Emotional Stroop interference in trauma-exposed individuals:

A contrast between two accounts

Serge Caparos¹ & Isabelle Blanchette²

¹ Université de Nîmes, CHROME EA 5372, France
² Université du Québec à Trois-Rivières, Canada

Contact: serge.caparos@unimes.fr

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Abstract

In the Emotional Stroop task, trauma-exposed victims are slowed when naming the colour print of trauma-related words, showing the presence of interference. This interference has been assumed to reflect emotional reactions triggered by experience-relevant emotional content which interfere with the task. However, it may equally reflect the activation of task-competing thoughts triggered by experience-relevant semantic content, thus resulting from cognitive- rather than emotion-driven processes. This study contrasted these possibilities by measuring the relationship between Emotional Stroop interference, on the one hand, and severity of sexual-abuse experience, subjective ratings of emotionality, and working-memory measures, on the other. Whereas there was no relationship between working-memory measures and interference, providing no support for the cognitive-based account, experience severity, emotionality ratings and abuse-related interference were all positively related, providing support for the emotion-based account. These findings support the idea that the Emotional Stroop task can be used as a diagnostic tool for emotion-filtering impairment.

Key words

Emotional Stroop, Trauma, Attention, Emotion, Cognition, Interference
1. Introduction

Traumatic experiences are common with a lifetime prevalence rate of more than 60% in the general population (e.g., Resnick, Kilpatrick, Dansky, Saunders, & Best, 1993). People subject to traumatic experiences, such as sexual abuse, are exposed to intense emotions and this has cognitive consequences not only during the traumatic experience but also long after it, notably on short-term verbal memory, working memory and sustained attention (Jenkins, Langlais, Delis, & Cohen, 1998; Navalta, Polcari, Webster, Boghossian, & Teicher, 2006; Stein, Hanna, Vaerum, & Koverola, 1999; Stein, Kennedy, & Twamley, 2002). Importantly, trauma-exposed victims present a long-term alteration of selective attention characterised by an impaired attentional filtering for trauma-related emotional information (Cisler et al., 2011; Williams, Mathews, & MacLeod, 1996). A good understanding of the effect of trauma on attention is important, not least because this effect might play a role in the causation and maintenance of trauma-related psychopathologies such as anxiety and posttraumatic stress disorder (PTSD; Williams et al., 1996). Thus far, however, this effect has been studied mostly using the Emotional Stroop task (Ray, 1979), a task that remains controversial with regard to the processes it indexes. Specifically, the Emotional Stroop task might index general cognitive effects, such as semantic interference, rather than emotion-specific effects as classically assumed (Becker, Rinck, Margraf, & Roth, 2001; Williams et al., 1996). The present study aimed to shed new light on this issue. It contrasted and tested two accounts, one emotional and one cognitive, for the impact of trauma on attention as observed with the Emotional Stroop task.

The Emotional Stroop task was designed by analogy to the Cognitive Stroop task (Stroop, 1935). In the Cognitive Stroop task, participants are asked to name the colour print of a word; reaction times (RTs) are slowed when colour print and semantic meaning of a colour word are inconsistent (e.g., the word ‘green’ presented in red). The extent to which participants are slowed by inconsistent semantic information, compared to neutral semantic information, provides an index of participant’s attentional inefficiency, that is, their difficulty in focusing on the primary colour-naming task and ignoring task-unrelated distracting stimuli. The Emotional Stroop task is similar to the Cognitive Stroop task except that it uses emotional words instead of colour words. In the Emotional Stroop task, participants are slower when they name the colour of an emotional word compared to when they name the colour of a neutral word (Ray, 1979). The amount of interference, namely, the extent to which participants are slowed by emotional semantic information, provides an index of participant’s difficulty in ignoring task-unrelated emotional content. A crucial aspect of this task is that the effect of emotional words largely depends on experience: the more an emotional word is relevant to the personal experience of an individual, the stronger its effect on this individual. For instance, while sexual-abuse words produce strong interference for rape victims (e.g., Cassiday, McNally & Zeitlin,
1992) and war-related words exert strong influence in Vietnam-war veterans (e.g., Litz et al., 1996), the same words exert little interference in controls.

