WITHIN BLOCK HABITUATION DETERMINES THE EMOTIONAL STROOP EFEECT

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Abstract

In the emotional Stoop task, people name the ink color of words. The words come from two categories, emotion items and neutral items. It is typically found that it takes longer to name the ink color of emotion items than that of neutral items, the emotional Stoop effect (ESE). Virtually all studies of the effect used a small set of words in each category that were repeatedly presented. We argue that this design entails a great amount of habituation, thereby compromising the ESE.

Modern life is replete with emotion and stress. Who has avoided the emergency room or (witnessing) a traffic accident? In order to perform efficiently under such stressful situations, it is extremely important to preserve one's composure and focus on the relevant stimuli. Various factors can influence attention and performance, but people habitually exposed to such situations (e.g., emergency personnel, medical professionals, police) typically perform better than those hit by these scenes for the first time. In order to mimic real life performance in the laboratory, the emotional Stroop task has been commonly applied. A small set of words is exposed repeatedly for view, and the participant's task is to name, while timed, the ink color in which each word is printed. The basic finding is that it takes people longer to name the ink color of emotional words than that of neutral words, the emotional Stroop effect (ESE). However, is this emotional slowdown dependable? Given the critical role played by habituation in everyday life, the extensive repetition of the same emotion items exposes the responses to experimental habituation. The observed ESE may well be diluted and underestimate the true effect of emotion.

The experimental setup of the emotional Stroop task is well known. Words in color are presented singly for view and the participant's task is to name the ink color of each word as quickly and accurately as possible. The words come from two categories differing in valence: negative and neutral. The stimuli can be presented in a single block with the emotion and neutral items intermixed in a random fashion or in two separate blocks defined by valence. The slowdown in naming the ink color of the emotion words is usually more pronounced when the ESE is derived in the blocked design (e.g., Algom, Chajut, & Lev, 2004; Holle, Neely, & Heimberg, 1997; Richards et al., 1992). Therefore, the block design has become the method of choice for investigators of the ESE and it is the method applied in this study, too.

The task has been employed with a gamut of pathologies from generalized anxiety (e.g., Mathews & MacLeod, 1985; Mogg & Bradley, 2005) to trait anxiety (e.g., Mogg, Kentish, & Bradley, 1993; Rutherford, MacLeod, & Campbell, 2004) to depression (e.g., Mogg & Bradley, 2005; Mitterschiffthaler et al., 2008) to social phobia (Amir, Freshman, & Foa, 2002; Andersson et al., 2006) to post-traumatic stress disorders (e.g., Paunovic et al, 2002; Constans et al, 2004). The ESE has also been studied with unselected populations (e.g., Algom et al., 2004; McKenna & Sharma, 1995). The popular use of the ESE in research and practice alike is likely attributable to its value as a diagnostic tool. The emotion words can be tailor-cut to match the specific pathology under test or the current concerns of the patient. Moreover, this tool is neither intrusive nor self-report-based.

Nevertheless, the ESE has been found quite variable in experimental research. In a review of 50 studies, Williams et al (1996) found the effect to vary between -1 and 400 ms. The present study focuses on one potential factor contributing to the observed variability: the repetitive nature of exposure to the negative stimuli.

Within the context of the ESE, habituation refers to the emotion content of the carrier word. With repeated presentation, the interference to color naming diminishes with the proportional loss in the emotive power of the carrier word. In the typical ESE experiment, four words appear in four ink colors with each combination presented three times. Note that in this most common design a word repeats 12 times in a block of 48 trials. This number of repetitions can reduce the observed ESE due to habituation to the emotional content of the words.

Habituation has a profound role in the realm of anxiety, fear, and emotion. The decrease in emotional responding with repeated exposure to fearful material is evident in physiological indicators such as cardiac activity (Anderson & Borkovec, 1980; Borkovec & Sides, 1979) and skin conduction (Watson, Gaind and Marks, 1972) as well as in self reports (Foa & Chambless, 1978). Given the role of habituation in adjusting to threat and emotion, a range of behavioral therapy techniques harness habituation as a therapeutic tool (see Foa & Kozak, 1985, and Marks,1978, for reviews).

Habituation typically follows a negative exponential function (Thompson, 2009). Considering the block with emotion items along with that with neutral items (whose difference defines the ESE), this function applies to both blocks with a larger initial value of RT in the former block. This means that the major impact of habituation is felt on the few first repetitions of the stimulus. If the two sets of words habituate to a common asymptote, the ESE is zero at the end of the experiment although it is large at the beginning (when there is little if any habituation). The vanishing effect of word content simultaneously disables the omnipotence of threat to slow down the response. With habituation complete, the response to an immediately following threat word would not be different (longer) than that to a neutral word.

