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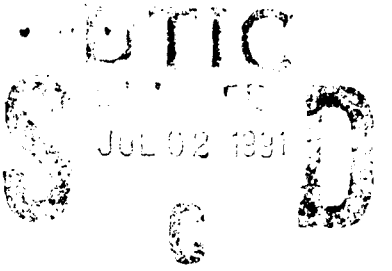

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Predicting Performance Breakdown in Pilots Through Objective Measures of Stress Sensitivity: Annual Report

Frank P. McKenna and Dinkbar Sharma

University of Reading

for

Contracting Officer's Representative
Milton Katz

Office of Basic Research
Michael Kaplan, Director

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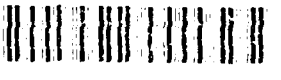

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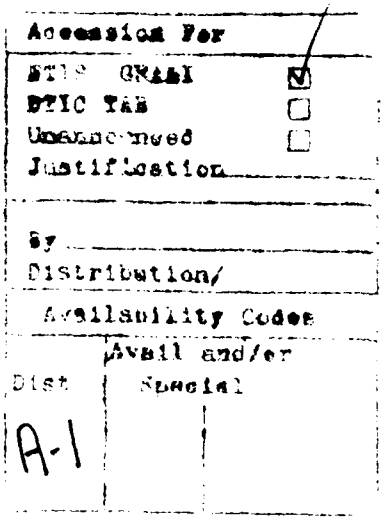

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While the adverse effects of stress are widely recognized, researchers have difficulty n developing appropriate measures. Previous research has rested heavily on subjective easures. The present approach is based on development of a simple objective performance-ased measure. By showing that emotional stimuli disrupt performance, the basis of a test f stress resistance is formed. Major progress has been made by putting the test on a omputer, where a more detailed investigation reveals that (1) the performance decrement ue to emotional stimuli occurs early in the test, and (2) the time pressure results in arge fatigue effects. Both these findings have implications for future developments of he test.

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PREDICTING PERFORMANCE BREAKDOWN IN PILOTS THROUGH OBJECTIVE MEASURES OF STRESS SENSITIVITY: ANNUAL REPORT

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PREDICTING PERFORMANCE BREAKDOWN IN PILOTS THROUGH OBJECTIVE MEASURES OF STRESS SENSITIVITY: ANNUAL REPORT

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 result in general performance decrements. Horowitz (1979)[2] has found that problems in concentration and paying attention occur and these alone could account for performance decrements. 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. The long term aims of this project is therefore to develop a test which will allow the assessment of individual differences and result in a measure of stress resistance.

Recent investigations into the disruptive effects of emotion on performance have moved away from using projective tests (Neiman, 1971)[3] or personality questionnaires such as Spielberger's Trait Anxiety and the Neuroticism scale of the Eysenck Personality Inventory because they are prone to self presentation biases and can be difficult to score, McKenna (1985)[4]. In an attempt to use a simpler less subjective technique McKenna (1986)[1] used a variant of the Stroop Test (Stroop, 1935)[5] in which subjects are asked to name the colour of ink in which an item is printed while trying to ignore the item itself. The items used are either emotional stimuli (death, crash) or emotionally neutral stimuli (field, clock) which are used as controls. It was found that in two groups, pilots and bus drivers, subjects take longer to name the colours when the items are emotional than when neutral, even though they are asked to ignore the words. This task has also been successfully applied (using emotional words that are appropriate to the group) in a number of clinical groups: spider phobic's (Watts et al, 1986)[6], anxious groups (Mathews & MacLeod, 1985)[7], panic attack patients (Ehlers et al, 1988)[8], depressed groups (Williams & Nulty, 1986; Gotlib & McCann, 1984)[9,10], and over-dose patients (Williams & Broadbent, 1986)[11]. One implication of these results is that it shows that the emotional stroop task is sensitive to group (or individual) differences, that is groups (or individuals) who have a particular emotional problem can be detected if words that are specific to their problem are used. Although these studies have provided important replications and extensions to the emotional stroop task, the task itself is little studied and understood.

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. It has been

suggested by McKenna (1986)[1] that the effects of emotional stimuli are generally disruptive on performance and that these effects take some time to decay. Ehlers et al (1988)[8] on the other hand, have suggested that the emotional effects build up with time and has speculated on a possible association with attentional mechanisms. Such hypotheses pose important questions about the nature and the time course of the emotional effects. Do the disruptive effects of emotional stimuli build up or diminish over time? This would not only be of theoretical importance but also have a number of paractical benefits. For example, as a tool for observing the effects of therapy or training, and as a tool for the selection of individuals who are put under situations of stress.

EXPERIMENTS 1 AND 2

INTRODUCTION

The way in which the emotional stroop task is administered varies in detail from one experiment to another. The general method involves presenting two cards on which are written a set of 100 words in a 10 x 10 matrix in various ink colours. On one of the cards is printed a set of emotional (E) words and the other card a set of neutral (N) words. The dependent measure is the overall time to colour name all 100 stimuli on each card. Most experimenters present the two cards in one order, the neutral words before the emotional words (ie. order NE). However, in one study where order effects were reported, McKenna (1986)[1], it was found that when the neutral words were presented before the emotional words (order NE), the emotional words took longer to colour name than the neutral words whereas with the order EN there was no difference. This result goes against a simple account of practice effects since it would predict a larger difference between the words in the order EN than NE. McKenna (1986)[1] has suggested an alternative hypothesis involving two assumptions to account for the order effects. Firstly, that emotional words disrupt colour naming performance compared to neutral words (which accounts for the emotional stroop effect). Secondly, that the disruptive effects of emotional stimuli take some time to decay and therefore slow the colour naming of neutral words (which accounts for the result that neutral words take longer to colour name when they are presented in the order EN than NE, and also why there is no difference with the emotional words).

In all experiments conducted on the emotional stroop effect subjects are asked to make a vocal response. It can therefore be asked whether a vocal response is necessary for this effect. The effect of the response modality on performance in the classic Stroop task (using colour words rather than emotional words) has been studied by Simon & Sudalaimuthu (1979)[12] and recently by McClain (1983)[13] and Virzi & Egeth (1985)[14]. It is found that with a vocal response the time taken to say the colour of the ink

is longer if the ink colour and word are incompatible than when compatible, whereas if subjects ignore the ink colour and say the word then there is no difference between the incompatible and compatible stimuli. However, if a key-press response is required then the effects are reversed, the difference between the incompatible and compatible stimuli is larger when subjects ignore the ink colour and respond to the word. These results therefore suggest the relative importance of response modality in any stroop-like effects.

The emotional stroop effect shows that emotional words produce longer colour naming latencies than neutral words. In order to explain this effect it could be suggested that emotional words require more attentional resources, or are given a higher priority for processing, than neutral words. One implication of assuming an attentional bias to emotional stimuli is that it predicts that emotional words will be remembered more than neutral words.

In Experiment 1 we try to replicate the results of McKenna (1986)[1] using a vocal response and as an extension also use a key-press response. At the end of the experiment subjects are given an unexpected memory task to free recall all the words presented in the emotional stroop task.

Theoretically the recall data can be accounted for by the operation of two effects, a recency effect in which those stimuli presented last are recalled best and an emotional effect in which emotional stimuli are recalled more effectively than neutral stimuli. These effects can operate in opposition or in an additive manner. For example, when the emotional words are presented after the neutral words (NE) we would expect the emotional stimuli to reflect a recency and an emotional effect, whereas the neutral words reflect neither. However, when the neutral words are presented after the emotional words (EN) we would expect the neutral words to reflect only a recency effect and the emotional words to reflect only an emotional effect. In this case three outcomes are possible, if the emotional and recency effects are equally effective in aiding recall then no difference is expected. If the emotional effect is more effective than the recency effect in aiding recall then we would expect the emotional words to be recalled more often than the neutral words, whereas if the recency effect is more effective than the emotional effect then the neutral words are recalled more often than the emotional words.

Experiment 2 was conducted to replicate and generalize our findings in Experiment 1 by using a different experimental design.

METHOD

Subjects. Forty-eight University of Reading students took part in each of the two experiments, Experiments 1 and 2, 24 in the vocal response condition and 24 in the key-press response condition.

Design. The design for Experiment 1 formed a 3 X 2 X 2 factorial model with the Emotional Class condition (letter strings, neutral or emotional) a within-subjects factor, Type of Response (vocal or key-press) and Order (Neutral presented before emotional, NE, and emotional presented before neutral, EN) between-subject factors. In Experiment 2 the design formed a 2 X 2 X 2 factorial model with the Emotional Class condition (neutral or emotional) a within-subject factor, the type of response and Order between-subject factors. The stimulus conditions were all completely counterbalanced.

Materials. The words and letter strings used were all written in capital letters as follows. Letter strings: OOOOO, XXXX, HHHH, SSSSS and PPPPP. Neutral words: CLOCK, GATE, NOTE, THUMB and FIELD. Emotional words: CRASH, FAIL, FEAR, GRIEF and DEATH. The neutral and emotional words were taken from McKenna (1986)[1], which were equated for word length and frequency (Kucera & Francis, 1967)[15].

Procedure. Each of the five words and five letter strings were written in four different 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 which were presented on a computer screen (270 cm X 200 cm) in a 10 X 10 matrix on a white background.