The effect of emotional words in the Emotional Stroop task is believed to reflect a failure of selective attention to filter out experience-relevant emotional content. The exact processes involved however remain disputed despite over thirty years of research using the task (Becker et al., 2001; Gilboa-Schechtman, Revelle, & Gotlib, 2000; Williams et al., 1996). On the one hand, experience-relevant emotional words might exert their impact through their high emotional salience (e.g., their threat value), suggesting that attention is affected by the emotional reactions triggered by semantic content. On the other hand, experience-relevant emotional words might exert their impact through their high conceptual salience (e.g., they match participant’s current thoughts), suggesting that attention is affected by interfering thoughts triggered by salient semantic content.

If the Emotional Stroop effect results from conceptual salience, the Emotional Stroop task may not actually index emotional processing. Words relevant to an individual relate to ‘current concerns’ and might more readily generate task-unrelated thoughts that compete for cognitive resources and slow the primary colour-naming task (Williams et al., 1996). This cognitive account is supported by findings of a large overlap in the brain regions activated by Emotional and Cognitive Stroop tasks (Whalen et al., 1998). It is also supported by findings showing that words that are not emotional can nevertheless generate interference when they match personal interests (Gronau, Cohen, & Ben-Shakhar, 2003). For instance, in one study (Dalgleish, 1995), bird names were found to produce interference in ornithologists but not in controls. In sum, the cognitive account suggests that Emotional and Cognitive Stroop tasks tap similar cognitive processes.

Numerous studies have shown that Cognitive Stroop interference is predicted by participants’ working-memory efficacy (e.g., Long & Prat, 2002; Kane & Engle, 2003; Kiefer, Ahlegian, & Spitzer, 2005). Differences in the efficiency of two subcomponents of working memory, the central executive and the phonological loop (Baddeley, 2003), are likely to account for interindividual differences in Cognitive Stroop interference. Participants with a less efficient central executive, which is involved in controlling and regulating information (Baddeley, 2003), are less effective at inhibiting task-irrelevant semantic information (Long & Prat, 2002). In addition, participants with a less efficient phonological loop, which is involved in rehearsing processed information and has a limited capacity (Baddeley, 2003), might be more handicapped by the involuntary storage of task-irrelevant semantic information (Saeki, 2007). If the Emotional Stroop effect is in fact a Cognitive Stroop effect, then interindividual differences in Emotional Stroop interference should be predicted by differences in working-memory efficacy, and more specifically by differences in the efficiency of the central-executive subcomponent and/or of the phonological-loop subcomponent. We tested these predictions in the present study.
We measured working-memory efficacy using the running-span task (Pollack Johnson, & Knaff, 1959), a task which allowed us to isolate the respective contribution of central executive and phonological loop (Vieillard & Bougeant, 2005).

In contrast, or in addition, to the cognitive account, a more widely-held view suggests that the Emotional Stroop task measures emotion-driven interference (Ben-Haim, Mama, Icht, & Algom, 2013). Words reminiscent of past emotional experiences are relevant to people’s goals, core beliefs or identity and trigger emotional reactions (e.g., increases in arousal levels; Dresler, Mériaux, Heekeren, & Van der Meer, 2009). This idea is compatible with findings that, unlike the Cognitive Stroop task, the Emotional Stroop task modulates brain activity in the amygdala and occipito-temporal areas, regions involved in emotional processing (Compton et al., 2003). However it is impossible to know whether this activation of emotional brain areas is causal or necessary to the resulting interference. If the effect of emotional words relies on emotional rather than cognitive processes, it should bear little relation to differences in working-memory efficacy. Instead, it should be linked to the ‘emotionality’ of the stimuli used.

Emotionality refers to the emotional impact of a stimulus, regardless of its valence (i.e., both positive and negative stimuli can be highly emotional; Gilboa-Schechtman et al., 2000; Schimmack & Derryberry, 2005). Emotional stimuli have an impact both on individuals’ physiological state (e.g., increase in arousal; Lang, Greenwald, Bradley, & Hamm, 1993) and on their subjective state (e.g., mood; Ben-Haim et al., 2013), effects which are intimately related (Greenwald, Cook, & Lang, 1989). Previous findings suggest that emotionality is central to predicting Emotional Stroop interference (e.g., Ben-Haim et al., 2013; Hart, Green, Casp, & Belger, 2010; Salters-Pedneault, Gentes, & Roemer, 2007). Accordingly, some data showed that emotional stimuli, which were more arousing to participants with high than with low state anxiety, also caused more Emotional Stroop interference in participants with high than with low state anxiety (Dresler et al., 2009). In addition, non-words that had been conditioned to have a negative connotation generated longer reaction times than non-words that had been conditioned to have a neutral connotation, thus highlighting the role of emotionality in Emotional Stroop interference (Richards & Blanchette, 2004). In sum, an emotional account suggests it is the emotional reactions triggered by the trauma-related contents, rather than trauma-related semantic contents per se, that are responsible for Emotional Stroop interference.

