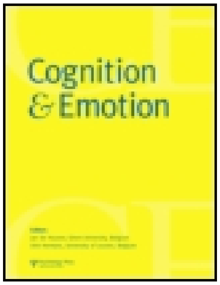

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When emotion does and does not impair performance: A Garner theory of the emotional Stroop effect

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When emotion does and does not impair performance: A Garner theory of the emotional Stroop effect

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It takes people longer to name the ink colour of emotion or threat words than that of neutral words, the emotional Stroop effect (ESE). In three experiments with normal and patient populations, we show that the ESE is a special case of a generic attention model and effect entailed in Garner's speeded classification paradigm. Guided by the Garner model we demonstrate that task-irrelevant dimensions that differ in salience can produce the ESE and mimic it with neutral stimuli. When each word appears in a constant colour, as mandated in the correlation condition of the Garner design, the ESE is eliminated. This important result is consistent with the attention account of the ESE. We conclude that when emotion stimuli appear in a random fashion they interfere with task performance. However, when emotion stimuli are correlated with features of the ongoing task they help task performance not least due to their extreme salience.

Keywords: The emotional Stroop effect; The Garner paradigm; Attention; Dimensional salience; Performance under emotion.

Virtually all stimuli in people's perceptual milieu are multidimensional, yet a single dimension only is consequential for action at any given moment. People attend to the velocity of the approaching car while crossing an intersection, ignoring momentarily other dimensions such the car's size, shape, or colour. Size may well be the target dimension for action at another time, such as when one wishes to cross a narrow bridge. However, selective attention is not always successful at excluding effects of task-irrelevant dimensions. Emotion stimuli are notoriously difficult to ignore so that such stimuli routinely interfere with ongoing behaviour. A common laboratory demonstration of emotional interference with performance is the emotional Stroop effect (ESE): Participants are slower to name the ink colour of emotion words than that of neutral words. The ESE is a robust phenomenon, but it is not clear why emotion items precipitate sluggish performance. In the present study we attempted to answer this question by pinpointing the kinship between the ESE and a generic model from mainstream attention research, Garner's speeded

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classification paradigm and effect (Garner, 1974). We show that the ESE is actually a Garner effect, which means that the ESE is a standard attention result generated by known variables of attention. A notable variable of attention is stimulus salience and the association with Garner interference explains how emotional salience exerts its influence on behaviour. Significantly, implementing conditions of the Garner paradigm enables a decision between competing theories of the ESE.

Consider emotional salience. Given their adaptive value, signifying looming danger or the availability of reward, humans are extremely sensitive to the presence of emotional stimuli. This extra sensitivity, sustained by a long evolutionary trajectory and dedicated brain mechanisms, expresses itself perceptually by enhanced salience of emotion stimuli. A recent neural network model (Wyble, Sharma, & Bowman, 2008) establishes convincingly how "emotional salience" regulates cognitive control in a range of situations (see also Botvinick, Braver, Barch, Carter, & Cohen, 2001). Enhanced salience is probably the most widely recognised feature of emotion stimuli, but it is not completely clear how this salience translates into performance. The kinship with Garner research explicates the systematic effect of salience on performance. The association also highlights the fact that salience is not limited to emotional stimuli and that all salient stimuli act in a similar fashion.

Consider next theoretical resolution. Two competing accounts of the ESE are those of attention and of threat or freezing. According to the former (e.g., Williams, Mathews, & MacLeod, 1996), the carrier word commands attention, thereby compromising full focusing on the target ink colour. Attention to words laden with emotion is especially acute and the toll taken by this extra processing is expressed in longer colour-naming latencies. According to the latter (Algom, Chajut, & Lev, 2004; McKenna & Sharma, 2004), the slowdown is related to exposure to threatening stimuli. This exposure mandates reprioritising of resources at the expense of performing all ongoing activity (Öhman, Flykt, & Esteves, 2001). The result is a temporary freezing of all ongoing activity. Harnessing the machinery of the Garner model enables a strong test of telling the two accounts apart.

A Garner theory of the ESE: It is the difference between a pair of filtering conditions

In the Garner experiment (Garner, 1974; Melara & Algom, 2003), as in the ESE experiment, the participants make speeded responses to values of a stimulus dimension (say, ink colour) while ignoring values on a second, irrelevant dimension (the carrier word). For example, the participant decides whether the ink colour is red or green while ignoring the carrier word (say, DESK or BOOK). The full Garner paradigm includes three blocks of trials defined by what happens to the task-irrelevant dimension of word.

In the baseline condition, the task-irrelevant dimension is held at a constant value (e.g., the invariant word DESK is presented throughout all the trials in the block). In the filtering condition, the carrier word changes from trial to trial in a random fashion. In the correlation condition, the task-irrelevant attribute of word again varies, but it does so in a corresponding fashion with respect to the target attribute of colour (e.g., DESK appears all or most of the time in red and BOOK appears all or most of the time in green). The left-hand portion of Figure 1 gives a schematic depiction of the Garner paradigm along with the associated measures of Garner interference (the difference in colour performance between the filtering and the baseline blocks) and Garner facilitation (the difference in colour performance between the filtering and the correlation conditions).