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. Subjects were shown 20 letter strings written in these colours to familiarize them with the colours. They were instructed to ignore the words and make a response (vocal or key-press) to the colour of the ink as quickly and accurately as possible. If any errors were made they were to correct themselves before continuing. In the vocal response condition subjects called out each ink colour aloud whereas in the key-press response condition subjects pressed one of four black buttons. All subjects positioned their first and second fingers from their left and right hands on top of each of the buttons. Each black 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 whereas the other half in reverse order.

Before conducting the experiment all subjects were given two practice sessions. In Experiment 1 each session involved presenting a colour word (red, green, blue and brown) written in black ink twenty times in a random order, and presented on the screen as a 10 X 8 matrix on a white background. The experiment involved presenting the emotional class conditions such that before each condition subjects were informed that letter strings

or real words were going to be presented (the difference between the emotional and neutral words was not mentioned to the subjects) however, all subjects were instructed to ignore the word stimuli and report only the ink colours as quickly and accurately as possible. The experimenter measured the time taken for the subjects to respond to 100 stimuli with a stop watch.

There were two main differences in Experiment 2. Firstly, subjects were presented only the neutral and emotional stimuli in the test sessions and secondly, subjects were not given practice on colour words written in black ink but on the letter strings used in Experiment 1.

At the end of the experiment subjects were unexpectantly asked to free recall all the words seen in the experiment. In Experiment 1 subjects were also asked to recall the letter string stimuli.

RESULTS and DISCUSSION.

(A) Analysis of Emotional Stroop.

The analysis was conducted on the total time taken to respond to 100 stimuli for the vocal and key-press response conditions separately.

Comparing Experiments 1 and 2.

The first question asked about the data was, do the different designs used in the two experiments have any influence on the *emotional stroop effect*. That is, are there any interactions between the two experiments (Experiments 1 or 2), and Emotional Class (Neutral or Emotional)? To compare the data of Experiments 1 and 2 a three-way analysis of variance with Experiment and Order as between-subject factors and Emotional Class as a within-subjects factor was conducted. For both the vocal and key-press response conditions there were no main or interaction effects with Experiment, all F values were less than 1. This therefore indicates that the different designs used in the two experiments did not make any difference to the emotional stroop effect.

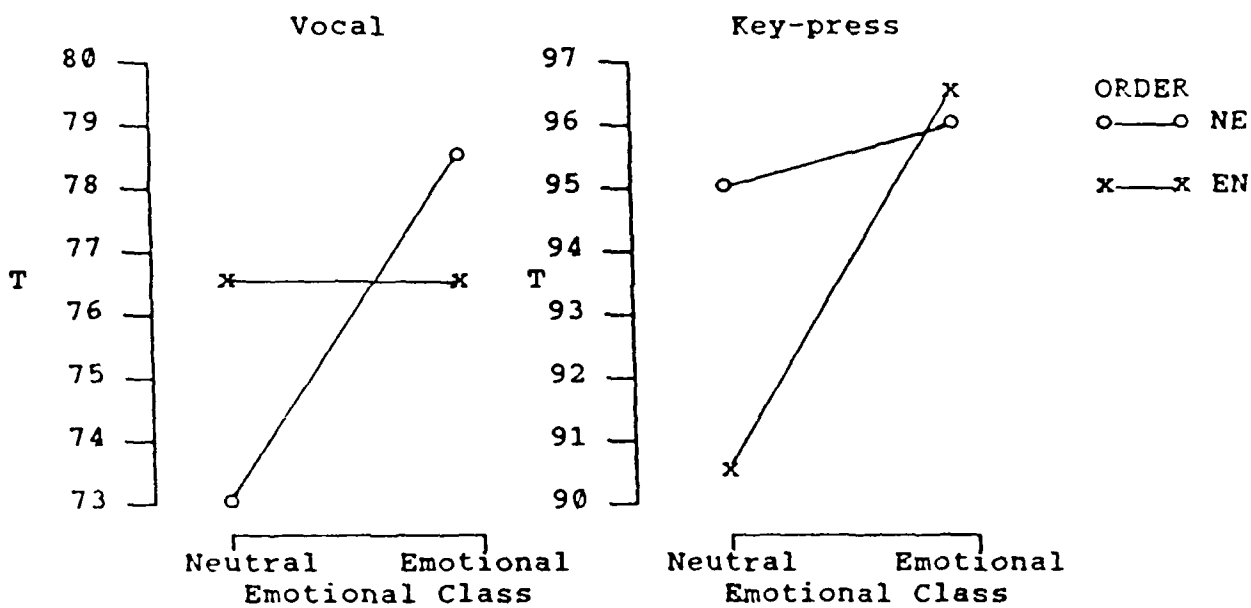
The main question asked in these two experiments is, are there any effects of Emotional Class for the vocal and key-press response conditions?

Vocal response.

For the vocal response condition there was a main effect of Emotional Class, $F(1,44)=6.39$ $p=0.0152$, which indicates that the emotional words took longer to colour name than the neutral words (the emotional stroop effect). However, this interacts with Order, $F(1,44)=7.89$ $p=0.0074$, (see Figure 1). The two-way interaction was further investigated by simple main effects analyses. This showed that the emotional stroop effect occurred when the emotional words followed the neutral words (NE), $F(1,44)=14.24$ $p<0.001$, but not when the neutral words followed the emotional words (EN), $F(1,44)=0.04$ $p>0.1$. Also, when the

emotional words were presented first in the order they took longer to colour name than when presented second, $F(1,44)=6.37$ $p<0.025$, whereas there was no significant difference for the emotional words, $F(1,44)=2.10$ $p>0.1$. The interaction of Emotional Class with Order replicates the findings of McKenna (1986)[1].

Figure 1. Mean time (sec) to respond to 100 stimuli for the emotional and neutral word conditions in Experiments 1 and 2 for the Vocal and Key-press response conditions in the orders NE and EN.



Can these order effects be explained by the effects of practice? If practice was involved in these order effects it would be predicted that when the neutral or emotional words were presented second in the order they would be colour named faster than when presented first. In fact the results go in the opposite direction for the neutral words (which may indicate effects of fatigue) and for the emotional words there is no difference (suggesting that fatigue or practice cannot fully account for the results). McKenna (1986)[1] has suggested an alternative hypothesis involving the general disruptive effects of emotional stimuli. Two assumptions were made to account for the order effects. Firstly, that emotional words disrupt colour naming performance compared to neutral words (which accounts for the emotional stroop effect). Secondly, that the disruptive effects of emotional stimuli take some time to decay and therefore slow the colour naming of neutral words (which accounts for the result that neutral words take longer to colour name when they are presented after the emotional words than before the emotional words, and also why there is no difference with the

Key-press response.

For the key-press response condition there was a main effect of Emotional Class, $F(1,44)=8.20$ $p=0.0064$, indicating that Emotional words take longer to colour name than neutral words. Again the emotional stroop effect interacted with Order, $F(1,44)=4.57$ $p=0.038$, (see Figure 1). Simple main effects analyses suggested that the emotional stroop effect occurred when the emotional words preceded the neutral words (EN), $F(1,44)=15.66$ $p<0.001$, but not when they followed the neutral words (NE), $F(1,44)=0.33$ $p>0.1$. This result is in contrast to the vocal response data which showed the emotional stroop effect for the order NE. Simple main effects also showed that when the neutral words came second in the order they were colour named faster than when they came first, $F(1,44)=7.57$ $p<0.01$, which is in the opposite direction to that found for the vocal response condition. The emotional words showed no significant difference, $F(1,44)=0.07$ $p>0.1$.

These results generalize the findings with the vocal response in showing that emotional words take longer than neutral words to colour name, and extends the results by showing that the effects of order are reversed for a key-press response compared to a vocal response. While the key-press data supports McKenna's (1986)[1] argument that emotional stimuli disrupt performance, the present results refute McKenna's proposed explanation of the order effect since, for the key-press data the order effects are reversed.

(B) Analysis of free recall.

The analysis of the data was conducted on the Freeman-Tukey Arc-Sine Transform scores of the number of correctly recalled words. A four-way analysis of variance with Experiment, Order and Type of Response as between-subject factors and Emotional Class a within-subject factor. The main question asked here is, are there any effects of Emotional Class on the frequency with which words are recalled?

The analysis showed (i) that there was no main effect of Experiment, $F(1,88)=1.29$ $p>0.2$, which indicates that the two experiments did not differ in the number of words recalled. (ii) No main or interaction effect with the Type of Response, all F values are less than 2.64 $p>0.1$, indicating that subjects in the key-press and vocal response conditions did not differ in the pattern of their results. (iii) A main effect of Emotional Class, $F(1,88)=10.97$ $p=0.0013$, which showed that emotional words are more effectively recalled than neutral words. However, this interacted with Order, $F(1,88)=12.27$ $p=0.0007$ (see Table 1).

Table 1. Shows the proportion of words recalled in Experiments 1 and 2 for the emotional and neutral word conditions in the two orders, NE and EN.