The present study contrasted the cognitive and emotional accounts for Emotional Stroop interference. Though they are not mutually exclusive, we attempt to investigate their relative influence. Participants were recruited among a female undergraduate population who had a varying experience of sexual abuse, from no abuse to high-severity abuse. We used a standard Emotional Stroop task (Ray, 1979) in which target words
pertained to one of three semantic contents (neutral, generally emotional or sexual-abuse related) and were presented in one of four possible colours (red, green, yellow or blue). Participants’ reaction times at discriminating colour print (using a four-alternative forced choice) were measured. Emotional Stroop interference was indexed by subtracting RTs for neutral words from RTs for sexual-abuse and generally emotional words. After performing the Emotional Stroop task, participants rated the emotionality of the target words.

We expected a positive relationship between severity of abuse experience and sexual-abuse interference (Cassiday et al., 1992). In addition, two possibilities were considered in terms of the relationships between sexual-abuse interference, on the one hand, and emotionality and working-memory measures, on the other. First, an absence of relationship between interference and working-memory measures would make the cognitive account unlikely. Second, in the absence of a relationship between interference and working-memory measures, a relationship between interference and emotionality ratings would make the emotional account likely.

2. Method

2.1 Participants

Participants were undergraduate Psychology students recruited from the Université du Québec à Trois-Rivières, Canada, using a participant database. Sexual abuse was not mentioned at the recruitment stage; participants were informed that they would answer questions about past experiences of abuse during the information and consent stage. Only women were recruited since sexual abuse is more relevant to this group (e.g., in 2008, more than 80% of sexual-abuse victims were women in Canada; see www.statcan.gc.ca). Twenty-three participants had experienced no abuse (Mean age 21.7 years, \(SEM = 1.1\); 14.7 years of education in average, \(SEM = 0.4\); see Table 1) and 35 participants had experienced at least one type of sexual abuse (Mean age 23.5 years, \(SEM = 0.9\); 14.6 years of education in average, \(SEM = 0.2\)). None of the participants had reported being diagnosed with Posttraumatic Stress Disorder (PTSD) at the time of testing. All participants had normal or corrected-to-normal vision and spoke French as their first language. They received $10 as a compensation for their time. Participants were debriefed at the end of the experiment and were provided with local and national
contact details should they require psychological help following the experiment. No participant reported feeling distressed or requiring counselling.

**Table 1. Demographics, PCL-C score and working memory**

<table>
<thead>
<tr>
<th>Group</th>
<th>Age (yrs)</th>
<th>Edu (yrs)</th>
<th>PCL-C</th>
<th>PL capacity</th>
<th>CE efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
</tr>
<tr>
<td>Abuse victims</td>
<td>21.7 (4.6)</td>
<td>14.6 (1.2)</td>
<td>28.9 (10.5)</td>
<td>2.0 (1.0)</td>
<td>0.4 (0.4)</td>
</tr>
<tr>
<td>(35)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No-abuse controls</td>
<td>23.5 (5.2)</td>
<td>14.7 (1.9)</td>
<td></td>
<td>2.9 (1.1)</td>
<td>0.3 (0.3)</td>
</tr>
<tr>
<td>(23)</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

yrs = Years; Edu = Education; PCL-C = Posttraumatic Checklist – Civilian version; PL = Phonological Loop; CE = Central Executive; n = Number of participants; M = Mean; SD = Standard Deviation.

### 2.2 Experimental Setup

Testing took place in dimly-lit and quiet testing room. Questionnaires and stimuli were presented on an LCD 22-inch monitor, operating at a resolution of 1280 x 1024 pixels. Viewing distance was 60 cm. The stimuli were generated and the experiment was run using EPrime (Schneider, Eschman, & Zuccolotto, 2002).