Worse colour performance in the filtering condition than in the baseline condition documents the toll exacted on colour naming by random variation of the irrelevant word. This deficit in performance is called Garner interference. Performance in the correlation condition is often better than that in the filtering condition (and even than that at baseline). When performing in the correlation condition, the participant

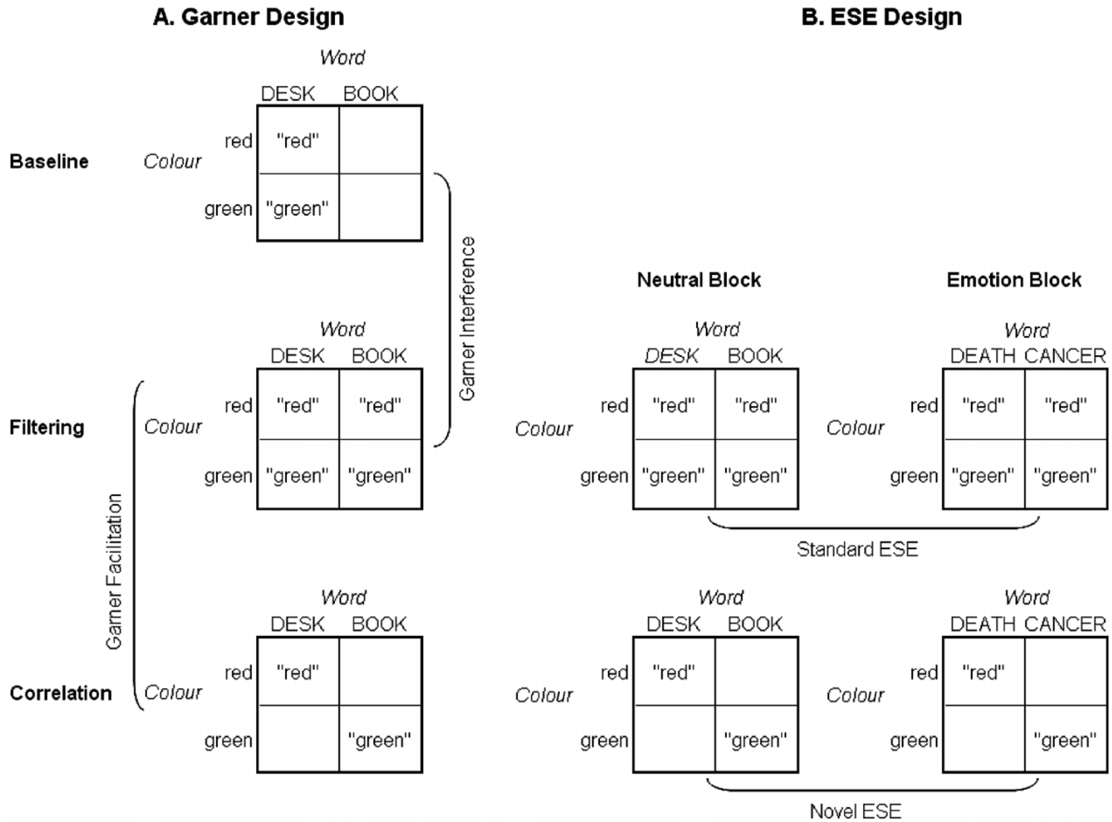

Figure 1. *The correct response is depicted in each cell by the name in quotation marks of the appropriate ink colour. (A) The Garner Paradigm. In the Baseline condition (top), the word DESK is held constant and the participant responds to its colour, which changes from trial to trial in a random fashion. In the Filtering condition (middle), the task remains that of speeded classification of colour but the irrelevant word also changes from trial to trial in a random fashion. In the correlation condition (bottom), the participant classifies colour yet another time, but the irrelevant word changes in a correlated fashion with respect to the target colour. (B) The ESE design. In the standard design (upper row), the participant classifies the ink colour of words that vary from trial to trial in a random fashion. In one block, the words are neutral, whereas in the other block the words are emotional. The ESE is the difference in colour performance between two Garnerian filtering conditions. In the novel ESE design (lower row), the ESE is given by the difference in colour performance between two Garnerian correlation conditions, one entailing neutral words and the other entailing emotion words.*

may notice the fact that the nominally irrelevant dimension of word is actually predictive of the target colour. The presence of this predictive relationship, in turn, can maximise performance with respect to the colour. This redundancy gain is called Garner facilitation.

Inspection of Figure 1 makes it clear that the standard ESE task is an example of the Garnerian filtering task. In the ESE task, various ink colours are combined with various words in a random fashion and the participant's task is to classify the colour while ignoring the word. This preparation is precisely that of the Garnerian filtering task (the Garner paradigm is typically introduced with binary valued dimensions, but it is easily extended to many-valued dimensions). The ESE is actually the difference in performance between two filtering blocks, one in which the words are laden with emotion or threat and one in which the words are of neutral valence.

Having construed the emotional Stroop task as a pair of Garnerian filtering blocks, the theoretical quest remains in force: Why is colour performance worse in the filtering condition with emotion words than that in the filtering condition with control words (= ESE)? Half a century of research with the Garner paradigm implicates the variable of salience or what is otherwise known as relative dimensional discriminability.

The role of salience or relative dimensional discriminability

Discriminability specifies the psychological difference separating stimulus values along a dimension (Melara & Algom, 2003; Melara & Mounts, 1993). The greater the psychological separation, the more salient each stimulus value is to perception. Salience, in turn, affects performance in a systematic and well-documented fashion. The classic study on the effect of dimensional salience was that by Garner and Felfoldy (1970). When they presented equally discriminable values of circle size and angle of diameter, neither dimension intruded on performance with the other dimension. However, when the authors presented extreme values of circle size, thereby making each circle disproportionally salient, circle size interfered with performance with angle orientation, but angle orientation did not interfere with performance with circle size. These results have since been replicated numerous times (e.g., Algom, Dekel, & Pansky, 1996; Dishon-Berkovits & Algom, 2000; Melara & Mounts, 1993; Sabri, Melara, & Algom, 2001), unravelling a general principle governing attention: A highly discriminable distractor dimension disrupts performance with a less discriminable target dimension. It is this principle that explains the propensity of emotion stimuli to interfere with ongoing action.

As we recounted earlier, the signal property of emotion stimuli is their salience. Emotion stimuli are detected swiftly (Öhman et al. 2001), recalled well (Mackay et al., 2004; see also Kensinger & Corkin, 2003; Ochsner, 2000), are strong attractors of attention (MacLeod, Mathews, & Tata, 1986), and enjoy priority over competing tasks (Jones & Fazio, 2010; Pratto & John, 1991; Williams & Bargh, 2008). Given their superior salience, emotional stimuli intrude on ongoing performance (when they do not comprise the target dimension for responding). Within the framework of the Garner tradition, the disruptive effects of a salient irrelevant dimension are couched in valence free attention terms. Viewed at from this vantage point, the ESE is merely an example of a salience produced difference in colour classification.