Memory Task	Order	Emotional Class	
		Neutral	Emotional
Free Recall	NE	0.21	0.45
	EN	0.33	0.33

Simple main effect analyses showed that emotional words were more effectively recalled than neutral words in the order NE, $F(1,88)=23.22$ $p<0.0001$, whereas this was not significant for the order EN, $F(1,88)=0.02$ $p>0.1$, which suggests that the emotional and recency effects are equally effective in aiding recall. Simple main effects also showed effects of recency, such that when the emotional or neutral words were presented second in the order they were more effectively recalled than when they were presented first in the order, $F(1,88)=4.25$ and 8.37 respectively, $p<0.05$.

One other effect that reached significance was the Experiment x Emotional Class interaction, $F(1,88)=4.46$ $p=0.04$ (see Table 2),

Table 2. Shows the proportion of words recalled in Experiments 1 and 2 for the emotional and neutral word conditions.

Experiment	Emotional Class	
	Neutral	Emotional
1	0.29	0.33
2	0.26	0.43

which suggested that emotional words were recalled more often than neutral words in Experiment 2 (simple main effect of Emotional Class, $F(1,88)=14.71$ $p<0.001$) than Experiment 1 (simple main effect, $F(1,88)=0.72$ $p>0.1$). Also, more emotional words were recalled in Experiment 2 than Experiment 1 (simple main effect of Experiment, $F(1,88)=5.81$ $p<0.05$) whereas there was no difference for the Neutral words (simple main effect, $F(1,88)=0.33$ $p>0.1$). The difference in the number of emotional words recalled in the two experiments can be attributed to the different designs used to present the stimuli. In Experiment 1 three types of stimuli were presented, Letter strings, Neutral words and Emotional words, which were completely counterbalanced. However, in Experiment 2 only Neutral and Emotional words were

presented (orders NE and EN).

EXPERIMENT 3

INTRODUCTION

The two main results from Experiments 1 and 2 are that, firstly, both vocal and key-press responses show effects of emotional stroop, that is, emotional words take longer to colour name than neutral words; and secondly, that emotional words are more effectively recalled than neutral words. Thus, the main conclusion to be drawn from these results is that emotional words are processed in a different way from neutral words which is indexed by a colour naming task and a free recall memory task. One major problem in making this conclusion is that it suggests that all emotional words show effects of emotional stroop. It is therefore of clear importance to know whether all or some of the emotional words used in Experiments 1 and 2 have an emotional stroop effect. The emotional stroop task, as it has been used, does not allow us to make this observation since the dependent measure often used is the total time taken to colour name 100 stimuli. Gotlib & McCann (1984)[10] have conducted such an experiment and found that a group that was classified as depressed took longer to colour name emotional words that were specific to depression as compared to neutral or positive words. No results were however presented for individual words.

The next step in the investigation was a finer grained analysis to observe the effects of individual words in the emotional stroop effect. Once we are able to measure the reaction time to individual words it is possible to investigate other theoretical issues. It has been suggested by Ehlers et al (1988)[8] that the interfering effects of emotional words on colour naming could be a result of various attentional disturbances. This is highlighted by the fact that emotional stroop effects have been found in a number of clinical groups with words that are specific to that group, suggesting that emotional words are more effective in capturing attention and hence disrupting colour naming performance, Williams et al (1988)[16]. One implication of such an effect is the length of time for which the emotional stroop effect operates. For example, does the effect last for just one presentation of the stimulus or does it last for many, and if so how many. Also the nature of the effect can be investigated: does the effect steadily increase, does it take time to develop or does it decrease? Ehlers et al (1988)[8] for example, have suggested a flagging attention hypothesis in which the emotional stroop effect increases with time. It is suggested that over time responses get slower, indicating that subjects pay less attention to the colour naming task (the flagging attention hypothesis). It is suggested that part of the reason for this flagging attention is the greater demand on attentional resources by the emotional stimuli, therefore it is hypothesized that this

will lead to a greater disruption of the colour naming task by the emotional stimuli. Such questions were addressed in Experiment 3.

METHOD.

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

Design. The design formed a 2 X 2 factorial modal with Emotional Class (Neutral or Emotional words) as a within-subject factor and Order (NE or EN) a between-subject factor.

Materials. The words used in the experiment were all written in capital letters and were as follows, Neutral words: CLOCK, GATE, NOTE, THUMB and FIELD. Emotional words: CRASH, FAIL, FEAR, GRIEF and DEATH. In the practice session repeated letter strings were used: OOOOO, XXXX, HHHH, SSSSS and PPPPP.

Procedure. The emotional task involved presenting a single word at the centre of the screen. Each stimulus remained on the screen until a response was made and the next stimulus presented immediately, that is the interstimulus interval was 0 sec. Each of the five neutral or 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 which were presented sequentially in the centre of the computer screen (270 cm X 200 cm) on a white background.

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 shown 20 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 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 using 100 coloured letter string stimuli. The experiment involved presenting 100 emotional or 100 neutral stimuli. Subjects were informed that real words were going to be presented (the difference between the emotional and neutral words was not mentioned) however, 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 black buttons by positioning the first and second fingers from the left and right hands on top of each of the buttons. Each black 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 whereas the other half in reverse order.

At the end of the experiment subjects were unexpectantly asked to free recall all the words seen in the experiment.

Hence the design and procedure was identical to Experiment 2 except that in Experiment 3 there was only a key-press response and that the stimuli were not presented on a 10 x 10 matrix simultaneously but sequentially in the centre of the screen. Also subjects were asked not to correct their errors if any were made.

RESULTS AND DISCUSSION

(A) Analysis of Emotional Stroop.

Subjects reaction time (in milliseconds) to each stimulus was recorded. The scores were analyzed in a four-way analysis of variance, with Order (NE or EN) a between-subject factor, Emotional Class (neutral or emotional), Block and Words as within-subject factors. Block refers to the way in which the stimuli were presented. One block involves a random presentation of the 20 stimuli (5 words x 4 ink colours), and Words refers to the five emotional or neutral words. This design was chosen so that the time course of the emotional stroop effect could be investigated. Note that this design is exactly the same for Experiments 1 and 2.

The analysis showed that emotional words took longer to colour name (910.52 msec) than neutral words (890.85 msec), $F(1,42)=6.92$ $p=0.012$. There was no interaction with Order, $F(1,42)=0.07$ $p>0.1$. This result is in contrast to the Order effects found in Experiments 1 and 2 and indicates that the order effects are partly a function of the type of stimulus presentation (i.e. sequential or simultaneous).

Are there differential effects of emotional stroop for the five words used in this experiment? There were no main or interaction effects with Words, all F ratios are less than 2.19 $p>0.06$, and the Emotional Class x Word interaction was insignificant, $F(4,168)=0.64$ $p>0.6$, suggesting that all the five words showed an emotional stroop effect.

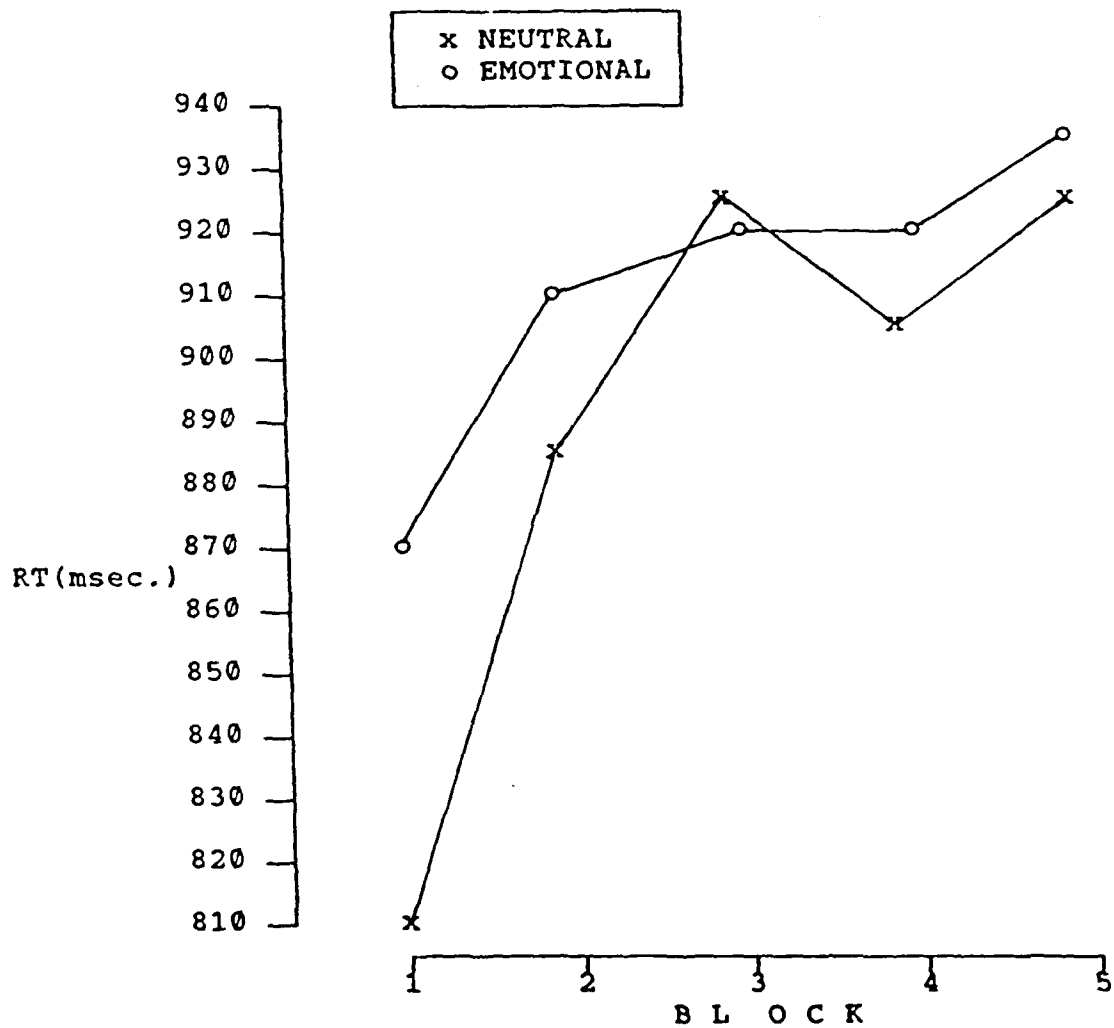
The analysis also showed a main effect of Block, $F(4,168)=17.30$ $p=0.0001$, which indicated that subjects responded faster in the first Block than the other four blocks (means are 842.09, 896.77, 923.05, 912.10 and 929.43 milliseconds for blocks 1 to 5 respectively).