### 2.3 Procedure

**2.3.1 Questionnaires**

Participants first completed a French-translated 6-item adaptation of the Stressful Life Events Screening Questionnaire (SLESQ; Goodman, Corcoran, Turner, Yuan, & Green, 1998) which screened for the occurrence of traumatic sexual event(s). Participants were asked whether they had ever (1) been touched against their will on intimate parts of their body, (2) been rubbed by someone else’s private parts against their will, (3) been forced to touch the intimate parts of someone else’s body, (4) been forced to take part in a genital sexual intercourse, (5) been forced to take part in an oral sexual intercourse, and/or (6) been forced to kiss someone in a sexual way. They gave yes/no answers to each of these six possibilities. ‘No’ answers were coded as zero and ‘yes’ answers as one; each participant was thus given a score from zero to six. This score was used as a measure of the ‘objective’ severity of the experience of abuse. Participants scoring above
zero filled a second questionnaire, namely, a French-translated version of the Posttraumatic Stress Disorder CheckList – Civilian Version (PCL-C; Blanchard, Jones-Alexander, Buckley, & Forneris, 1996). This 17-item questionnaire indexed the incidence of posttraumatic stress symptoms related to the traumatic sexual event(s). Participants gave an answer from one (not at all) to five (extremely) to each item. Items addressed symptoms often associated with PTSD, such as the occurrence of disturbing dreams, the inability to concentrate or the intrusion of disturbing thoughts related to the event. Answers were added to produce a score from 17 (no post-traumatic stress symptoms) to 85 (maximum level of post-traumatic stress symptoms). The PCL-C questionnaire was used to confirm that SLESQ scores indexed experience severity; higher SLESQ scores were expected to be related to higher PTSD symptoms. The questionnaire was also used to identify participants with clinical levels of PTSD symptoms since, in these participants, cognitive differences may pre-exist trauma exposure (Navalta et al., 2006).

2.3.2 Emotional Stroop Task

After filling in the questionnaire(s), participants performed an adaptation of the Emotional Stroop task. At the beginning of each trial, a fixation cross was displayed for a varying duration, selected randomly between 100 and 300 ms. Following fixation-cross offset, a target word (1° in height and 4-12° in width) printed in red, blue, green or yellow was presented at fixation. Participants indicated the word colour in a speeded way using four colour-stickered keys: the ‘1’, ‘2’, ‘9’ and ‘0’ keys (from the top side of the keyboard) indicated red, green, yellow and blue, respectively. Responses were given using the middle finger and forefinger of the left hand for red (‘1’) and green (‘2’), respectively, and using the forefinger and the middle finger of the right hand for yellow (‘9’) and blue (‘0’), respectively. Following key press, the target word disappeared and a 200-ms blank followed, after which the next trial started. At the beginning of the experiment, participants were informed that the meaning of the target word was irrelevant to the task.

The words used in the task pertained to three types of semantic content; ten words were neutral (i.e., the French words for ‘turnip’, ‘board’, ‘fan’, ‘shelf’, ‘bag’, ‘discussion’, ‘keyboard’, ‘typical’, ‘lettuce’ and ‘formulate’), ten words were generally emotional (i.e., the French words for ‘death’, ‘murder’, ‘mourning’, ‘funeral’, ‘cancer’, ‘tumour’, ‘stress’, ‘abandonment’, ‘panic’ and ‘hatred’), and ten words were related to sexual abuse (i.e., the French words for ‘erection’, ‘exploited’, ‘pawed’, ‘penetrated’, ‘victim’, ‘incest’, ‘molested’, ‘abused’, ‘rape’). The words of each type of semantic content were presented in separate blocks of trials (because blocked presentation has been found to potentiate the Emotional Stroop effect; e.g., Kaspi, McNally, & Amir, 1995). Within each block of trials, each word was presented in each of the four colours once, giving a total of 40 trials. Words were selected at random within each block of trials and
the three blocks (‘neutral’, ‘generally emotional’ and ‘sexual abuse’) were performed in a random order across participants.

Before starting the task, participants performed a 12-trial practice using twelve neutral words drawn from a pool other than the one used in the task. After completing the task, participants rated the emotionality of the 30 words used in the task (presented in a random order) using a scale ranging from one (completely neutral) to five (intensely emotional).

2.3.3 Running span

After performing the Emotional Stroop task, participants performed an adaptation of the Running Span task (Bunting, Cowan, & Saults, 2006; Van der Linden et al., 1999; Vieillard & Bougeant, 2005) which comprised two blocks. In the first block, on each trial, a list of four, six or eight randomly-selected consonants were presented serially at fixation. There was no repetition within a list. Each consonant was presented for 850 ms and followed by a 650 ms blank. Participants were told that they would have to recall (type in) the last four consonants of each list upon hearing a 900ms beep that followed the presentation of the last consonant. The block consisted of 12 lists and was preceded by a two-list practice. The second block was identical to the first, except that (1) the lists contained five, seven or nine consonants (instead of four, six or eight) and (2) participants were asked to remember the last five consonants (instead of the last four) of each list. A trial was counted as correct when all four/five consonants were correctly recalled (sequence knowledge was required).

