A SIGNAL DETECTION ANALYSIS OF THE EMOTIONAL STROOP EFFECT

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Abstract

The Emotional Stroop Effect (ESE) was tested for accuracy. A severe time limit imposed on reporting produced relatively high rate of errors, documenting the ESE for the first time for accuracy (higher error rates in naming the color of emotional words), and enabling the application of the Theory of Signal Detectability. The results showed that the presence of threat (emotional words) diminished the psychological distance (d') between the print colors. However, decision (β) remained invariant. These results support an explanation of the ESE as product of a defense mechanism that responds to threat by temporarily appropriating resources away from the threat-irrelevant attributes.

In the "emotional Stroop paradigm," the participants are asked to name the colors in which various words are printed. Naming the color of emotional words is performed slower than that of neutral words. This difference is labeled the "emotional Stroop effect" (ESE) and is theorized (Williams, Mathews, & MacLeod, 1996) to be the product of subliminal processes of word reading interfering with the color naming response. If the participant focuses exclusively on the print colors and ignores the carrier words, then no difference in color naming between emotional and neutral words is expected. The emotional Stroop effect is, therefore, an indication of the failure to pay exclusive attention to print color, and mainly, of the threat-induced disruption of color naming.

The emotional Stroop paradigm is popular in current clinical psychology (see Williams et al., 1996, for review). The effect has been demonstrated with a variety of psychopathological populations, using emotional words related to the respective clinical conditions. There have been relatively few studies investigating the emotional Stroop effect with non-pathological participants (but see, Algom, Chajut & Lev, 2004; McKenna & Sharma, 1995, 2004). Therefore, the ESE is also documented for the normal population.

To date, investigations of the ESE used reaction time (RT) as the indicator of the effect of emotional content on color naming. Accuracy in extant studies was usually close to perfect. In the present study we, for the first time, gauged the ESE for accuracy. Extending the arsenal of ESE measures is important, but the use of accuracy accomplishes more than this limited goal. It enables the application of the Theory of Signal Detectability (TSD) to ESE research and analysis. A range of intriguing questions can be answered.

Does the ESE obtain for accuracy? What, exactly, is impaired under threat? Does threat impair genuine perceptual processing of stimuli in the environment? Alternatively, does threat effect response bias rather than actual stimulus discriminability? Concerning classifications of print colors, do the colors of threat words appear less salient to perception (hence, d' decreases), or does the criterion of reporting them change (hence, β is altered) under threat? These questions were considered in the present pioneering application of the TSD to the ESE.

Therefore, in this experiment emotionally charged and neutral words were presented, in separate blocks, printed in either red or orange font. The participant's task was to decide whether the presented word was printed in red or not in red (i.e., in orange), by pressing the appropriate key. To generate high rates of error, we introduced a time limit of 500 milliseconds for responding (i.e., responses longer than 500 milliseconds were discounted and punished by an unpleasant sound).

Method

Participants

Twenty-eight young men and women from the Department of Psychology, Tel Aviv University, and from the Department of Criminology, Bar-Ilan University, volunteered to take part in the experiment in a partial fulfillment of course requirement. All participants were native Hebrew speakers and had normal or corrected-to-normal visual acuity assessed by self-reports.

Stimuli and apparatus

There were 16 neutral words, names of items of clothing (e.g., hat, shoe), and 16 emotionally charged words associated with terrorism (e.g., terrorist, bomb). Words were balanced in terms of length and frequency of usage within the student population. The stimuli were identical to those used by BenDavid, Levy and Algom (2003), yielding a substantial ESE for RT. Stimulus presentation and measurement were performed by a Macintosh computer with a standard Macintosh keyboard, using PsyScope (version PPC 1.2.5) software. Words were presented in red and orange on a white background in Arial font (size 48), on a 17” color screen.

Procedure.

Participants were tested individually. Each participant performed in two experimental blocks**:** one with 16 neutral words and one with 16 emotional words. The order of the blocks was counterbalanced between participants. Each word appeared 6 times in each of the print colors, red and orange, making for 192 experimental trials per block. Order of trial presentation was random and different for each participant. Each block was preceded by 8 training trials that were later discarded from analysis. Responses were produced by pressing one of two designated keys on a standard keyboard. Key designation was counterbalanced between participants.