Therefore, espousing the Garner paradigm along with a vast supporting literature helps us to understand why performance with respect to a feature of negative stimuli can be worse than that with the same feature of control stimuli (= the standard ESE). Garnerian analysis shows that the ESE pattern is not unique to emotion stimuli but rather comprises a standard result in mainstream attention research wrought about by the enhanced salience of task-irrelevant information. Recognition of the association with the Garner paradigm carries another even more valuable dividend, advancing theoretical resolution. Comparison of performance between two blocks in the correlation condition of the Garner paradigm provides for a decision between the attention and the freezing accounts.

Theoretical resolution: Elimination the ESE under correlation?

In the correlation condition (see Figure 1 again), the word DEATH appears always (mostly) in red and the word CANCER appears always (mostly) in green. The same constant colour–word combinations also hold in the block with neutral words. This novel ESE paradigm includes thus two correlation conditions, one with emotion words and the other with neutral words as carriers of colour. As usual, the ESE is the difference in colour performance between these two blocks. Note that the new ESE design entails an innocuous change in the way that the colours and the words are combined to create the stimuli: random in typical studies of ESE (as in all Garnerian filtering conditions), but constant for a given word in the new condition (as in all Garnerian correlation conditions). This seemingly small change is consequential according to the attention account of the ESE but much less consequential according to the threat or freezing account of the ESE.

According to the attention account, emotion words attract attention more than do neutral words, which, in turn, takes a toll on colour performance in filtering (i.e., in the standard ESE design). By the same token, the salient emotion words become powerful predictors of colour under correlation, so that attending to the word actually facilitates colour performance in this condition. Neutral words are also good predictors of colour under correlation, but the facilitation is probably smaller than that with emotion words due to the extra salience of the latter. The net result is the elimination or even reversal of the ESE under correlation. According to the rival freezing account, the ESE results from exposure to the menacing content conveyed by the threat words. Because exposure to negative content is comparable in filtering and correlation, the ESE is expected to be comparable too. Therefore, the threat or freezing approach does not predict the elimination of the ESE under correlation. These opposing predictions as well as the viability of the Garner framework were tested in a series of three experiments.

EXPERIMENT 1

The goal of this basic experiment was to test the current Garner theory of the ESE. Each of 96 participants, drawn from the general population, performed in four blocks of trials naming the ink colour of words presented singly for view. Two blocks included emotion and neutral words in colour with random assignment of the ink colours to the words (the standard ESE preparation). Two additional blocks included the same words and colours but now each word appeared in a constant colour (the novel correlation conditions). The critical question was this. Does the seemingly innocuous change in colour–word combinations engender a difference in performance?

Method

Participants. Ninety-six young men and women from the Department of Psychology, Tel Aviv University, and from the Department of Psychology, the Open University of Israel, volunteered to perform in the experiment in partial fulfilment of course requirement. All participants were native Hebrew speakers and had normal or corrected-to-normal visual acuity.

Apparatus and materials. There were 10 neutral words, names of items of clothing (the Hebrew words for hat, shoe, skirt, shirt, scarf, coat, dress, glove, tie, and sandal). There was another set of 10 emotionally charged words associated with terrorism (terrorist, bomb, danger, death, war, wounded, pus, suicide, burn, and murder). The neutral and emotion words selected were equal in length and frequency (Ben-David, Levy, & Algom, 2003). Stimulus presentation and time measurement were governed by DirectRT Precision Timing Software (Version 2008.1.0.11). The stimuli were displayed on a 17″ colour monitor set to a resolution of $1,024 \times 768$ pixels. Using the standard colour palettes, we created the prototypical colours for red, blue, green, brown, and orange. A Logitec external headset with a microphone, fitted to each participant, collected the vocal responses.

Design. Of the four blocks of trials, two included emotion words and two neutral words. In order to avoid excessive habituation, the two emotion blocks included different sets of five words. The two neutral blocks also included different sets of five words. In two blocks (one with emotion items and one with neutral items) the assignment of colours was random. Each of the five words was presented in each of the five ink colours twice, making 50 trials per block in all. In two other blocks (one with emotion items and one with neutral items) the assignment of colour was constant for each word. Each word was presented 10 times in the same ink colour, making 50 trials per block in all. The order of the blocks was counterbalanced across participants. Order of trial presentation was random and different for each participant. We exhausted all possible 96 orders (2 sets of words $\times$ 2 conditions $\times$ 4! arrangements). This was the reason for recruiting the large sample of 96 participants.

The participants were sitting approximately 60 cm from the screen, so that the words subtended a maximum of 5.4 degrees of visual angle in width and 1.52 degrees in height. The words were presented in Arial 28 point font over a white background. The word appeared at the centre of the screen and remained visible until the participant's vocal response. The next stimulus appeared 1 s after the response. In order to avoid adaptation or strategic responding (e.g., fixating on a small portion of the print to avoid reading), we introduced a trial-to-trial spatial uncertainty of 50 pixels around the centre location.

Procedure. The participants were tested individually. Each participant was randomly assigned to one of the 96 orders. The participant performed the task of speeded colour naming in a sequence of four blocks separated from each other by breaks of approximately 1 minute. The entire experiment lasted between 15–20 minutes.

Data analysis. Errors amounted to 2.3% and did not differ across conditions ($F < 1$). We do not discuss errors further in this report.