For each participant and for each list type (i.e., for the four-, five-, six-, seven-, eight- and nine-item lists), a memory span was calculated by multiplying the number of item in the list by the average accuracy for that list. Two indices were then extracted. First, for each participant, the spans for the four- and five-item lists were averaged. Because the four- and five-item lists did not necessitate any information manipulation (all the items of the list had to be maintained in memory), this first index was hypothesized to measure phonological-loop capacity (Vieillard & Bougeant, 2005). The higher the value of this index (minimum 0; maximum 4.5), the better participants were at holding information in their phonological loop. Second, for each participant, the six-, seven-, eight- and nine-item spans were averaged and the resulting average was divided by the average of the four- and five-item spans. Because the 6/7/8/9-item spans involved information manipulation (inhibiting old information and replacing it with new information), this second index was posited to measure central-executive efficiency (Vieillard & Bougeant, 2005). The higher the value of this second index was, the greater the central executive resources (minimum 0, maximum 1; note that, while participants might have an index greater than one if they memorised more items in the 6/7/8/9-item
lists than in the 4/5-item lists, there is no theoretical justification for predicting this possibility).

3. Results

3.1 Questionnaires

Participants’ questionnaire scores were examined. In the Stressful Life Events Screening Questionnaire (sexual trauma subscale), 23 participants scored zero (i.e., they reported no traumatic sexual event). Thirty-five participants reported one or more traumatic sexual event; 17 scored one, eight scored two, three scored three, three scored four, three scored five and one scored six. Of these 35 participants, 32 filled the Posttraumatic Stress Disorder Checklist – Civilian Version (three participants did not fill this second questionnaire due to a technical issue). Their average score was 28.9 (SEM = 1.8; range 17 to 57). Scores on the PCL-C were highly correlated with their scores on the SLESQ, r(32) = .72, p < .001, confirming that SLESQ scores were an indicator of experience severity (Dickinson, DeGruy, Dickinson, & Candib, 1999). Only one participant had a PCL-C score higher than the PTSD cut-off score (50; Blanchard et al., 1996).

3.2 Effect of severity of sexual-abuse experience

In a first set of analyses, we examined the effect of severity of sexual-abuse experience on working-memory spans, emotionality ratings and Emotional Stroop interference.

3.2.1 Running Span

We tested whether there were significant correlations between severity of abuse experience (SLESQ scores), on the one hand, and phonological-loop capacity and central-executive efficiency, on the other. There was a significant negative relationship between severity of abuse and phonological-loop capacity, r(58) = -.26, p = .051, describing the fact that participants who had experienced a more severe form of abuse had a smaller phonological-loop capacity. In contrast, there was no relationship between severity of abuse and central-executive efficiency, r(58) = .11, p = .419, suggesting that the experience of abuse did not affect the central executive.

3.2.2 Emotionality Ratings

Participants’ emotionality ratings for the thirty words used in the Emotional Stroop task were examined (see Table 2). First, a bivariate correlation showed that emotionality ratings for neutral words (M = 1.1, SEM = 0.04) did not vary as a function of SLESQ scores (i.e., severity of abuse experience), r(58) = -.08, p = .567. Ratings for
neutral words were used as a baseline from which relative emotionality ratings could be extracted for each participant. Relative emotionality ratings were indexed by partialling out emotionality ratings for neutral words from emotionality ratings for generally emotional and sexual-abuse words. A mixed-design analysis of covariance (ANCOVA) tested for the effect on relative emotionality ratings of semantic content (generally emotional or sexual abuse; within-subject variable) and SLESQ scores (severity of experience, entered as a between-subject continuous covariable). It showed a significant interaction between the two factors, $F(1,56) = 5.49$, $p = .023$, $\eta^2_p = .089$. To understand the origin of this interaction, the relationship between SLESQ scores and emotionality ratings was tested separately for each semantic content. Whereas there was a positive relationship between SLESQ scores and emotionality ratings for sexual-abuse words, $r(58) = .36$, $p = .006$ (see Figure 1a), there was no significant relationship between SLESQ scores and emotionality ratings for generally emotional words, $r(58) = .20$, $p = .147$ (see Figure 1b).