One other effect was marginally insignificant, a two-way interaction between Emotional Class x Block, $F(4,168)=2.35$ $p=0.056$ (see Figure 2). Simple main effects analysis showed that the emotional words took longer to colour name than neutral words on the first block, $F(1,168)=12.74$ $p<0.001$, but not on any of the other four blocks, $F(1,168)< 2.7$. A simple main effect of Block on the neutral and emotional words showed significant effects, $F(4,168)=16.56$ and 4.11 for the neutral and emotional words respectively, $p<0.01$. Tukey multiple comparison tests showed that the response latencies for the first block was significantly

faster than the other four blocks.

It should also be noted that as compared to Experiments 1 and 2 there are no effects of Order in Experiment 3, suggesting that the order effects are a function of the type of display used, that is simultaneous or sequential display presentation.

Figure 2. Mean reaction time of the neutral and emotional words for the five blocks in Experiment 3.



There are two main findings from the emotional stroop task.

(1) Subjects responses for all stimuli get longer across the five blocks and therefore supports the flagging attention hypothesis.

(2) Emotional words take longer to colour name than neutral words, but only on the first block. This suggests that the emotional stroop effect is short lived lasting for just one block. This refutes the suggestion made by Ehlers et al (1988)[8] that a flagging attention is associated with a greater

disruptive effect by emotional stimuli since our data show that the disruptive effects decrease. One alternative explanation for this result is that it may reflect repetition effects. Each block in the experiment contained five words which were presented four times, once in each colour. This therefore suggests that the first block effect is due to a word repetition effect (that is, the effect lasts for only four repetitions of a word) or a class repetition effect (that is, the effect lasts for twenty stimulus repetitions of any one class of word).

(B) Analysis of Free Recall.

The number of neutral and emotional words recalled were transformed using the Freeman-Tukey Arc-Sine Transform. These scores were analyzed in a two-way analysis of variance with Emotional Class a within-subject factor and Order a between-subject factor. This analysis showed that emotional words were recalled more often than neutral words, $F(1,42)=13.69$ $p=0.0006$, and that this interacted with Order, $F(1,42)=4.18$ $p=0.0047$. Simple main effects on the two-way interaction showed that emotional words were recalled more than neutral words for the order NE, $F(1,42)=16.50$ $p<0.001$, but there was no difference for the order EN, $F(1,42)=1.37$ $p>0.1$ (see Table 3).

Table 3. Shows the proportion of words recalled in Experiment 3 for the emotional and neutral word conditions in the two orders, NE and EN.

Memory Task	Order	Emotional Class	
		Neutral	Emotional
Free Recall	NE	0.32	0.54
	EN	0.39	0.45

These results show, as in Experiments 1 and 2, the effect of two factors on recall performance. Firstly, the effect of the emotional class, such that emotional words are recalled more effectively than neutral words, and secondly, the effect of recency, such that those words that are presented last are recalled best. Indeed, an analysis comparing the recall results using the key-press response in Experiments 1 and 2 with Experiment 3 produced no significant differences between the three experiments: the interaction effects with the factor for Experiment, all F ratios were less than 1.2 $p>0.3$. (The main effect of Experiment was marginally insignificant, $F(2,86)=3.06$ $p=0.052$, suggesting that there were more words recalled in Experiment 3 than in Experiments 1 and 2.)

EXPERIMENT 4

INTRODUCTION

The main aim of Experiments 1, 2 and 3 was to investigate whether we could transfer the emotional stroop effect onto a computer and analyze the effects in detail. The success of this was shown in Experiment 3 in which we were able to conclude that all the words used in this experiment produced an emotional stroop effect and that this effect is short lived, such that it lasted for only one block. Experiment 4 was conducted to further simplify the task by using only two response buttons (hence only two colours), and to present the emotional and neutral stimuli in a mixed (random) order rather than a fixed order.

The general aim of this research was to investigate the processing of emotional stimuli. As a result we included a free recall memory task at the end of Experiments 1 to 3, which showed that emotional words were recalled more effectively than neutral words. One reason for this could be that more elaborative processing is conducted with emotional words than neutral words. This is reminiscent of the memory literature in which it is generally found that recall or recognition performance are higher following elaborative or semantic processing than following shallow or nonsemantic processing (e.g. Craik & Tulving, 1975; Hyde & Jenkins, 1973)[17,18]. For many years free recall and recognition tasks have been used to investigate memory processes. One predominant feature of these tests is that they involve subjects recollecting a specific learning episode. However, during the past few years there has been increasing interest in tasks where subjects are asked not to recall a learning episode, but are given partial cues which they have to complete with the first word that comes to mind, for example, a stem completion or fragment completion task. The descriptive terms Explicit and Implicit have been used to describe the forms of memory involved in the recall/recognition tasks and stem completion tasks.

There is now much evidence which shows that implicit and explicit tasks are affected by different variables. One of the most impressive of these is the manipulation of levels of processing (e.g. Graf, Mandler & Haden, 1982)[19]. Graf & Mandler (1984)[20] showed that semantic verses nonsemantic encoding for words (e.g. CLOUD) had little effect on the magnitude of priming on a word completion task in which subjects wrote the first word that came to mind in response to a three letter stem (e.g. _ _ OUD). There were also priming effects such that words presented for study were word completed more than words that were not presented for study. However, the levels of processing manipulation had large effects on an explicit memory task, such as recognition. Graf & Mandler (1984)[20] have therefore suggested that the explicit remembering of recent events depends on the richness of newly created representations, whereas implicit

memory is based on the automatic activation of preexisting memory representations. One implication of the activation hypothesis is that items which are highly integrated can be activated automatically and influence implicit memory performance. Some support for this hypothesis comes from studies which show that (i) nonwords produce less priming than familiar words (Forbach, Stanners & Hochhaus, 1974 but see also Whittlesea & Cantwell, 1987)[21,22], and (ii) newly acquired associations (such as WINDOW-REASON) affect word completion performance (WINDOW-REA____) following elaborative encoding, whereas priming of familiar words is independent of type of encoding (Graf & Schacter, 1985; Schacter & McGlynn, 1989)[23,24].

These results have important implications for the effects of emotional stimuli on explicit and implicit memory tasks. We have already shown in three experiments that emotional words are recalled more than neutral words in an incidental memory experiment. What would be the effects on an implicit memory task? The above discussion suggested that implicit tasks are influenced by items that are highly integrative. This may predict one of two outcomes, firstly, there are no differences between emotional and neutral stimuli since they are both equally familiar or secondly, that since emotional stimuli are more highly integrative than neutral words then emotional words will be reported more often than neutral words in an implicit memory task. Experiment 4 was therefore extended to test this prediction. Thus in Experiment 4 subjects conducted two memory tasks. A recognition memory task in which subjects are presented a list of words, some of which are target words that were presented earlier in the experiment and some distracter words. Subjects are asked to circle those they remember seeing earlier in the experiment. A stem completion task was also presented such that some of the stems could be completed with the words from the experiment (e.g. FEAR for FE_ _). Subjects are asked to complete all the stems with the first word that comes to mind. Half the subjects are presented the recognition task before the stem completion task whereas the other half are presented the tasks in reverse order.

METHOD

Subjects. Forty subjects from the University of Reading took part in Experiment 4.

Design. The design formed a 2 x 2 x 5 x 5 factorial modal with all factors as within-subject factors (Session x Emotional Class x Block x Word).

Materials. The same set of words were used as in Experiment 3. The distracter and control words used for the memory tasks are shown in appendix 1.

Procedure. Each of the ten words were written in one of two ink colours, red and blue. These twenty stimuli were randomized with two restrictions, that the same colour or class of word (emotional or neutral) did not repeat itself on more than two consecutive presentations, and that the same word did not repeat itself on consecutive presentations. This formed one block in the experiment (10 neutral and 10 emotional words), five such blocks were formed so that there were 100 stimuli. This formed the first session of the experiment (Session A), in which all the stimuli were presented sequentially at the centre of the screen. After about thirty to sixty seconds the second session was conducted (Session B) which were the same stimuli as in Session A but with a different random sequence.

