a comparison can be made of priming effects below objective and subjective detecion threshold. As subjective threshold is associated with higher stimulus energy levels than objective threshold (Cheesman & Merikle 1984) the finding that subjective detection threshold, assessed in Experiment 9, was on average 8 msec lower than objective detection threshold, assessed in Experiment 5, was a little surprising. However, there are large individual differences in visual threshold (see Marcel 1983a, Experiment 1) and different participants took part in each of these studies.

From Tables 11.2 and 11.3 it can be seen that lexical decisions were made significantly faster when primes were presented below objective threshold than when they were presented below subjective threshold. To the author's knowledge no previous study has investigated lexical decision times below subjective and objective detection threshold in a semantic priming experiment although faster lexical decisions have been associated with subliminal presentation in studies comparing priming above and below threshold (Fowler et al. 1981; Balota 1983). Having collapsed results across short and long SOAs Balota (1983) found that lexical decisions were made on average 58 msec faster in the threshold condition than in the suprathreshold condition, a difference which was significant at the 1% level of confidence. Balota claims that a faster response time would be expected in the threshold condition because reading the primes requires mental capacity and therefore less capacity is available for responding to the target in comparison to the subliminal condition in which the primes are processed automatically. But, it is difficult to extend this argument to account for the significant difference in response time between presentation below objective and subjective detection threshold in Experiments 5 and 8. Moreover, Marcel's (1983a, Experiment 4) results differ from those of Balota (1983) in that he found that lexical decisions were made more quickly when the primes were pattern masked (subliminal condition) than when they were unmasked (supraliminal condition).

It was hypothesised above that semantic and emotional priming of emotional target stimuli would be greater in magnitude when the primes were presented below the less stringent subjective detection threshold than when they were presented below objective detection threshold. Tables 11.4 and 11.5 show that while there was a trend in this direction the difference between percentage semantic and emotional priming effects below subjective and objective detection threshold was not statistically significant. However, between Experiments 5 and 9 there was on average a 2.9% increase in the semantic priming effect and a 161% increase in the emotional priming effect. Interestingly, the larger percentage priming effects occurred in the experiment in which lexical decision times were significantly longer overall. This supports the findings of Fischler and Goodman (1978) who found a significant association between average lexical decision time and strength of priming effect.

CHAPTER 12

OVERALL DISCUSSION OF SEMANTIC AND EMOTIONAL PRIMING WITH EMOTIONAL TARGETS

The experiments reported in Part III were designed to investigate subliminal priming of emotional targets. The conclusions drawn from this work are presented below under three subheadings: Target repetition; Semantic and emotional priming below objective detection threshold and Priming effects below objective and subjective detection threshold compared.

Target repetition

Frequency of occurrence has a significant effect on lexical decision time (Rubenstein et al. 1970; Scarborough et al. 1977; Gardner et al. 1987) and it is therefore very important that frequency is matched across conditions in a semantic priming experiment. In some experiments this has been achieved by creating two sets of semantically related (SR) word pairs. One set is then 'scrambled' to form the unrelated (UR) prime-target word pairs for half the participants and the other set 'scrambled' to form word pairs in the unrelated condition for those participants remaining. This procedure ensures that the differential effect of target frequency in the SR and UR conditions is cancelled out while complicated matching procedures are avoided. In the majority of semantic priming experiments however, frequency effects are controlled by matching targets for frequency of occurrence according to some published norms. Norms which have been used for this purpose include the Kucera and Francis (1967) and Thorndike and Lorge (1944) word counts. The disadvantage of this method of frequency control is that the norms are often based on word counts of literature in a country other than that in which the experiment is to be conducted and the norms are often out dated.

A third method for controlling target frequency is to repeat the same target stimuli in each experimental condition and it was this method that was chosen for Experiment 6. That is, in Experiment 6 one set of real word targets were chosen and shown three times: once preceded by semantically related primes; once preceded by emotionally related primes and once preceded by unrelated primes . A fully crossed experimental design was then used to ensure that presentation order would not confound the results. Unfortunately the semantic and emotional priming effects which had occurred in a previous experiment failed to emerge in Experiment 6. However, there was a significant effect of target repetition with lexical decisions having been made relatively slowly when the targets were first shown, more quickly when they were shown for the second time and fastest of all when they appeared for the third occasion. In previous studies repetition effects have been found to occur more strongly and to last longer than semantic priming effects (Dannenbring & Briand 1982; Mayer et al. 1975; Forbach et al. 1974; Scarborough et al. 1977; Ratcliff et al. 1985). It was therefore hypothesised that the semantic and emotional priming effect which failed to occur in Experiment 6 had been masked by the stronger effects of target repetition. This hypothesis was supported by the findings of Experiment 7 which was a supraliminal replication of Experiment 6. It was argued that while the existence of subliminal semantic and emotional priming effects is still contentious, supraliminal semantic priming is a well documented phenomenon. Thus if the results of Experiment 6 were replicated they would be consistent with, and thus offer some suppot for, the hypothesis that semantic and emotional priming effects failed to occur because of target repetition. In fact the results of Experiment 7 were very comparable to those of Experiment 6. Significant semantic and emotional priming effects failed to occur while lexical decisions were made faster with each presentation of the target stimuli and the effect of repetition was significant at the 7% level of confidence.

Taking the results of Experiments 6 and 7 together one is led to the conclusion that subliminal and supraliminal semantic and emotional priming effects are likely to be masked if an experimental design is chosen in which priming and repetition effects are confounded. Frequency effects cannot of course be ignored but in semantic priming experiments they should be controlled without adopting an experimental design which involves target repetition.

Semantic and emotional priming below objective detection threshold

Semantic and emotional priming of emotional target stimuli was investigated below objective detection threshold in Experiments 5 and 8. In Experiment 5 there was a significant emotional priming effect while the semantic priming effect was significant at the 7% level of confidence. However, in Experiment 8 the semantic priming effect was highly significant while the emotional priming effect failed to reach statistical significance at all. One way in which the two experiments differed was the method by which stimuli were chosen. In Experiment 5 the experimenter and her supervisor chose 'emotional' and 'neutral' words on the basis of their personal evaluations and they also decided whether word pairs were semantically related or unrelated. Prior to Experiment 6 two different word rating exercises were conducted. In one exercise students rated the quality and strength of emotion they associated with a large number of words and in the second exercise they rated degree of relatedness between potential prime-target word pairs. Thus in Experiment 8 emotional and neutral stimuli had been rated 'emotional' and 'neutral' respectively; semantically related word pairs were considered likely to 'go together' and semantically unrelated word pairs had been rated 'unrelated'. A fairly large number of people took part in the rating exercises and all ratings were made by members of the student population from which the subsequent experimental sample was drawn, although none of those who took part in the rating exercise subsequently took part in the experiment.

In some experiments the magnitude of semantic priming effect has been associated with degree of relatedness between the prime and target stimuli (e.g. Fischler & Goodman 1978; McCauley et al. 1976). One might speculate that the increase in percentage semantic priming effect from Experiment 5 to 8 occured because in Experiment 8 the prime-target word pairs in the semantically related condition were more strongly related. An ex post facto analysis of semantic relatedness between prime-target word pairs in Experiments 5 and 8 however showed that they did not differ significantly in this respect, but of course the control (unrelated) condition was different in each experiment and as the difference in degree of relatedness between the semantically related and unrelated word pairs was not computed it is not possible to draw any firm conclusions about strength of relationship and the strength of semantic priming effect in Experiments 5 and 8.

From the results of Experiments 5 and 8 it seems not unreasonable to conclude that semantic priming of emotional target stimuli can occur below objective detection threshold. However, the magnitude and therefore statistical significance of the effect probably depends upon choice of stimuli and in particular on the degree of relatedness between the semantically related and control conditions.

The results of Experiments 5 and 8 suggest that one can be less certain about the existence of the emotional priming effect. While there was a large and statistically significant emotional priming effect in Experiment 5, the effect was small and non-significant in Experiment 8. One can be more confident that the prime-target pairs were semantically unrelated in the emotionally related condition of Experiment 8 than in the emotionally related condition of Experiment 5. However, it seems quite unreasonable to assume that the emotional priming effect in Experiment 5 was entirely due to a semantic relationship between prime-target word pairs which had gone unrecognized when the stimuli were chosen. A more likely explanation of the unreliability of the emotional priming effect was suggested in the discussion of Experiment 8. It was argued there that the emotional priming effect is probably a variant of the conventional semantic priming effect and that if this is the case, it is probably a weak effect which may at times be difficult to demonstrate. When more is known about emotional priming those variables which affect the strength with which it occurs can probably be manipulated to demonstrate that it can occur more reliably.

Priming below subjective and objective detection threshold compared

In Chapter 10 it was argued that the apparent unreliability of priming effects in Experiments 5 and 8 may have arisen because primes were presented at such a low level of stimulus energy. Not only was objective detection threshold assessed conservatively with stimuli whose length and frequency was equal to, or greater than, the longest and most frequent occurring prime but primes were then presented at

90% of this value. It was hypothesised that priming effects may occur more strongly and reliably if a less stringent measure of detection threshold were assessed.

When the effects of priming below subjective (Experiment 9) and objective (Experiment 5) detection thresholds were compared priming was indeed found to occur more strongly below subjective detection threshold but the difference in magnitude of effect did not reach statistical significance. Moreover, lexical decisions were generally made significantly more slowly in Experiment 9 than in Experiment 5 regardless of type of prime. Thus the increase in magnitude of priming effect may have occurred as a consequence of this rather than as a result of higher energy associated with the prime. This view is supported by the work of Fischler and Goodman (1978) who found that semantic priming effects were large and significant when lexical decision times were generally slow, and small and non-significant when lexical decision times were relatively fast.

