Theory and Test of Stress Resistance

Frank P. McKenna and Dinkar Sharma
University of Reading

for

DTIC
SELECTE
MAY. 12 1992
S B D

April 1992

92-12415

United States Army
Research Institute for the Behavioral and Social Sciences

U.S. ARMY RESEARCH INSTITUTE
FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency Under the Jurisdiction
of the Deputy Chief of Staff for Personnel

EDGAR M. JOHNSON
Technical Director

MICHAEL D. SHALER
COL, AR
Commanding

Research accomplished under contract
for the Department of the Army

University of Reading

REPORT DOCUMENTATION PAGE

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE 1992, April	3. REPORT TYPE AND DATES COVERED Final Report Nov 90 – Nov 91

4. TITLE AND SUBTITLE Theory and Test of Stress Resistance	5. FUNDING NUMBERS DAJA45-90-C-0031 61102B 74F N/A
6. AUTHOR(S) McKenna, Frank P.; and Sharma, Dinkar	N/A N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of Reading Department of Psychology Building 3 Earley Gate Whiteknights, Reading RG6 2AL	8. PERFORMING ORGANIZATION REPORT NUMBER --

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Institute for the Behavioral and Social Sciences 5001 Eisenhower Avenue Alexandria, VA 22333-5600	10. SPONSORING / MONITORING AGENCY REPORT NUMBER ARI Research Note 92-22

11. SUPPLEMENTARY NOTES

Contracting Officer's Representative, George Lawton

12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.	12b. DISTRIBUTION CODE --

13. ABSTRACT *(Maximum 200 words)*

In this report, we developed a laboratory model to test hypotheses concerning the disruptive effects of emotional stimuli. The research assesses the potential of the computerized emotional Stroop task. We discovered that the task was sensitive to two important elements of stress resistance, threat and habituation. The Stroop task is sensitive to the nature of the stimuli, namely that threatening stimuli can be distinguished from nonthreatening stimuli and that with stimulus repetition the stimuli show effects of habituation.

Important findings emerged from the research in the following areas.

1. <u>Time pressure and task difficulty.</u> One of the most important findings demonstrates the importance of time pressure and information load on overall performance and the adaptive process that eliminates emotional interference. When an individual is under time pressure and/or is performing a difficult task, there is greater emotional interference than when there is no time pressure or the task is easy. The important role that time pressure and task difficulty play in tasks such as this has not, to this point, been acknowledged. The research also points to two

(Continued)

14. SUBJECT TERMS Stress resistance Attention Emotional Stroop task Time pressure	15. NUMBER OF PAGES 48
	16. PRICE CODE --

17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT Unlimited

13. ABSTRACT (Continued)

methods of reducing the adverse effects of stress--reducing time pressure and information load.

2. Emotional lingering. The disruptive effects of emotional stimuli under time pressure may be explained by the "emotional lingering hypothesis." It is hypothesized that emotional stimuli are still being processed after a response has been made. When time pressure does not exist, processing of the preceding stimulus is completed before the next stimulus is presented. However, when an individual is under time pressure, the present stimulus is still being processed when the next stimulus is presented--hence the disruption. Using randomized presentations of emotional and neutral stimuli it was found that the neutral stimuli showed disruptive effects similar to those found with emotional stimuli. The fact that emotional stimuli have an impact not only at the time of exposure but thereafter is well illustrated in Post-Traumatic Stress Disorder, in which a traumatic experience continues to have a disruptive effect on performance long after its exposure. To directly observe the emotional lingering, we have just completed a new experiment in which an emotional stimulus is presented before a sequence of neutral stimuli. It was found that there was emotional lingering, but only to the first neutral stimulus that followed the emotional stimulus. In addition, there were no immediate disruptive effects on the emotional stimulus itself. These results are of great importance because they not only increase the sensitivity of the task under development (because we are now able to observe the emotional disruption for individual stimuli) but, for the first time, demonstrate the nature of the emotional disruption, namely, that it is a lingering effect.

3. Lie detector. One application of our test is a lie detector. This application is sensitive to the threatening nature of emotional stimuli. As a preliminary study we asked subjects to consider themselves spies and to learn a randomly chosen set of neutral words that they were to consider secret code words. Once they learned these words, they were asked not to reveal them to the computer on which they were to be tested. They were given a monetary incentive if they were able to beat the lie detector. In fact, only 8 out of 32 subjects were able to beat the lie detector--a success rate of 75%.

In summary, the results of our research show that the paradigm that we developed can be used to study the effects of stress on performance. The data we are now collecting are changing our understanding of the nature of the performance disruption and allowing us to develop a more powerful model of the effects of stress on performance.

Accession For

NTIS GRA&I	☑
DTIC TAB	☐
Unannounced	☐
Justification	

By

Distribution/

Availability Codes

Dist	Avail and/or Special
A-1	

ii

THEORY AND TEST OF STRESS RESISTANCE

CONTENTS

LIST OF TABLES

THEORY AND TEST OF STRESS RESISTANCE

GENERAL INTRODUCTION

Exposure to threat is a normal part of everyday life. At various points in an individual's life that person will be exposed to situations which are stressful and which can result in general performance decrements. This position is particularly true of military life which is characterised by potential exposure to threat. Performance decrements under threat have considerable military implications. For example, Marshall (1947)[1] pointed to the fact that during World War II only 15% of the men available in a company normally fired their weapons at the enemy during a exchange of fire. It is not only during the presence of threat that performance may deteriorate. Even at considerable delays following the threat performance decrements may continue. In the extreme case post-traumatic stress disorder may occur, which reflects the psychological problems which may follow the exposure to a traumatic experience. Marks (1987)[2] has noted that between 12% and 50% of all battle casualties are psychological in nature. One of the striking features in this area however, is the great variability, that is, a stimulus which evokes fear and stress in one person does not necessarily do so in another. This variability has both advantages and disadvantages. The major disadvantage is that it is difficult to predict in advance who will be adversely affected and who will not. The major advantage is that one has a clear demonstration that performance decrements are not inevitable in all situations. General problems which emerge here concern the prediction of those most vulnerable to stress, the design of techniques which can be used in training to reduce the *effects of exposure to threat and the introduction of methods designed to reduce the* effects of past exposure to threat. In addition, an ability to predict the likely pattern of any performance disruption would greatly aid our understanding.

In order to survive, biological systems require mechanisms to deal with threat. To be effective these mechanisms should be fast acting and take precedence over other less pressing goals. The importance of the power to interrupt ongoing activity is a factor emphasised by Mandler (1975)[3] and Oatley and Johnson-Laird (1987)[4]. However, the power to interrupt information processing may manifest itself as performance disruption. Horowitz (1979)[5] has found that under stress, problems in concentration and paying attention occur and these alone could account for performance decrements. The role of attention has long been implicated in the relationship between stress and performance (Easterbrook, 1959)[6]. In an attempt to construct a laboratory analogue McKenna (1986)[7] developed a variant of the Stroop test which required the naming of the colours of emotional and neutral stimuli. Despite the fact that the emotional stimuli were irrelevant to the task the emotional stimuli disrupted task performance. Clearly people are unable to avoid the disruptive effects of emotional processing. We labelled this the emotional Stroop effect. We have introduced the theoretical concept of uncontrolled processing to describe processing which occurs outside the individual's control. Uncontrolled processing is defined as processing which does not map onto the individual's explicit goal. In the emotional Stroop task the individual attempts to ignore the emotional stimuli and the task assesses the person's ability to do so. It has been shown that the disruption is indicative of the types stressful events people have experienced. For example, McNally, Kaspi, Rieman and Zeitlin (1990)[8], investigating a group of Vietnam combat veterans with post-traumatic stress disorder found selective impairments in the performance of

trauma related stimuli. The selective impairment has also been demonstrated in other groups with specific fears and concerns for example, phobias (Watts, McKenna, Sharrock and Trezise, 1986)[9], depression (Gotlib & Cane 1987)[10], anxiety states (Ehlers, Margraf, Davies, Roth 1988[11]; Mogg, Mathews & Weinman 1989[12]; Hope, Rapee, Heimberg & Dombeck 1990[13]) and attempted suicide (Williams & Broadbent, 1986)[14]. Although the above results have not been interpreted in terms of uncontrolled emotional processing this approach seems both possible and parsimonious. Without asking subjects to make explicit judgments about the significance of stimuli it is clearly possible to make inferences concerning the salience of particular stimuli and to investigate how these stimuli come to command and dominate information processing.

The overall aim of the present work is to provide a paradigm where the detailed effects of emotional stimuli may be more readily investigated. The development of an objective measure for the effects of emotional stimuli would enable us to address and examine a number of theoretical issues. For example, it has been suggested by McKenna (1986)[7] that the effects of emotional stimuli are generally disruptive on performance and that these effects take some time to decay. Ehlers, Margaraf, Davies and Roth (1988)[11] on the other hand, have suggested that the emotional effects build up with time and have speculated on a possible association with attentional mechanisms. Such hypotheses pose fundamental questions about the nature and the time course of the emotional effects.

The long term aim of the research programme is to develop a theoretical understanding which will inform practical issues related to stress and performance. At a theoretical level the aim is to illuminate some of the fundamental mechanisms underlying the processing of threatening or stressful events. The paradigm we have produced is being used as a laboratory model for testing hypotheses concerned with the development and modification of the processing of threatening stimuli. At a practical level the paradigm could be used to directly inform the development of an objective measure of stress resistance. It is also hoped that the research may lay the foundations upon which training programmes may be devised which would result in individuals being more effectively prepared for high stress situations. The test we have developed also has some properties which relate to the fact that it can reveal the significance of particular stimuli even though there is no intent to do so. In other words the test has some properties which make it compatible with its use as a lie detector. A preliminary investigation on this issue will be presented in the current report.

We have developed an analog of fear processing by examining the effects of emotional stimuli on a colour categorisation task. While the original aim was to develop a simple portable version of the test, the drawback has been that a range of methodological and theoretical issues could not be addressed because of the limitations in the paradigm. With the aid of a previous US Army Research Institute research contract we were able to develop a computerised version of the test which allowed these issues to be tackled. Our major findings were as follows:

1. Habituation.

Our new computerized paradigm allowed investigation of the time course of the disruptive emotional effect. It was found that the emotional stimuli have a greater

2

disruptive effect early in the experiment and disappear later on. Theoretically these disruptive effects could be time dependant or stimulus dependent. That is, the disruptive effects could decay over time regardless of stimulus repetition or the decay could be a function of the repetition of the stimulus. We have shown that it is the repetition of the stimulus which is the critical factor. The decay of the disruptive effect can be seen as an adaptive process one which resembles habituation albeit only for emotional stimuli and not for the neutral stimuli. As a laboratory model of fear processing this may have widespread implications since the theoretical construct of habituation is widely implicated in fear reduction (Foa & Kozak 1986[15]; Rachman & Levitt 1988[16]; Watts 1979[17]).

2. Threat.

Many of the early studies using this task have not addressed themselves to the nature of the disruptive effects of emotional stimuli. This issue is of central concern for any development of a human experimental model of the effects of stress on performance. Here we addressed ourselves to two issues. First, are the disruptive effects of emotional stimuli general to all emotional stimuli or are they only to be found with threatening stimuli? Second, are the disruptive effects related to the personal salience of the stimuli? We have demonstrated that only threatening stimuli show any disruptive effects.

3. Flagging Attention

There is clear evidence of large decrements in performance over time thus indicating flagging attention. It has been argued (Ehlers et al 1988)[11] that the emotional interference may occur under conditions of maximum flagging attention. We have shown that this is not the case. We have also demonstrated the conditions under which flagging attention is eliminated.

4. Order Effects

Using the standard non-computerised format there are clear interactions with order. (It makes a difference whether emotional or neutral stimuli are presented first). Order effects are rarely reported in the literature but must be having an unacknowledged effect. The computerised paradigm is an advance in that there are no complicated order effects.