The subjects were introduced to the task as a colour perception task in which they would be presented a word in one of two ink colours. They were shown 10 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 accurately as possible. If any errors were made they were asked not to correct themselves.

All responses were made using one of two black buttons by positioning the first finger from the left and right hands on top of each of the buttons. Each black button was labelled with one of two words written in black ink, BLUE and RED. Half the subjects received the red label in the left hand and the blue label in the right hand whereas the other half in reverse order.

Before conducting the experiment all subjects were given two practice sessions using 100 coloured letter string stimuli. The experiment involved presenting 100 stimuli (50 emotional and 50 neutral stimuli in a mixed order). Subjects were informed that real words were going to be presented (the difference between the emotional and neutral words was not mentioned) however, all subjects were instructed to ignore the word stimuli and report only the ink colours as quickly and accurately as possible.

At the end of the experiment subjects were unexpectantly asked to conduct two memory tasks, a recognition and a stem completion task. For the recognition task the 10 words used in the emotional stroop experiment were presented to the subjects with 20 other words as distracters. Four different random orders were produced for the 30 stimuli and presented in a random order to the subjects. The stimuli were presented simultaneously in 3 columns of 10 rows and subjects were asked to circle all the words they remembered seeing in the experiment.

The stem completion task was introduced to the subjects in the following way. "I would like you now to take part in another experiment. This is an experiment that I will be conducting in the future and involves presenting certain types of words to subjects. What I would like you to do is to help me generate some of these words." A stem completion task was then presented in which the first two letters, and blank lines to represent the length of the word, were provided as partial cues and subjects

were asked to complete the stem with the first word that came to mind. However, proper nouns and plurals which ended in an 's' could not be used. 40 stem completions were presented (ten with the same prefixes as the words in the experiment (e.g. DE _ _ _ for DEATH and FI_ _ _ for FIELD), ten were controls that were matched for frequency and number of possible completions as the experimental stimuli, and 20 distracters which were the same as the distracters used in the recognition task. The 40 stimuli were presented on a sheet of paper simultaneously in 10 rows of 4 columns. Four random sets of 40 stimuli were produced and presented to the subjects in a random order. Subjects were given as much time as they need to complete all the stems and could complete the stems in any order. Subjects were encouraged to complete all the stems, which most of them were able to do.

RESULTS

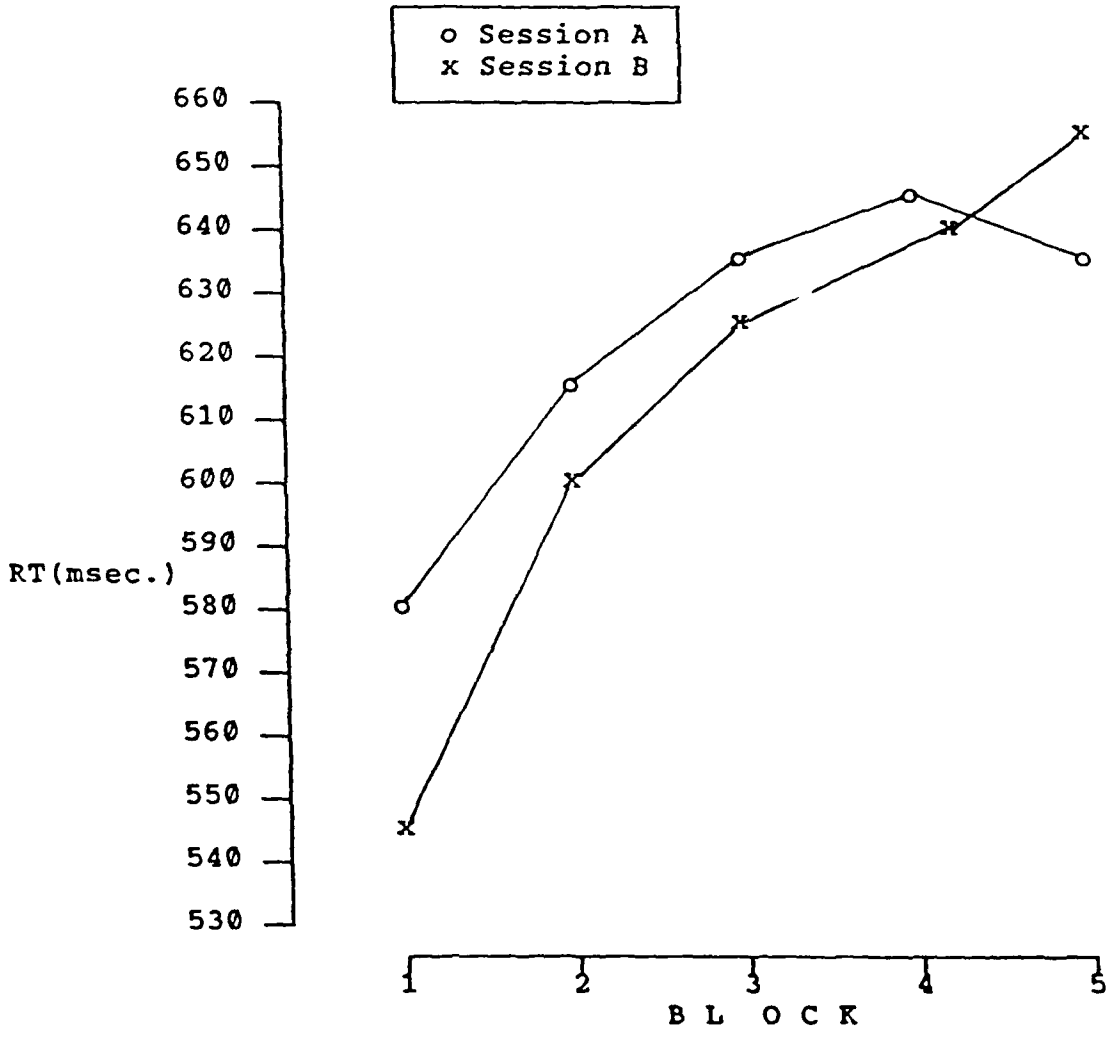
(A) Analysis of Emotional Stroop.

A four-way analysis of variance was conducted with Emotional Class, Session, Block and Words as within-subject factors. The results showed that there was no main effect of Emotional Class, $F(1,39)=0.04$ $p=0.84$, indicating that there was no emotional stroop effect. (Although there was a three-way interaction of Emotional Class x Block x Words, $F(16,624)=1.74$ $p=0.036$, this seemed to be a result of a long reaction time to one of the words in one of the blocks. This conclusion was supported by a second analysis of variance in which all responses greater than 2 seconds were removed. This involved removing 12 responses (0.2% of the data) and showed that the three-way interaction was insignificant, $F(16,624)=1.42$ $p=0.13$).

The main result in Experiment 4 was a Session x Block interaction, $F(4,156)=5.19$ $p=0.006$ (see Figure 3). Simple main effects analyses showed that this interaction was a result of faster reaction times for Session B but only in the first block, $F(1,156)=15.49$ $p<0.001$. Tukey multiple comparisons for Session A showed that blocks 1 and 2 were significantly faster than blocks 3, 4 and 5 which were insignificant from each other. Session B also showed that blocks 1 and 2 were faster than the other three blocks, and also that block 3 was significantly faster than block 5. This result shows that response latencies increase across the five blocks and hence supports the flagging attention hypothesis as in Experiment 3.

The main finding in Experiment 4 is that with a mixed presentation of neutral and emotional words and two responses, there is no emotional stroop effect. Also, across the five blocks subjects responses get slower which is consistent with a flagging attention hypothesis.

Figure 3. Mean reaction time of the two Sessions (A and B) for the five blocks in Experiment 4.



(B) Analysis of Memory tasks.

The number of neutral and emotional words reported in the recognition memory task and the stem completion task was transformed using the Freeman-Tukey Arc-Sine Transform. These scores were analyzed in a three-way analysis of variance, with Emotional Class (emotional or neutral) and Memory Task (recognition, stem completion and stem completion controls) as within-subject factors and Order as a between-subjects factor.

The analysis showed no main or interaction effects of Order which indicates that presenting the recognition or stem completion task first or second has no effect on subjects memory performance. The main result was a two-way interaction between Emotional Class and type of Memory Task, $F(2,76)=11.30$ $p<0.0001$ (see Table 4). Simple main effects of Emotional Class showed that, for the Recognition task more emotional words were

recognized than neutral words, $F(1,76)=11.70$ $p<0.0001$; for the Stem Completion task the emotional words were stem completed less than the neutral words, $F(1,76)=9.44$ $p<0.01$; and for the Stem Completion Control stimuli there was not significant difference in the number of emotional or neutral words completed, $F(1,76)=2.85$ $p>0.1$.

Table 4. Shows probability of reporting an emotional or neutral word in the recognition or stem completion tasks.