Results

Figure 2 gives the results. Consider first the data in the left-hand half of Figure 2,which was obtained using the standard ESE procedure of random pairings of colours and words. It took participants longer to name the colour of emotion words (751 ms) than of neutral words (739 ms), the difference amounting to a reliable ESE, $t(95) = 2.17$, $p < .05$. Notably, the pattern of data changed in a qualitative fashion when the same words appeared each in a constant colour. Under colour–word correlation depicted in the right-hand half of Figure 2, responses to emotion items (727 ms) were actually faster than those to neutral items (730 ms), although this small difference was not reliable statistically. Never-

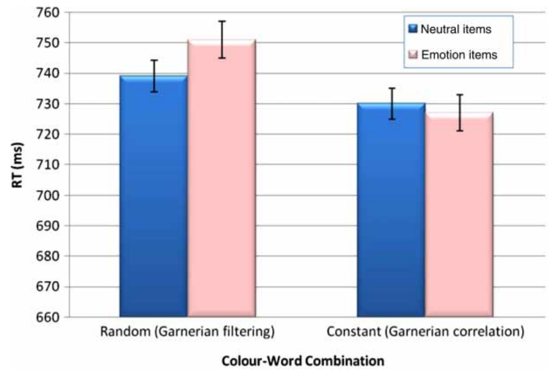

Figure 2. *Results of Experiment 1. Mean RTs for the standard emotional Stroop arrangement (the Garnerian filtering condition) on the left and for the novel constant colour arrangement (the Garnerian correlation condition) on the right. The dark columns depict colour naming for neutral items, whereas the light columns depict colour naming for emotion items. The bars represent one standard error around the mean.*

theless, the remarkable reversal in the pattern of data was supported by the interaction of word valence (negative, neutral) and colour assignment (random, correlated), $F(1, 95) = 3.80$, $p < .05$. A final notable feature of the data depicted in Figure 2 is the overall speedup on performance under correlation, $F(1, 95) = 4.8$, $p < .01$.

Discussion

The signature of the present results is the dramatic effect of colour–word allocation. The typical ESE obtained with random allocation (the usual ESE design) evaporated under correlated allocation. The elimination of the ESE is all the more remarkable realising that the participants were naming the same colours of the same words with the seemingly innocuous modification of the way that the colours were assigned to the words. Considering the pertinent conditions as special cases of Garnerian filtering and correlation provides a ready explanation of the data as a whole.

In filtering, the enhanced salience of the emotional words grabbed extra attention, which, in turn, took a toll on colour performance. Under correlation, by contrast, attending to the same words facilitated colour performance because the nominally irrelevant word now became a perfect predictor of colour. Attention to neutral words also facilitated colour performance but the benefit reaped was greater with emotion words due to their enhanced salience. The upshot is that salience impacted performance in opposite ways in filtering and correlation with the net result of eliminating the ESE under the latter regimen.

To a first approximation, the results of Experiment 1 are inconsistent with a freezing account of the ESE. According to this account, exposure to negative stimuli should take a toll on performance regardless of the way that these stimuli are conjoined with other features. Conversely, the results are largely consistent with the attention account. Attention to the emotion word impairs colour naming, but the predictive power of the same word under correlation offsets or even reverses the former adverse effect on colour processing. In other words, the task-irrelevant meaning of the emotion word in filtering becomes a relevant cue for responding under correlation, the process abetted by the attention attracted to such words. We note that recent results reported by De Houwer and Tibboel (2010; see also Verbruggen & De Houwer, 2007) are also inconsistent with the freezing account. The freezing account predicts that emotional distractors should not be detrimental to performance on no-go trials within the framework a go/no-go task; in contrast with this prediction, the authors found interference in no-go trials too.

EXPERIMENT 2

The results of Experiment 1 invite replication and extension. Experiment 1 possesses extra statistical power (nearly a hundred participants performing in all possible orders), but the effects were fairly small. One should also note that the majority of ESE studies were conducted with patient populations, whereas Experiment 1 engaged normal participants. Therefore, in Experiment 2 we applied the design of Experiment 1 with anorexic and/or bulimic participants.

There are a number of ESE studies with young women suffering from eating disorders (e.g., Ben-Tovim & Walker, 1991; Ben-Tovim, Walker, Fok, & Yap, 1989; Channon, Hemsley, & De Silva, 1988; Cooper, Anastasiades, & Fairburn, 1992; Cooper & Fairburn, 1992; Green, McKenna, & De Silva, 1994; Jones-Chester, Monsell, & Cooper, 1998; Long, Hinton, & Gillespie, 1994; Orimoto, 1997; Perpina, Hemsley, Treasure, & De Silva, 1993). All of these researchers reported a slowdown in naming the colour of weight-related, food-related, or body-size-related words relative to naming the colour of neutral words. They have also found that it took patients longer than normal cohorts to identify the colour of the same food words. Nevertheless, these studies did not consider colour assignment regime in the ESE, or methodological issues. In particular, none employed the present condition of correlation. We used this condition to explore the pertinent issues with anorexic and bulimic female adolescents.

Method

Participants. The participants were 15 female adolescents, in-patients recruited from a treatment facility. All participants met the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV; American Psychiatric Association, 1994) criteria for anorexia nervosa and/or bulimia (AN-R, $N=7$; AN-P, $N=3$; BN, $N=5$) when first admitted to the clinic. An experienced clinician made the diagnosis in all cases. Several criteria had to be satisfied for participation. First, all participants were in the last quarter of their hospitalisation in order to prevent distraction due to poor health condition. Second, no participants had acute manifestation of their disorder in the week before participating in the experiment. Third, no participants were diagnosed with additional psychiatric disorders. Finally, participation was confirmed only with parents' approval (parents signed a consent form).

Apparatus and materials. For emotion items, we used words referring to food and body size. The words were, CREAM, CAKE, OVEREATING, FAT, and BLOATED. For neutral stimuli, the words were FLUTE, HEARING, HAT, CHAIR, and CAT. The sets of words (in Hebrew) were equal in length and approximate frequency based on the word-frequency database for printed Hebrew (Frost & Plaut, 2001). Stimulus presentation and measurement conditions were the same as in Experiment 1.

Procedure. Experiment 2 was conducted in a small room within the closed psychiatric ward. The participants were accompanied by an instructor who was waiting outside the room. The experimenter emphasised to the participants that, if, for any reason, they felt that they could not complete the experiment, they would not be compelled to do so. The procedure was the same as in Experiment 1.