EXPERIMENTS 1 AND 2: EFFECTS OF TIME PRESSURE

INTRODUCTION

Many of the important decisions that one faces in life are often made under time pressure. Imposing time constraints may lead to changes in mood states such as anxiety, stress, elation, anger, and hopelessness, which in turn may change the subject's perception of the problem, motivational structure and choice of cognitive strategies. A number of researchers in the field of judgement and decision-making have shown the importance of time pressure (Edland 1989[18]; Mross & Hammond 1990[19]). It has been

3

shown that under time pressure the nature of the decision making process changes. For example, Miller (1960)[20] has suggested three possible coping strategies that can be used under time pressure: acceleration, avoidance and filtration. Acceleration refers to all information being processed at a faster rate. Avoidance refers to the proposal that under time pressure individuals avoid making a decision. Filtration refers to a hierarchical structure in processing of information such that the most important information is processed first and the rest in order of priority. If time pressure does increase stress then one hypothesis which has received much emphasis is that the effects of stress on performance are mediated by a narrowing of attention (Easterbrook 1959)[6]. A number of researchers have suggested that the effects of time pressure are consistent with Easterbrook's hypothesis (Wright & Weitz 1977[21]; Wallsten & Barton 1982[22]; Payne, Bettman & Johnson 1988[23]). In addition it has also been found that during time pressure negative aspects of the information are given more weight (eg. Wright 1974[24]; Wright & Weitz 1977[21]; Ben Zur & Berznitz 1981[25]; although see also Svenson, Edland & Slovic 1990[26]).

During the last decade the Stroop task has been extensively used in a modified form, often referred to as the emotional Stroop task, McKenna (1986)[7]. Essentially this task involves presenting a word which could either be an emotional or a control neutral word, written in different ink colours. The subjects task is simple, they respond to the colour of the ink and ignore the words. The result is that subjects show more interference on colour naming when the to-be-ignored word is emotional than when it is neutral. In fact the emotional words often used are negative emotional words. This task has therefore been shown to be sensitive to the negative aspects of a stimulus (Watts et al 1986[9], Ben-Tovim, Walker, Fok & Yap 1989[27], Channon & Hayward 1990[28], McKenna & Sharma in preparation[29], but see also Richards & Millwood 1989[30], Martin, Williams & Clark 1991[31]). What would be the effect of time pressure on this task? One prediction that can be made is that under time pressure subjects pay more attention to the negative aspects of the stimulus and hence show a larger interference effect on the emotional stroop task.

The manipulation that we used in this study to vary time pressure is the interstimulus interval. At what time intervals should one expect an emotional interference effect? Previous studies using the emotional stroop task have presented a single word in the centre of a screen with an interstimulus interval of either three or five seconds (Gotlib & McCann (1984)[32], Gotlib & Cane (1987)[33], McNally et al (1990)[8] and Foa, Feske, Murdock, Kozak & McCarthy (1991)[34]. In all these studies subjects make a vocal response to the coloured stimuli. It is interesting to note that none of these studies have found significant emotional effects for normal non-clinical groups. Our first experiment examined the hypothesis that the introduction of an interstimulus interval would eliminate the emotional Stroop effect.

4

EXPERIMENT 1: CONSTANT INTER-STIMULUS INTERVAL
METHOD

Subjects

Forty university of Reading undergraduates volunteered to take part in the study for which they were paid. Half of the subjects were randomly assigned to the stimulus order neutral then emotional (NE) and the other half were assigned to the order emotional then neutral (EN).

Design

The design formed a 2 X 2 X 5 factorial model with Order as a between-subjects factor, Emotional class and Block as within-subject factors. In each of the five blocks a different set of five words were used. The first five neutral and emotional words outlined in the materials section were presented as part of one block, the second five as part of another block and so on. The words presented in the five blocks were counterbalanced across all the subjects, and within each block the word-colour combinations were presented randomly to each subject.

Materials

The words used in the experiment were all written in capital letters and were as follows, Neutral words: GATE, NOTE, CLOCK, THUMB, FIELD, ROSE, LEVER, CURVE, LEAGUE, PATROL, WIRE, BREAD, COVER, AUTUMN, ANCHOR, FOOT, SHOP, NAVAL, SENIOR, EXCEED, CALL, LINK, PLATE, DIVIDE, and WILLOW. Emotional words: FAIL, FEAR, CRASH, GRIEF, DEATH, PAIN, GLOOM, ANGRY, MURDER, CANCER, HATE, SHOCK, ENEMY, AFRAID, MISERY, EVIL, KILL, GUILT, TRAGIC, THREAT, FIRE, RAGE, PANIC, BEATEN, and SORROW. The emotional and neutral words were matched for word length and frequency using Kucera & Francis (1967)[35].

Procedure

The task involved presenting a single colour-word at the centre of a white coloured screen using a Victor V286A pc computer. Each stimulus remained on the screen until a response was made. Following the subjects' response the next stimulus was presented with an interstimulus interval of one second. Each of the five neutral and emotional words were written in four ink colours, red, green, blue, and brown. These twenty stimuli were randomized with one restriction, that the same word or colour did not repeat itself on consecutive trials. This formed one block in the stimulus array, five such blocks were formed to produce 100 stimuli.

The subjects were introduced to the task as a colour perception task in which they would be presented a word in one of four ink colours. They were initially shown twenty examples of the four ink colours written in repeated letter strings to familiarize them with the ink colours. They were instructed to ignore the words and make a key-press response to the colour of the ink as quickly and as accurately as possible. If any errors

5

were made they were asked not to correct themselves.

Before conducting the experiment all subjects were given two practice sessions. Each practice session involved presented 100 stimuli made up of repeated letter strings of varying length written in one of the four ink colours (the design was identical to the experimental words). The experiment involved presenting 100 emotional and 100 neutral stimuli. Subjects were informed that real words were going to be presented but were not informed of the nature of these words. All subjects were instructed to ignore the word stimuli and report only the ink colours as quickly and accurately as possible. All responses were made using one of four buttons by positioning the first and second fingers from each hand on top of each of the buttons. Each button was labelled with one of four words written in black ink, BLUE, BROWN, RED and GREEN. Half the subjects received the red and green labels on the left hand and the blue and brown labels on the right hand and the other half in reverse order.

RESULTS

The analysis was carried out on the mean correct reaction time scores. The scores were analyzed in a three-way analysis of variance, with Order a between-subject factor and Emotional class and Block within-subject factors. The analysis showed that there were no significant effects. The emotional words did not take longer to colour name (699.49 msec.) than neutral words (687.97 msec.), $F(1,38) = 1.24$ $p > 0.2$ and the interaction with Block, $F(4,152) = 1.89$ $p > 0.1$, was not significant.

DISCUSSION

The results from Experiment 1 clearly show that by using an interstimulus interval of one second subjects do not selectively attend to the negative aspects of the stimulus. The obvious reason for this is that subjects are not put under excessive time pressure and therefore do not show any emotional effects. This result therefore, presents a potential explanation of the two apparently contradictory bodies of research, one demonstrating a clear disruptive effect of emotional stimuli for normal subjects (Williams & Broadbent, 1986[14]; McKenna, 1986[7]; Watts et al 1986[9]) and the other showing no such effect (Gotlib & McCann (1984)[32], Gotlib & Cane (1987)[10], McNally et al (1990)[8] and Foa, Feske, Murdock, Kozak & McCarthy (1991)[33].

EXPERIMENT 2: VARIABLE INTER-STIMULUS INTERVAL

INTRODUCTION

To test more thoroughly the hypothesis that time pressure is a critical factor in the emotional Stroop task we conducted a second experiment in which we employed a parametric variation of interstimulus intervals to determine the time pressure necessary for the production of an emotional Stroop effect in normal subjects. Experiment 2 thus used five interstimulus intervals ranging from 30 to 400 milliseconds.

METHOD

Subjects

Forty university of Reading undergraduates volunteered to take part in the study for which they were paid. Half of the subjects were randomly assigned to the stimulus order neutral then emotional (NE) and the other half were assigned to the order emotional then neutral (EN).

Design

The design formed a 2 X 2 X 5 factorial model with Order as a between-subjects factor, Emotional class and Time as within-subject factors. There were five interstimulus intervals: 30, 80, 160, 240 and 30 milliseconds. In each of the five interstimulus intervals twenty stimuli were presented (five words in each of the four ink colours). The neutral and emotional words that were used are the same as Experiment 1 and are outlined in the materials section. The words were blocked such that the first five were presented in the first time interval, the second five in the second time interval and so on. Thus each group of five words was presented to each subject in the same order. The five time intervals were, however, counterbalanced across all the subjects (so that all the words occurred equally often in all time intervals) using Williams squares, Cocharan & Cox (1957)[35]. Williams squares ensure that (a) each of the time intervals occurs equally often in each of the five blocks, (b) each pair of time intervals occurs equally often and (c) each pair occurs equally often in each block. Within each time interval the word-colour combinations were presented randomly to each subject.

Materials

The words used in the experiment were all written in capital letters and were as follows, Neutral words: GATE, NOTE, CLOCK, THUMB, FIELD, ROSE, LEVER, CURVE, LEAGUE, PATROL, WIRE, BREAD, COVER, AUTUMN, ANCHOR, FOOT, SHOP, NAVAL, SENIOR, EXCEED, CALL, LINK, PLATE, DIVIDE, and WILLOW. Emotional words: FAIL, FEAR, CRASH, GRIEF, DEATH, PAIN, GLOOM, ANGRY, MURDER, CANCER, HATE, SHOCK, ENEMY, AFRAID, MISERY, EVIL, KILL, GUILT, TRAGIC, THREAT, FIRE, RAGE, PANIC, BEATEN, and SORROW. The emotional and neutral words were matched for word length and frequency using Kucera & Francis (1967)[34].

Procedure

The procedure was identical to Experiment 1 except that the interstimulus time intervals were varied automatically by the computer according to the design of the experiment. Two practice sessions using repeated letter strings were given before the experiment. Each practice session contained 100 stimuli and the interstimulus intervals were presented in the same order as for the experimental stimuli.

RESULTS

The analysis was carried out on the mean correct reaction time scores and the overall results can be seen in figure 1.

Figure 1: Mean reaction times to emotional and neutral words for inter-stimulus intervals of 30, 80, 160, 240 and 400 milliseconds.
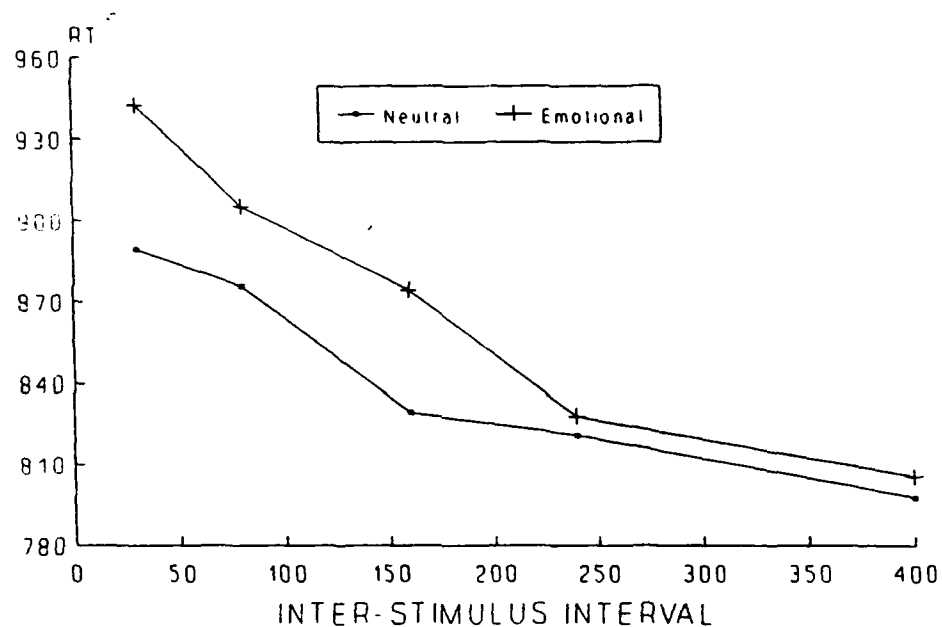
The scores were analyzed in a three-way analysis of variance, with Order a between-subject factor and Emotional class and Time interval within-subject factors. The analysis showed a main effect of Time, $F(4,152) = 14.28$ $p < 0.001$, thus demonstrating that with increasing time pressure there is an increase in overall response latency. The analysis also showed that emotional words took longer to colour name (871.09 msec.) than neutral words (844.40 msec.), $F(1,38) = 6.27$ $p < 0.02$ and the interaction with Time interval $F(4,152) = 0.92$ $p > 0.1$ was not significant. Although the interaction of Emotional Class and Time Interval was not significant figure 1 seems to indicate that the emotional interference decreases with an increase in interstimulus interval. This impression was largely confirmed by simple main effects analyses which showed that for interstimulus intervals of 30 and 160 msec there was a significant emotional interference effect, $F(1,152) = 5.13$ and 5.34 respectively $p < 0.025$, whereas for time intervals of 240 and 400 msec. it was not significant, $F(1,152) = 0.13$ and 0.16 $p > 0.1$ respectively. The interference

8

effect at time interval 80 msec. approached significance $F(1,152)=2.29$ $0.1<p<0.25$. There was no main or interaction effects with order (all F's less than 0.7 $p>0.5$).