In Experiment 9 primes were presented below subjective detection threshold. In Cheesman and Merikle's (1984) research subjective threshold was assessed by asking participants to guess the accuracy of their responses after a set of trials had been completed (Cheesman & Merikle 1984, Experiment 2), but in Experiment 9 subjective threshold was assessed more objectively. It is possible that the method of assessing subjective threshold resulted in a particularly stringent measure and this view is supported by the non-significant correlation between detection performance and percentage semantic priming effect.

A final comment

In chapter 7 it was suggested that if internal emotional concepts could be activated through a semantic priming effect then this might be the mechanism by which spontaneous panic attacks arise. It was noted that such an explanation relies on two assumptions. Firstly, that internal emotional stimuli can be semantically activated and secondly that once activated (without awareness) emotional stimuli can give rise to an emotional response. Support for the first of these assumptions comes from the experiments reported above. It is to the question 'Can non-conscious emotional stimuli give rise to emotional responses?' that we turn in Part IV.

PART IV

THE SUBLIMINAL ACTIVATION OF ANXIETY

CHAPTER 13

THE SUBLIMINAL ACTIVATION OF ANXIETY: A REVIEW OF LITERATURE

The origins of spontaneous panic attacks in patients diagnosed as suffering anxiety states are far from clear. Typically such attacks do not occur at particular times, in particular places or in the course of particular activities. Thus there are no apparent environmental events which could plausibly be considered as precipitants. When questioned patients often report thoughts of personal danger during a panic attack and such thoughts are frequently reactions to somatic symptoms (Hibbert 1984). For example, an individual may think a heart attack is about to occur following the onset of palpitations. But patients rarely report significant mental content immediately prior to the onset of the somatic symptoms and so awareness of threatening thoughts, impulses, images or memories cannot be held responsible for the onset of the panic attack. However, it could be argued that spontaneous attacks arise following the activation of non-conscious stimuli associated with threat and such a view is, of course, a cornerstone of psychoanalytic theories. In previous chapters (especially those in Part III) the means by which these internal threatening stimuli could be activated was investigated and a semantic priming mechanism postulated. Part IV is concerned with the question 'Can non-conscious threatening stimuli give rise to anxiety related responses?' Evidence that they can would offer further support for, and thus strengthen, the hypothesis that spontaneous panic attacks arise following the non-conscious perception of internal threatening stimuli. Research into this hypothesis has been laboratory based and has sought to determine whether anxiety can be generated (usually in non-clinical populations) as a result of the subliminal presentation of emotionally threatening stimuli.

One of the first studies to investigate emotional responses to stimuli tachististicopically presented below recognition threshold was carried out by McGinnies (1949). McGinnies found that pre-recognition guesses as to the identity of taboo words were accompanied by a significantly larger galvanic skin response (GSR) than were guesses to neutral stimuli. A few years later Dixon (1958) found that a significantly greater GSR response was evoked by taboo words in comparison to neutral words when the stimuli were presented below awareness threshold. Dixon's research was extended by Worthington (1961) who discovered that an electrodermal response conditioned to particular verbal stimuli generalised to semantically related words presented below recognition threshold. This finding has been replicated in the field of selective attention research. Corteen and Wood (1972) for example, conditioned a GSR to three city names and subsequently found significantly greater electrodermal activity in response to other city names than to unrelated nouns presented to the non-attended ear in a dichotic listening paradigm, even though none of these stimuli had been presented in the shock association procedure. Corteen and Wood's (1972) study has been criticised on the grounds that participants could have momentarily switched their attention from the passage of prose they were shodowing and then forgotten that this occurred. However, the results were replicated by Corteen and Dunn (1974) in a study in which participants were asked to stop shodowing immediately they heard a city name and press a buzzer. As this occurred only once out of the posible 114 opportunities it seems unlikely that the results of the original study by Corteen and Wood were artefactual.

Forster and Govier (1978) extended Corteen and Wood and Corteen and Dunn's findings by showing that once an electrodermal response had been conditioned to particular words a GSR was induced with much greater than chance probability to synonyms presented in an unattended message. Moreover, while participants also showed a GSR to words which sounded like the conditioned stimulus (CS) they were significantly more likely to do so when the CS was embedded in a context which was appropriate rather inappropriate. The studies cited above were all concerned with a psychophysiological component of anxiety (GSR) and collectively they lead to two conclusions. First that stimuli which are not consciously perceived can nevertheless be semantically analysed and second, that non-conscious stimuli are evaluated and can give rise to psychophysiological changes consistent with an anxiety response.

The influence of subliminal emotional stimuli on the generation of psychological aspects of anxiety, including aspects having somatic referents, has been investigated in two experiments by Tyrer, Lewis and Lee (1978). In their first experiment 20 anxiety associated words were presented subliminally to a group of nurses and the same words presented supraliminally to a second group matched with the first on a measure of trait anxiety. Seven dependent variables, all representing psychological aspects of anxiety, were assessed before and after the stimuli were presented. The dependent measures were all self ratings and included two measures of state anxiety, one from the State-Trait Anxiety Inventory (Spielberger et al. 1970; STAI), the other from the Bond and Lader (1974) factor score measure. Analogue scales were also used to obtain five further self ratings of muscular tension, sweating, shaking, difficulty breathing and palpitations. Results appeared to show significant increases in the two measures of state anxiety for both subliminal and supraliminal groups although no other dependent measures changed significantly.

In Tyrer et al.'s second experiment a speeded up film of a drive through a busy city was shown to one group of volunteers who subsequently viewed supraliminally a film of a swan floating on a lake. A second group matched to the first in terms of trait anxiety first viewed the 'floating swan' film subliminally and subsequently viewed the 'speeding car' film supraliminally. The 'speeding car' film was considered to have anxiety inducing qualities (i.e. to be 'emotional') while the 'floating swan' film was thought to be 'neutral'. Thus differential effects of emotional and neutral, subliminal and supraliminal stimulation could be investigated. Six of the seven anxiety measures used in the tachistoscopic study were taken before and after each film was viewed. Results appeared to show that the factor score measure of anxiety increased following subliminal presentation of the 'emotional' film and decreased following subliminal presentation of the 'neutral' film. No significant changes were found for the remaining five dependent variables with subliminal presentation. Comparison of pre-post change scores for supraliminal presentation of the emotional and neutral films showed significant differences on all six dependent measures, though ratings of sweating decreased slightly for the emotional film.

At first glance the results of the two experiments by Tyrer et al. (1978) appear to offer impressive support for the hypothesis that non-conscious stimuli can give rise to mental components of anxiety. However, on closer inspection it can be seen that both studies were so seriously flawed that one cannot have confidence in conclusions drawn from them.

The credibility of the film investigation suffers from the fact that it was assumed rather than demonstrated that the emotional film produced anxiety. The finding that increases occurred in all but one of the dependent measures when the emotional film was viewed supraliminally does not necessarily support this assumption. It is equally, if not more, plausible to consider this film produced feelings of 'thrill' such as may be obtained from a fairground ride. The experience of thrill would be expected to produce increases in perceived muscle tension, palpitations etc. and these may have been misinterpreted as anxiety following supraliminal viewing of the emotional film. Such a misinterpretation seems especially likely since participants were apparently given no explanation of the purpose of the experiment.

A further difficulty with the film study is that some participants reported seeing 'flickering' during subliminal presentation. Tyrer et al. (1978) do not say if this was confined to the emotional film though this seems very likely as a speeded up view of streets from a moving car is likely to involve large and rapid luminance changes compared to a view of a swan on a lake. As participants were unaware of the purpose of the experiment the sight of 'flickering' may well have caused them to wonder what was going on and what was likely to happen, thus generating genuine anxiety quite artefactually.

The tachistoscopic study was seriously flawed in three major ways. First there was a most implausible 'cover story'. Participants were told the investigation was concerned with "testing eye movements so that there was no pre-existing expectation that anxiety levels might be altered during the experiment" (Tyrer et al. 1978, p.90). It scarcely seems likely that participants given this 'explanation' and subsequently asked to make seven ratings of aspects of anxiety both before and after the experiment would believe the stated purpose. But if they did not, then they may well have wondered what the true purpose was, and their uncertainty may artefactually have generated the apparent change in state anxiety. A second and more serious procedural flaw was the complete failure to employ an adequate control condition in the experiment. Participants in the subliminal condition were compared with those in the supraliminal. To draw any defensible conclusion about subliminal activation of anxiety, a control condition should have been included in which emotionally neutral words, or blank cards, or both, were presented. It is plausible to suppose that the increase in anxiety in the supraliminal group resulted from a genuine increase in anxiety but that the increase in the subliminal group stemmed from uncertainty and apprehension about the true nature of the experiment.

Finally, the tachistoscopic study was deficient in it's statistical analyses. Measures were taken of a set of seven dependent variables, but no multivariate comparison on this set was made. Instead seven separate 2 x 2 ANOVA's were carried out in which 21 'F' ratios were computed, only two of which were significant. It seems very likely that had a preliminary MANOVA been used it would have indicated no significant overall multivariate difference.

Taken together the methodological weaknesses in both studies reported by Tyrer et al. (1978) were so severe that the results do not offer clear support for the hypothesis that psychological components of anxiety may be caused by non-conscious emotional stimuli.

Experiment 10, which is reported in the next chapter, was designed to replicate and extend Tyrer et al.'s study while avoiding the methodological flaws associated with their work.

CHAPTER 14

PSYCHOLOGICAL AND PSYCHOPHYSIOLOGICAL RESPONSES TO MILD SUBLIMINAL STRESS: EXPERIMENT 10

Experiment 10 was designed to investigate the influence of subliminal emotional and neutral stimuli on psychic, somatic and psychophysiological aspects of anxiety. The study was broadly similar to that of Tyrer, Lewis and Lee (1978) discussed in the previous chapter. One group of participants was shown 'emotional' words subliminally while a second group, matched to the first on trait anxiety, was subliminally presented with 'neutral' stimuli. Psychic, somatic and psychophysiological aspects of anxiety were measured before and after stimulation and the differences between groups and across time was investigated. Stimuli were rendered subliminal by means of the backward pattern masking technique used in Experiments 1 - 3.