The problem of habituation has been recognized in the ESE research. In an early study by McNally, Riemann, and Kim (1990), selective processing of threat information was tested in panic disorder patients and normal cohorts. Notably, the ESE waned over trials. It was larger in the first than in the last 100 trials, exhibiting the effect of habituation. In a subsequent study with normal participants, McKenna and Sharma (1995) found an overall slowdown in color naming over successive blocks of trials, probably due to flagging attention and fatigue. Most important, the ESE was present only in the first blocks (of emotion and of neutral items), underscoring the effect of habituation. When the authors replaced the words in each successive block with new ones, thereby reducing habituation, the ESE was present in most blocks of trials.

MacKay and colleagues (MacKay et al., 2004) have similarly demonstrated habituation with naming the ink color of taboo words (sex or profanity words). The ESE was larger in the first 100 trials than in the last 100 trials. A second experiment revealed that the ESE remained roughly equal when novel words were presented in the last 100 trials. More recently, Witthoft , Rist, and Bailer (2008) tested attention bias in anxious individuals and normal cohorts. The anxious participants suffered stronger interference to color naming than did those in the control group. Notably, the difference was more pronounced in the first 20 trials than in the last 20 trials. The authors concluded that habituation reduces the ESE, and recommended to analyze in a routine fashion the time course of the ESE within an experimental session.

These valuable contributions notwithstanding, the effects of habituation to date have been tested at a relatively coarse level of granularity. The smallest unit examined was that of a block (however small) or a rough cut across the first versus the last few trials of an experiment. Missing are data at the level of individual words. What is the fate of the response to an individual word over its successive presentations in the course of the experiment? How early does habituation occur? How many repetitions are needed to produce a decent habituation effect? Are there ways to avoid or bypass habituation? These are the questions that were addressed in the current study.

For that purpose we generated the emotional Stroop effect via the standard paradigm. A small set of words was repeatedly presented in the block with emotion items and another small set of words was repeatedly presented in the control block with neutral items. A unique feature of this experiment was the measurement of RT to each individual word over its repeated presentation in the block. In this way we followed the evolution in time of the ESE. We predicted that habituation would exert its effect on the initial presentations of the words, keeping in mind that the starting RTs are longer for emotion than for neutral carriers of the colors. Because both habituation curves approximate exponential functions that asymptote to the same minimum, the ESE is expected to be large in the beginning, but decrease rapidly with repetitions.

Methods

Participants: The participants were 30 Tel Aviv University undergraduates, with a mean of 26 years of age. The participants performed against course credit. All had normal or corrected vision and all were native speakers of Hebrew. Each participant was assigned in a random fashion into one of two groups defined by the order of exposure to the emotion and the neutral items. Thus, half of the participants performed first in the neutral block and the remaining half first performed in the emotional block. Regardless of order, the mean RT difference in color naming between the two blocks defined the ESE.

Stimuli and design: There were five emotion words, the Hebrew equivalents of *injured, terrorist, suicide bomber, danger* and *terrorist act*. The five neutral words were *street, table, bench, cupboard* and *neighborhood.* All the words were matched for length and for average frequency using the Word Frequency Database for Printed Hebrew (Frost & Plaut, 2001).

The five emotion words and the five neutral words were presented in separate blocks. Within a block, each word appeared 10 times (twice in each of the ink colors, red, brown, orange, blue, and green), making 50 trials per block in all. The participants reported the ink color orally by speaking the name of the ink color into a microphone. They were given 5 practice trials with the Hebrew equivalent of the word *example*. The emotion and the neutral blocks were separated by a break of 30 seconds.

Apparatus: The stimuli were generated in Microsoft Word (in Hebrew font Ariel, 28-point size) via a Pentium(R) 4, 2.8GH computer and displayed on a 15-in. color monitor set at a resolution of 1,024 X 768 pixels. Using standard palettes, we created prototypical colors for red, brown, orange, blue, and green. The words appeared in color over the white background of the screen within an invisible frame of a 61 x 19 pixels rectangle. Viewed from a distance of approximately 60 cm, the words subtended 1.53° of visual angle in width and 0.48° of visual angle in height. In order to avoid adaptation or strategic responding (e.g., fixating on a small portion of the print to avoid reading when naming the colors), we introduced a trial-to-trial spatial uncertainty of approximately 50 pixels around the center location. A microphone headset served to transduce the oral responses.

Procedure: The participants were tested individually in a dimly lit room. They were instructed to report the ink color of the word as quickly and accurately as possible by speaking its name into the microphone headset. The computer software recorded the responses and their timing. Stimulus exposure was response terminated. The interval between the participant's response and the appearance of the next stimulus was 500 ms. Following the experiment, the participants were debriefed and thanked for their participation.