DISCUSSION

Together the results of the above two studies show the importance of time pressure in producing an effect on negative emotional processing. They indicate that with groups of normal subjects the effects of irrelevant emotional stimuli on the main task of colour naming is shown only when extreme levels of time pressure are used. In our experiment the effects of negative emotional words were apparent only when interstimulus time intervals of 160 milliseconds or less were used. The results from the 240 and 400 millisecond interstimulus intervals replicate the non-effect found in Experiment 1 using one second. These results clearly indicate the importance of time pressure and provide an explanation of the differentiating factor between those studies which show disruptions in performance versus those which do not. It seems clear that uncontrolled emotional processing is very sensitive to time pressure.

One explanation for these results is that under time pressure subjects are put under greater levels of stress which takes up greater processing resources and hence leads to greater disruption on the task. If emotional stimuli consume resources and these resources are limited then emotional interference may occur. If the task is made easier so that fewer resources are necessary then the extra resources required by the emotional stimuli may not exceed the limited resources. However, if the disruption is simply due to the temporal nature of the task then emotional disruption should occur despite any reduction in the demand for resources. An attempt was made to examine this issue of task difficulty by retaining time pressure but making the task simpler and observing whether the emotional interference remains or disappears.

EXPERIMENT 3: TASK DIFFICULTY

INTRODUCTION.

The experiment involves using a single interstimulus interval of 30 milliseconds. A task difficulty manipulation was then introduced. The task was made easier by changing the stimulus response mapping. In Experiments 1 and 2 the subject had to respond to four colours by making four responses. In the present experiment subjects were presented with four colours but had to make only two responses. Thus although there is still time pressure the task is easier to perform and hence the demands are reduced. It is hypothesized that if the temporal nature of the task is sufficient to produce a disruptive effect then this experiment should show a significant disruption, whereas if the time pressure leads to competition of limited resources then by reducing task difficulty there should also be a reduced disruptive effect of emotional stimuli.

METHOD

Subjects

Forty University of Reading students took part in Experiment 3. Twenty in each order (NE and EN).

Design

The design was the same as Experiment 1.

Materials

The words used in the experiment were all written in capital letters and were as follows, Neutral words: GRIP, WAIT, FLEET, VIOLA, PRESS, MARK, LEVER, SOLAR, NOBODY, BARREL, POND, TRUCK, WAGON, SAMPLE, ANCHOR, SEND, FLAT, FEWER, BRANCH, EXCEED, SOON, RUIN, LAYER, POTATO and DIVIDE. Emotional words: HURT, HELL, CHAOS, FATAL, ALONE, LOSS, GLOOM, TENSE, DANGER, INJURY, BORE, SPITE, WORRY, BITTER, HAZARD, EVIL, BEAT, DIRTY, SUFFER, BURNED, MEAN, WEEP, HARSH, HORROR and BEATEN. The emotional and neutral words were matched for word length and frequency using Kucera & Francis (1967)[34].

Procedure

This experiment was exactly the same as Experiment 1 except that (i) there was an interstimulus interval of 30 milliseconds instead of one second and (ii) there was a stimulus-response mapping of 4 to 2 such that the responses to the four ink colours (red, green, blue and brown) were made by using the index fingers from each hand. For half the subjects the red and green ink colours were responded to with the left finger and the blue and brown colours with the right finger, and the reverse for the other half of the subjects.

RESULTS

The mean correct reaction time scores were analyzed. A three-way analysis of variance was conducted, with Order as a between-subjects factor, Emotional Class and Block as within-subject factors.

The analysis showed that there was no difference in the colour naming of emotional words (823.63 msec) over neutral words (812.29 msec), $F(1,38) = 1.47$ $p > 0.20$.

DISCUSSION

Manipulating task difficulty by making the task easier eliminated emotional interference suggesting that competition for limited resources may be a critical feature in the occurrence of the emotional performance decrement under time pressure. The link between task difficulty and emotional arousal goes back to Yerkes & Dodson (1908)[36]

10

who suggested that high levels of arousal could be tolerated for simple tasks but not for difficult tasks. The uncontrolled extra processing demands which occur for emotional stimuli may result in interference only when there is competition for limited resources. This suggest that one general method of reducing performance disruption under stress is to reduce the complexity of the task.

EXPERIMENT 4: TIME PRESSURE AND THE LEXICAL DECISION TASK

INTRODUCTION

Another task that has extensively been used to observe the effects of emotional processing is the lexical decision task. In this task a subject is presented with a series of letter strings which could either be real words (unless, sad etc.) or non-words (bobble, kad etc.). The task for the subjects is to make a lexical decision as quickly as possible concerning whether the letter strings are words or non-words. The main question addressed here is whether subjects show faster or slower response latencies for emotional words than a set of neutral words. Although such an hypothesis is straight forward to test, the experimental evidence to date is equivocal.

There are a number of studies which give support to the hypothesis that emotionally negative words produce response latencies that are faster than neutral words (Strauss,1983[37]; Williamson, Harper & Hare, 1989[38] and Challis & Krane, 1988[39]; Green & McKenna, in preparation[40]). Some studies show no differences in response latency between negative and neutral words (Bray, 1984[41]; Clark, Teasdale, Broadbent & Martin, 1983[42]). And to make the picture more murky there is one study which shows longer response latencies for negative words than neutral words (Williams & Evans, 1980)[43].

What are we to make of these apparently contradictory results?
In the vast literature of the lexical decision task it is well known that various aspects of the stimulus and the type of procedure employed can influence the response latencies to the stimuli. For example, word frequency (Scarborough et al, 1977)[44] and the length of the word (Whaley, 1978)[45] have an influence on response latencies, such that as word frequency increases and word length decreases the latencies become faster. Other factors are also important, such as, the form of the nonword, that is whether the nonword is pronounceable or non-pronounceable, Balota & Chumbley (1984)[46]. Other factors that may also be important are the ratio of the words to the nonwords, the number of repetitions of the stimuli used, whether the task is subject terminated or computer terminated, the exposure time of the stimuli and the interstimulus interval.
If we compare a number of studies that have looked for emotional processing in the lexical decision task, it becomes apparent that there are many differences between studies. For example, there are some studies which do not adequately match word frequency and word length for emotional and control stimuli (Williams & Evans, 1980;[43] Challis & Krane, 1988[39]). Some studies are computer terminated, that is they present the stimuli for a fixed duration (Challis & Krane, 1988[39]; Strauss, 1983[37]; Green & McKenna, in preparation[40]) whereas other studies are subject terminated, that is, they

leave the stimulus on the screen until subjects make their response (Clark et al, 1983[42]; MacLeod & Mathews, in preparation[47]; Bray, 1984[41]). Since there are many differences between experiments and a number of confounding factors within experiments, it is not clear which of the factors are critical for producing emotional effects in the lexical decision task. We therefore decided to investigate one manipulation that we know from Experiments 1 and 2 to be important for the emotional Stroop task, namely the effect of time pressure.

In our next experiment we would like to address the issue of whether time pressure is as critical a factor in the lexical decision task as it has been shown to be in the emotional Stroop task. We have found from the emotional Stroop studies (Experiments 1 and 2 above) that when the interstimulus interval is very short (less than 160 msec.) an emotional effect is observed whereas when the interstimulus interval is very long (greater than 160 msec.) then no emotional effects are observed. In experiment 4 we conducted a subject terminated lexical decision task and induced time pressure by using a short inter-stimulus interval of 30 milliseconds.

METHOD

Subjects

Forty University of Reading students took part in Experiment 3. Twenty in each order (NE and EN).

Design

The design formed a 2 X 2 X 5 factorial model with Order as a between-subjects factor, Emotional class and Block as within-subject factors. In each of the five blocks a different set of eight words were used. The first eight neutral and emotional words, and their appropriate set of non-words, outlined in the materials section were presented as part of one block, the second eight as part of another block and so on. The words presented in the five blocks were counterbalanced across all the subjects, and within each block the word-colour or nonword-colour combinations were presented randomly to each subject. Two sets of nonwords were used in this study. For half the subjects one of the two sets of nonwords was mixed with the emotional words and the other set with the neutral words whereas for the other half the order was reversed.

Materials

The words used in the experiment were all written in capital letters and were as follows,

emotional words:-
BURNED, MEAN, WEEP, HARSH, HORROR, SUICIDE, ASHAMED, UGLY
WORSE, TORTURE, NERVOUS, ANXIOUS, UNEASY, OMINOUS, INHIBIT, ACHE
ADVERSE, CRUEL, CROSS, HOSTILE, ASSAULT, ANNOY, PROVOKE, STERN
EDGY, GHOST, BEAST, MOURN, DEFEAT, REBUKE, LOATHE, STAB

ENVY, AGONY, UPSET, BULLY, BLOOD, DROWN, TERROR, COFFIN

Neutral words:-
BOUND, SOON, RUIN, LAYER, POTATO, FLOWING, PRIESTS, PORT
EXTRA, SAWDUST, CHANCES, STAINED, SPHERE, SURVEYS, ROUSING, POLO
ARISING, ONION, WAGON, DAYTIME, TEXTURE, FLICK, SLUMBER, CABIN
MOOR, BASIN, WATER, BROOK, HOLLOW, BRIDGE, PLANET, LAKE
LAND, RIVER, COAST, BEACH, SWAMP, GORGE, ISLAND, CRATER

Non-words:-
NEWELS, MAON, EMOT, MOLUD, MUGGIE, FINKERS, FLAZENS, FIKE
SANKY, RUMOIRS, GROANID, GREANLY, OATHER, OUTPOTT, PANDORE,
OOTS
DETANID, BELED, BREIN, ABUSIRE, ACOURFE, ABUSD, ACCERED, ACHIS
CHOE, CHENC, BOKED, BICKE, PREEKA, FEEDED, NOKLED, GOTE,
SCOF, LATT, MUCKI, MELIT, LOKED, YOLIS, MENET, SCKOOL

Non-words:-
MUCKAR, MOIK, MOSP, MUNZO, MORLES, FISSTED, FIPEMEN, FEID
SEKTA, STELART, GROOVID, GRIPPIN, OUTWID, OTERLYS, OVERELM,
OUZE
DEELSED, BRIND, BRODE, ACKLAIM, ACORNIS, ACENT, ACRIDED, ACEED
ATON, CHOCE, BEETH, BEBLE, SONKAT, BALIED, NEEDLE, EFAT
LEAT, LOODI, ESKIE, MOASE, PORFS, EMNET, DAMMID, HANMAN

The emotional and neutral words were matched for word length and frequency using Kucera & Francis (1967)[34].

Procedure

The procedure was almost identical to that used for an emotional stroop study. The lexical decision task involved presenting a single colour stimulus at the centre of a white coloured screen using a Victor V286A pc computer. Each stimulus remained on the screen until a response was made. Following the subjects' response the next stimulus was presented almost immediately. The interstimulus interval was approximately 30 milliseconds. All the words and nonwords were written in one of four ink colours, red, green, blue, and brown. Within each block the stimuli were presented in the following manner. Each of the four ink colours were randomly assigned one of the eight words an equal number of times. This was repeated for the nonwords. These sixteen stimuli were randomized with one restriction, that the same word or colour did not repeat itself on consecutive trials. This formed one block in the stimulus array, five such blocks were formed to produce 80 stimuli.

The subjects were introduced to the task as a word recognition task, in which they would have to decide if the letter string presented was a real english word or not. They were asked to ignore the ink colours and to respond by pressing the button labelled 'yes' if the letter string was a word or 'no' if not a word, as quickly and as accurately as possible. All responses were made by positioning the two index fingers from each hand on top of

each of the buttons. Half the subjects received the button labelled 'yes' on the left hand and the button labelled 'no' on the right hand and the other half in reverse order. If any errors were made they were asked not to correct themselves.

Before conducting the experiment all subjects were given a practice session which involved presenting 80 stimuli made up of neutral words and nonwords that were not used in the experiment The design was identical to the experimental words except that the eight neutral words and nonwords were repeated in each of the five block. The experiment involved presenting 40 emotional and 40 nonwords as part of one session, and 40 neutral and 40 nonwords as part of another session, with a short break between the two sessions. The order of presentation of each session was counterbalanced across subjects.