METHOD

Participants

Twenty-eight undergraduate students (16 women, 12 men) aged 18-24 took part in the experiment. Each was paid £2.00 for participating. Two groups were established matched in terms of score on the trait version of the State Trait Anxiety Inventory (STAI) Form X (Spielberger et al. 1970). During the experiment one group (E) was presented with emotional words and the other group (N) with neutral words. The mean trait anxiety scores for the E and N groups were 39.8 (SD 9.16) and 40.1 (SD 9.23) respectively. Both groups contained eight women and six men and the mean age was 19.7 years

(SD 1.39) for the E group and 19.4 years (SD 1.04) for the N. The groups did not differ significantly in trait anxiety ($t = 0.07$, df 26, $P > 0.1$) or age ($t = 0.74$, df 26, $P > 0.1$).

Apparatus and stimuli

Heart rate (HR) and respiration rate (RR) were measured using a Grass 78 series polygraph. HR was recorded using three plate electrode placements (left and right wrist and left ankle) and the extrapolated beats per minute HR was computed and printed using the integrated Grass tachograph. RR was recorded using a temperature sensor incorporated in a nose clip inserted in one nostril. Stimuli were presented by means of the Electronic Developments 3-field tachistoscope used in Experiments 1 - 3. The stimuli were presented at a luminance of 2.35 lg cd/m^2 and the mask at a luminance of 1.90 lg cd/m^2.

Twenty emotionally unpleasant (E) and 20 emotionally neutral (N) words individually matched for length and frequency of occurrence using the Kucera and Francis (1967) norms served as verbal stimuli. The 40 words were selected from a total of 146 words rated for emotional pleasantness/unpleasantness in a pilot experiment. In the pilot study 124 undergraduates rated words considered to be associated with threat and frequency matched words believed to be emotionally neutral. Participants were asked to rate the quality and strength of emotion they associated with each word on a 7-point scale (7: Very strong unpleasant emotion, 6: Fairly strong unpleasant emotion, 5: Mild unpleasant emotion, 4: No emotion, 3: Mild pleasant emotion, 2: Fairly strong pleasant emotion, 1: Very strong pleasant emotion). The questionnaire used in the rating study has already been described as it was also used in another rating exercise (see Appendix E). However, when used previously the numbers were assigned for scoring in a different order (i.e. 7 = very strong pleasant emotion and 1 = very strong unpleasant emotion).

All but two of the E words used in the experiment had median emotionality ratings of 6 or 7. The two exceptions had ratings of 5. All but two of the N words had median ratings of 4 (i.e. no emotional association), the two exceptions having ratings of 3. The E and N stimuli (which are shown in Appendix J) varied in length from two to nine letters and in frequency of occurrence from 3 to 89 in the Kucera and Francis norms. Four stimuli were abbreviations rather than proper words. Two of these were emotional (TB, VD) and two were neutral (AC, BC). The emotional abbreviations were used because they had been used in the study by Tyrer et al. (1978) and had also emerged as strongly emotional in the pilot rating study. The neutral abbreviations were rated as neutral in the pilot investigation.

In addition to the verbal stimuli a set of five numerical stimuli was constructed. These consisted of the numerals 3, 5, 6, 7 and 8 printed on tachistoscope cards. All stimuli were printed on transparent tape using the KROY 80 lettering system (wheel size 10). The printed stimuli were then fixed in the centre of white cards 101 x 152 mm in size. The stimuli were 2.5 mm in height and subtended horizontal visual angles in the range 0.90^{o} to 3.21^{o}. The pattern mask used in all previous experiments except 4 and 7 was used again in this experiment.

<u>Overview of Procedure</u>

Participants were told that two experiments were to be carried out. The first (which actually consisted of detection threshold assessment) was said to be one of a series of studies concerned with individual differences in visual acuity for different types of stimuli. Following threshold estimation participants were told the second experiment was concerned with the relationship between visual acuity and emotion. It was explained that a series of trials would be given and that on some occasions a stimulus would be shown briefly. Participants were told that they were to look very carefully as they would be asked to report what they had seen at the end of the experiment. To give credence to this 'story' the five numerical stimuli were mixed in with both the E and N verbal stimuli and were presented at 10 times the exposure duration of the verbal stimuli, thus giving something to be seen and reported.

The binocular backward pattern masking procedure investigated in Experiments 1 - 3, and reported in Chapter 4, was used to render stimuli subliminal in the current experiment. Eight emotionally neutral nine letter words were used for the assessment of detection thresholds. These were chosen to have frequencies equal to, or marginally greater than, the most frequently occurring E and N words used in the experiment. The use of neutral test words equal in length and frequency to the E and N stimuli was considered likely to yield conservative estimates of detection threshold. The stimuli used for assessment of detection threshold are shown in Appendix J. Detection thresholds were assessed using a forced choice procedure in which participants attempted to discriminate between blank and stimulus cards. A full description of the procedure is given in Chapter 4. Detection threshold was assumed to have been reached when the probability of a correct response was within the 95% confidence limits of the chance expectency 0.5 (0.35 - 0.65) and participants were responding non-discriminatively. Non-discriminative responding was defined as occurring when chi square indicated that the response distribution for hits, false alarms, misses and correct negatives did not differ from that expected by chance. In Chapter 3 it was argued that at objective threshold non-discriminative responding should be demonstrated by showing that the probability of a correct response, a hit and a false alarm all fell within the 95% confidence limits of the chance expectancy of 0.5. However, these criteria for assessing objective threshold were proposed after the completion of the current experiment. To see whether participants' response distributions conformed to the criteria proposed in Chapter 3 ex post facto analyses were carried out and these are reported below.

Dependent variables assessed

After detection threshold had been assessed the 'cover story' for the 'second experiment' was given to participants who were then wired for recording of heart and respiration rate. Following a period of approximately 10 minutes during which the polygraph was calibrated, participants made ratings of state anxiety on the STAI. Ratings of a variety of feelings were also made on the 16 analogue scales developed by Bond and Lader (1974). Only two of these (Calm-Excited and Tense-Relaxed) were used in the analysis of data, the remainder were given to obscure the fact that the experimenter was chiefly interested in anxiety. The Calm-Excited and Tense-Relaxed scales were shown by Bond and Lader (1974) to define a factor in their factor analysis of analogue scale ratings. In comparison with a placebo condition scores on this factor decreased following administration of an anxiolytic drug (Flurazepam) and it therefore seems reasonable to consider the factor offers a valid measure of state anxiety. The procedure described by Bond and Lader (1974) was used to compute a 'factor score' measure of state anxiety from ratings on the Calm-Excited and Tense-Relaxed scales. Finally, participants made ratings on the five analogue scales used by Tyrer et al. (1978) to measure aspects of (perceived) somatic anxiety. These scales, like the Bond and Lader measures, required participants to draw a vertical pencil line through a 100 mm horizontal line to indicate strength of feeling. The five somatic anxiety scales measured perceived sweating, shaking, palpitations, difficulty in breathing and muscular tension. Each was verbally labelled 'not at all' at one end and 'very severely' at the other.

Presentation of stimuli

When all ratings had been made the main part of the investigation began with a 30 second resting baseline recording of the psychophysiological variables. Following this the word stimuli were presented 10% below each participant's detection threshold, each stimulus being immediately followed by the pattern mask for a period of 500 msec. Following the mask a dark field was viewed prior to the next stimulus. An inter-stimulus interval of approximately 6 seconds was used and 1 sec before the onset of each stimulus an audible warning sounded. The five numerical stimuli were presented (at ten times the duration of the verbal stimuli) in the following serial positions for each group; 5th, 8th, 14th, 18th, and 23rd. Packs of stimulus cards (E or N) were made up prior to each experimental session. The experimenter's supervisor assigned participants to the E or N groups according to their score on the STAI measure of trait anxiety which was assessed at the very beginning of the session. He then gave the appropriate pack of cards (E or N) to the experimenter for presentation. Thus the experimenter was able to present stimuli blind with respect to experimental group although of course she knew where the numerical stimuli appeared so that she could adjust stimulus duration appropriately. Following the last (i.e. 25th) stimulus psychophysiological recording was continued for 15 seconds with the participant at rest. Immediately this recording finished the analogue rating scales and the STAI measure of state anxiety were readministered. Stimuli and mask in the main part of the study were presented in the same manner and under the same levels of illumination as in the threshold determination procedure.

When all post-stimulation ratings had been completed participants were asked what they had seen during stimulation. All but one remembered seeing numbers, indeed most remembered the actual numbers seen. None reported seeing anything else. Probe questions asking if colours, shapes, letters, or words had been seen were all answered in the negative.

RESULTS

Thresholds and detection performance

The mean probability of a correct response P(C), a hit P(H) and a false alarm P(FA) at detection threshold (DT) are given in Table 14.1 together with the mean value of d' and mean DT. As can be seen the groups viewing emotional (E) and neutral (N) words did not differ significantly on any of these measures and the average values for P(C), P(H) and P(FA) all fell within the 95% confidence limits about the chance expectency of 0.5. However, inspection of the individual response distributions revealed that 3 participants in the N group and 1 participant in the E group were responding discriminatively as defined by the objective criteria proposed in Chapter 3. Three participants in the N group and one in the E group had a probability of a hit less than the value defined by the lower boundary of the 95% confidence limits about the chance expectency of 0.5 (i.e. $P < 0.3$). One of these participants (in the N group) also had a probability of a false alarm less than 0.3.

Table 14.1 Mean detection threshold (DT) and value of d', P(C), P(hit) and P(F/A) in Experiment 10.