	Emotional Class	
Memory Task	Neutral	Emotional
Recognition	0.71	0.84
Stem Completion	0.37	0.25
Stem Completion Controls	0.05	0.12

The results show that although there were no emotional stroop effects on the latency data we did find effects of emotional stimuli on the memory tasks, indicating an interesting dissociation between the type of measure (reaction time or memory performance) and the effects of emotional stimuli. While it is generally supposed that latency is a more sensitive measure of performance than an all or none response such as the recall or failure to recall a word, the present experiment indicates that this is not universally true. The recognition memory task supported the results from Experiments 1 to 3 in showing that emotional words were reported more often than neutral words. The Stem Completion task shows a different pattern of results from the recognition memory task. Specifically it shows that under the implicit memory task emotional words are reported less frequently than neutral words. This is contrary to previous findings which suggest that implicit memory tasks are influenced by items that are highly integrative. This result suggests that emotional words are activated less than neutral words, which may be a reflection of the emotional words decaying faster from priming effects. It could also be argued that emotional words are processed more effectively than neutral words, thus they are primed quicker and decay faster, and that they produce more elaborative processing and therefore are recognised more than neutral words.

EXPERIMENT 5

INTRODUCTION

In general the experiments so far have shown that for the emotional stroop task emotional words take longer to colour name than neutral words. However, as shown in Experiment 3 this only occurs in the first block of the experiment. Experiment 4 has also shown that by using a mixed presentation of emotional and neutral words the emotional effect disappears. Experiments 3 and 4 have both shown that across the five blocks subjects take longer to colour name any word stimulus. This result suggests a flagging attention which is probably a result of the speed with which the task is performed. That is, in Experiments 3 and 4 when subjects made a response the next stimulus came on the screen immediately. Thus one way of reducing this flagging attention is to provide a *longer* interstimulus interval. Experiment 5 was therefore conducted as an identical experiment to Experiment 4 but with an interstimulus interval of three seconds.

The results from the memory tasks have shown a dissociation in the effects of emotional stimuli between the explicit memory tasks (recognition and recall) and implicit memory tasks (stem completion). Recognition and recall show that emotional words are reported more frequently than neutral words and the stem completion task shows that emotional words are stem completed less than neutral words. One problem in making this conclusion is that the stimuli presented under the two tasks were not identical, that is, in the recognition task the full word was presented as a cue for recognition whereas in the stem completion task only the first two letters were presented. It could therefore be argued that this difference in stimulus presentation accounts for the difference in the two tasks. Experiment 5 therefore used an alternative control task to compare the effects of explicit and implicit memory tasks. This involved using a cued stem completion task, in which subjects are presented the identical stimuli as in the stem completion task but are asked to complete only the stems that they thought were presented in the experiment.

METHOD.

Subjects. Forty subjects from the University of Reading took part in Experiment 5.

Design and Procedure. The design and procedure was identical to Experiment 4, the only difference being the rate at which the stimuli were presented. In Experiment 4 the interstimulus interval was 0 seconds, that is, the next stimulus was presented immediately after a response was made to the previous stimulus.

In Experiment 5 the interstimulus interval was 3 seconds.

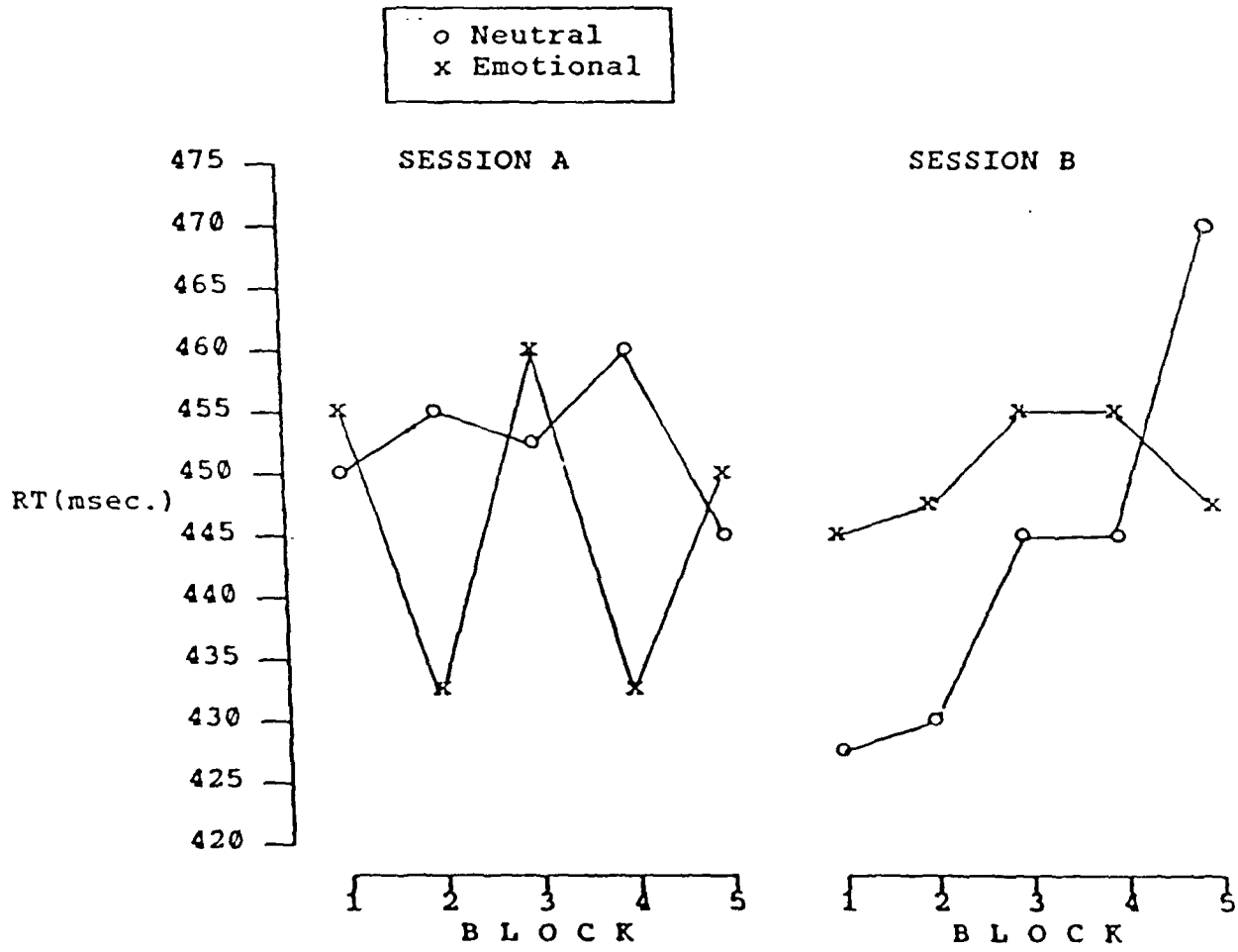
After completing the emotional stroop task half the subjects were presented a cued stem completion task. This involved presenting the same stimuli as in the stem completion task but with the instruction to complete only those stems that they thought were presented in the emotional stroop task. The other half of the subjects were presented the recognition and stem completion tasks in counterbalanced order, with the same instructions as in Experiment 4.

RESULTS.

(A) Analysis of Emotional Stroop.

The analysis revealed a three-way interaction between Emotional Class, Session and Block, $F(4,156)=4.4$ $p=0.0021$ (see Figure 4).

Figure 4. Mean reaction time of the two Sessions (A and B) for the five blocks in Experiment 5.



Simple main effects analysis showed that in Session A emotional words were colour named faster than neutral words but only in

blocks 2 and 4, $F(1,156)=5.60$ and 8.08 respectively $p<0.025$. There was no difference for blocks 1, 3 or 5, $F(1,156)=0.33$, 0.61 and 0.45 respectively $p>0.1$. In Session B emotional words were colour named faster than neutral words but only in block 5, $F(1,156)=6.56$ $p<0.025$. In blocks 1, 2, 3 and 4 emotional words took longer to colour name than neutral words (the emotional stroop effect) but this was only significant for block 1, $F(1,156)=4.42$ $p<0.05$.

One other important result was that in this experiment we were able to reduce the increase in response latency across the blocks. That is, across the five blocks there was little evidence that the subjects responses were getting slower, this was reflected in the main effect of Block being insignificant, $F(4,156)=1.01$ $p>0.40$.

Thus the main result from Experiment 5 is that there are no consistent emotional stroop effects, which may be attributed to presenting a mixed set of neutral and emotional stimuli, and hence indicates that in future experiments the emotional and neutral words should be blocked and presented in counterbalanced order. Also introducing a three second interstimulus interval reduced the flagging attention across the five blocks.

(B) Analysis of Memory Tasks.

The probability of reporting an emotional or neutral word in the memory tasks are shown in Table 5.

Table 5. Shows probability of reporting an emotional or neutral word in the recognition, stem completion and cued stem completion tasks.

Memory Task	Emotional Class	
	Neutral	Emotional
Recognition	0.87	0.96
Stem Completion	0.21	0.23
Stem Completion Controls	0.04	0.15
Cued Stem Completion.	0.62	0.69

In this experiment half the subjects (N=20) were given the Cued Stem Completion task. The other half of the subjects were given the Recognition and Stem Completion tasks, half of whom (N=10) were given the Recognition task first and the other half the Stem Completion Task first.