Data analysis. Errors amounted to 3.8% and did not differ across conditions ($F<1$). One participant was excluded due to a high error rate (>10%) and two more participants were excluded due to self-reported learning disabilities. Therefore, data analysis was completed for twelve participants.

Results

Figure 3 gives the results. Consider first the results in the left-hand side of Figure 3 obtained in the standard ESE paradigm. It took the

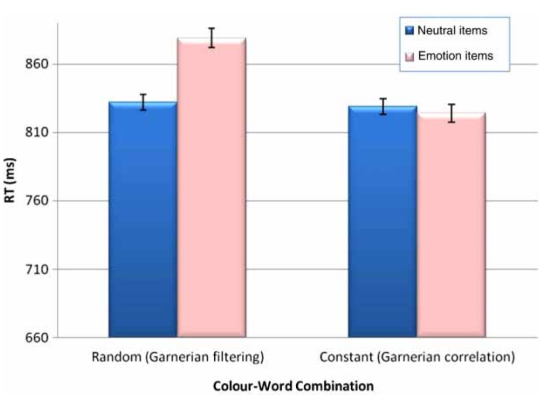

Figure 3. *Results of Experiment 2. Mean RTs for the standard emotional Stroop arrangement (filtering condition) and for the novel constant colour arrangement (correlation condition). The bars represent one standard error around the mean.*

participants 879 ms, on average, to name the colour of emotion words, but it took them 832 ms, on average, to name the colour of emotion words. The 47 ms difference defined a reliable ESE, $t(11)=1.95$, $p<.05$. The pattern of data changed in a qualitative fashion in the constant-colour condition depicted in the right-hand half of Figure 3. Under the correlation regime, it took participants 824 ms, on average, to respond to the colour of emotion items, but it took them 829 ms to respond to that of neutral items. So, in the correlation condition, responses to emotion items were faster than those to neutral items. Although this reverse ESE was not reliable ($t<<1$), the interaction of valence and condition supported the effect of colour allocation, $F(1, 11)=5.34$, $p<.05$.

Discussion

The results of Experiment 2 with anorexic and bulimic patients replicated the pattern obtained in Experiment 1 with normal participants. The ESE obtained under the routine preparation was much larger with this group of patients, yet it completely evaporated under the constant word–colour preparation. The collective results of Experiments 1 and 2 are consistent with the role of stimulus salience as explicated within the Garner tradition. In most situations involving emotion and neutral stimuli, dimensional salience is mismatched in favour of the former. The imbalance is detrimental to performance (with the neutral stimuli) when the two dimensions are orthogonal, but it is helpful if one dimension is predictive of the other.

Differences in salience or in relative dimensional discriminability are present in many situations in and out of emotion. The mismatch impacts performance in a systematic, widely documented way (Garner, 1974; Garner & Felfoldy, 1970; Melara & Algom, 2003). Within the framework of Garner research, the ESE is thus a special case of a salience-produced asymmetry in performance. If so, one can mimic the typical ESE without using emotion stimuli at all. The single stipulation needed is that one set of stimulus attributes is made more salient than another set (by whatever means). This inference was tested in Experiment 3.

EXPERIMENT 3

In Experiment 3, all the words were neutral and word salience was manipulated by means of legibility. The participant performed in the same four conditions of Experiment 1 with high legibility stimuli replacing emotion stimuli, and low legibility stimuli replacing the former neutral stimuli. Therefore, Experiment 3 was a conceptual replication with non-emotional stimuli of Experiments 1 and 2 (and of ESE studies in general).

Method

Participants. Twenty young men and women from the Department of Psychology, Tel Aviv University, volunteered to perform in the experiment in partial fulfilment of course requirement. All participants were native Hebrew speakers and had normal or corrected-to-normal visual acuity.

Apparatus and materials. We used only neutral words in this experiment. The words were presented singly in various ink colours. Stimulus presentation and measurement were governed by DirectRT Precision Timing Software (Version 2008.1.0.11). The stimuli were displayed on a 17″ colour monitor set to a resolution of $1{,}024 \times 768$ pixels. Using the standard colour palettes, we created the prototypical colours of red, blue, green, brown, and orange. A Logitec external headset with a microphone, fitted to each participant, collected the vocal responses.

Design. The neutral words in colour were manipulated in two ways. First, they were presented under high or low legibility. Second, the words and the colours were conjoined in a random fashion in one condition (filtering) and in a consistent fashion (correlation) in another condition. Word legibility was manipulated by controlling the space between the letters. Highly legible words were presented without spaces between the letters (e.g., "CHAIR", "TABLE"), and the less readily legible words were presented with three spaces inserted between consecutive letters ("C H A I R", "T A B L E").

In two blocks, the arrangement was that of filtering: Each of the five words was presented in each of the five ink colours twice, making for 50 trials per block in all. In two other blocks, the arrangement was that of correlation: Each word was presented 10 times in the same ink colour, making 50 trials per block in all. The order of the blocks was counterbalanced across participants. In order to avoid habituation, a new set of neutral words was used in the second Garner condition (filtering or correlation).

The participants were sitting approximately 60 cm from the screen, so that the words subtended a maximum of 5.4 degrees of visual angle in width in the high-legibility condition and almost 15 degrees of visual angle in the low-legibility condition. The words subtended 1.52 degrees in height. The words were presented in Arial 22 point font over a white background. The word appeared at the centre of the screen and remained visible until the participant's vocal response. The next stimulus appeared 1 s after the response. In order to avoid adaptation or strategic responding (e.g., fixating on a small portion of the print to avoid reading), we introduced a trial-to-trial spatial uncertainty of 50 pixels around the centre location.

Procedure. The participants were tested individually. Each participant was randomly assigned to one of the orders. The participants performed the task of speeded colour naming in a sequence of four blocks separated from each other by breaks of approximately 1 minute. The entire experiment lasted approximately 15 minutes.