Data analysis: The error rates were very low [~4% for emotion and neutral words]; we do not discuss error further on in this report. For RT, responses longer than 2200 ms or shorter than 250 ms were discarded from the analysis. The order of block presentations was not insignificant, nor did it interact with any other variable.

Results

The words' mean reaction times (RTs) were analyzed across repetitions in a three-way analysis of variance with valence (emotional vs. neutral) and repetition number (0-9) as within subject variables and block order (EN vs. NE) as a between subject variable. The analysis revealed a main effect of valence with longer RTs for the emotional words than that of the neutral words. However, the analysis also indicated a more complex pattern of results, revealing an interaction of valence with repetition number (see Figure1). Tukey's Post Hoc analysis revealed a reliable source for this interaction; as the mean for the first appearance of the emotional words being significantly slower than the first appearance of the neutral words and from all other repetitions of the neutral words. No other difference between the emotional and neutral words was significant in any other repetition. This clearly indicates that the source of the ESE lies solely on the first appearance of the words.

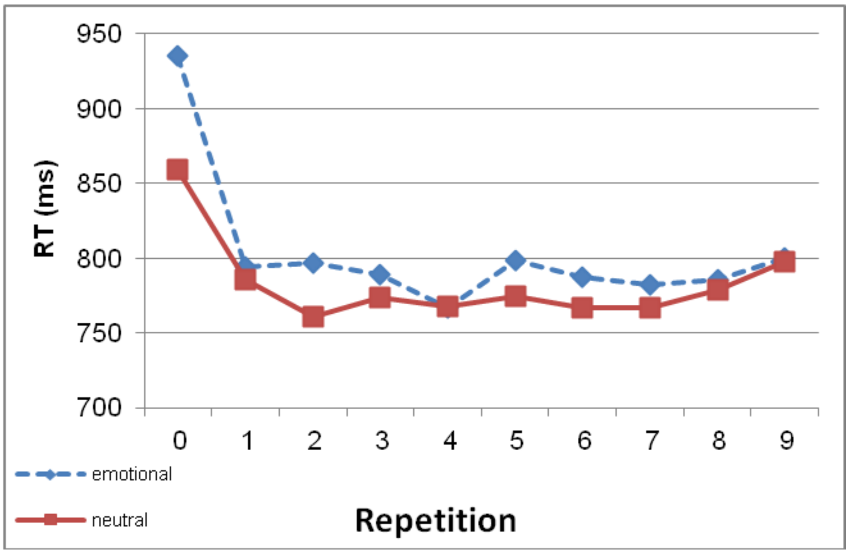

Figure1: Mean reaction time plotted against the word repetition. Repetition denotes the ordinal number of the presentation of a word. It should be distinguished from trial number of the experiment. If a given word first appears in the fourth trial its repetition number is 0. The ordinate gives the mean RT for the first appearance (on different trials) of the words in the experiment. Note that the curve of emotion items and neutral items are obtained separately from different blocks and are plotted together for ease of comparison purposes.

Discussion

In this experiment we used the standard procedures of the Emotional Strop task . In each block, a small set of carrier words was repeatedly presented for color naming. These standard procedures yielded the standard ESE result. We recorded a slowdown in naming the color of emotion or threat items compared with that of neutral items. The slowdown amounted to an overall ESE of 20 ms. One should realize that the ESE of 20 ms obtained in our experiment is a global measure, based on all trials in both blocks. It is this global measure that is routinely reported in ESE studies. What we do not know is the contribution of the individual trials to this measure. Are those contributions equal? Is the global ESE mainly attributable to the last couple of items? Or, is the ESE mainly arises during the first few presentations? Providing answers to these questions formed the purview of our effort. The novel contribution of this experiment therefore was the item-by-item dissection of the ESE. By calculating the momentary ESEs, we followed the temporal evolution of the global ESE.

Our analysis revealed that the global ESE -- the statistics typically reported -- is actually produced by the first few emotion and neutral items presented, if not on the very first ones. The momentary ESE amounted to 76 ms upon the first appearance of the emotion and the neutral items, but it diminished noticeably beyond those presentations. In fact, none of the momentary ESEs beyond that first one was reliable statistically. So, the dilution over trials of an initially large ESE produced the present global value of 20 ms.

Why does the ESE diminish over repetitions? We attribute the trend to habituation to the word stimuli over their repeated presentation. Responses to both types of items undergo habituation so that the difference between the respective curves diminishes with repetition. Repeated presentation of the carrier words renders them less salient. For emotion words in particular, excessive repetition cripples their extra emotive power, leaving most of the remaining experiment nonproductive and the ESE considerably diluted. In this work we demonstrated the destructive effect of habituation on the ESE. Hence, it is strongly suggested to keep word repetitions in the common task to the minimum possible or simply avoid it altogether.

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