Although the results of the Recognition Task data suggests that emotional words are recognized more often than the Neutral words, the data could not be analyzed because of ceiling effects, that is, all subjects reported almost perfect recognition: in the Emotional condition 16 subjects recognized all the emotional words (i.e. 5/5 or 100%) and the other 4 subjects recognized 4/5 of the words. In the Neutral condition 13 subjects produced a

score of 5/5 and 5 subjects a score of 4/5. Similarly, for the Stem Completion Control stimuli the data could not be analyzed due to floor effects: in the emotional condition 7 subjects produced a score of 0/5 and 11 subjects a score of 1/5. In the Neutral condition 16 subjects produced a score of 0/5 and 4 subjects 1/5. Due to these problems we analyzed only the Stem Completion and Cued Stem Completion tasks by using a t-test.

For the Cued Stem Completion task a related t-test was carried out on the number of words correctly reported in the neutral and emotional conditions. This showed that there was no difference between the Emotional Class conditions, $t(20)=0.57$ $p>0.1$. For the Stem Completion task it was also found that there was no difference between the number of neutral and emotional words that were stem completed, $t(20)=0.195$ $p>0.1$. From Table 5 it can be seen that the difference between the neutral and emotional scores is larger for the Controls than the Stem Completion task, which suggests that for the subjects in this experiment there was a bias towards stem completing a word with an emotional word than a neutral word. Therefore a second analysis was conducted on the Stem Completion scores to correct for this bias. This was done by taking the difference between the score in the Stem Completion Control condition from the Stem Completion condition. A t-test was conducted on these difference scores which again showed no significant differences between the neutral and emotional conditions, $t(20)=0.77$ $p>0.1$.

Thus the main conclusion from this experiment is that we have no evidence for emotional words being reported more than neutral words in the implicit memory (stem completion) task. Although the trend in the explicit memory (recognition) task is towards emotional words being reported more than neutral words we cannot make this conclusion because of ceiling effects. These results can be accounted for by the addition of a 3 second interstimulus interval which may allow subjects more time to rehearse and remember the words presented and hence recognize more of the words. Ceiling effects were not found in the cued stem completion task and again no effects of emotional words was found. This therefore suggests that either the addition of a 3 second interstimulus interval reduces the difference between the emotional and neutral words in an explicit task, or that the type of stimulus presentation (complete word in the recognition task or partial word in the cued stem completion task) produces different results such that there are effects of emotional words on a recognition task but no effects on a cued stem completion task.

EXPERIMENT 6

INTRODUCTION

The main results from Experiments 3, 4 and 5 in the emotional stroop task suggest firstly that using a mixed stimulus presentation of emotional and neutral words reduces or eliminates the emotional stroop effect. Hence in Experiment 6 we return to using individual blocks of emotional and neutral words similar to Experiment 3. Experiment 5 showed that by including a 3 second interstimulus interval we were able to reduce the increase in response latencies across the five blocks. In Experiment 3 it was found that the emotional stroop effect only occurred on the first block and that on subsequent blocks subjects responses were slower.

It has been suggested that the slower responses may be due to a flagging attention, Ehlers et al (1988)[8], and that this may interact with the emotional stroop effect. Ehlers et al (1988)[8] suggestion that the disruptive effects of emotional stimuli increase with flagging attention was not supported by the data in Experiment 3 since the emotional stroop effect decreased with an increase in flagging attention. Could it be that the flagging attention hypothesis can also account for the reduced emotional stroop effect? The implication here is that the emotional stroop effect is in some way related to the flagging attention. This could be tested experimentally by trying to eliminate the flagging attention and seeing if this has any effect on the disruptive effects of emotional stimuli. One possibility is that by trying to keep subjects attention constant across the blocks will result in the emotional stroop effect lasting for a longer period. In Experiment 6 emotional and neutral words were presented in different blocks and a 3 second interstimulus interval was used to test if there was a relationship between the emotional stroop effect and the flagging attention.

The results from the memory task have shown that emotional words are recalled and recognised more than neutral words but stem completed less than the neutral words. One problem in Experiment 5 was that by using a 3 second interstimulus interval there were ceiling effects in the recognition task. Thus in Experiment 6 we return to using a recall memory task since this should be less prone to ceiling effects. Experiment 5 also showed that for a cued stem completion task (which did not show ceiling effects) there was no effect of emotional class. Two reasons were suggested for this. Firstly, by using a 3 second interstimulus interval the effect of emotional class disappears or secondly, that the type of stimulus cue used to measure the memory performance has an influence on the emotional class effect. In Experiment 6 we were only able to test the first of these hypotheses (due to the small number of subjects available)

by presenting to the subjects a recall memory task to see if a 3 second delay produced any effects of emotional class. If we find that emotional words are recalled more than neutral words we can therefore argue that the 3 second interstimulus interval does not affect the explicit (recall or recognition) memory task.

METHOD.

Subjects. Sixteen subjects from the University of Reading took part in experiment 6.

Design. The design formed a 2 x 2 x 5 x 2 x 5 factorial model with Order (NE or EN) a between-subjects factor and Emotional Class, Block, Trial and Words as within-subject factors.

Materials. The same set of stimuli as used in Experiment 4 were used in Experiment 6. Except that in the memory tasks only the stem completion stimuli were used.

Procedure. Each of the five emotional and five neutral words were printed in one of two ink colours, red and blue. These ten stimuli were randomly presented with the restriction that the same colour was not repeated on more than two consecutive presentations. These ten stimuli formed one trial in the experiment, two such trials were presented which formed one block. Subjects were presented, in a consecutive manner, one block of neutral words followed by one block of emotional words. Half the subjects were presented the emotional words before the neutral words (Order EN) and half in the reverse order (NE). Five neutral and five emotional blocks were presented consecutively with a delay of about 10 to 15 seconds between each block. The interstimulus interval was 3 seconds.

Two memory tasks were given to the subjects, a free recall and a stem completion task. Half the subjects received the free recall task before the stem completion task whereas the other half in reverse order.

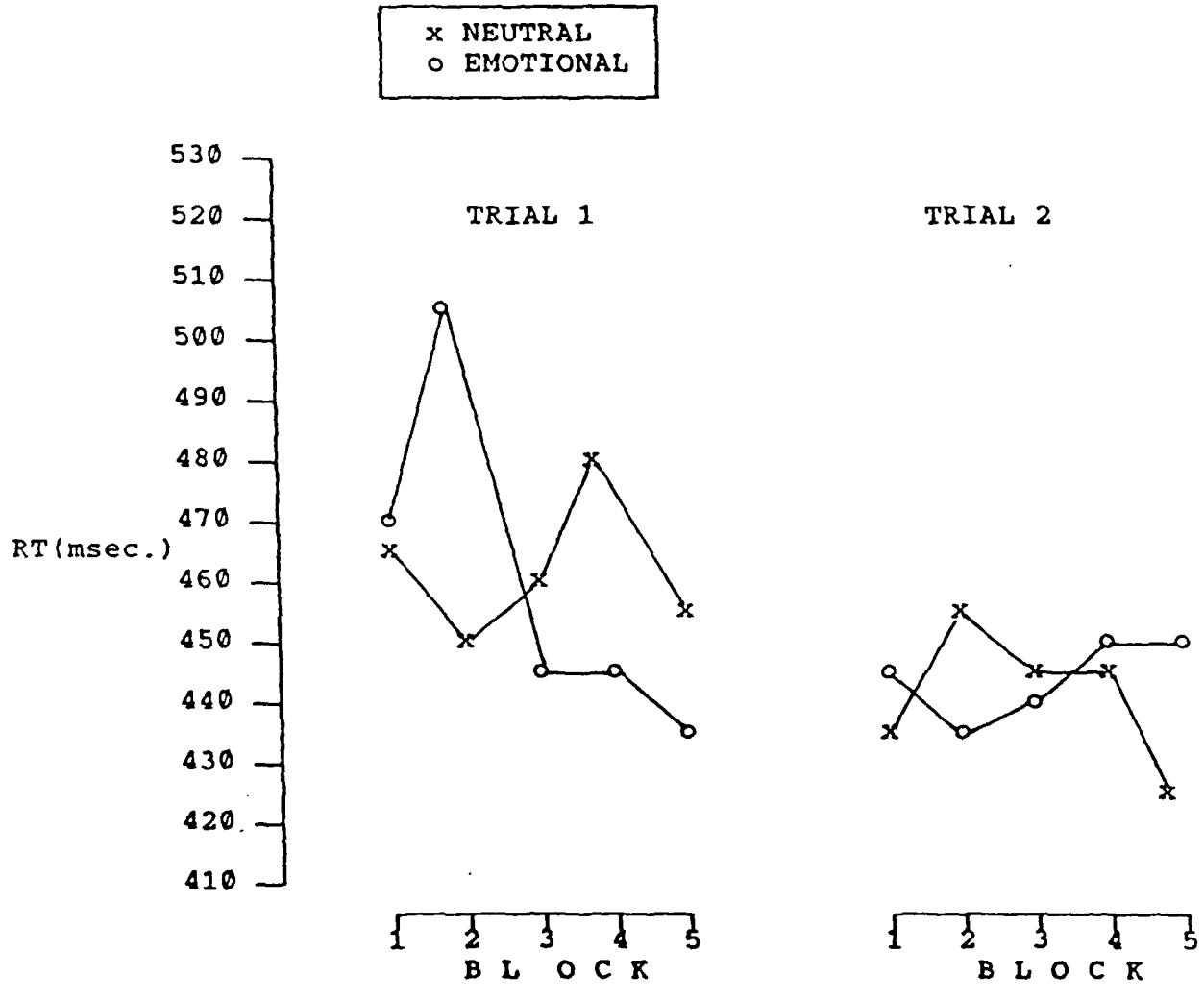
RESULTS

(A) Analysis of Emotional Stroop.