	Group E	Group N	t	Sig.
Detection Threshold (msec)	40.0 (18.9)	38.9 (19.6)	0.1417	P > 0.05
P(C)	0.483 (0.039)	0.473 (0.038)	0.629	P > 0.05
P(H)	0.470 (0.085)	0.407 (0.127)	1.469	P > 0.05
P(FA)	0.505 (0.053)	0.461 (0.146)	1.005	P > 0.05
d'	-0.086 (0.191)	-0.084 (0.256)	0.024	P > 0.05

* Standard deviations are shown in parentheses.

Psychological data

When all 28 participants had completed the experiment analogue rating scale responses were measured to the nearest half millimetre by the experimenter who was blind with respect to group (E or N) and time of recording (Pre or Post). The Bond and Lader factor score measure of state anxiety was also computed blind as was the STAI measure of state anxiety. Inspection of the score distributions on the seven psychological measures (perceived sweating, shaking, palpitations, difficulty breathing, muscular tension, STAI anxiety, anxiety factor score) suggested a degree of positive skewing and so scores were normalised using a logarithmic transformation. The Pre and Post stimulation means for normalised scores in the E and N groups are shown in Table 14.2. The raw scores are shown in Appendix K.

Table 14.2 Normalised mean pre- and post-stimulation scores for E and N Groups.

	E GROUP			N GROUP		
VARIABLE	PRE	POST	%CHANGE	PRE	POST	%CHANGE
Sweating	1.062 (0.59)	1.160 (0.61)	+ 9.2	0.660 (0.66)	0.544 (0.61)	-17.6
Shaking	0.543 (0.48)	1.123 (0.45)	+106.8	0.807 (0.66)	0.992 (0.74)	+22.9
Palpitations	0.744 (0.56)	1.170 (0.60)	+57.3	1.050 (0.53)	1.374 (0.27)	+30.9
Breathing	0.531 (0.69)	0.817 (0.73)	+53.9	0.702 (0.66)	1.058 (0.69)	+50.7
Muscular tension	0.907 (0.61)	1.304 (0.59)	+43.8	1.079 (0.60)	1.142 (0.67)	+5.8
Anxiety (STAI)	1.545 (0.07)	1.566 (0.11)	+1.4	1.582 (0.08)	1.580 (0.09)	-0.1
Anxiety (Factor Score)	0.704 (0.09)	0.737 (0.07)	+4.7	0.729 (0.06)	0.691 (0.07)	-5.21
Heart Rate (HR)	1.875 (0.06)	1.889 (0.05)	+0.8	1.857 (0.08)	1.869 (0.08)	+0.7
Respiration Rate (RR)	0.619 (0.08)	0.649 (0.09)	+4.9	0.560 (0.10)	0.639 (0.09)	+14.1

Psychophysiological data

Mean heart rate (HR) and respiration rate (RR) during the last 15 seconds of resting baseline prior to the onset of stimulation were compared with mean HR and RR during the 15 seconds of rest after stimulation. Mean HR in each period was computed from the heart rate in beats per minute automatically extrapolated from beat to beat intervals. Respiration rate was calculated as the number of respiratory cycles occurring in the 15 second epochs. Mean Pre and Post stimulation values of HR and RR for the E and N groups are shown in Table 14.2 for normalised scores. The raw scores are shown in Appendix K.

Analysis of Results

A 3-way MANOVA for repeated measures with subjects nested within experimental group (E/N) and crossed with time (Pre/Post stimulation) was carried out on normalised scores in the set of nine dependent variables. Results from MANOVA showed no significant main effect for experimental group (G), F = 1.600; df 9,18; P = 0.189. However, a significant main effect for Time (T), F = 8.489; df 9,18; P = 0.00007 and a significant interaction (G x T), F = 2.885; df 9,18; P = 0.028 was found. Subsequent 2 x 2 ANOVAs showed a significant main effect for time on four psychological variables; shaking (P = 0.0004), palpitations (P = 0.002), difficulty breathing (P = 0.0006) and muscular tension (P = 0.003). Both psychophysiological variables also showed a significant main effect for Time; HR (P = 0.038), RR (P = 0.0021). Examination of the means in Table 14.2 shows that values of all these six variables increased following stimulation and that this occurred in both E and N groups. Sweating, STAI and the factor score measure of anxiety did not show significant changes over time at the 5% level.

The univariate ANOVAs showed significant Group x Time interactions for four psychological variables; sweating (P = 0.048), shaking (P = 0.043), muscular tension (P = 0.025) and the anxiety factor score (P = 0.026). Neither of the psychophysiological variables showed a significant interaction effect (HR; P = 0.877, RR; P = 0.141). Table 14.2 shows that for sweating the E group mean increased and the N group decreased following stimulation. The same was true for the anxiety factor score. For both shaking and muscular tension the mean scores in both groups increased following stimulation, though the increase for the E group was much greater than that for the N. Five dependent variables showed no significant Group x Time interaction at the 5% level; palpitations, difficulty breathing, STAI anxiety, HR and RR. It is interesting to note the univariate ANOVAs revealed that only one variable, the STAI measure of state anxiety, showed neither a significant main effect for time nor a significant interaction effect.

It seems reasonable to conclude that the significant increase in ratings of palpitations which occurred in both groups following stimulation resulted from conscious experience of the actual increase in heart rate which is evident in the data. Thus changes in rating of palpitations would be expected to correlate positively and significantly with the psychophysiologically measured change in heart rate. To examine this point data from the E and N groups were pooled, an operation legitimized by the lack of a significant difference between groups in both the MANOVA and subsequent univariate ANOVAs. As the correlation of interest was one between Pre and Post stimulation change scores, it was considered appropriate to correlate the component of post stimulation palpitation scores orthogonal to the pre-stimulation score with the corresponding orthogonal component for HR. This procedure gives a better indication of the correlation between 'true' change scores than is given by using raw Post minus Pre scores. The correlation was computed as 0.428 ($P < 0.05$ for a two-tailed test).

The 'difficulty in breathing' measure is not clear enough in nature to permit an unequivocal prediction of its relationship with RR. It might be argued that difficulty in breathing could be related either to an increase or a decrease in actual respiration rate depending on the nature of the difficulty. However, out of interest the correlation between difficulty in breathing and RR was computed using the orthogonal component procedure and found to be 0.225 ($P > 0.05$ for a two-tailed test).

DISCUSSION

Threshold values for the E and N groups were closely comparable and the analysis of detection performance at threshold showed no significant differences between the groups. The mean value for the probability of a correct response did not differ significantly from the chance expectancy of 0.5 at threshold, though four of the 28 participants failed to show non-discriminative responding in terms of the criteria proposed in Chapter 3. However, as the mean value of d' very closely approximated zero in each group the data for the four aberrant cases were included in the analysis and it seems reasonable to conclude that thresholds were adequately assessed and that the verbal stimuli presented in the main part of the experiment were generally presented below objective detection threshold. Further assurance that stimuli were unavailable to awareness comes from the failure of participants to report any of the verbal stimuli, though numerical stimuli were reported as expected.

The failure in the univariate ANOVAs to find a significant main effect for Time (Pre/Post stimulation) together with the significant Group x Time interaction for sweating and the factor score measure of anxiety are the most interesting results. It is clear from Table 14.2 that subliminal exposure to emotionally unpleasant words having connotations of threat produced increases in subjective feelings of sweating and anxiety (on the factor score measure). By contrast similar exposure to emotionally neutral words produced decreases in feelings of sweating and anxiety. The significant differential change on these variables in relation to type of stimulation is entirely consistent with the lack of significant change reflected in the ANOVA main effect for Time. That is, an increase in the emotional word group following stimulation and a decrease in the neutral word group would be expected to cancel one another out leaving no significant change over time for the groups considered together.

The results for sweating and the anxiety factor score measure cannot plausibly be explained as an artefact of the stimuli used as these were matched across the emotional and neutral groups for length and frequency. Also, the emotional and neutral words were respectively shown to have emotionally unpleasant and emotionally neutral qualities. Neither can the results be attributed to a partial cueing effect resulting from an inadequate threshold determination procedure.

The significant main effect for Time and the significant Group x Time interaction for muscular tension and shaking in the univariate ANOVAs presents an interesting finding. Table 14.2 shows mean increases in both variables following stimulation, and although this occurred in both the emotional and neutral groups the emotional group showed much greater increases (44% and 107% as against 6% and 23% in the neutral group). The increase for both groups indicates the presence of an experimental artefact. This might have been a 'demand characteristic' in the sense that participants in both groups might have believed they were expected to rate themselves as experiencing more somatic features of anxiety following stimulation. However, this explanation seems unlikely. No such demand characteristic is evident in the case of sweating and the factor score and it is difficult to believe that a demand characteristic would be so selective in its effects. Probably a more plausible explanation may be found in considering the nature of the participants' task. Looking into a tachistoscope and viewing a series of supraliminal stimuli (the recurring mask and the five numerals) as well as a series of subliminal stimuli requires concentration and maintenance of a still posture, albeit for a short time of about 150 seconds. The need to remain still could well have been a situational characteristic which contributed to increases in perceived muscle tension and shaking in both groups. However, the differentially greater increase in shaking and tension in the emotional group, as evidenced by the significant interaction term, is difficult to explain except in terms of the emotional stimuli making some genuine contribution to increased feelings of shaking and tension which was not made, or not made so strongly, by the neutral stimuli. It seems, therefore, that the results for shaking and tension were in part an artefact of the need to maintain a still posture and in part the result of a genuine disturbance of mood produced by the emotional stimuli. Thus there is additional, if slightly more equivocal, evidence from the shaking and tension results that non-conscious emotional stimuli can evoke psychological responses consistent with elevated anxiety, particularly those associated with muscular activity.

