

# Effects of Unattended Emotional Stimuli on Color-Naming Performance

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The effect of irrelevant emotional and neutral stimuli on the performance of a color-naming task is examined with two groups of subjects: pilots and bus drivers. It is found that (1) the emotional stimuli disrupt performance in both groups, (2) the decrement in performance is relatively larger in the pilot group, and (3) the effect of the emotional stimuli appears to persist over time.

One of the clinical features of those engaged in emotional events in everyday life is that they experience problems in concentration and paying attention (Horowitz, 1979). In attempting to provide a theoretical link between emotional stimulation and performance, Easterbrook (1959) has argued that emotional stimulation acts by restricting the use of cues used in a situation (narrowing of attention). Whether this action has a beneficial or detrimental effect depends on the complexity of the task. Simple tasks may benefit from the exclusion of irrelevant cues; complex tasks that involve many cues may suffer because relevant as well as irrelevant cues have been excluded. Easterbrook's hypothesis can go some way to explaining the Yerkes-Dodson Law, which proposes an inverted-*U* relationship between emotional arousal and performance. As arousal increases, irrelevant information is precluded and performance is more efficient; but further increases in arousal may result in the exclusion of primary task information, resulting in performance decrements.

A simple task that has been said to benefit from stress and to fit Easterbrook's hypothesis is the Stroop test. As Broadbent (1979) has noted, this test has often been used as a measure of selective attention because it requires the ability to resist distraction from irrelevant stimulation. Using threat of electric shock, Agnew and Agnew (1963) found that color-naming performance on this test improved, supporting the narrowing of attention interpretation. Tecce and Happ (1964), also using the threat of electric shock, found improvements in performance. It should be noted that although the improvements in performance reported in these papers are often cited as supporting Easterbrook's hypothesis, they were not statistically significant and contrary results have been reported (Pallak, Pittman, Heller, & Munson, 1975).

It has been argued that emotional stimulation has two major components: worry and emotionality (Liebert & Morris, 1967; Morris, Davis, & Hutchings, 1981). Worry is a cognitive component concerned with negative expectations and self-preoccupation, whereas emotionality is a physiological component concerned with one's perception of autonomic arousal. Morris, Davis, and Hutchings argued that it is the cognitive component that is by far the better predictor of performance.

In agreement with the position that worry is a critical feature, Wine (1971, 1980) argued that the decrements in performance observed in highly anxious persons are due to their division of attention between task-relevant processes and task-irrelevant, self-preoccupying processes.

To examine in more detail the hypothesis that emotional stimuli can produce performance decrements that may be attributed to a cognitive worry component, a variant of the Stroop test was designed in which the irrelevant distraction consisted of either emotional or neutral stimuli. The argument here is that attention to the primary task of color naming may be disrupted by the automatic allocation of resources to process the word meanings. In the present experiments the threat was of a cognitive nature only, and did not have a physical component (as in, for example, electric shock).

## EXPERIMENT 1

### *Method*

*Subjects.* Two groups of subjects were tested: one group of 153 who had applied for the position of bus driver and one group of 66 who had applied for the position of aircraft pilot. All subjects had normal color vision. Both groups were, at the time of testing, under selection for their respective organizations. They were informed that the tests administered here would not form part of the selection criteria.

*Design and Procedure.* Two tests were presented to each subject: the standard Stroop test and the variant developed here, which will be called the emotional Stroop test. Because both groups of subjects were tested as part of a larger project on individual differences, the order of presentation of the tests was standardized. In each test the subject was presented with a white card (39 cm × 39 cm) on which colored letter strings were printed, and had to name the color as quickly as possible. The letters were 0.5 cm in height. The dependent measure was the time per card. Five colors were used: blue, green, brown, orange, and red. Each test consisted of the presentation of a control card and an experimental card. The order of presentation was the standard Stroop followed by the emotional Stroop. Within each test the control card was presented first. The arrangement of colors (and where applicable words) was random with the constraint that each color (word) was presented twice per row of 10 letter strings and there were no immediate repetitions.

*Standard Stroop.* The control card consisted of 100 letter strings, which were rows of Os varying in length from three to six to match the lengths of strings in the experimental condition. This latter condition consisted of two color-incongruent cards. One of the incongruent cards was used for practice and consisted of 20 letter strings. The other consisted of 100 letter strings. Each string was the name of a color different from the color of the ink. Each of the ink colors and each of the color words were presented 20 times.

*Emotional Stroop.* On the control card each of the following five words, "clock," "gate," "thumb," "field," and "note," was presented 20 times with each word being

**TABLE 1**  
**Mean Performance (in seconds) on the Standard and Emotional Stroop Tests**

	STANDARD STROOP		EMOTIONAL STROOP	
	Color Patch	Incongruent Names	Neutral Words	Emotional Words
Drivers	65.6	112.8	86.5	88.9
Pilots	59.8	93.9	71.7	77.3

presented in every color equally often. These words were matched in terms of word length and word frequency with the words on the experimental card. The corresponding words on the emotional word card were “fail,” “fear,” “death,” “crash,” and “grief,” again being presented 20 times with each word being presented in every color equally often. The emotional words were rated as such in a previous experiment (Broadbent & Gregory, 1967).