The participant was asked to decide, as accurately as possible, whether the print color of the word appearing on the screen was red or not (i.e., orange). Each trial began with the presentation of a mask ("XXXXXXX" in Arial font, size 72, bold) for 500 milliseconds, at the center of the screen. The mask was immediately followed by the presentation of the stimulus. As soon as a response was made, or after a 500 milliseconds time limit, the stimulus was removed for a blank inter-trial interval of 50 milliseconds. The participants were notified that failure to respond within the time limit will be penalized by an unpleasant tone (it was a standard Macintosh error tone) and that the trial will be discarded.

Results and Discussion

Figure 1 gives the results. A glimpse of Panel A shows that the participants were more accurate to discriminate the print colors of neutral words (M= 65.93%) than to discriminate the same colors of emotional words (M= 58.68%). The difference was 7.25% in favor of the former [$t(27)=6.66$ $p<0.001$]. Therefore, emotional stimuli effected color naming (= the ESE). For the first time, we recorded an ESE for accuracy (rather than for RT).

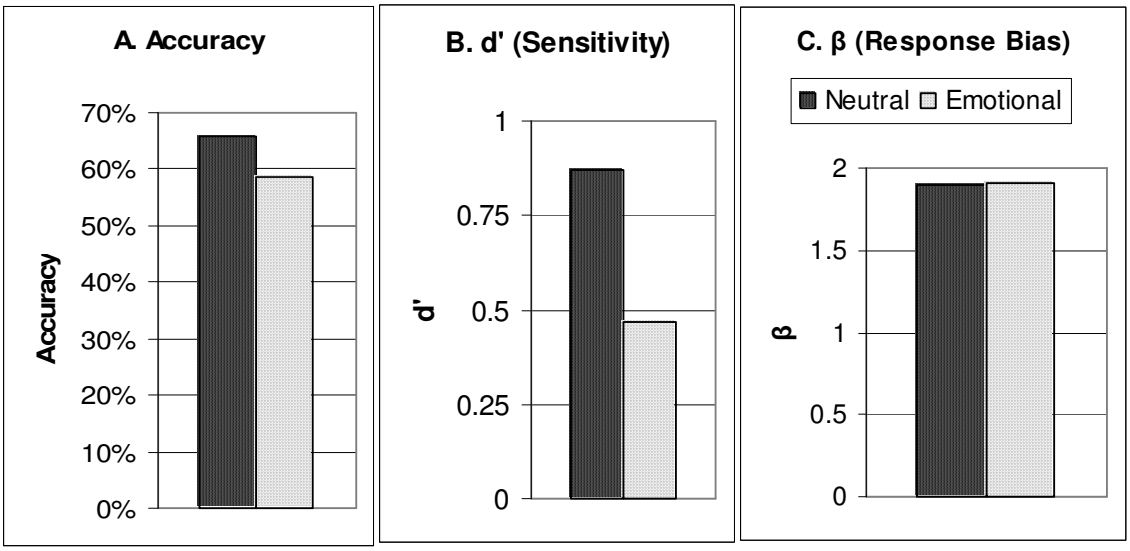

Figure1: A. Accuracy of discriminating print colors for neutral and emotional words; B. Sensitivity measures (d') for discriminating print color of neutral and emotional words; C. Response bias (β) for discriminating print color of neutral and emotional words.

Applying the TSD to these non-speeded data can reveal two possible sources for the disruption: sensitivity, d', or response bias, β. What makes the color naming of emotional words worse than color naming of neutral words? Panels B and C give the answer. Notice in Panel B that the average d', for discriminating print color, of neutral words was larger by 0.4 than the d' for emotional words [0.869, and 0.468 respectively, $t(27) = 6.48$ $p<0.001$]. Therefore, the participants were much more sensitive to the difference between the two print colors when the carrier words were neutral than when they were emotional. In contrast, Panel C does not show a difference in β, for discriminating print color, between neutral and emotional words [1.901 and 1.903 respectively, $t<1$].

These results show that the content of the words exerts a deep sensory effect on the perception of their colors. The presence of threat (emotional words) diminishes the psychological distance (d') between the colors of the carrier words, desensitizing participants to the differences between the colors. Notably, decision making (β) is not altered by threat.

Taken together, the results support an explanation of ESE in terms of a generic inhibitory defense mechanism that responds to threat by temporarily freezing all ongoing activity (Algom et Al., 2004). The presence of threat (emotional words) distorts perception of the threat-irrelevant attributes. The slowdown in the color naming of an emotional word (the emotional Stroop effect) is the product of a preattentive (or an early attentive) inhibitory mechanism that appropriates resources away from the color naming activity. This mechanism is activated by the sheer presence of a threat-inducing stimulus.

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