RESULTS

The mean correct reaction time scores for the words were analyzed. A three-way analysis of variance was conducted, with Order as a between-subjects factor, Emotional Class and Block as within-subject factors.

The analysis showed that the response latencies for the lexical decision to emotional words (770.66 msec) was slightly longer than that to neutral words (752.07 msec), however, this did not reach significance $F(1,38) = 3.33$ $p = 0.08$. Also this did not interact with block, $F(4,152) = 2.08$ $p = 0.09$, see Table 1.

Table 1. Mean correct reaction times (msec.) to emotional
and neutral words in the lexical decision task.

Emotional	BLOCK				
Class	1	2	3	4	5
Neutral	705.21	743.29	771.23	773.04	767.56
Emotional	752.25	754.46	772.63	819.43	754.54

DISCUSSION

The results from this experiment show no clear effects of negative emotional stimuli in a lexical decision task, even though the interstimulus interval was very small (approximately 30 msec.). We can therefore conclude that a subject terminated version of the lexical decision task is not sensitive to the emotional content of the word. From Experiment 3 we found that not only time pressure but also task difficulty was an important factor in producing emotional effects in the emotional stroop task. It may therefore be argued that one reason why the lexical decision task shows no emotional effects in the lexical decision task is because the task is too easy even though the interstimulus interval is very short. One reason for this is because in a lexical decision task only two responses are made, either a "yes" response if the stimulus is a word or a "no" response if the stimulus is not a word. We found in Experiment 3 that by using only two responses the emotional effects in a Stroop task disappear. However, although it is

14

possible to increase the number of responses in the Stroop task it is not possible to increase the number of responses in the lexical decision task without changing the nature of the task. The results confirm that the most effective task currently available for examining reliable emotional effects is the emotional Stroop task.

EXPERIMENT 5: MULTIPLE DISTRACTERS

INTRODUCTION

One of the important findings in these series of experiments is that time pressure and task difficulty have an important influence on the emotional Stroop effect. It was found in Experiment 3 that by reducing the task demands we were able to eliminate the emotional effect. We can therefore ask the opposite question that, if the task demands were made greater would the emotional effect be increased? In Experiment 5 we addressed this issue by presenting emotional words as targets and comparing whether the response latencies to the colours were longer when two emotional words were presented as distracters than when two neutral words were presented as distracters.

METHOD

Subjects

Forty eight university of Reading undergraduates volunteered to take part in the study for which they were paid. Half of the subjects were randomly assigned to the stimulus order neutral then emotional (NE) and the other half were assigned to the order emotional then neutral (EN).

Design

The design formed a 2 X 2 X 4 factorial model with Order as a between-subjects factor, Emotional class of the distracter and Block as within-subject factors. In each of the four blocks a different set of five words were used. The first five neutral and emotional words outlined in the materials section were presented as part of one block, the second five as part of another block and so on. The words presented in the four blocks were counterbalanced across all the subjects, and within each block the word-colour combinations were presented randomly to each subject.

Three sets of neutral (N1, N2, N3) and emotional (E1, E2, E3) words were used. Each of the three sets of emotional words were used as targets and distracters in a counterbalanced order. That is, if set E1 emotional words in the emotional condition were used as targets then either set E2 or set E3 were used as distracters. Similarly, for the neutral condition all three sets of emotional words were used as targets but this time the neutral set of words were used as distracters. This design produced six different orders. These orders can be represented as ratios of Emotional target(distracter):Neutral target(distracter). E1(E3):E2(N3), E1(E2):E3(N2), E2(N3):E1(N3), E2(E1):E3(N1),

15

E3(E2):E1(N2), E3(E1):E2(N1). These six orders were also counterbalanced such that for half the subjects they received the emotional condition first and the neutral condition second, whereas for the other half this was in the reverse order.

All stimulus words were written in one of four ink colours, red, green, blue, and brown. The stimuli were randomized with two restrictions. Firstly, that the same word or colour did not repeat itself on consecutive trials and secondly, that the colour of the target and distracters were never identical.

Materials

The words used in the experiment were all written in capital letters and were as follows,
Neutral words:
Set N1.
ROSE,LEVER,CURVE,REGION,PATROL,WIRE,PULL,COVER,REMARK,ANCHOR,
FOOT,PANEL,EXTRA,SENIOR,FOURTH,CALL,LINK,PLATE,MOTIVE,WILLOW

Set N2.
BANK,LOGIC,SOLAR,FACTOR,BARREL,POND,SEND,WAGON,AUTUMN,MELODY
STAY,TRUCK,FEWER,PARADE,SMOOTH,SOON,RUIN,LAYER,POTATO,DERIVE

Set N3.
PARK,USAGE,VAGUE,AGREED,SUBTLE,CORE,SHOP,QUIET,SAMPLE,HOLLOW
NOTE,NAVAL,FENCE,BRANCH,EXCEED,READ,SLIP,CLOCK,DIVIDE,JACKET

Emotional words:
Set E1.
PAIN,GLOOM,ANGRY,MURDER,CANCER,HATE,SICK,ENEMY,DEFEAT,MISERY
EVIL,SHOCK,WORSE,TRAGIC,FAILED,FIRE,RAGE,PANIC,UNEASY,SORROW

Set E2.
LOSS,ABUSE,TENSE,DANGER,INJURY,HANG,DOOM,WORRY,AFRAID,SCARED
POOR,SPITE,DIRTY,LONELY,BURNED,MEAN,WEEP,HARSH,HORROR,SCREAM

Set E3.
HELL,UPSET,DEVIL,CRISIS,TERROR,HURT,KILL,KNIFE,BITTER,HAZARD
FEAR,GUILT,CRIED,SUFFER,THREAT,DEAD,FURY,CRASH,BEATEN,DAMAGE

The emotional and neutral words were matched for word length and frequency using Kucera & Francis (1967)[34].

Procedure

The task involved presenting an emotional word at the centre of a white coloured screen using a Victor V286A pc computer, with two distracter words, one above and one below the target word. Each stimulus remained on the screen until a response was made. Following the subjects' response the next stimulus was presented immediately.

The subjects were introduced to the task as a colour perception task in which they would be presented a word in the centre of the screen with two other words one above and one below the target word, in one of four ink colours. They were instructed to ignore all three words and to make a key-press response to the colour of the ink of the centre word as quickly and as accurately as possible. If any errors were made they were asked not to correct themselves.

Before presenting the practice session subjects had taken part in two other emotional stroop experiments (experiments 6 & 7). In total there were about 600 stimuli and therefore all subjects had extensive practice on emotional stroop tasks. Subjects were given one practice session which involved presenting 80 stimuli (made up of repeated letter strings for the targets and distracters) of varying length written in one of the four ink colours (the design was identical to the experimental words). The experiment involved presenting 80 emotional stimuli as targets and 80 as distracters in the emotional condition and 80 emotional targets and 80 neutral distracters in the neutral condition. Subjects were informed that real words were going to be presented but were not informed of the nature of these words. All subjects were instructed to ignore the word stimuli and report only the ink colours as quickly and accurately as possible. All responses were made using one of four buttons by positioning the first and second fingers from each hand on top of each of the buttons. Each button was labelled with one of four words written in black ink, BLUE, BROWN, RED and GREEN. Half the subjects received the red and green labels on the left hand and the blue and brown labels on the right hand and the other half in reverse order.

RESULTS

The analysis was carried out on the mean correct reaction time scores. The scores were analyzed in a three-way analysis of variance, with Order a between-subject factor and Emotional class of distracter and Block as within-subject factors. The analysis showed that there were no significant effects. The emotional words with emotional distracters did not take longer to colour name (966.82 msec.) than emotional words with neutral distracters (976.02 msec.), $F(1,46)=0.88$ $p>0.3$ and the interaction with Block, $F(3,138)=1.03$ $p>0.3$, was not significant.

DISCUSSION

The results from this experiment are very clear. They demonstrate that the emotional content of the distracters do not have any effect on the target words when these words are of negative emotional valance. We can therefore conclude that the emotional stroop effect found in previous experiments cannot be changed by using either neutral or negative emotional distracters. However, it is still theoretically possible that the

distracters may have an effect but only when a larger number of distracters are used. This however remains an empirical issue.

EXPERIMENTS 6 AND 7
The Pattern of Disruption in the Emotional Stroop Task.

INTRODUCTION

The inquiry into the relationship between emotion and cognition has received increasing attention in recent years. One area of growing interest is the influence of emotion on attentional processing. It is a common experience that objects that are important are more easily attended to. For example, buying a car leads to other cars of the same make or type being more frequently noticed or, while taking part in another conversation the sound of ones name can still be heard. It has been suggested that one of the characteristics of emotional disturbance is the way in which people selectively attend to an emotional stimulus (Williams, Watts, MacLeod & Mathews, 1988)[48]. That is, certain emotional stimuli have the capacity to capture one's attention. This is particularly shown in people with specific fears. For example, a spider phobic fears not only the sight of spiders but may also be extremely sensitive to stimuli that approximate to spiders such as, other insects, toy spiders or even a shadow that forms the general shape of a spider.

The emotional Stroop task has become increasingly important in the study of attentional processing. This task highlights the fact that despite explicit instructions to ignore the words, subjects are not able to selectively filter out emotional stimuli. That is, subjects show uncontrolled processing of emotional stimuli (McKenna & Sharma, in preparation)[29].

The original form of the emotional Stroop task is such that all stimuli are presented simultaneously on a card in a matrix format. The dependant measure being the total time to colour name a certain number of stimuli, either emotional or neutral. The result that emotional stimuli produce greater disruption has often been described as the greater attention capturing ability of emotional stimuli over neutral stimuli. Although the task is to identify the colour the simultaneously present emotional stimulus produces a disruption in performance. The implicit assumption has been that an emotional stimulus has the immediate effect of slowing the colour naming of that particular stimulus. All analyses have been based on this assumption. In experiments 6 and 7 we would like to address this issue and investigate the precise nature of the disruptive effect.

How can we investigate the pattern of the emotional disruption? One way is to produce a working model that will explain the available data. We would like to propose that in principle the emotional stimuli could produce a disruption as a result of two effects. The first we label the immediate effect and the second a lingering effect. If we consider two sequentially presented emotional stimuli, the word 'death' written in 'green' ink followed

18

without delay, after the response to green is made, by the word 'fear' written in 'blue' ink, then the immediate effect is the disruptive effect of an emotional word on the ink colour in which that word is written. For example, the word death has its effect only on the ink colour green and not blue. It is described as an immediate effect because the word has its effect only on the latency of the "immediate" ink colour (green) in which that word is written and not on any succeeding ink colours (such as blue). The lingering effect is the disruptive effect which an emotional word has on succeeding ink colours. For example, the word death has its effect on the ink colour blue and not green.

The main assumption made by this model is that the two effects can be assessed independently.
This can be written as :-

Emotional Disruption = Immediate effect + Lingering effect

The immediate effect and the lingering effect could vary in a number of ways, see Figure 2.

Figure 2: Modelling the emotional disruption in terms of the
immediate effect and the lingering effect.

Parameters of disruption
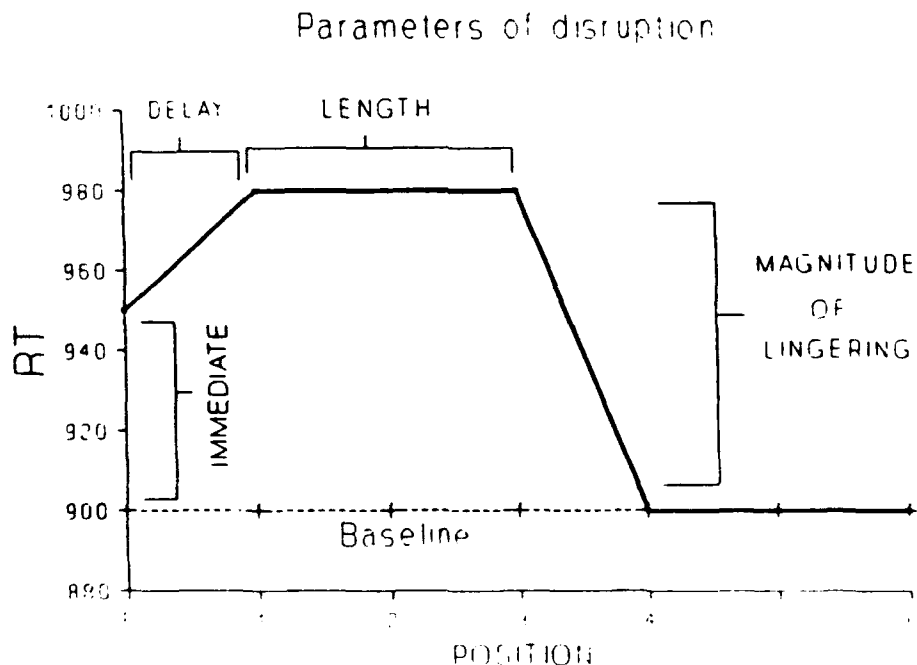
The immediate effect as we have described it can vary only in one direction, namely in the magnitude of the effect. The lingering effect on the other hand can vary in a number of ways (some more plausible than others). (1) It could vary in the **magnitude** of the effect. (2) It could vary in the number of succeeding stimuli onto which it has an effect (this parameter we label as the **length** effect). That is, there may be a lingering effect onto the following stimulus or onto more than one stimulus. If the disruptive effect occurs over more than one stimulus then the disruptive effect could itself vary. For example, it could decrease exponentially as length increases or alternatively it could increase or remain of the same magnitude. (3) The lingering effect may also vary in terms of when it starts to have its effect (this we label the **delay** effect). That is, the lingering effect may start to have its effect on the following stimulus, in which case delay equals one, or it may start to have an effect on the second or further succeeding stimuli, in which case delay equals two or more. It is therefore possible that the emotional disruption could be either a immediate effect or a lingering effect or indeed both an immediate effect and a lingering effect.