Results

Consider the data in the left-hand half of Figure 4. They come from the pair of filtering conditions in which various neutral words were paired with various colours in a random fashion. In these blocks, colour naming of the high legibility words (Mean of 743 ms) was slower than that of low

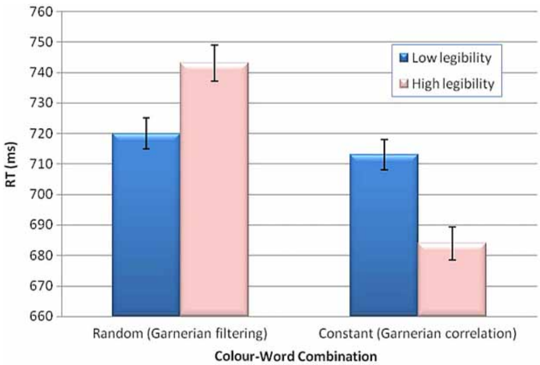

Figure 4. *Results of Experiment 3. Mean RTs for naming the colour of low and high legibility words, all neutral, in the filtering and the correlation conditions. The bars represent one standard error around the mean.*

legibility words (720 ms), the difference reflecting the cost incurred by task-irrelevant variation of a highly salient distractor dimension. This salience produced difference was reliable, $t(19) = 1.66$, $p < .05$. Notably, a complete reversal of this pattern of responding is evident in the correlation conditions depicted in the right-hand half of Figure 4. In these conditions, the participants responded to the colour of highly legible words faster than they did to that of poorly legible words means of 684 and 713 ms, respectively, $t(19) = -1.68$, $p < .05$. The interaction of Word Legibility (high, low) and Colour Assignment (random, constant) documented the full reversal of the pattern of results, $F(1, 19) = 8.13$, $p < .01$.

Discussion

Our hypothesis asserts that the standard task used to derive the ESE consists of two filtering conditions that differ in valence (negative, neutral) of the carrier word. This difference in valence translates into a corresponding difference in salience, which, in turn, produces the ESE. In this scheme, the role of emotion is that of enhancing the salience of the task-irrelevant dimension of word. Because salience can be manipulated outside emotion, the ESE pattern is expected to emerge with non-emotion stimuli whose dimensions differ in salience. Indeed, what is most revealing about the results of Experiment 3 is the (almost full) reproduction of the ESE pattern with non-emotion stimuli. Valence (Experiments 1 and 2) or salience (Experiment 3) of the carrier words impacted colour performance similarly. Negative or highly salient words intruded on colour performance when varying from trial to trial in a random fashion, but they helped colour performance when varying in tandem with target colour.

Nevertheless, we note that the reversal of the RT pattern observed in Experiment 3 was absent in Experiments 1 and 2. The ESE (or its neutral substitute) was eliminated in all three experiments, yet a fully reverse ESE-like pattern appeared only with the neutral stimuli of Experiment 3. The collective results mandate a broader conception of the nature of negative stimuli. Apart from their conspicuousness, one cannot ignore their meaning as deep seated, evolution-honed signals of danger. This last feature can offset, to some extent, the gain reaped from correlation produced predictability. It therefore seems likely that residual interference from emotional content prevented a complete reversal in Experiments 1 and 2. One should entertain the possibility that both the attention and the freezing accounts contribute to explanation of various facets of the ESE (Frings, Englert, Wentura, & Bermeitinger, 2010).

An arguable alternative explanation for the results of Experiment 3 implicates the variable of fluency (Dreisbach & Fischer, 2011; Reber, Schwarz, & Winkielman, 2004; Reber, Winkielman, & Schwarz, 1998). Fluency of processing is more difficult with low legibility than with high legibility words and this difference translates onto affective states with the former inducing negative mood, the latter positive mood. If so, Experiment 3 was not valence free but introduced valence through the difference in fluency. This view holds a certain interest, but it is clear that fluency cannot provide a viable account of the ESE. In current ESE studies, lexical variables (such as word frequency, length, or orthographic neighbourhood) are matched or radically controlled (as in the study by Algom, Zakay, Monar, & Chajut, 2009, in which the same words served as negative and positive stimuli) so that fluency is held constant. Nevertheless, appreciable amounts of ESE are recorded in the face of invariant fluency. The fluency approach is also ill suited to account for the processing of negative stimuli (cf. Reber et al., 2004). Suppose that the manipulation of Experiment 3 is applied to the word DEATH. Inevitably, a highly legible DEATH is of high processing fluency. In the fluency approach, this stimulus is one with a positive valence!

Viewed from a broader perspective, fluency produced values of valence are generally fairly small, many comprising examples of what is currently dubbed "micro-valence" (Lebrecht, Bar, Barret, & Tarr, 2012, p. 107; see also Reber et al., 2004). It is unlikely that they would have been able to produce the strong effects of Experiment 3. The vast majority of the research on Stroop and Garner effects entails variables that possess micro-valence at best, which explains the minimal role played by affect in that body of research. Nevertheless, some researchers extend the purview of fluency to include purely perceptual (i.e., non-alphabetical) stimuli, a dubious extension in our view. It is difficult to justify defining a certain position in space (direction of motion or a certain colour) as being more "fluent" than another position (direction of motion or colour). We conclude that fluency is a poor surrogate for salience, particularly in the domain of emotion.

GENERAL DISCUSSION

The three experiments of this study converge on the conclusion that the ESE is a salience-produced phenomenon. In particular, task-irrelevant emotion stimuli interfere with task performance more than do task-irrelevant neutral stimuli due to the superior salience of the former. Although emotional salience is widely documented, espousing the Garner perspective highlights the fact that salience is a generic variable of attention with the ESE comprising a special case. Harnessing the Garner design also prompts examination of its correlation condition, a newcomer to the ESE domain. This condition carries ecological validity because aversive stimuli in everyday life often come dressed in constant features (characteristic colours, movements, or odours). This condition is also useful for theoretical resolution. Notably, we found that the ESE was eliminated under correlation, an important result consistent largely with the predictions of the attention account of the ESE.