The significant main effect for time in the case of palpitations and difficulty in breathing, together with the lack of a significant interaction term, suggest the increases in these variables was purely artefactual. However, the perceived increases appear to be genuine and not the result of error in measurement because there were significant increases in actual heart and respiration rate following stimulation, and the increase in palpitations was significantly correlated with the increase in actual heart rate. The nature of the artefact is not clear but it seems likely that participants tended to hold their breath to some extent while viewing stimuli as an aid to concentration and postural stillness. Such a tendency would very probably leave a legacy of increased heart and respiration rate when relaxation occurred at the end of the task.

The two psychophysiological variables, heart and respiration rate showed increases following stimulation in both groups but like their psychological counterparts, palpitations and difficulty breathing, the increases are probably best interpreted as resulting artefactually from participants holding their breath as an aid to concentration and postural stillness. However, an alternative explanation might be that participants in both groups became concerned about consciously seeing relatively few stimuli and this concern was reflected in increased heart and respiration rates.

The failure of the STAI measure of state anxiety to show a significant differential effect in the two groups is, at first sight, puzzling. The increase in the emotional group following stimulation and the decrease in the neutral group are of course in the expected directions, but the increases were too small to produce a significant interaction term. This result may indicate that the STAI was too insensitive a measure for the experimental manipulation carried out. By contrast the Bond and Lader (1974) analogue scales from which the factor score measure of anxiety was derived, and indeed the analogue scales of somatic anxiety taken from Tyrer et al. (1978), seem adequately sensitive for attempts to activate anxiety with the brief, mild and subliminal stimuli used in this experiment.

The present results confirm the finding by Tyrer et al. (1978) that feelings of anxiety as measured by the Bond and Lader (1974) factor score can be induced by mildly stressful subliminal stimuli. But the results fail to support Tyrer et al.'s finding in respect of the STAI measure of anxiety. In addition the results indicate that some aspects of anxiety having somatic referents, perceived sweating, shaking and muscular tension, can be activated by emotionally threatening subliminal stimuli. Other aspects of anxiety with somatic referents, palpitations and difficulty in breathing, do not appear to be activated by this type of stimulus. Because no attempt was made to assess changes in mood states other than anxiety one cannot be certain that the changes in perceived sweating, shaking and muscular tension which have been ascribed to anxiety were in fact specific to anxious mood. The emotional stimuli, though selected to present mild stress capable of inducing anxiety, could also be considered gloomy or dispiriting in nature and could have acted like the statements in a Velten type of mood induction procedure (Velten 1968) to bring about, at least in part, a depressed or dysphoric mood. But the differential change in the well validated factor score measure clearly indicates that anxiety increased in the group viewing emotional words and decreased in the neutral word group.

PART V

OVERALL DISCUSSION AND CONCLUSIONS

CHAPTER 15

TOWARDS AN UNDERSTANDING OF PANIC ATTACKS

In this final chapter findings from the research will be drawn together in the form of a 'model' which, it will be argued, may go some way towards explaining the clinical problem outlined in Chapter 1. The problem was: How are anxiety (panic) attacks generated without apparent precipitants? It is not claimed that the model is complete or that all features of it have been supported by the present research. Nor is it claimed that the model has been tested and shown to be adequate; that would obviously require additional clinical research. Rather the model is put forward as a set of hypotheses, some of which have been shown by the research reported in the thesis to be plausible.

A COGNITIVE MODEL OF PANIC

Figure 15.1 shows a schematic view of processes which may account for the generation of spontaneous and apparently unprecipitated attacks of anxiety. This view assumes that emotionally neutral concepts are stored in semantic memory. One such concept is depicted as N_1 in Figure 15.1. It is also assumed that any given concept is a member of a set of other similar concepts [N_2 ......N_p] which together form an associative network of the sort postulated by Collins and Loftus (1975). Emotional concepts, that is, concepts which are associated with particular emotions, are envisaged as stored in a similar manner within semantic memory. Following Posner and Snyder (1975) it may be assumed that the emotional information is stored as an associate to the neutral semantic features of emotional concepts, though this

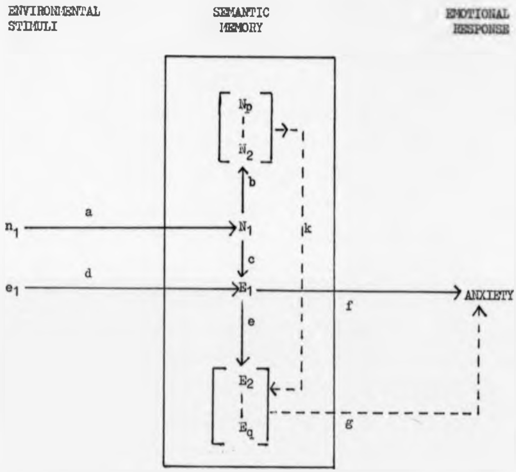

Figure 15.1 A model of anxiety

assumption is not viewed as necessary to the model and for ease of exposition the emotional and semantic features of emotional concepts will not be separated in Figure 15.1. In the figure E_1 depicts an emotional concept which is a member of a set $[E_2 \ldots\ldots E_q]$ of such concepts which collectively forms an associative network. It is assumed that all members of the set are relevant to the emotion of anxiety. Unlike Bower's (1981) associative network theory the present model does not assume that emotions themselves are stored as part of the associative network. In the author's view this is an unecessary, and probably untenable, assumption. Rather emotion is viewed as being created by the activation of emotional concepts and their associated emotional information. Such a view would explain the mood dependent recall effects found by Bower, Monteiro and Gilligan (1978) equally well as the Bower (1981) network theory without the implausible need to conceive of emotion as a form of information which may be stored.

The terms n_1 and e_1 in Figure 15.1 represent environmental stimuli; n_1 is an emotionally neutral stimulus and e_1 is an emotionally aversive (threatening) stimulus. Each stimulus represents a possible input to semantic memory. On the output side of the model is a set of anxiety responses including general subjective feelings of anxiety (dread) and more specific psychological components having somatic referents (feelings of increased muscular tension and shaking, feelings of sweating, palpitations etc). Physiological responses are also postulated to occur (increased heart and respiration rate, sweating etc).

Cognitive processes and the generation of anxiety.

According to the model of Figure 15.1 the simplest explanation of how an anxiety attack may develop can be seen in considering links d and f. If e_1 is either clearly present in the environment, but unattended consciously, or present so fleetingly, or in a context such that it has a very low signal to noise ratio and cannot be perceived consciously, it may nonetheless be registered and activate its representation E_1 in semantic memory (link d). The activation of E_1 will then drive at least some psychological components of an anxiety response (link f). Clear evidence for the operation of the conjoint d and f links was found in Chapter 14 though the anxiety responses driven by subliminally perceived stimuli were confined to the general feeling of anxiety and anxiety features having some somatic referents (i.e. feelings of sweating, tension and shaking). Anxiety generated by a non-consciously perceived emotionally aversive stimulus such as e_1 may be strengthened through an 'emotional priming effect'. That is, e_1 may activate its memory representation E_1 which primes another aversive stimulus representation E_2 which generates an anxiety response additional to that generated by E_1. This sequence of events involves the joint operation of links d, e and g. The joint operation of d and e was supported by the 'emotional priming effect' found in Chapters 8 and 11, though the failure to replicate the effect below objective threshold in Chapter 10 lessens the confidence one can have in the joint operation of links d and e.

A slightly more circuitous, and it must be admitted, less well evidenced, route to an anxiety attack may be postulated in the conjoint operation of links a, c and f. Here it is envisaged that a brief, weak or unattended but emotionally neutral stimulus n_1 is registered and activates its representation N_1 in semantic memory (link a). It is further envisaged that N_1 in turn activates, via priming link c, the memory representation of an emotionally aversive (threatening) stimulus E_1 which in this case is not present in the external environment. The activation of E_1 is hypothesised to result in anxiety responses (link f). It was found in Chapters 8, 10 and 11 that neutral stimuli can prime (activate) emotionally aversive stimuli and so there is clear evidence for the joint operation of links a and c. The joint operation of links a, c and f has not been demonstrated as this was not investigated in the research. However, it was found in Chapter 14 that when the memory representation of an aversive stimulus such as E_1 was activated by an external stimulus e_1 an anxiety response occurred. It therefore seems plausible to hypothesise that however E_1 is activated (i.e. whether by an emotional stimulus such as e_1 or by a neutral stimulus such as n_1) its activation will result in an anxiety response. Of course the activation of E_1 by a neutral stimulus n_1 is indirect in the sense that it relies on a priming effect, and for this reason E_1 may be less strongly activated by n_1 than by e_1 and hence the anxiety response may be weaker. In this account the emotionally aversive stimulus activated in memory is not present in the external environment but it may be thought of as the memory of repressed events associated with pain, guilt, shame or fear. Alternatively, it may be the memory representation of a stimulus associated with repressed conflicts or frustrations and Silverman (1985) has shown that such stimuli can be non-consciously activated.

A third, much more speculative route to anxiety attacks may be hypothesised from Figure 15.1. A weak neutral stimulus n_1 may activate, through a semantic priming effect, the memory representation of another neutral stimulus N_2 which in turn activates the representation of an aversive stimulus E_2 through a second priming link; E_2 then drives an anxiety response. This involves links a, b, k and g, and of these only links a and b have been demonstrated in the present research (Chapter 4 and 5). However, as Collins and Loftus (1975) consider that activation of a single concept in semantic memory produces an automatic spread of activation through the memory network, and as the automatic spread of activation for short duration prime stimuli has been supported by work on supraliminal priming (Neely 1977), it seems not unreasonable to postulate the 'second order' priming link k in Figure 15.1. But as there is little direct evidence to support this third view of how anxiety attacks may arise the view will not be emphasised. However, it does offer an interesting set of hypotheses for future investigation. Two hypotheses seem crucial. The first predicts that a neutral subliminal stimulus n_1 will activate the memory representation of an emotional stimulus E_2 to which it is semantically unrelated through the intermediate activation in memory of a neutral stimulus N_2 which is semantically related to both n_1 and E_2. In such a case N_2 would be a target for the prime n_1 and would also act as a 'ghost' prime (i.e. one not actually present in the environment) for the target E_2. The hypothesis that 'ghost' priming could occur is implicit in Collins and Loftus (1975) view of semantic memory and can easily be tested in a lexical decision task. The second hypothesis would test the operation of conjoint links a, b, k and g by observing whether appropriately chosen neutral stimuli could generate anxiety responses.