We will now consider the implications this hypothesis has for experimental results. As a starting point we would like to consider the situation where emotional and neutral words are presented in blocked format. This is the most common form in which the emotional Stroop task has been used. In this task the stimuli are presented such that, an emotional word follows an emotional word for the whole set of emotional words and similarly, a neutral word follows a neutral word for the whole set of neutral words. Hence, there is an emotional block and a neutral block. In such a design the set of neutral words do not produce an immediate or a lingering effect since by definition this only occurs for the emotional words. Since the immediate and the lingering effect both occur within the emotional set of words these two effects are confounding factors in the emotional disruption. How can we disentangle these two effects?

If we assume that the lingering effect slowly decays after stimulus onset then, one clear prediction that this model makes is that, if stimuli are presented individually and succeeding stimuli are presented with some interstimulus interval then the only effect that we can observe is the immediate effect. A number of individual stimulus presentation experiments have been reported in the literature using long interstimulus intervals, between three to five seconds (see McNally et al, 1990[8]; Foa et al, 1991[33]). These studies have shown clear disruptive effects of emotional stimuli. This therefore supports the hypothesis that the disruptive effects are indeed immediate effects. However, this does not necessarily exclude the fact that there may be
lingering effects. Indeed, if we look more closely at the studies where single stimulus presentations have been used, we find that disruptive effects have only been found with clinical groups, whereas with normal non-clinical groups null effects are usually reported. Therefore, it is possible that clinical groups show immediate effects and or lingering effects whereas non-clinical groups show only lingering effects.

Two studies have been reported that do show disruptive effects with non-clinical groups. In one study (McKenna & Sharma, in preparation)[29] presented succeeding stimuli immediately one after another and found a disruptive effect of emotional stimuli. This effect could be due to immediate and or lingering effects. The second study (experiment 2 above) varied interstimulus interval and found disruptive effects for short interstimulus

intervals (less than or equal to 160 milliseconds) but not for long interstimulus intervals. This result has important implications for our model. Our model predicts that at long interstimulus intervals there should only be an immediate effect whereas the lingering effect should be eliminated. In fact, the results show that after 160 milliseconds there is no disruptive effect indicating that there is no immediate effect. This implies that with short interstimulus intervals the emotional disruption found may only be a lingering effect. If this is the case then it could explain why many single presentation experiments do not show any emotional disruption for non-clinical groups.

It is clear from this analysis that, by using blocked presentations of emotional words the lingering effect cannot be observed because it is confounded with the immediate effect. Therefore, it becomes necessary to conduct experiments in which emotional and neutral words are mixed together. There are two possible questions we can ask. First, do the neutral words when mixed with emotional words show longer latencies than when they are mixed with other neutral words? Second, do the neutral and emotional words when mixed together show any differences? If our hypothesis is correct that there are lingering effects from the emotional words, then we should find that neutral words that are mixed with emotional words do show longer latencies than when mixed with other neutral words. When comparing neutral and emotional words that are mixed one might intuitively predict that the neutral and emotional words do not show any differences. However, in fact the predictions vary depending on the precise way in which the words are mixed (whether completely random or in a pseudo-random manner) and on the relative magnitudes of the immediate and lingering effects.

To get a feel for the type of outcomes possible we produced computer simulations for two types of experiments. First, an experiment in which the emotional and neutral words were presented equally often but in a completely random way, and second in a pseudo-random way. The pseudo-random sequences that we have chosen are based on common restrictions used in psychology and which have been used in the emotional Stroop experiments. For example, the emotional and neutral words are mixed randomly with the restriction that an emotional (or neutral) word could not follow another emotional (or neutral) word more than twice in succession. The effect of this manipulation is to increase the probability of a neutral word following an emotional word compared to the completely random sequence.

Table 2 shows emotional disruption scores for two levels of magnitude of the immediate effect (0 and 40 milliseconds) and five levels of magnitude of the lingering effect (0, 20, 40, 60 and 80 milliseconds). The emotional disruption scores were calculated as the difference between the emotional and neutral stimuli when they are mixed together. Table 2 presents simulated data with the following assumptions made in the model. (1) The lingering effect starts to have its effect immediately on the following stimulus, i.e. delay = 1. (2) If the length of the lingering effect is greater than one then the magnitude of the disruption for all succeeding stimuli is equal. That is, the lingering effect does not decrease or increase as the length increases. The scores in each cell of Table 2 are means that have been calculated across five different sequences and four different values of length (1,2,3 and 4) for the lingering effect. The data was collapsed across length because by varying the length the emotional disruption for different magnitudes of immediate and lingering effects did not change.

21

Table 2: Emotional disruption scores in milliseconds for
different values of the magnitude of the immediate
effect and the magnitude of the lingering effects
for random and pseudo-random sequences.

magnitude of lingering	RANDOM		PSEUDO-RANDOM	
	magnitude of immediate effect			
	0	40	0	40
0	0	40	0	40
20	-1	39	-9	32
40	2	40	-17	24
60	-3	38	-23	16
80	-3	39	-32	6

Table 2 illustrates that with random presentations of the stimuli any change in the magnitude of the lingering effect has no effect on the emotional disruption scores. In fact, only the immediate effect can be observed. It is interesting to note that a potentially important effect such as the lingering effect may be masked by using completely random sequences. However, with pseudo-random sequences the magnitude of the lingering effect produces a different pattern of results. Table 2 shows two main properties. (1) As the relative magnitude of the lingering effect increases the difference in latencies between emotional and neutral words decreases. (2) When there is no immediate effect (or when the lingering effect is much larger than the immediate effect), there is a negative difference between the emotional and neutral latencies. That is, it is theoretically possible for the neutral words to be responded to slower than the emotional words (a reversal of the emotional Stroop) even though the effects are entirely due to the emotional words. However, when the immediate and lingering effects are of the same magnitude then the difference between emotional and neutral words is either positive or there is no difference.

The modelling conducted here suggests that it is possible to test the hypothesis that emotional stimuli produce lingering effects in an emotional stroop task but only if pseudo-random sequences are used. The main prediction made by this model is that if the lingering effect is substantially larger than the immediate effect then the difference between the emotional and neutral stimuli should be negative. That is, the neutral words show a larger disruption than the emotional words.

EXPERIMENT 6
PSEUDO-RANDOM PRESENTATION OF EMOTIONAL AND NEUTRAL STIMULI

The analysis of the modelling in the introduction shows that by conducting an experiment in which neutral and emotional words are mixed in a pseudo-random sequence the influence of lingering effects can be detected. Experiment 6 was therefore conducted to test the hypothesis that emotional stimuli produce lingering effects. It was predicted that if the emotional disruption was mainly due to an immediate effect then there would be a positive difference between emotional and neutral words. However, if the effect was mainly due to a lingering effect then there would be a negative difference between emotional and neutral words. One problem with this second prediction is that even if there are significant immediate effects these may be small compared to the lingering effect, and therefore by just comparing the emotional and neutral words that are mixed together we do not know if there are any immediate effects. Therefore, a neutral control condition was included in Experiment 6 in which a set of neutral words were mixed with another set of neutral words. These neutral words can then be compared with the emotional words to see if there are any immediate effects.

METHOD

Subjects

Forty university of Reading undergraduates volunteered to take part in the study for which they were paid. There were two conditions in the experiment an emotional (E) and a neutral (N) condition. In the emotional condition subjects were presented an equal number of emotional and neutral words mixed together, whereas in the neutral condition subjects were presented two sets of neutral words mixed together. Half of the subjects were randomly assigned to the stimulus order neutral then emotional (NE) and the other half were assigned to the order emotional then neutral (EN).

Design

The design formed a 2 X 4 X 5 factorial model with Order as a between-subjects factor, Emotional class and Block as within-subject factors. The neutral (N1) and emotional (E) stimuli were mixed with two groups of neutral (N2 and N3) stimuli. For half the subjects N2 was mixed with N1 and N3 with E, whereas for the other half N3 was mixed with N1 and N2 with E. When either the neutral words N2 or N3 are mixed with N1 we refer to them as <u>blocked neutral</u> words, whereas when they are mixed with E they are referred to as <u>mixed neutral</u> words.

In each of the five blocks a different set of five words were used. The first five neutral and emotional words outlined in the materials section were presented as part of one block, the second five as part of another block and so on, hence there were 10 different words (5 neutral and 5 emotional) in each block. Each of these 10 words were presented in one of four ink colours, red, green, blue and brown, therefore each block contained 40 stimuli. These forty stimuli were randomized with two restrictions. (1) That an identical word or colour did not repeat itself on consecutive trials. (2) That the same word type (emotional or neutral condition) could not repeat itself more than twice in

23

successive presentations. This formed one block in the stimulus array, five such blocks were formed to produce 200 stimuli.

The words presented in the five blocks were counterbalanced across all the subjects, and within each block the word-colour combinations were presented randomly to each subject.

Materials

The words used in the experiment were all written in capital letters and were as follows.
Neutral (N1) words: GATE, NOTE, CLOCK, THUMB, SHALL, BARK, SCHEME, PREFER, COLUMN, SEASON, WASH, ALTER, LOWER, SADDLE, DECIDE, FOOT, SHOP, NAVAL, SENIOR, EXCEED, CALL, LINK, PLATE, DIVIDE, and WILLOW.
Emotional (E) words: FAIL, FEAR, CRASH, GRIEF, DEATH, WEEP, SUFFER, INJURY, DANGER, ATTACK, HURT, TENSE, BLOOD, TERROR, BURNED, DOOM, KILL, GUILT, TRAGIC, THREAT, FIRE, RAGE, PANIC, SCREAM, and SORROW.
Neutral (N2) words: SAND, CLAY, CLOUD, SLOPE, FIELD, RUIN, BRANCH, RUSHED, MASTER, ACTUAL, FOAM, SOLAR, RADIO, ABOARD, OBTAIN, HILL, TREE, OCEAN, FLOWER, LEAVES, ROAD, BUSH, FAULT, MEADOW and GRAVEL.
Neutral (N3) words: CORE, FARM, NEWER, FLOCK, TODAY, MIST, JACKET, BARREL, FACTOR, EXPECT, PLOT, STOVE, DAILY, SUBTLE, FINGER, BOAT, GROW, SWIFT, PHRASE, GOLDEN, KEPT, PEAK, CRAFT, RUBBER and RADIUS.

The emotional and neutral words were matched for word length and frequency across the five blocks using Kucera & Francis (1967)[34].

Procedure

The task involved presenting a single colour-word at the centre of a white coloured screen using a Victor V286A pc computer. Each stimulus remained on the screen until a response was made. Following the subjects' response the next stimulus was presented immediately.

The subjects were introduced to the task as a colour perception task in which they would be presented a word in one of four ink colours. They were initially shown twenty examples of the four ink colours written in repeated letter strings to familiarize them with the ink colours. They were instructed to ignore the words and make a key-press response to the colour of the ink as quickly and as accurately as possible. If any errors were made they were asked not to correct themselves.