Note that in the current application of Garner's insights, the ESE is not Garner interference (consult Figure 1 again). Garner interference registers the cost incurred to performance by mere presence of task-irrelevant variation (absent in baseline, present at filtering), so that this measure is not primarily concerned with salience. Given that (a) task irrelevant variation in the carrier word is present in all ESE studies (but see Algom et al., 2004, for a single notable exception) and that (b) our goal was to emulate the standard ESE task, we compared performance across a pair of filtering conditions differing in salience of irrelevant variation. In the literature on the classical Stroop (Stroop, 1935) and Garner effects, interest typically focused on the seesaw relationship within a given pair of dimensions engendered by manipulations of salience. For example, the classical Stroop effect is present when the colour words and the ink colours are mismatched in favour of the former (the typical or default preparation), but the effect is eliminated when the two dimensions are matched, and it reverses when the ink colours are of superior salience (Algom et al., 1996; Melara & Algom, 2003; Melara & Mounts, 1993; Sabri et al., 2001). In the present research, we studied salience in a between-condition design (inspired by the quest to emulate the ESE); although implicit in the Garner tradition, this is the first time that such a comparison has been performed.

Having referred to Stroop and Garner effects, it is instructive to mention the role of dimensional correlation. Correlation is a structural part of the Garner paradigm and it has been studied quite extensively within the framework of the classic Stroop effect too (e.g., Algom et al., 1996; Bugg, Jacoby, & Toth, 2008; Dishon-Berkovits &

Algom, 2000; Melara & Algom, 2003; Sabri et al., 2001; Schmidt & Besner, 2008; Schmidt, Crump, Cheesman, & Besner, 2007). Schmidt and Besner in particular (see also Schmidt & De Houwer, 2012) have suggested an influential contingency learning account to explain effects of colour–word (and other examples of dimensional) correlation. Their account easily explains the facilitation observed under correlation in the current study: Learning of correlations speeds up responses. Again, this is the first study to import colour–word correlation into the ESE domain.

In conclusion, we suggest that the effect of emotion depends on its place and function in the situation. If emotion or threat stimuli appear in a random fashion, they interfere with any ongoing task. However, if the threat stimuli are correlated with features of the ongoing task, their extreme salience facilitates performance. A fresh look at the literature shows that the effect of emotion on performance has not been uniformly negative. Öhman et al. (2001) found that participants were faster to find an emotional stimulus (snake) than a neutral stimulus (flower) in a visual search paradigm. In the dot-probe paradigm, reduced detection latencies are found for probes appearing in the vicinity of negative stimuli (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; MacLeod et al., 1986). Mackay et al. (2004) reported superior recall for taboo (emotion) words than for neutral words in a surprise memory test. In the study by D'Argembeau and Van der Linden (2004), participants remembered the font colour and spatial location of emotion words better than they did those of neutral words. Further studies report better memory for negative words compared with neutral words (e.g., Kensinger & Corkin, 2003; Ochsner, 2000). The upshot is, emotional stimuli do not always impair performance.

Finally, the current results can provide one clue to explain the asymmetry found between negative and positive emotion stimuli within the ESE. As a rule, ESE studies have shown effects for emotion words with negative valence but not for emotion words with positive valence. Negative emotional stimuli may simply be more salient than positive emotional stimuli.

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REFERENCES

Algom, D., Chajut, E., & Lev, S. (2004). A rational look at the emotional Stroop phenomenon: A generic slowdown, not a Stroop effect. *Journal of Experimental Psychology: General*, *133*, 323–338.

Algom, D., Dekel, A., & Pansky, A. (1996). The perception of number from the separability of the stimulus: The Stroop effect revisited. *Memory & Cognition*, *24*, 557–572.

Algom, D., Zakay, D., Monar, O., & Chajut, E. (2009). Wheel chairs and arm chairs: A novel experimental design for the emotional Stroop effect. *Cognition and Emotion*, *23*, 1552–1564.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van IJzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin*, *133*, 1–24.

Ben-David, B., Levy, L., & Algom, D. (2003). The emotional Stroop effect is a generic reaction to threat, not a selective reaction to specific semantic categories. In B. Berglund & E. Borg (Eds.), *Fechner Day 2003* (pp. 21–24). Stockholm, Sweden: International Society for Psychophysics.

Ben-Tovim, D. I., & Walker, M. K. (1991). Further evidence for the Stroop test as a quantitative measure of psychopathology in eating disorders. *International Journal of Eating Disorders*, *10*, 609–613.

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

Botvinick, M. M., Braver, T. S., Barch, D. M., Carter, C. S., & Cohen, J. D. (2001). Conflict monitoring and cognitive control. *Psychological Review*, *108*, 624–652.

Bugg, J. M., Jacoby, L. L., & Toth, J. P. (2008). Multiple levels of control in the Stroop task. *Memory & Cognition*, *36*, 1484–1494.

Channon, S., Hemsley, D., & De Silva, P. (1988). Selective processing of food words in anorexia nervosa. *British Journal of Clinical Psychology*, *27*, 259–260.

Cooper, M. J., Anastasiades, P., & Fairburn, C. G. (1992). Selective processing of eating-, shape-, and weight-related words in persons with bulimia nervosa. *Journal of Abnormal Psychology*, *101*, 352–355.

Cooper, M. J., & Fairburn, C. G. (1992). Selective processing of eating, weight and shape related words in patients with eating disorders and dieters. *British Journal of Clinical Psychology*, *31*, 363–365.

D'Argembeau, A., & Van der Linden, M. (2004). Influence of affective meaning on memory for contextual information. *Emotion*, *4*, 173–188.

De Houwer, J., & Tibboel, H. (2010). Stop what you are not doing! Emotional pictures interfere with the task not to respond. *Psychonomic Bulletin & Review*, *17*, 699–703.

Dishon-Berkovits, M., & Algom, D. (2000). The Stroop effect: It is not the robust phenomenon that you have thought it to be. *Memory & Cognition*, *28*, 1437–1449.