COMPARISON OF THE PRESENT MODEL WITH OTHER CURRENT VIEWS OF PANIC

Recently Clark (1986) argued that panic attacks which appear to come 'out of the blue' in fact stem from a misinterpretation of bodily disturbances caused by a different emotional state or by exercise, partial anoxyation through standing up too quickly, or a mild stimulant such as coffee. The innocuous bodily disturbances, it is argued, are interpreted in catastrophic ways. For example, the person may interpret slight breathlessness and palpitations as an indication that a heart attack or some other serious illness is imminent. Hibbert (1984) likewise argued, that a full panic attack results from inappropriate cognitions applied to somatic disturbances. Although these two views have much to commend them neither satisfactorily explains spontaneous panic attacks. To see why this is so a brief case history will be presented of an anxiety state patient treated by the author.

The case of Miss P.

Miss P gave the impression of a fairly immature 21 year old. She lived in modest circumstances with her mother and younger brother aged 17, her father having died of a frontal lobe tumour when she was 18. A qualified hairdresser Miss P had given up her job 18 months prior to her appearence in the clinic after experiencing a number of panic attacks at work. From her spontaneous report, and from a diary the author asked her to keep, it was clear that there was no pattern to the occurrence of the panic attacks which had first started 2 years before. The panic attacks started, as is usual, with the perception of somatic symptoms: sweating, shaking and tachycardia followed by feelings of anxiety, loss of control and panic. The attacks might occur indoors or out, during conversation, while watching television, during a meal or while taking a walk either alone or in company. They did not appear to be associated with mood so far as could be ascertained, and did not appear to have external precipitants or to be associated with particular thoughts or memories. During the few months before his death Miss P's father had been unaccustomedly aggressive and shown other personality changes. This was a period of considerable strain for Miss P who became involved with a group of teenagers who took (relatively) hard drugs. Against her better judgement she once tried a drug cocktail, had a very upsetting experience and never took drugs again. Later, after her father's death she learned that one of the drug taking group had suffered brain damage. She did not admit to believing she was brain damaged herself though friends whose opinion she valued told her she might be. Miss P did not associate the panic attacks with thoughts about taking drugs or with recall of her bad experience of drug taking.

It is clear from the case of Miss P that the panic attacks started with perceived autonomic symptoms and progressed to subjective feelings of anxiety and panic. What is not clear in the case of Miss P, or in the explanatory accounts of panic attacks offered by Hibbert (1984) and Clark (1986), is how the perceived somatic disturbances came about. Hibbert and Clark's accounts make excellent sense given the occurence of the perceived somatic symptoms. But Miss P, like so many anxiety state patients who experience panic attacks, could not associate the onset of the somatic symptoms with any of the causes suggested by Clark (1986) and careful recording by means of the diary and extensive questioning by the author failed to elicit awareness of precipitants including conscious cognitions.

The model presented in Figure 15.1 can account for at least some of the feelings of bodily disturbance particularly feelings of sweating, tension and shaking. It can also account for the subjective component of anxiety either in terms of direct non-conscious perception of external aversive stimuli or, perhaps more plausibly, in terms of non-conscious registration of neutral stimuli which activate memory representations of internal threatening stimuli through a semantic priming effect.

The intention here is not to argue that the views of Hibbert and Clark are incorrect, but rather that they are incomplete. It makes excellent clinical sense to suppose that it is probably the initial stages of a panic attack which are elicited by subliminal perception and/or priming effects and that the later development of the attack is largely influenced by inappropriate thoughts, beliefs or causal attributions concerning the significance of the early somatic features. It is of course quite characteristic for patients who suffer panic attacks to believe that they cannot control the early symptoms and as the author has shown elsewhere (Hill & Kemp-Wheeler 1986) certain types of attribution made to aversive events believed to be uncontrollable are associated with emotional upset.

In conclusion it merely remains to say that the research presented in this thesis has provided further evidence that stimuli may be perceived without awareness and that such stimuli may have dynamic effects in changing the individual's emotional state. The model of anxiety offered must be viewed as provisional pending confirmation of the links not yet investigated, though in the author's view it has potential for explaining the initial stages of panic attacks which are not adequately explained by other contemporary accounts of anxiety. The links and implications of the model are clearly investigable and like all models and theories it will survive or perish on the basis of evidence gained from further empirical research.

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APPENDICES

APPENDIX A

Prime and target letter strings in the SR, UR and WN conditions of Experiment 1

SR		UR	
Prime	Target	Prime	Target
BREAD	BUTTER	REPLY	BIRTH
SALT	PEPPER	PEACE	IVORY
HAMMER	NAIL	LOANS	ATOMS
DOCTOR	NURSE	EMPEROR	FROZEN
TOBACCO	SMOKE	ENERGY	PURPLE
SWEET	SOUR	CLEAN	DISC
TABLE	CHAIR	LOUNGE	DREAM
SOFT	HARD	HOT	SWAN
BLOSSOM	FLOWER	DUTY	FARMER
BED	SLEEP	CONCEAL	PLAY

WN		WN	
Prime	Target	Prime	Target
TEACH	WENTAL	ROUGH	MARLOT
BOND	LIGNER	LOAD	MIGLON
WILLOW	SCOD	TRIFLE	EXIN
SUNDAY	FILAD	SUPPLY	ESPET
AIRPORT	POLID	DAYTIME	BONER
FIFTY	LERT	UNITY	SUBN
VALUE	ANGIT	WOMEN	DIFLET
MOON	EVAT	NOSE	DOSK
COMPUTE	SHURBL	ERUPTED	FOSKIT
EYE	APERD	FARM	ANLOFT

Practice stimuli for Experiment 1

Condition	Prime	Target
SR	CARPET	RUG
	MUTTON	LAMB
	SLOW	FAST
UR	PILOT	BUZZING
	LYRICS	PENCIL
	BALLOT	CRAB
WN	HEDGE	HOGTINE
	CLOCK	FARGER
	KEYS	LESTONE
	SHOE	LESHY
	OBOE	GALLOCK
	APPLE	SHAN

APPENDIX A cont'd

Stimuli used for the assessment of detection threshold in Experiment 1

SURFACE
BELIEVE
VARIOUS
MILLION
USUALLY
CENTURY

The pattern mask

APPENDIX 1

Prime and target letter strings in the SR, UR and WW conditions of Experiment 2

SR		UR	
Prime	Target	Prime	Target
DREAM	SLEEP	EMPTY	PLAYS
EAGLE	BIRD	TWEED	PAGES
MOON	STARS	TEXT	HONEY
FRUIT	APPLE	WASTE	DICE
NEEDLE	THREAD	REWARD	SHOWER
FOOT	SHOE	DUST	PULSE
ROUGH	SMOOTH	TEACH	MUSCLE
SCISSORS	CUT	STUDIOUS	RED
COLD	HOT	MOVE	AID
KING	QUEEN	LOSS	RAPID

WW̄		WW	
Prime	Target	Prime	Target
BLOCK	FILAD	SCORE	ESPET
SHINE	EVAT	TRUCE	BOSK
TASK	ANGIT	NOSE	RONER
GRADE	UPERD	BENCH	SELIP
CLIENT	WENTAL	POTATO	ANLOFT
SONG	LERT	RAIN	SURN
BREAD	RIGNER	MATCH	FOSKIT
PRODIGAL	CIB	SCALLOPS	JID
READ	TET	HOLD	WOF
SIGHT	WERET	PASS	OLIBE

Stimuli used for the assessment of detection threshold in Experiment 2

PERSONAL
INCREASE
EXPECTED
PRESSURE
COMPLETE
EVIDENCE

APPENDIX C

Prime and target letter strings in the SR, UR and WW conditions of Experiment 3

SR		UR	
Prime	Target	Prime	Target
EATING	FOOD	REMOTE	FALL
LAMP	LIGHT	SOLE	THING
LOUD	SOFT	FOIL	VAST
MUTTON	LAMB	PARDON	DAME
OCEAN	WATER	ITALY	UNTIL
PRIEST	CHURCH	IDEALS	SEEMED
SLOW	FAST	GOAL	EDGE
STEM	FLOWER	FEES	CHAIRS
BATH	CLEAN	HANG	UNITY
BITTER	SWEET	AUGUST	DRAWN

WW		WW	
Prime	Target	Prime	Target
MUSEUM	FLUP	DEBATE	JATE
TRAY	BLOPE	WING	YANIE
CAFE	AREF	BOSS	PUGE
PILOTS	CHIA	NOTIFY	RELT
CRIME	DUTOM	SMELL	MIZED
HEATED	ELGONE	FRINGE	NORMIL
MOON	OGUE	SANG	FOSP
BELT	GEAVET	BARN	LIGGOT
GEAR	HOOWY	FIST	POULD
BREATH	INCAL	HANDLE	WAFYN

Practice stimuli for Experiment 3

Condition	Prime	Target
SR	HAMMER	NAIL
	SALT	PEPPER
	BREAD	BUTTER
UR	LOUNGE	DREAM
	TWEED	PAGES
	TEXT	APPLE
WW	EAGLE	ESPET
	REWARD	SURN
	LOCKER	FOSKIT
	LOAD	EVAT
	BENCH	LERT
	NOSE	WERET

APPENDIX C cont'd

Stimuli used for the assessment of detection threshold in Experiment 3

CIRCLE
FRIDAY
GARDEN
STARED
TRAVEL
SPEECH
PRICES
CLOSER
BOSTON
ACTING

APPENDIX D Prime and target stimuli in the SR, ER and UR conditions of Experiment 5