Before conducting the experiment all subjects were given extensive practice. There were two practice sessions which were in fact part of another experiment not reported here. Each practice session involved presenting at least 300 stimuli made up of repeated letter strings, neutral words and emotional words. The words used during the practice session were not repeated in this experiment. This experiment involved presenting 200 stimuli

(100 emotional and 100 neutral words mixed together) and 200 neutral stimuli (two sets of neutral words mixed together). Subjects were informed that real words were going to be presented but were not informed of the emotional nature of these words. All subjects were instructed to ignore the word stimuli and report only the ink colours as quickly and accurately as possible. All responses were made using one of four buttons by positioning the first and second fingers from each hand on top of each of the buttons. Each button was labelled with one of four words written in black ink, BLUE, BROWN, RED and GREEN. Half the subjects received the red and green labels on the left hand and the blue and brown labels on the right hand and the other half in reverse order.

RESULTS

The analysis was carried out on the mean correct reaction time scores. The scores were analyzed in a three-way analysis of variance, with Order a between-subject factor and Emotional class and Block within-subject factors. The analysis showed that there was a main effect of Emotional Class, $F(3,114)=4.96$ $p<0.01$, with no other main or interaction effects reaching significance. Table 3 shows the mean reaction times for the four different types of word stimuli.

Table 3.   Mean reaction times for Emotional and neutral words in Experiment 6.

	Emotional Class			
	Emotional	Neutral	Mixed Neutral	Blocked Neutral
RT	886.94	877.52	903.95	881.47

Tukey Multiple comparison tests showed that the only significant difference was between the Mixed neutral words and all the other three sets of words. For a significant effect the difference in the means must be greater than 16.24 $p<0.05$.

DISCUSSION

There are two important questions that are addressed in Experiment 6. First, do emotional words show any immediate disruptive effects? The comparison of the emotional words with the blocked neutral words shows that there was no difference between the two. This shows that the emotional disruption is not an immediate effect. Second, do emotional words show any lingering effect? This was addressed in two ways. First, by comparing mixed neutral words with blocked neutral words. The results showed that there was a disruptive effect for the mixed neutral words. Second, by comparing the mixed neutral words with the emotional words. It was predicted that if the lingering effect was much larger than the immediate effect then there would be a negative difference between the emotional and mixed neutral words. This prediction was supported by the data.

The results from Experiment 6 are very clear. We have shown that the emotional disruption is a lingering effect with no evidence of an immediate effect. These results are contrary to the implicit assumptions made in most emotional Stroop studies that assume the disruptive effects are immediate effects.

EXPERIMENT 7
IMMEDIATE AND LINGERING EFFECTS

In experiment 6 we discovered evidence suggesting that the emotional disruption is a lingering effect and not a immediate effect. The obvious next question is, what is the pattern of this lingering effect? More precisely, what is the magnitude, length and delay of the lingering effect? From the results of experiment 6 we are not able to determine these parameters. Table 3 shows that the difference between the emotional words and the mixed neutral words is about -17 milliseconds. From Table 2 we can see that a difference of -17 milliseconds could occur if the magnitude of the lingering effect is 40 and the immediate effect is zero. However, this could also occur if the immediate effect is 40 and the magnitude of the lingering effect is greater than 80.

To discover these parameters and to plot out the total pattern of disruption we conducted Experiment 7. The main feature of Experiment 7 is the way in which we *present the emotional and neutral words. During the experiment an emotional word was* always followed by six neutral words. This allowed us to plot the time course of the lingering effect. By presenting six successive neutral words after the emotional word, we are able to observe lingering effects which occur during these six positions. For example, a lingering effect that has values of length from one to six and delay of one can be observed. This design also enables us to observe the pattern of disruption for individual emotional stimuli. Thus we are now able not only to make general conclusions about emotional words but also to make specific conclusions about the pattern of disruption for individual stimuli. For example, are there some emotional words which do not show a disruptive effect and, is the pattern of disruption the same for all emotional words.

METHOD

Subjects

Forty-eight university of Reading undergraduates volunteered to take part in the study for which they were paid.

Design

The design formed a 2 X 2 X 7 X 5 factorial model with Order as a between subject factor and Emotional Class, Position and Words as within-subject factors. In the emotional sequence the seven positions contained an emotional stimulus (E) in the first position followed by a sequence of six neutral stimuli (N1-N6) which were counterbalanced. In the neutral sequence the first position contained a neutral stimulus (N) followed by a sequence of six neutral stimuli (N1-N6).

When an emotional (or neutral) word was presented this was followed by the appropriate matched sequence of neutral words (N1-N6). There were five such sequences, one for each emotional or neutral word, see Table 4. The five emotional sequences were repeated six times with a different order for the sequence N1-N6, thus there were 30 different sequences. The sequence N1-N6 was counterbalanced to control for any position effects. These 30 sequences were presented in a completely random order to each subject, hence there were 210 stimuli. The same design was followed for the neutral sequence, which acted as a control. Each of the words in the neutral and emotional sequences were written in one of four ink colours, red, green, blue, and brown. The colours were assigned randomly to each word across all the subjects with the restriction that the same colour did not repeat itself on consecutive trials.

Materials

The words used in the experiment were all written in capital letters and are presented in Table 4. The emotional and neutral words were matched for word length and word frequency using Kucera & Francis (1967)[34].

Table 4. Shows all the stimuli used in Experiment 7.

Emotional words followed by a sequence of six neutral words.

		POSITION				
E	N1	N2	N3	N4	N5	N6
FAIL	GATE	CORE	FOAM	WASH	PLOT	CREW
FEAR	NOTE	FARM	EASY	LEAD	WIDE	GAME
CRASH	CLOCK	NEWER	AWAKE	SLIDE	SAUCE	CHEEK
GRIEF	THUMB	FLOCK	MERGE	PASTE	BATON	DITCH
DEATH	FIELD	SHALL	TODAY	TAKEN	WHOSE	QUOTE

Neutral words followed by a sequence of six neutral words.

		POSITION				
N	N1	N2	N3	N4	N5	N6
WEAR	COPY	KNEE	ATOM	PUSH	HOST	MYTH
STEP	SIZE	LIST	DEAL	FIRM	NONE	ROLE
COACH	AIMED	CHEAP	DRAFT	CYCLE	MOTEL	SWING
JUICE	GLAZE	ARRAY	MOIST	OVERT	SHAFT	FLUSH
CLOSE	HEARD	KNOWN	SOUTH	BOARD	VOICE	CLEAR

Procedure

The task involved presenting a single colour-word at the centre of a white coloured screen using a Victor V286A pc computer. Each stimulus remained on the screen until a response was made. Following the subjects' response the next stimulus was presented immediately.

The subjects were introduced to the task as a colour perception task in which they would be presented a word in one of four ink colours. They were initially shown twenty

examples of the four ink colours written in repeated letter strings to familiarize them with the ink colours. They were instructed to ignore the words and make a key-press response to the colour of the ink as quickly and as accurately as possible. If any errors were made they were asked not to correct themselves.

Before conducting the experiment all subjects were given two practice sessions. Each practice session involved presenting 200 stimuli made up of different repeated letter strings. The experiment involved presenting 210 words in the emotional sequence and 210 words in the neutral sequence. Subjects were informed that real words were going to be presented but were not informed of the emotional nature of these words. All subjects were instructed to ignore the word stimuli and report only the ink colours as quickly and accurately as possible. All responses were made using one of four buttons by positioning the first and second fingers from each hand on top of each of the buttons. Each button was labelled with one of four words written in black ink, BLUE, BROWN, RED and GREEN. Half the subjects received the red and green labels on the left hand and the blue and brown labels on the right hand and the other half in reverse order.

The order of presentation of the neutral and emotional sequences was counterbalanced such that half the subjects were presented the order emotional then neutral and the other half the order neutral then emotional. There was a short break before presenting the next sequence, either emotional or neutral.

RESULTS

The analysis was carried out on the mean correct reaction time scores. The scores were analyzed in a four-way analysis of variance, with Order a between-subject factor and Emotional class Word and Position within-subject factors. The analysis showed that the interaction between Emotional Class and Position, $F(6,276) = 4.61$ $p < 0.001$, was significant. Figure 3 shows the mean reaction times for this interaction.

Simple main effects analysis revealed that there was a simple main effect of emotional class at position 2, $F(1,276) = 19.10$ $p < 0.001$, and position 7, $F(1,276) = 4.07$ $p < 0.05$, all other comparisons had F values that were less than 2.1, $p > 0.05$.

Figure 3. The pattern of emotional disruption.
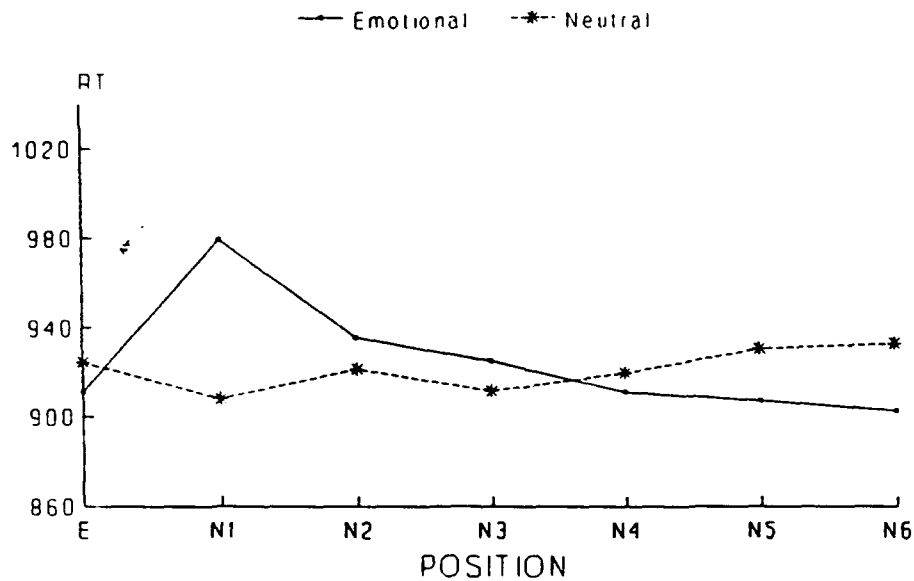
Although this is the general pattern of results there was however, a three-way interaction between emotional class, position and words, $F(24,1104) = 1.67$ $p < 0.03$, which modifies these general results. The means for this interaction are presented in Figure 4.

Simple main effects analysis showed that for the words FAIL and DEATH there was a significant main effect of emotional class at position 2 ($F(1,1104) = 14.64$ and 8.59 respectively for fail and death, $p < 0.005$), but not at any of other six positions (all F values are less than 3.77, $p > 0.1$). For the word GRIEF there was a significant main effect of emotional class at position 2 ($F(1,1104) = 6.99$, $P < 0.01$) and positions 5 ($F = 4.23$, $P < 0.05$), 6 ($F = 4.73$, $p < 0.05$) and 7 ($F = 21.20$ $p < 0.001$). This result for the word GRIEF at positions 5, 6 and 7 we cannot explain. This result is strange because firstly, we would not expect any difference between two sets of neutral words in these positions and secondly, these same words show no effects at positions 3 and 4.