A five-way analysis of variance was conducted with Order as a between-subjects factor and Emotional Class, Block, Trials and Word as within-subject factors. The analysis produced three three-way interactions that were significant. A Block x Trial x Order interaction, $F(4,56)=3.57$ $p=0.012$, which showed that for the Order NE subjects responded progressively faster from block 1 to block 5 but only in trial 2, whereas for the order EN there was no such effect. This interaction does not seem to be easily interpretable. The Emotional Class x Block x Word interaction, $F(16,224)=1.77$ $p=0.04$, was also significant. Two explanations could be found for this interaction, firstly that for one of the words subjects responded progressively faster from block 1 to

block 5 for both the neutral and emotional class conditions, whereas for the other four words this was not the case. Secondly, there seemed to be a two-way interaction between Emotional Class and Block such that on block 2 emotional words took longer to colour name than neutral words but not on blocks 1, 3, 4 and 5. This interaction is highlighted further in the Emotional Class x Block x Trials interaction. The Emotional Class x Block x Trials interaction, $F(4,56)=2.47$ $p=0.055$, was more easily interpretable (see Figure 5):

Figure 5. Mean reaction time of the neutral and emotional words for the five blocks and the two trials.



Simple interaction effects showed a significant interaction for Trial 1, $F(4,56)=4.46$ $p<0.01$, but not Trial 2, $F(4,56)=0.58$ $p>0.1$. Simple main effects analysis on Trial 1 showed that emotional words took longer to colour name than neutral words on block 2, $F(1,56)=11.09$ $p<0.001$, and were faster to colour name

than the neutral words on block 4, $F(1,56)=4.28$ $p<0.05$. Also there was no simple main effect of Block for the neutral words, $F(4,56)=0.99$ $p>0.1$, but there was for the Emotional words, $F(4,56)=6.24$ $p<0.001$ which indicated that Block 2 was significantly slower than any other block except Block 1.

Thus the main result from this analysis is that Emotional words take longer to colour name than neutral words but only on Block 2 of the first trial. This result is very similar to the result found in Experiment 3 where it was also found that the effects of emotional stroop only occurred in the first block of the experiment. (Note that in Experiment 3 one block refers to presenting 20 stimuli, 5 words in 4 colours, whereas in Experiment 6 one block refers to 20 stimuli, 2 trials x 5 words x 2 colours). Experiment 6 also showed that by using a 3 second interstimulus interval subjects response latencies do not increase across the blocks. We can therefore conclude that the flagging attention has been reduced. This result addresses a theoretical point of whether the emotional stroop effect is related in any way to subjects flagging attention. Figure 5 clearly shows that by reducing the flagging attention the emotional stroop effect does not get larger or extend over a number of blocks. This result does not therefore support the view that there is a relationship between the flagging attention and the emotional stroop effect.

(B) Analysis of Memory Tasks.

The number of neutral and emotional words reported in the Recall and Stem Completion Tasks are shown in Table 6.

Table 6. Shows probability of reporting an emotional or neutral word in the recall or stem completion tasks.

	Emotional Class	
Memory Task	Neutral	Emotional
Recall	0.45	0.70
Stem Completion	0.25	0.29
Stem Completion Controls	0.05	0.13

Analysis of variance was conducted on the Freeman-Tukey Arc-Sine Transform Scores. This showed that emotional words were reported more than neutral words, $F(1,14)=6.35$ $p=0.025$, however this interacted with the type of memory task, $F(2,28)=3.17$ $p=0.057$. Simple main effects analyses showed that emotional words were reported more than neutral words in the Recall memory task, $F(1,28)=17.27$ $p<0.001$, but not in the Stem Completion Task, $F(1,28)=0.49$ $p>0.1$, the simple interaction between these two tasks was significant, $F(1,28)=5.98$ $p<0.025$. The Stem Completion Controls also showed no simple main effect of Emotional Class, $F(1,28)=2.84$ $p>0.05$, and they did not interact with the Stem

Completion Task, $F(1,28)=0.49$ $p>0.1$.

The only other effect that reached significance was the main effect of type of Memory Task, $F(2,28)=48.65$ $p<0.0001$. Tukey multiple comparison tests on the neutral and emotional conditions showed that all three memory tasks were significantly different from each other. This therefore shows that for those words that were presented in the experiment there were priming effects in the Stem Completion task compared to words that were not presented in the experiment (Stem Completion Controls). Also, that subjects report more words in the Recall task than the Stem Completion task.

The main result from the memory tasks is: (1) The recall task shows an effect of emotional class such that emotional words are reported more than neutral words. This result counters the argument presented in Experiment 5 that a 3 second interstimulus interval reduces the emotional class effect, and suggests that the reason why the recognition task in Experiment 5 did not show an emotional class effect was due to ceiling effects. (2) The stem completion task did not show any effects of emotional class. We have therefore not been able to replicate, in Experiments 5 or 6, the emotional class effect found in Experiment 4 for the stem completion task. A possible reason for this could be the 3 second interstimulus interval used in Experiments 5 and 6. This therefore suggests, in conjunction with the recall and recognition results, that a 3 second interstimulus interval has an effect of reducing the emotional class effect for the stem completion task but not the recall or recognition tasks.

CONCLUSIONS AND RECOMMENDATIONS

The main findings of these experiments are as follows.

Emotional Disruption.

Emotional stimuli disrupt performance but this effect occurs only on the first block of the experiment. One explanation of this result relates to repetition effects. The repetition effects hypothesis can be formulated in two ways, as a word repetition effect or as a class repetition effect. The word repetition effect suggests that the emotional stroop effect will last for about four repetitions of any word, whereas the class repetition effect suggests that the effect will last for about 20 stimulus presentations of the same class. These two effects can be easily dissociated if an experiment is conducted in which a different set of word stimuli are presented in each of the five blocks. If the results show that the emotional stroop effects occur in every block then this will support the word repetition hypothesis, whereas if it shows that the emotional stroop effect occurs only in the first block then the class repetition hypothesis is supported. The investigation of repetition effects suggests one main aim for future research, to devise techniques to increase the magnitude of the effect, thus producing a more

robust test.

One important implication of this result is that emotional stimuli have an immediate disruptive effect, but subjects quickly adapt to this disruption. It would therefore be of interest to know how individuals who are put under stress or who are prone to emotional problems will behave on this task. It could be the case that such groups show a larger disruptive effect of emotional stimuli because (1) the disruption is larger on the first block or (2) the disruption is not larger but extends over more blocks.

Flagging Attention.

There are performance decrements in a task that involves time pressure. If subjects conduct the task in a way which involves responding to each stimulus immediately and without delay, then response latencies increase from the first block to the last block of the experiment. This suggests a flagging attention to the colour naming task.

The flagging attention hypothesis was also suggested as an explanation for the emotional disruption occurring in the first block. This was tested in Experiment 6 in which we were successful in reducing the response latencies by using an interstimulus interval of three seconds. However, there was no increase in the emotional stroop effect across the five blocks. We can therefore conclude that our results do not support the flagging attention hypothesis as an explanation for the emotional stroop effect.

Emotional Class effects on Memory.

Two results were found with the memory tasks in showing a dissociation between explicit and implicit memory on two variables, emotional class and interstimulus interval.

(i) Explicit memory tasks, such as recognition and free recall, show that emotional words are reported more often than neutral words. Implicit memory tasks, such as stem completion, show the reverse effect, that neutral words are reported more than emotional words (see Experiment 4).

(ii) The effects of emotional class disappear in the implicit memory task if an interstimulus interval of three seconds is used, whereas for the explicit memory task the emotional class effect is unaffected (compare Experiment 4 with 5 and 6).

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APPENDIX A

The words used in the Recognition and Stem Completion tasks in Experiments 4, 5 and 6. (Note: L=Word length, F=Word frequency and D=number of distracters)

Emotional Words	L	F	D	Neutral Words	L	F	D	
CRASH	5	20	47	CLOCK	5	20	30	
FAIL	4	37	18	GATE	4	37	21	Experimental
FEAR	4	127	9	NOTE	4	127	14	Stimuli
DEATH	5	277	26	FIELD	5	274	15	
GRIEF	5	10	40	THUMB	5	10	26	
PAIN	4	88	26	ROSE	4	86	23	
RAGE	4	16	20	FLAG	4	16	16	Stem
WORRY	5	55	10	WAGON	5	55	9	Completion
MEAN	4	199	14	SOON	4	199	21	Controls
DREAD	5	9	25	SALAD	5	9	26	
SPITE	5	56	44	MOTOR	5	56	23	
GLOOM	5	14	18	LEVER	5	14	15	Distracters
HURT	4	37	10	PLOT	4	37	9	used in the
ANGRY	5	45	12	CURVE	5	45	11	Recognition
PANIC	5	22	25	PLATE	5	22	20	and Stem
HATE	4	42	28	WIRE	4	42	20	Completion
TENSE	5	15	17	ELDER	4	45	11	tasks
KILL	4	63	10	GROW	4	63	14	
REBEL	5	18	26	BRICK	5	18	40	
ENEMY	5	88	10	COVER	5	88	31	