Condition					
SR		ER		UR	
Prime	Target	Prime	Target	Prime	Target
FEELINGS	GRIEF	GUNMAN	GERMS	PENINSULA	THUG
IVY	POISON	CONFLICT	PLAGUE	SHORTHAND	BURGLAR
COLLECTOR	DEBT	SNAKE	WARS	BREAD	GANG
CIRCUS	FLEA	PRISON	WASP	PILOT	RATS
CHAMBER	TORTURE	VENOM	DENTIST	NOBLEMAN	INJURY
DREAM	NIGHTMARE	FAILURE	INJECTION	CLOTHES	BLACKMAIL
CATCH	TRAPS	FUNERAL	PERIL	FORTUNE	CRUSH
ASPIRIN	PAINS	DROUGHT	MUGGERS	DOZEN	MADMAN
DENNIS	MENACE	ENEMY	ORDEAL	POETRY	MALICE
SIGNAL	DANGER	RIDICULE	MURDER	TAPESTRY	CRISIS
PROMISES	THREATS	INFECTION	TERROR	REGISTRY	REVENGE
FLIES	SPIDER	CRIMINAL	SHARKS	WINES	FERRET
TRIGGER	PISTOL	CANCER	BLAME	ALTAR	GRENADE
STIFF	CORPSE	RABIES	CRIPPLE	CAKES	FRAUD
SUGAR	CANE	EARTHQUAKE	RAPE	JACKET	GUILT
SMART	STING	EVIL	AGONY	RESOURCES	BULLY
POLITICS	FASCISM	DISEASE	AMBUSH	SAMPLE	MANIAC
SWEAR	CURSE	DESPAIR	GHOST	MELODY	RIVAL
FUSE	BOMB	COFFIN	HARM	TENORS	HURT
ELECTRIC	SHOCK	CRUELTY	PANIC	TOWEL	DEVIL

APPENDIX D cont'd Prime and Target stimuli in the WW conditions of Experiment 5

Condition					
WW_1		WW_2		WW_3	
Prime	Target	Prime	Target	Prime	Target
EMOTION	TARLS	CRAMP	ESPET	FINDINGS	BILOD
STARTLE	GILLACK	ILLNESS	WISPOCE	MILLS	CHOLTOR
LOANS	FERG	WARNING	GEND	WARMTH	MOOF
POWDER	SHAN	ACCIDENT	FILT	WISHES	SURN
BARREL	BOLFES	STRESS	SHARID	CONTROLS	ARPACE
SLEEP	PRENTAGES	DEPRESSION	CORSTATES	CHART	JANISTRY
ANIMAL	SCOD	BULL	FIRT	COINS	MELK
MEDICINE	BEASY	EXPLOSION	POLID	ADVISOR	PILTS
BOTHER	THROPE	EPIDEMIC	PULACE	FOUNTAIN	SHUMER
COBWEBS	FLIRDS	MOB	ESTONE	DRAUGHT	DIFLET
HINTS	MULSTER	KILLER	BARTING	RESPONSE	EBENAGE
SIGN	GOGGET	DISASTER	HEPONE	PLAYS	FOSKIT
MEDIEVAL	HARSING	VITRIOL	RONDACE	HORSES	GRONSEY
LIFELESS	VIPAGE	POLLUTION	MALOCK	PARK	WENTEL
GARDEN	LISH	ATTACK	VODE	PLANTERS	GLOC
BUZZING	ASPAT	PUNISHMENT	LESHY	FRIDAY	NAWIS
CAPSULE	JOBLEY	VIOLENCE	ONSTIP	SUNDOWN	LITCHY
OATH	DAFIL	ARREST	FUMAT	MERGERS	ROWER
PARCEL	EXIN	SUFFERING	YEMD	TACT	GURP
ELECTION	RUFER	LICE	JOSTE	NURSES	FILOW

APPENDIX D cont'd

Practice stimuli for Experiment 5

Condition	Prime	Target
SR	STOMACH	ACHE
	HEALTH	SICKNESS
ER	SCALD	DROWN
	MICE	CRASH
UR	GLOVES	FALL
	CUBIC	DEAF
$W\bar{W}$	GATES	ELPOCK
	HAMMER	DUTOM
	NOSE	INCAL
	PERCENT	ANGIT
	WRIST	LIGNER
	CAPSULE	BOSK

Stimuli used for the assessment of detection threshold in Experiment 5

IMPORTANCE
DEMOCRATIC
COMPLETELY
ACTIVITIES
DETERMINED
ADDITIONAL

APPENDIX E

Questionnaire used for rating degree of 'emotionality'

All words in our language may be described as either "emotional" or "neutral". Emotional words are those which are associated with an emotional feeling which may be either pleasant or unpleasant. In contrast, neutral words are not associated with emotional feelings at all.

Please look at each word (and set of initials which stand for words) listed below and put a tick (✓) against the rating which best describes the feeling you associate with it.

Do not rate words or initials you do not understand.

Please use a ruler or edge of a sheet of paper to help you keep your place.

Work quickly. It is your first impressions that are of interest to me.

	EMOTIONALLY UNPLEASANT			EMOTIONALLY NEUTRAL	EMOTIONALLY PLEASANT		
	A very strong unpleasant emotion	A fairly strong unpleasant emotion	A mild unpleasant emotion	NO EMOTION	A mild pleasant emotion	A fairly strong pleasant emotion	A very strong pleasant emotion
PUPILS							
SADDLE							
CANCER							
ETC.							

APPENDIX F Prime and target stimuli in the SR, ER and UR conditions of Experiment 6. Median ratings of emotionality (E) are also listed

		Condition						
		SR		ER		UR		
Target	E	Prime	E	Prime	E	Prime	E	
SNAKE	3.00	GRASS	4.69	FAILURE	2.18	PERCENT	3.96	
NIGHTMARE	2.11	DREAM	5.27	ENEMY	2.18	GLOVES	4.13	
POISON	2.50	IVY	4.11	GUNMAN	2.24	WRIST	3.99	
BOMB	1.58	FUSE	3.94	RAPE	1.18	MEASURE	3.99	
CORPSE	2.00	STIFF	3.67	RIDICULE	2.26	RESOURCE	4.14	
GRIEF	2.07	FEELINGS	4.92	MALICE	2.23	NOBLEMAN	4.06	
FUTURE	1.46	CHAMBER	3.99	SPIDER	3.27	PILOT	4.08	
DANGER	2.69	SIGNAL	4.02	HATRED	1.60	REGISTRY	3.99	
FLEA	3.08	CIRCUS	4.66	AGONY	1.97	SAMPLE	4.02	
RABIES	1.63	DOG	4.25	MUTILATE	1.30	BREAD	4.36	
FASCISM	2.07	POLITICS	3.76	CANCER	1.50	TOWEL	4.11	
CRUELTY	1.80	KINDNESS	5.75	DISEASE	2.45	JACKET	4.08	
SHOCK	2.66	ELECTRIC	3.99	MURDER	1.48	POCKETS	4.02	
PAIN	1.93	ASPIRIN	3.95	CRISIS	2.76	DOZEN	4.00	
GERMS	2.83	ANTISEPTIC	3.54	TERROR	1.84	CUBIC	4.01	
TRAPS	2.98	CATCH	4.09	DESPAIR	2.21	OWNER	4.06	
DENTIST	3.05	TOOTH	3.83	WARS	1.17	MINERAL	4.10	
MENACE	2.53	DENNIS	4.02	GUILT	2.29	SEES	4.06	

APPENDIX F cont Prime and target stimuli in the $W\bar{W}$ conditions of Experiment 6. Median ratings of emotionality (E) are also listed

	Condition					
	$W\bar{W}_1$		$W\bar{W}_2$		$W\bar{W}_3$	
Target	Prime	E	Prime	E	Prime	E
ESPWT	FIXTURES	4.03	COFFIN	1.62	CAPSULE	4.06
CORSTATES	CONNECT	4.06	HURT	2.45	ELECTION	3.93
PULACE	STUFF	3.78	CRIPPLE	2.30	HAMMER	3.90
GEND	POWDER	4.02	INJURY	2.37	NOSE	4.00
ESTONE	SLEEP	5.41	SUICIDE	1.61	TEACH	4.29
POLID	ANIMAL	4.56	FUNERAL	1.93	BOND	4.75
RONDACE	MEDICINE	3.69	PANIC	2.60	MOON	4.21
SHAVID	SPHERE	3.95	GANG	3.05	LOAD	3.91
VODE	GARDEN	4.78	HARM	2.64	UNITY	4.57
MALOCK	PLAYS	4.82	BLAME	2.85	ERUPTED	3.58
BARTING	COINS	4.17	INFECTION	2.72	DAYTIME	4.21
HARSING	TACT	4.40	CURSE	2.56	REPLY	4.10
DAFIL	SUNDOWN	4.61	VIOLENCE	2.23	DUTY	3.74
LISH	SIGN	4.00	MUGGERS	1.79	CONCEAL	3.71
FLIRD	MEDIEVAL	4.18	STRESS	2.28	LOUNGE	4.32
TARLS	HORSES	4.32	ATTACK	2.41	BROADER	3.97
WISPOCE	ADVISOR	4.06	WARNING	3.22	BLOSSOM	5.12
GOGGETS	NURSES	4.11	DEVIL	2.60	TRIFLE	4.29

APPENDIX F cont'd

Practice stimuli for Experiment 6

Condition	Prime	Target
SR	BANK	DEBT
	SUGAR	CANE
ER	GRENADE	PLAGUE
	RIVAL	FRAUD
UR	PENCIL	FERRET
	RULER	GHOST
WW	AIRPORT	LERT
	FIFTY	FILAD
	BULLY	ANGIT
	AMBUSH	BOSK
	WILLOW	APERD
	CLOTH	ONSTIG

Stimuli used for the assessment of detection threshold in Experiment 6

IMPORTANCE
DEMOCRATIC
COMPLETELY
ACTIVITIES
DETERMINED
ADDITIONAL

APPENDIX G

Questionnaire used for the rating of semantic relatedness

In a priming experiment participants are asked to say aloud the first word which comes into their heads after hearing a prompt word read by the experimenter. In some experiments each prompt is read 5 times and 5 different responses are required. Five common responses to the prompt MOUSE are shown below:

Prompt	Response
MOUSE	CAT
MOUSE	CHEESE
MOUSE	ANIMAL
MOUSE	TRAP
MOUSE	HOLE

Please look at the word pairs listed below. The first word of each pair is a prompt word and the second word is a response. Imagine that participants are asked to make 5 responses to each prompt. How likely is it that the response shown will be one of them?