Figure 4: The pattern of disruption for the five words used in experiment 7

FAIL

FEAR

CRASH

GRIEF

DEATH
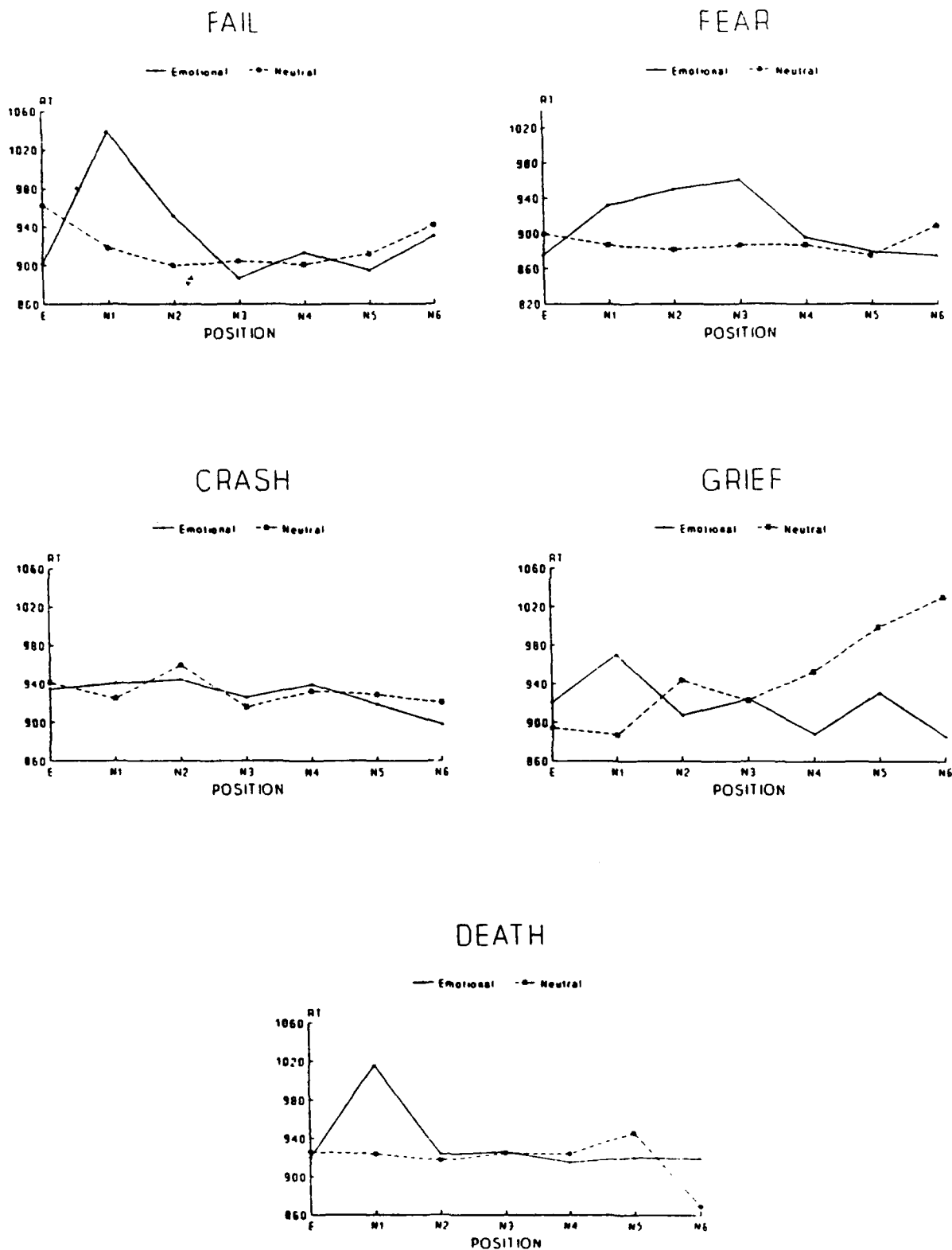
In addition, for the other four sets of words no other set of neutral words shows this pattern at these positions. For the word FEAR there was a significant main effect only at positions 3 ($F(1.1104) = 4.80$, $p < 0.05$) and 4 ($F = 5.65$. $p < 0.025$). For the word CRASH there were no significant main effects of emotional class at any of the seven positions (all F values were less than 0.54, $p > 0.1$).

DISCUSSION

Two important questions are addressed by this experiment. First, do emotional words show any immediate disruptive effects? From the results of Experiment 6 we might predict that there would be no immediate effects. From Figure 3 we can see that the comparison of the emotional words with the neutral control words at position 1 showed no significant differences. Hence there is no immediate effect. Second, do neutral words which follow the presentation of the emotional words show any lingering effects? Figure 3 shows that the emotional disruption can be completely described as a lingering effect. The results from the emotional sequence shows that only the neutral words that immediately follow the emotional words show any disruption. Other neutral words are not significantly different from each other.

The results of Experiment 7 support the results of Experiment 6 in showing that the emotional disruption is not an immediate effect but a lingering effect. In addition Experiment 7 reveals the pattern of the lingering effect. From Figure 3 it can be seen that the lingering effect has a magnitude of about 70 milliseconds with a length of one and a delay of one. From Table 2 we can see that when the lingering effect is of magnitude 70, the predicted emotional disruption is about -28 milliseconds. We can get a more precise prediction by simulating the emotional disruption for a lingering effect of magnitude 70 and length one. It was found that this was -23 milliseconds. This result is compatible with the magnitude of the disruption found in Experiment 6 of -17 milliseconds.

In addition to the general conclusion that emotional words show no immediate effects but do show lingering effects we were able to show that this pattern of disruption may be different for different emotional words. We have shown that for all the five emotional words used in Experiment 7 not one showed any immediate effects. However, this does not mean that other sets of emotional words would not show immediate effects. For the words FAIL, DEATH and GRIEF there was a lingering effect at position 2, whereas for the word FEAR the lingering effect showed a different pattern such that the disruption increased from position 2 to position 4 that is, it has a lingering effect with length two and delay two. The word CRASH showed no disruptive effects.

These results have major implications for the way in which we understand the emotional disruption that is observed in this task and as a consequence the way in which emotional words are processed. If we assume that the disruptive effects are a product of attentional mechanisms such that emotional words capture ones attention more than neutral words then one important implication of the results in Experiments 6 and 7 is that this capturing of attention is not an immediate effect but one that takes some time to develop. In addition the nature and speed with which individual words capture attention

31

can vary with different words. For some emotional words there are no effects whereas for others the emotional lingering is for a longer delay or length. It would therefore be interesting to speculate on the possible reasons why some emotional words show a disruptive effect whereas others do not.

The paradigm that we have developed is designed to observe two effects, either an immediate effect or a lingering effect. As yet we have only found emotional lingering effects. However, it seems possible that there are some stimuli which show immediate effects. Indeed, it is possible to find three different patterns. an emotional lingering effect, an immediate effect or a combined emotional lingering and an immediate effect. If different patterns are observed for different threatening stimuli then it would be of theoretical importance to speculate on possible mechanisms which might produce these different patterns. For example, are these different patterns due to a single mechanism or a number of different mechanisms? One hypothesis for a single mechanism may be one involving speed of activation. This suggests that the most potent threatening stimuli may be activated more quickly than less potent stimuli. Hence, the most potent stimuli will show either immediate effects and lingering effects whereas the less potent stimuli will only show lingering effects. An hypothesis which involves different mechanisms may be one which describes processing in terms of a threat effect and a priming effect. For example, the immediate effect may be due to a mechanism which identifies only threatening stimuli whereas the lingering effect occurs only for stimuli that are primed. One implication of this hypothesis is that this test is sensitive not only to threatening stimuli but also to non-threatening primed stimuli. Although these two hypotheses are not the only ones possible, it does nevertheless show the theoretical importance of using this new paradigm.

EXPERIMENT 8: LIE DETECTOR

INTRODUCTION

In the previous experiments we have shown how the emotional Stroop task has been successfully developed as a tool for observing uncontrolled emotional processing. One major feature of this task is that it indicates that information may be revealed about the salience of particular stimuli even though there is no intent to do so. This task therefore has some properties which are compatible with its use as a lie detector. In our final experiment we investigate the extent to which we can use the emotional Stroop task as a lie detector. The experiment involves asking subjects to behave as if they were spies. They are all given a set of words which they must learn and treat as secret code words. The main hypothesis tested is whether in an emotional Stroop task the secret code words will take longer to colour name than another set of matched control words, even though subjects are given a monetary incentive to ignore the words. The extent to which subjects give longer latencies to secret code words will indicate the extent to which subjects are unable to keep the codes a secret.

METHOD

Subjects

Thirty-two university of Reading undergraduates volunteered to take part in the study for which they were paid.

Design

The design formed a 2 X 2 X 4 factorial model with Order as a between-subjects factor, Instruction and Block as within-subject factors. In each of the four blocks a different set of five neutral words were used. The first five neutral words outlined in the materials section were presented as part of one block, the second five as part of another block and so on. The words presented in the four blocks were counterbalanced across all the subjects, and within each block the word-colour combinations were presented randomly to each subject.

Materials

The words used in the experiment were all randomly selected neutral words. They were written in capital letters and were as follows, Set 1: ABILITY, LANE, BOOK, CAREER, LABEL, MONTH, CEMENT, CLASS, NEWLY, CARGO, MARKET, SCALE, WINDOW, PALACE, RADIUS, QUICK, SALT, CREAM, PAPER, SHAPE. Set 2: COMMAND, ROOT, NEAR, SEARCH, CROWN, CAUSE, EIGHTY, NORTH, CLOUD, ALGAE, GROWTH, NOVEL, MIDDLE, COTTON, CHEESE, DRESS, WAVE, SAUCE, FLOOR, BEGIN. The two sets of neutral words were matched for word length and frequency using Kucera & Francis (1967)[34].

Procedure

All subjects were given the following instruction before conducting the experiment.

"I would now like you to take part in another experiment. This experiment involves you trying to imagine that you are a spy. You will be given a list of 20 secret code words to remember. Once you have learnt these words you must keep these words a secret. That is, not to reveal in any way which are the secret code words. We will then use the computer and the skin conductance meter to try and detect from a long list of words which are the secret code words. If the computer is unable to detect which are the secret code words you will be rewarded by being paid and extra one pound. However, if the computer is able to discover which of the words are the secret code words you will not be paid the extra one pound, and as all spies will be sent to prison as a consequence."

Subjects were next presented with a list of one of the two sets of words, which they were to treat as secret code words. Subjects were asked to learn these twenty secret code words. As an aid for learning and to increase the effect of the instructions, subjects were encouraged to learn the words by trying to relate each word to some theme about spying or espionage. After five minutes of studying these words subjects were asked to free

33

recall as many of the words as they could remember. If a subject was unable to recall a minimum of nineteen words on this first attempt, they were again given the list of words to learn for a further two minutes. This procedure was repeated until the subject was able to recall fifteen words. Almost all subjects were able to do this within two attempts, only two subjects required three attempts to reach this criterion level. The mean of the last attempt at recall was 18.78 with a standard deviation of 1.74. After recall subjects were given a recognition task. The recognition task was made up of the twenty secret code words randomly mixed with another set of twenty randomly selected neutral words that were matched for word length and word frequency. These were presented one at a time on the computer screen. The average number of correct recognition responses was 19.22 with a standard deviation of 0.94. All subjects were informed of the number of correct responses that they had made, both in the recall and recognition tasks.

The lie detector part of the experiment was modelled on the emotional Stroop and hence the procedure was almost identical to it. The task involved presenting a single colour-word at the centre of a white coloured screen using a Victor V286A pc computer. Each stimulus remained on the screen until a response was made. Following the subjects' response the next stimulus was presented immediately. Each of the five control and secret code words were written in four ink colours, red, green, blue, and brown. These twenty stimuli were randomized with one restriction, that the same word or colour did not repeat itself on consecutive trials. This formed one block in the stimulus array, four such blocks were formed to produce 80 stimuli.

Before conducting this experiment all subjects had taken part in two other emotional Stroop experiments prior to this one and hence had extensive practice involving this task.

The subjects were introduced to the task as a colour perception task in which they would be presented a word in one of four ink colours. Before conducting the experiment all subjects were given a practice session with 100 stimuli made up of repeated letter strings of varying length written in one of the four ink colours (the design was identical to the experimental words).

The experiment involved presenting 80 secret code and 80 control stimuli. They were informed that some of the words in the experiment would be the secret code words that they had learned but others would not. However, they were instructed to ignore the words and make a key-press response to the colour of the ink as quickly and as accurately as possible. If any errors were made they were asked not to correct themselves. Subjects were reminded that they would be rewarded with an extra one pound if they were able to ignore the words and behave in exactly the same way to the secret code words and the control words. That is, if the computer was not able to tell the difference between the two sets of words. All responses were made using one of four buttons by positioning the first and second fingers from each hand on top of each of the buttons. Each button was labelled with one of four words written in black ink, BLUE, BROWN, RED and GREEN. Half the subjects received the red and green labels on the left hand and the blue and brown labels on the right hand and the other half in reverse order. Also, for half the subjects the words in set 1 were used as secret code words and the words in set 2 as the control words, whereas for the other half the reverse

order was used.

RESULTS

The analysis was carried out on the mean correct reaction time scores. The scores were analyzed in a three-way analysis of variance, with Order a between-subject factor and Instruction and block as within-subject factors. The analysis showed that the secret codes words took longer to colour name (932.63 msec.) than control words (910.95), $F(1,30) = 8.39$ $p < 0.007$. There was also a main effect of Block, $F(3,90) = 5.79$ $p < 0.001$. The interaction between Instruction and Block did not reach significance, $F(1,30) = 0.5$ $p > 0.4$.

DISCUSSION

The results from this experiment show that the emotional Stroop task has the potential to be used as a lie detector. The results show that when subjects treat a set of randomly selected neutral words as secret code words their colour naming latencies are longer than a control set of words. This is further demonstrated by the fact that 24 of the 32 subjects (that is seventy-five percent, $p < 0.01$ on a sign test) showed longer response latencies to the secret code words than the control words. We have therefore demonstrated that most subjects are not able to consciously control the processing of the secret codes to a level where these stimuli would show no disruptive effects, even when given monetary incentive to do so. That is, what we are observing are processes that are uncontrolled.