### *Results and Discussion*

The results are presented in Table 1. The important question is, Do the unattended emotional stimuli have any effect? For the bus drivers color naming the emotional stimuli takes longer than naming the neutral stimuli ( $F = 14.6$ ;  $df = 1,152$ ;  $p < .001$ ). In the pilot sample this decrement in performance produced by the emotional stimuli is also highly significant ( $F = 39.2$ ;  $df = 1,65$ ;  $p < .0001$ ).

The standard Stroop effect was observed in both samples. In other words both the drivers and the pilots found that color-incongruent words produced considerable interference ( $F = 839.0$ ;  $df = 1,152$ ;  $p < .0001$ ) and ( $F = 712.0$ ;  $df = 1,65$ ;  $p < .0001$ ) respectively.

The pilot group performs faster than the bus driver group on both the standard Stroop test ( $F = 26.2$ ;  $df = 1,217$ ;  $p < .001$ ) and the emotional Stroop test ( $F = 29.9$ ;  $df = 1,217$ ;  $p < .001$ ), a result that may be attributed to the fact that the pilot sample is a highly selected group. What is more interesting is that despite being faster overall, the pilots, in comparison with the bus drivers, show a larger decrement in performance with the emotional stimuli ( $F = 7.66$ ;  $df = 1,217$ ;  $p < .01$ ). This result is all the more interesting given that the decrements on the standard Stroop are exactly the opposite, that is, the pilots show less interference ( $F = 25.1$ ;  $df = 1,217$ ;  $p < .001$ ). To investigate this effect further it was thought useful to equate for overall level of performance. This was achieved by considering performance on the neutral words. It was possible to match 50 pilots with 50 bus drivers who had *identical* performance on the neutral words.

**TABLE 2**  
**Mean Performance (in Seconds) of Pilots and Drivers Who Are Exactly Matched on Their Performance on the Neutral Words**

	Incongruent Names	Emotional Words
Drivers	99.1	75.8
Pilots	96.3	78.9

The results are indicated in Table 2, where it can be seen that the interaction is such that even when matched on performance on the neutral words the pilots perform more effectively on the incongruent words but less effectively on the emotional words ( $F = 5.1$ ;  $df = 1,49$ ;  $p < .05$ ). Considering the emotional stimuli alone, it is found that the comparison is statistically significant ( $F = 4.47$ ;  $df = 1,49$ ;  $p < .05$ ).

As noted earlier, both groups were under selection, and so it was possible to consider those who were selected versus those who were not. For the bus driver group this consisted of the outcome (pass versus fail) on the public service vehicle (PSV) driving test. For the pilots this was more complicated and was determined by a battery of tests and an interview.

The results are presented in Table 3. For the drivers none of the differences or interactions between those who pass and fail was significant on either the standard Stroop or the emotional Stroop. The only differences that approached significance was the overall time on the standard Stroop ( $F = 3.28$ ;  $df = 1,151$ ;  $.07 < p < .08$ ). For the pilots none of the differences or interactions approached significance.

TABLE 3  
Mean Performance (in Seconds) of Those Who Meet the Selection Criteria  
Versus Those Who Do Not

	STANDARD STROOP		EMOTIONAL STROOP	
	Color Patch	Incongruent Names	Neutral Words	Emotional Words
<i>N</i>				
			<i>Drivers</i>	
Pass (111)	64.5	110.7	85.9	88.5
Fail (42)	68.5	118.3	88.0	88.9
			<i>Pilots</i>	
Pass (38)	59.2	93.6	71.8	77.2
Fail (28)	60.6	94.4	71.5	77.5

## EXPERIMENT 2

In the previous experiment it was shown that emotional stimuli disrupt performance and that the pilots were particularly susceptible to this effect. One possible account of this result is that the pilots are going through a more intensive and stressful selection system, which produces a sensitivity to emotional stimuli. To examine this possibility, a separate group of trainee pilots was tested who had successfully passed through the selection system. If the selection pressure were producing the effect, then the large decrement in performance should now disappear.

In the previous experiment the neutral stimuli were always presented before the emotional stimuli, the reason being that both groups were being tested as part of a larger project on individual differences and pragmatic and psychometric considerations made a constant order desirable. By presenting the neutral stimuli before the emotional stimuli, it was thought, any practice effect would act in the opposite direction to the proposed effect of emotional stimuli. Here that possibility is examined by reversing the order. It is, of course, possible that the emotional stimuli will produce a carry-over effect.

**TABLE 4**  
**Performance (in Seconds) of a Group of Pilots Presented with the**  
**Normal Order of Presentation of the Emotional Stroop Test Versus a Group Presented with**  
**the Reversed Order**

	STANDARD STROOP		EMOTIONAL STROOP	
	Color Patch	Incongruent Names	Neutral Words	Emotional Words
Normal Order	58.8	90.5	72.9	77.3
Reversed Order <sup>a</sup>	60.7	93.1	78.5	78.9

<sup>a</sup>Reversed order only on the emotional Stroop test.