PROMPT	RESPONSE	Extremely likely	Very likely	Fairly likely	Fairly unlikely	Very unlikely	Extremely unlikely
ADULT	DISASTER						
FEELINGS	GRIEF						
IVY	POISON						
COLLECTOR	DEBT						
ETC.							

APPENDIX H

Prime and target stimuli in the SR, ER, UR and WR conditions of Experiment 8. Median ratings of emotionality (E) and semantic relatedness (R) are also given

SR Condition

E	Prime	Target	E	R
4.16	SHIP	WRECKED	2.47	2.46
3.95	SANITY	MADNESS	2.54	2.94
3.63	BAIT	TRAP	2.18	2.73
3.80	VERDICT	GUILTY	1.82	2.62
3.59	MEDICINE	DRUGS	2.81	2.31
3.70	ATOM	BOMB	1.58	1.42
3.73	DOCTOR	ILLNESS	2.25	1.97
4.11	DONOR	BLOOD	3.13	1.23
3.95	LUNG	CANCER	1.50	2.00
3.83	TOOTH	ACHE	2.69	1.55
4.36	HEALTH	SICKNESS	2.27	2.92
3.67	STOMACH	ULCER	2.69	3.08
3.73	TRENCH	WARFARE	2.13	3.04
4.41	SWIM	DROWN	1.43	3.29
4.17	HEAR	DEAF	2.97	3.13
4.69	GRASS	SNAKE	2.31	3.05
4.05	TRAIN	CRASH	1.92	3.33

APPENDIX H cont'd

ER Condition

E	Prime	Target	E	R
1.18	RAPE	COFFIN	1.62	5.53
1.93	PAINS	NIGHTMARE	2.11	4.39
2.76	CRISIS	GERMS	2.83	5.44
1.97	AGONY	CORPSE	2.00	5.15
2.69	GUN	SUFFERING	1.83	3.79
2.66	SHOCK	TRIAL	3.18	5.63
1.48	MURDER	FASCISM	2.07	4.67
2.23	MALICE	INJURY	2.37	3.82
3.08	PLEA	PRISON	2.33	5.83
2.43	THREATS	GRIEF	2.07	4.33
1.84	TERROR	SUICIDE	1.61	4.06
2.45	HURT	POISON	2.50	4.65
2.18	FAILURE	CRIMINAL	2.68	5.63
2.30	CRIPPLE	FUNERAL	1.93	5.27
2.71	DEBT	CRUELTY	1.80	5.63
2.80	FALL	TORTURE	1.46	5.75
2.23	VIOLENCE	DISEASE	2.45	5.63

APPENDIX H cont'd

UR Condition

E	Prime	Target	E	R
3.99	UNITS	INFECTION	2.72	5.90
4.00	BREAKER	SPIDER	3.27	5.80
4.07	MATS	DESPAIR	2.21	5.92
3.95	RUBBER	CRAMP	2.89	5.95
4.03	AR[illegible]	PANIC	2.60	5.70
4.00	WATCH	ATTACK	2.41	5.88
4.07	GATES	KILLER	1.87	5.80
4.10	TUB	GUNMAN	2.24	5.95
4.04	PRODUCTS	DROUGHT	2.69	5.73
4.07	BENCH	RIDICULE	2.26	5.95
4.02	ADULT	DISASTER	2.14	5.88
4.00	TREBLE	CONFLICT	2.91	5.95
4.05	ATLAS	RABIES	1.63	5.94
4.02	PAPER	EARTHQUAKE	2.38	5.95
4.02	POCKET	EVIL	1.96	5.95
3.95	INDEX	EPIDEMIC	2.57	5.94
3.93	CLERK	KNIFE	3.12	4.90

APPENDIX H cont'd

WW_1 Condition

E	Prime	Target
4.10	MINERAL	SHAN
4.02	POUCH	MELK
4.09	TENORS	FLIEDS
4.04	CATTLE	JOSTE
3.96	PERCENT	LESHY
3.99	ELECTRIC	FIRT
3.97	INCHES	FUMAT
3.99	MEASURE	DUTOM
4.25	DOG	GLOC
3.99	WRIST	DIFLET
4.12	PENNY	LITCHY
4.07	BUCKLE	PILTS
4.06	CONNECT	EBENDAGE
4.00	COLUMN	JOBLEY
4.17	OXYGEN	THROPE
4.00	DEVICE	WAFYN
4.04	OUTPUT	FILOW

APPENDIX H cont'd

W_2 Condition

E	Prime	Target
2.53	HUNGER	SHUMER
2.25	SCALD	FERG
1.30	STABBED	MOOF
2.73	BLIND	ASPAT
2.15	HELL	BEASY
2.18	ENEMY	WENTEL
2.69	SHOT	GOGGET
2.60	FIGHT	HEPONE
3.09	CUTS	GRONSEY
1.59	HANGED	POULD
2.28	STRESS	GILLACK
3.38	BEE	HOONY
1.60	SCREAM	CHOLTOR
2.19	STING	BLOPE
2.59	ANXIOUS	SURN
2.11	CONDEMN	ELPOCK
2.22	ACCUSED	CHIA

APPENDIX H cont'd

WR_3 Condition

E	Prime	Target
4.14	RESOURCE	BILOD
4.13	GLOVES	FULP
3.89	STATIONS	NAWIS
4.01	CUBIC	RONER
4.08	JACKET	BOLFES
3.76	POLITICS	YEWD
4.11	IVY	INCAL
4.00	HOSES	JANISTERY
3.98	DECADE	VIRAGE
4.04	OWNER	EXIN
4.02	SIGNAL	ONSTIP
4.19	BREAD	AHPACE
4.11	TOWEL	MALOCK
3.99	REGISTRY	HUFER
3.95	CORNER	GURP
3.99	CHAMBER	FOSKIT
4.00	DOZEN	SCOD

APPENDIX H cont'd

Practice stimuli for Experiment 8

Condition	Prime	Target
SR	LETTER	BLACKMAIL
	FEELINGS	HATRED
ER	GANG	DENTIST
	WASP	MUGGERS
UR	VOMIT	CASTRATED
	LOST	SUFFOCATE
$\bar{W}W$	MODELS	RIALDI
	HOTEL	SEAPIL
	CURSE	ELPOCK
	MENACE	FOLEPT
	STAGE	MOLLED
	POND	OVIX

Stimuli used for the assessment of detection threshold in Experiment 8

BUILDING
RECEIVED
ACTUALLY
RESEARCH
INDUSTRY
FOLLOWED
COMPLETE
REQUIRED

APPENDIX J

Emotional and neutral stimuli used in Experiment 10. The median rating of emotionality (E) is also given

Condition

Emotional	E	Neutral	E
CANCER	7	JERSEY	4
COFFIN	6	GLOVES	4
HATRED	6	HOTELS	3
TB	6	AC	4
PAIN	6	PASS	4
RAPE	7	SKIP	3
DISEASE	6	PERCENT	4
SUICIDE	6	POCKETS	4
AIDS	6	CHIN	4
BOMB	6	SEES	4
DENTIST	5	MINERAL	4
TORTURE	7	CONNECT	4
INJECTION	5	UTILITIES	4
GUILT	6	OWNER	4
CRUEL	6	CUBIC	4
VD	6	BC	4
PLAGUE	6	DRIVES	4
MUTILATE	7	FIXTURES	4
GRIEF	6	WRIST	4
FAILURE	6	MEASURE	4

Stimuli used for the assessment of detection threshold in Experiment 10

PUBLISHED
OBJECTIVE
CONDITION
TRADITION
ANNOUNCED
AMERICANS
STRUCTURE
PRINCIPAL

APPENDIX K Raw mean Pre- and Post-stimulation scores for E and N groups

Variable	E Group (Emotional words) Pre	Post	%change	N Group (Neutral words) Pre	Post	%change
Sweating	22.857 (24.600)	29.286 (29.703)	+28.13	10.500 (11.971)	8.357 (13.400)	-20.41
Shaking	5.536 (5.347)	19.857 (15.859)	+258.69	14.786 (17.275)	22.464 (21.667)	+51.90
Palpitations	10.786 (12.490)	26.571 (23.210)	+146.68	20.107 (21.815)	28.179 (17.831)	+40.15
Breathing	9.286 (13.735)	18.429 (23.495)	+98.46	14.036 (22.863)	23.214 (20.293)	+65.39
Muscular tension	16.179 (15.474)	34.429 (24.673)	+112.80	22.464 (21.281)	26.750 (21.178)	+19.08
Anxiety (STAI)	35.571 (6.198)	37.857 (9.380)	+6.43	38.786 (7.245)	38.857 (8.365)	+0.18
Anxiety (Factor Score)	5.151 (0.922)	5.519 (0.847)	+7.14	5.400 (0.772)	4.974 (0.808)	-7.89
Heart Rate (HR)	75.604 (9.762)	78.000 (9.471)	+3.17	73.119 (13.899)	75.154 (13.872)	+2.78
Respiration Rate (RR)	4.227 (0.768)	4.549 (0.960)	+7.62	3.734 (0.926)	4.441 (0.895)	18.93