Two hypotheses can be put forward to explain these results. Firstly, the disruptive effect of the code words could be due to the fact that the neutral control words were made to behave like emotional words because subjects were asked to keep these words a secret. That is, the instructions in some way make the neutral words emotionally charged. Secondly, the disruptive effects could be due to repetition priming effects. That is, words that have been exposed prior to the task will show a disruptive effect because they have been pre-activated.

If priming effects can completely explain the disruption found in this task, then there are further far reaching implications as a result. One important implication is whether these priming effects are purely a result of stimulus exposure or due to more elaborate higher level priming. This could be easily tested in a levels of processing manipulation. The subjects could be asked to make a decision about a certain characteristic of the stimulus. Half the subjects are asked to count the number of phonetic features (low level decision), whereas the other half are asked to make a liking judgement (high level decision) to the stim   It is predicted that if stimulus exposure is the critical feature for the disruption, then both the high and low level decision conditions will produce a disruptive effect since they are both exposed equally. However, if the priming effect occurs at a higher level of processing then only the high level decision condition will show any disruptive effects. Clearly this would have major implications for any theory which describes the mechanisms by which humans deal with threat.

35

CONCLUSIONS AND RECOMMENDATIONS

In this report we have been largely concerned with developing a laboratory model to allow us to test hypotheses concerning the disruptive effects of emotional stimuli. The research outlined assesses the potential of the emotional Stroop task. With the aid of an earlier U.S. Army research contract we had developed and refined the task. We discovered that the task was sensitive to two important elements of stress resistance, threat and habituation. That is, the task is sensitive to the nature of the stimuli, namely that threatening stimuli can be distinguished from non-threatening stimuli and that with stimulus repetition the stimuli show effects of habituation.

In our present contract three findings have emerged that are of major importance.

1. Time pressure and task difficulty.

One of the most important findings from this research programme has been to demonstrate the importance of time pressure and information load on overall performance and the adaptive process which eliminates the emotional interference. When under time pressure and/or high task difficulty there is greater emotional interference than when there is no time pressure or the task is made easy. The important role which time pressure and task difficulty plays in tasks such as this has, up till this point, been unacknowledged. One implication for future research is that researchers should use the more sensitive methods we are now developing. The research also points to two methods of reducing the adverse effects of stress, namely reducing time pressure and information load.

2. Emotional lingering.

The disruptive effects of emotional stimuli under time pressure may be explained by the "emotional lingering hypothesis". It is hypothesized that the emotional stimuli are still being processed after a response has been made. Under no time pressure the processing of the preceding stimulus is completed before the next stimulus is presented. However, when under time pressure the present stimulus is still being processed when the next stimulus is presented and hence the disruption. Using randomized presentations of emotional and neutral stimuli it was found that the neutral stimuli now showed disruptive effects similar to that found with emotional stimuli. The fact that emotional stimuli have an impact not only at the time of exposure but thereafter, is well illustrated in Post-Traumatic Stress Disorder in which a traumatic experience continues to have a disruptive effect on performance long after its exposure. To directly observe the emotional lingering we have just completed a new and exciting experiment in which an emotional stimulus is presented prior to a sequence of neutral stimuli. It was found that there was emotional lingering but only to the first neutral stimulus that followed the emotional stimulus. In addition there were no immediate disruptive effects on the emotional stimulus itself. These results are of great importance because they not only increase the sensitivity of the task under development (because we are now able to observe the emotional disruption for individual stimuli) but for the first time demonstrate the nature

of the emotional disruption, namely, that it is a lingering effect.

3. Lie detector.

One application of our test, which is sensitive to the threatening nature of emotional stimuli, is as a lie detector. As a preliminary study we asked subjects to consider themselves as spies and to learn a randomly chosen set of neutral words which they were to consider as secret code words. Once they had learnt these secret codes they were asked not to reveal them to the computer on which they were to be tested. They were given a monetary incentive if they were able to beat the lie detector. In fact, only eight out of thirty-two subjects were able to beat the lie detector, which is a success rate of seventy-five percent.

In summary, the results from our research programme show that the paradigm that we have developed can be usefully used to study the effects of stress on performance. The data we are now collecting is changing our understanding of the nature of the performance disruption and allowing us to develop a more powerful model of the effects of stress on performance.

Future

The paradigm we have developed is new and the full ramifications of the associated theoretical model have yet to be fully realised. Already our understanding of the performance disruption has been transformed by the finding of an unanticipated pattern of performance disruption. A more clear understanding of the nature of the disruptive effects of threatening stimuli is now beginning to emerge. We would therefore recommend that if we are to understand the fundamental mechanisms of stress, that this general approach and paradigm be considered for further development. The paradigm offers an extremely powerful tool for analyzing the pattern of disruption. At a more detailed level we have now established some contacts that would allow the simultaneous theoretical development in our laboratory while the paradigm could be tested using military personnel going through the more stressful part of their training.

LITERATURE CITED

1. Marshall S.L.A. (1947) Men Against Fire. The Infantary Journal, Washington, D.C.

2. Marks I.M. (1987) Fears, Phobias, and Rituals. OUP.

3. Mandler G. (1975) Mind and Emotion. New York: Wiley

4. Oatley K. & Johnson-Laird P.N. (1987) Towards a Cognitive Theory of Emotions. Cognition and Emotion, 1, 29-50.

5. Horowitz M.J. (1979) Psychological response to serious life events. In V. Hamilton and D.M. Warburton (Eds.) Human Stress and Cognition, Chichester: Wiley.

6. Easterbrook J.A. (1959) The effect of emotion on cue utilization and the organization of behavior. Psychological Review, 66, 183-201.

7. McKenna F.P. (1986) Effects of unattended emotional stimuli on colour-naming performance. Current Psychological Research & Reviews, 5, 3-9.

8. McNally R.J., Kaspi S.P., Riemann B.C. & Zeitlin S.B (1990). Selective Processing of Threat Cues in Posttraumatic Stress Disorder. Journal of Abnormal Psychology, 99, 398-402.

9. Watts F.N., McKenna F.P., Sharrock R. & Trezise L. (1986). Colour naming of phobia-related words. British Journal of Psychology, 77, 97-108.

10. Gotlib I.H. & Cane D.B. (1987). Construct accessibility and clinical depression: A longitudinal investigation. Journal of Abnormal Psychology, 96, 199-204.

11. Ehlers A., Margraf J., Davies S. & Roth W.T. (1988). Selective processing of threat cues in subjects with panic attacks. Cognition & Emotion, 2, 201-219.

12. Mogg K., Mathews A. & Weinman J. (1989). Selective processing of threat cues in anxiety states: a replication. Behaviour Research and Therapy, 27, 317-323.

13. Hope D.A., Rapee R.M. & Heimberg R.G. (1990). Representations of the self in social phobia: Vulnerability to social threat. Cognitive Theary and Research, 14, 177-189.

14. Williams J.M.G. & Broadbent K. (1986). Distraction by emotional stimuli: Use of a Stroop task with suicide attempters. British Journal of Clinical Psychology, 25, 101-110.

15. Foa E.G. & Kozak M.J. (1986) Emotional processing of fear: Exposure to corrective information. Psychological Bulletin, 99, 20-35.

16. Rachman & Levitt (1988). Panic, fear reduction and habituation. Behaviour Research and Therapy, 26, 199-206.

17. Watts (1979). Habituation model of systematic desentization. Psychological Bulletin, 86, 627-637.

18. Edland A. (1989) On cognitive processes under time stress: A selective review of the literature on time stress and related stress. Reports from the Department of Psychology, University of Stockholm, Supplement series no. 68.

19. Mross E.F. & Hammond K.R. (1990) The effects of stress on judgement and decision making: An annotated bibliography. cited in

20. Miller J.G. (1960) Information input overload and psychopathology. American Journal of Psychiatry, 116, 695-704.

21. Wright P. & Weitz B. (1977) Time horizan effects on product evaluatuion strategies. Journal of Marketing Research, 14, 429-443.

22. Wallsten T.S. & Barton C. (1982) Processing probabilistic multidimensional information for decisions. Journal of Experimental Psychology: Learning, Memory and Cognition, 8, 361-384.

23. Payne J.W., Bettman J.R. & Johnson E.J. (1988) Adaptive strategy selection in decision making. Journal of Experimental Psychology: Learning, Memory and Cognition, 14, 534-552.

24. Wright P. (1974) The harassed decision maker: Time pressure, distraction and the use of evidence. Journal of Applied Psychology, 59,555-561.

25. Ben Zur H. & Breznitz S.J (1981) The effect of time pressure on risky choice behavior. Acta Psychologica, 47, 89-104.

26. Svenson O., Edland A. & Slovic P. (1990) Choices and judgments of incompletely described decision alternatives under tme pressure. Acta Psychologica, 75, 153-169.

27. Ben-Tovim D.I., Walker M.K., Fok D. & Yap E., (1989). An adaptation of the Stroop Test for measuring shape and food concerns in eating disorders: A quantitative measure of psychopathology. International Journal of Eating Disorders, 8, 681-687.

28. Channon S. & Hayward A. (1990). The effect of short-term fasting on processing of food cues in normal subjects. International Journal of Eating Disorders, 9, 447-452.

29. McKenna F.P. & Sharma D. (in preperation) Uncontrolled emotional processing: An examination of the Emotional Stroop effect.

30. Richards A. & Millwood B. (1989). Colour-identification of differentially valenced words in anxiety. Cognition and Emotion, 3, 171-176.

31. Martin M., Williams R.M. & Clark D.M. (1991). Does anxiety lead to Selective Processing of Threat-Related Information? Behaviour Research and Therapy, 29, 147-160.

32. Gotlib I.H. & McCann C.D. (1984). Construct accessibility and depression: an examination of cognitive and affective factors. Journal of Personality and Social Psychology, 47, 427-439.

33. Foa E.B., Feske U., Murdock T.B., Kozak, M.J. & McCarthy, P.R. (1991). Processing of Threat-Related Information in Rape Victims. Journal of Abnormal Psychology, 100, 156-162.

34. Kucera H. & Francis W (1990). Computational Analysis of Present-day American English. Providence: Brown University Press.

35. Cochran W.G. & Cox G.M. (1957) Experimental designs (2nd ed). New York: Wiley.

36. Yerkes R.M. & Dodson J.D. (1908) The relation of strength of stimulus to rapidity of habit-formation. Journal of Comparative and Neurological Psychology, 18, 459-482.

37. Strauss E. (1983) Perception of emotional words. Neuropsychologia, 21, 99-103.

38. Williamson S.E., Harpur T.J. & Hare R.D. (1989) Abnormal Processing of affective words by psychopaths. Submitted.

39. Challis B.H. & Krane R.V. (1988) Mood induction and the priming of semantic memory in a lexical decision task: Asymmetric effect of elation and depression. Bulletin of the Psychonomic Society, 26, 309-312.

40. Green M. & McKenna (in preperation) Making lexical decisions about eating related words.

41. Bray D.E. (1984) Influence of hedonic tone on lexical decisions. Current Psychological Research and Reviews, 3, 63-69.

42. Clark D.M., Teasdale J.D., Broadbent D.E. & Martin M. (1983) Effect of mood on lexical decisions. Bulletin of the Psychonomic Society, 21, 175-178.

43. Willianms L.J. & Evans J.R. (1980) Evidence of perceptual defence using a lexical decision task. Perceptual and Motor Skills, 50, 195-198.

44. Scarborough D.L., Cortese C. & Scarborough H.S. (1977) Frequencey and repetition effects in lexical memory. Journal of Experimental Psychology: Human Perception and Performance, 3, 1-17.

45. Whaley C.P. (1978) Word-nonword classification time. Journal of Verbal Learning and Verbal Behavior, 17, 143-154.

46. Balota D.A. & Chumbley J.L. (1984) Are lexical decisions a good measure of lexical access? The role of word frequency in the neglected decision stage. Journal of Experimental Psychology: Human Perception and Performance, 10, 340-357.

47. MacLeod C. & Mathews A. (in perperation) Biased cognitive operations of anxiety: Accessibility of information or assignment of processing priorities?

48. Williams J.M.G., Watts F.N., MacLeod C. & Mathews A. (1988)   Cognitive Psychology and emotional disorders. John Wiley & Sins Ltd.

920429