### Method

*Subjects.* A total of 113 pilots was tested. All were under training, though at the time of testing their flying training had not begun.

*Design and Procedure.* For 67 of the pilots the design and procedure was identical to that of Experiment 1. For the other 46 pilots the only difference was the order within the emotional Stroop test: the emotional stimuli preceded the neutral stimuli.

### Results and Discussion

The results are presented in Table 4. For the group presented with the normal order of presentation, performance on both the standard Stroop test ( $F = 713.6$ ;  $df = 1,66$ ;  $p < .0001$ ) and the emotional Stroop test ( $F = 35.1$ ;  $df = 1,66$ ;  $p < .0001$ ) replicates the results from the previous experiment. The major point to note is the similarity in level of performance between those pilots receiving the normal order of presentation in this experiment and the performance of the pilots in the previous experiment. None of the differences between these two groups approached statistical significance. This fact indicates that the selection system cannot be accounting for the larger disruption in performance shown by the pilots. Differing explanations that present themselves are (1) the emotional stimuli selected are more relevant to the pilot group; (2) the pilots, even when selected, are under continual assessment, leaving open the possibility that those under evaluation show larger decrements; and (3) candidates who present themselves as possible pilots may have some personality characteristics that make them more susceptible to emotional stimuli.

The second issue of interest concerns the effect of reversing the order within the emotional Stroop test (see Table 4). The results for the standard Stroop are presented for comparison. None of the differences between the two groups on the standard Stroop approached statistical significance. Comparing the two groups on the emotional Stroop test revealed a highly significant interaction ( $F = 11.5$ ;  $df = 1,112$ ;  $p < .001$ ). It can be seen from Table 4 in comparing performance on the two sets of neutral stimuli that the interaction is produced by the disruption of performance when the neutral stimuli follow the emotional stimuli ( $t = 2.53$ ;  $df = 111$ ;  $p < .02$ ). It is clear, therefore, that in comparison to the neutral words in the normal order, the

reversed order results in a decrement in performance on both the emotional and the neutral stimuli.

### *General Discussion*

The processing of emotional stimuli has often been examined in paradigms where replication has been difficult (Barber & Mahotiere, 1982; Jennings & George, 1975). The present experiments have indicated replicable and highly significant decrements in performance associated with emotional stimuli even though these stimuli were completely irrelevant to the task. The selective attention mechanism appears, therefore, to have considerable difficulty in overriding the emotional stimuli, indicating that these stimuli have considerable power to command and dominate psychological processing. The type of explanation offered by Easterbrook that emotion acts by narrowing attention cannot account for the present results. The narrowing of attention explanation is not sufficient since this has been used, as indicated in the introduction, to predict facilitation in color naming, whereas the results here indicate a decrement in performance. The present results are consistent with the view that attention to the primary task is disrupted by the automatic processing of the emotional stimuli and that this processing occurs at the semantic level. Nielsen and Sarason (1981) found in a shadowing experiment that emotional stimuli in the unattended channel had a greater tendency to intrude than neutral stimuli. Sarason (1980) argues that emotional stimuli act by stimulating task-irrelevant, self-preoccupying processes.

One general theoretical difficulty in considering the effects of emotional stimulation is in accounting for both the decrements and the improvements in performance that can follow. Given the present theoretical framework it will be argued that the critical feature is the translation process between emotional event and task-relevant versus task-irrelevant processes. Emotional stimulation may act as a motivational source, resulting in more resources being allocated to the task. Alternatively, emotional stimulation may result in the emotional content itself being processed, resulting in less allocation of resources to the task.

On both tasks used here the pilots were faster overall than the drivers. This result is perhaps not surprising since the pilots are selected on the basis of performance tests. However, while the pilots are better able to deal with the distraction in the standard Stroop test, they are relatively less effective in dealing with the distraction from the emotional stimuli. In Experiment 2 it was shown that this result is not due to differences in selection pressure that might have occurred between the two groups.

From the results of reversing the order within the emotional Stroop test it appears that the effect of the emotional stimuli may persist beyond their presentation. Once emotional stimuli have been primed, they may take some time to decay. This process may parallel the effect of emotional events in everyday life, where a major characteristic is the persistence of self-preoccupying thoughts. One possible line of investigation is to examine the decay of this effect and the interventions that decrease or block the persistence effect.

As a further examination of the view that emotional stimulation disrupts performance by stimulating task-irrelevant, self-preoccupying processes, Watts, McKenna, Sharrock, and Trezise (in press) examined the effect of stimuli that were hypothesized to be relevant to one group of subjects (phobic) but not to another (normal). The predicted interaction was observed: with the relevant stimuli the phobic group showed selectively large decrements in performance. This task may therefore be applicable to a variety of clinical problems in which an examination of the pattern of inhibitions should allow a more thorough understanding of the problems presented by individuals.

### NOTE

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