Dreisbach, G., & Fischer, R. (2011). If it's hard to read. Try harder! Processing fluency as signal for effort adjustments. *Psychological Research*, *75*, 376–383.

Frings, C., Englert, J., Wentura, D., & Bermeitinger, C. (2010). De-composing the emotional Stroop effect. *Quarterly Journal of Experimental Psychology*, *63*, 42–49.

Frost, R., & Plaut, D. (2001). *The word-frequency database for printed Hebrew*. (Retrieved 15 November 2006 from: http://word-req.mscc.huji.ac.il/index.html)

Garner, W. R. (1974). *The processing of information and structure*. Potomac, MD: Lawrence Erlbaum Associates, Inc.

Garner, W. R., & Felfoldy, G. L. (1970). Integrality of stimulus dimensions in various types of information processing. *Cognitive Psychology*, *1*, 225–241.

Green, M. W., McKenna, F. P., & De Silva, M. S. L. (1994). Habituation patterns to color naming of eating-related stimuli in anorexics and non-clinical controls. *British Journal of Clinical Psychology*, *33*, 499–508.

Jones, C. R., & Fazio, R. H. (2010). Person categorisation and automatic racial stereotyping effects on weapon identification. *Personality and Social Psychology Bulletin*, *36*, 1073–1085.

Jones-Chester, M. H., Monsell, S., & Cooper, P. J. (1998). The disorder-salient Stroop effect as a measure of psychopathology in eating disorders. *International Journal of Eating Disorders*, *24*, 65–82.

Kensinger, E. A., & Corkin, S. (2003). Memory enhancement for emotional words: Are emotional words more vividly remembered than neutral words? *Memory & Cognition*, *31*, 169–180.

Lebrecht, S., Bar, M., Barret, L. F., & Tarr, M. J. (2012). Micro-valences: Perceiving affective valence in everyday objects. *Frontiers in Psychology*, *3*, 107.

Long, C. G., Hinton, C., & Gillespie, N. K. (1994). Selective processing of food and body size words: Application of the Stroop test with obese restrained eaters, anorexics, and normals. *International Journal of Eating Disorders*, *15*, 279–283.

MacKay, D. G., Shafto, M., Taylor, J. K., Marian, D. E., Abrams, L., & Dyer, J. R. (2004). Relations between emotion, memory, and attention: Evidence from taboo Stroop, lexical decision, and immediate memory tasks. *Memory & Cognition*, *32*, 474–488.

MacLeod, C., Mathews, A., & Tata, P. (1986). Attentional bias in emotional disorders. *Journal of Abnormal Psychology*, *95*, 15–20.

McKenna, F. P., & Sharma, D. (2004). Reversing the emotional Stroop effect reveals that it is not what it seems: The role of fast and slow components. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *30*, 382–392.

Melara, R. D., & Algom, D. (2003). Driven by information: A tectonic theory of Stroop effects. *Psychological Review*, *110*, 422–471.

Melara, R. D., & Mounts, J. R. W. (1993). Selective attention to Stroop dimension: Effects of baseline discriminability, response mode, and practice. *Memory & Cognition*, *21*, 627–645.

Ochsner, K. N. (2000). Are affective events richly recollected or simply familiar? The experience and process of recognising feelings past. *Journal of Experimental Psychology: General*, *129*, 242–261.

Öhman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology: General*, *130*, 466–478.

Orimoto, L. N. (1997). *Schematic processing of body weight-shape and self-referent attributes in the eating disorders: A comparison of binge-purging anorexic,* *bulimic, depressed, dieting and non-dieting women* [CD-ROM]. (Abstracted from proQuest File: Dissertation Abstract Item: 9713972)

Perpina, C., Hemsley, D., Treasure, J., & De Silva, P. (1993). Is the selective information processing of food and body words specific to patients with eating disorders? *International Journal of Eating Disorders*, *14*, 359–366.

Pratto, F., & John, O. P. (1991). Automatic vigilance: The attention-grabbing power of negative social information. *Journal of Personality and Social Psychology*, *61*, 380–391.

Reber, R., Schwarz, N., & Winkielman, P. (2004). Processing fluency and aesthetic pleasure: Is beauty in the perceiver's processing experience? *Personality and Social Psychology Review*, *8*, 364–382.

Reber, R., Winkielman, P., & Schwarz, N. (1998). Effects of perceptual fluency on affective judgments. *Psychological Science*, *9*, 45–48.

Sabri, M., Melara, R. D., & Algom, D. (2001). A confluence of contexts: Asymmetric versus global failures of selective attention to Stroop dimensions. *Journal of Experimental Psychology: Human Perception and Performance*, *27*, 515–537.

Schmidt, J. R., & Besner, D. (2008). The Stroop effect: Why proportion congruent has nothing to do with congruency and everything to do with contingency. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *34*, 514–523.

Schmidt, J. R., Crump, M. J. C., Cheesman, J., & Besner, D. (2007). Contingency learning without awareness: Evidence for implicit control. *Consciousness and Cognition*, *16*, 421–435.

Schmidt, J. R., & De Houwer, J. (2012). Contingency learning with evaluative stimuli: Testing the generality of contingency learning in a performance paradigm. *Experimental Psychology*, *59*, 175–182.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, *12*, 242–248.

Verbruggen, F., & De Houwer, J. (2007). Do emotional stimuli interfere with response inhibition? Evidence from the stop signal paradigm. *Cognition and Emotion*, *21*, 391–403.

Williams, J. M., Mathews, A., & MacLeod, C. (1996). The emotional Stroop task and psychopathology. *Psychological Bulletin*, *120*, 3–24.

Williams, L. E., & Bargh, J. A. (2008). Keeping one's distance: The influence of spatial distance cues on affect and evaluation. *Psychological Science*, *19*, 302–308.

Wyble, B., Sharma, D., & Bowman, H. (2008). Strategic regulation of cognitive control by emotional salience: A neural network model. *Cognition and Emotion*, *22*, 1019–1051.