**Table 2. Emotional Stroop task: reaction times, errors and subjective emotionality ratings**

<table>
<thead>
<tr>
<th>Group</th>
<th>RT (ms)</th>
<th>Errors (%)</th>
<th>Subjective ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AR M (SD)</td>
<td>GE M (SD)</td>
<td>N M (SD)</td>
</tr>
<tr>
<td>Abuse victims</td>
<td>788.8 (205.4)</td>
<td>774.3 (199.6)</td>
<td>753.4 (177.6)</td>
</tr>
<tr>
<td>(35)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No-abuse controls</td>
<td>685.6 (90.6)</td>
<td>693.0 (116.1)</td>
<td>662.6 (92.4)</td>
</tr>
<tr>
<td>(23)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AR = Abuse Related; GE = Generally Emotional; N = Neutral; n = Number of participants; M = Mean; SD = Standard Deviation.

Other findings from the main analysis were (1) significant main effect of semantic content, $F(1,56) = 4.46$, $p = .039$, $\eta^2_p = .074$, describing the fact that relative emotionality
ratings were slightly higher for sexual-abuse content ($M = 1.9, SEM = 0.16$) than for generally emotional content ($M = 1.8, SEM = 0.12$), and (2) a significant main effect of SLESQ scores, $F(1,56) = 5.50, p = .023$, $\eta^2_p = .090$, describing an overall positive relationship between relative emotionality ratings and SLESQ scores.

3.2.3 Emotional Stroop Task

Participants’ mean reaction times (RTs) were averaged for each condition of the Emotional Stroop task (see Table 2). Only accurate responses and reaction times above 300 ms and below 2000 ms were included in the calculation (3.6% of RTs were excluded under these criteria). First, a bivariate correlation showed that RTs in the neutral condition ($M = 715$ ms, $SEM = 19.8$) did not vary as a function of SLESQ scores (i.e., severity of abuse experience), $r(58) = .08, p = .547$, showing that overall performance was not affected by the experience of abuse. Neutral-word RTs were used as a baseline from which interference from task-irrelevant emotional information could be calculated for each participant. Interference was indexed by partialling out neutral RTs from generally emotional and sexual-abuse RTs. A one-sample t-test showed that overall interference (i.e., pooled across semantic contents) was significantly higher than zero ($M = 27.6$ ms, $SEM = 8.4$), $t(57) = 3.27, p = .002, d = 0.621$, confirming that emotional words had a deleterious effect on performance. Then, a mixed-design ANCOVA tested for the effect on interference of semantic content (generally emotional or sexual-abuse; within-subject variable) and SLESQ scores (severity of experience; between-subject continuous covariable). While neither the main effect of semantic content nor that of SLESQ scores was significant, respectively, $F(1,56) = 0.84, p = .363, \eta^2_p = .015$ and $F(1,56) = 0.67, p = .416, \eta^2_p = .012$, there was a significant interaction between the two factors, $F(1,56) = 4.90, p = .031, \eta^2_p = .080$. To understand the origin of this interaction, the relationship between SLESQ scores and interference was tested separately for each semantic content. Whereas there was a relationship between SLESQ scores and sexual-abuse interference which was close to significance, $r(58) = .26, p = .055$ (see Figure 1c), there was no significant relationship between SLESQ scores and generally emotional interference, $r(58) = -.04, p = .757$ (see Figure 1d).
In summary, the severity of the abuse experience predicted the strength of the interference generated by sexual-abuse words. This relationship between severity and interference could be explained by the fact that subjective emotionality for sexual-abuse words increased as severity increased, and/or by the fact that phonological-loop capacity decreased as severity increased. A last set of analyses was performed to explore the relationship between Emotional Stroop interference, emotionality and working memory.

3.3 Effects of emotionality and working memory
A mixed-design ANCOVA tested for the effect on interference of semantic content (generally emotional or sexual-abuse; within-subject variable) and of phonological-loop capacity, central-executive efficiency, relative emotionality ratings for sexual-abuse words and relative emotionality ratings for generally emotional words (all between-subject continuous covariables).

There was a significant two-way interaction between semantic content and relative emotionality ratings for sexual-abuse words, \( F(1,53) = 12.79, p = .001, \eta_p^2 = .194 \). To understand the origin of this interaction, the relationship between emotionality ratings and interference was tested separately for each semantic content. Whereas there was a significant relationship between sexual-abuse emotionality ratings and sexual-abuse interference, \( r(58) = .27, p = .045 \) (see Figure 2a), there was no such relationship between sexual-abuse emotionality ratings and generally emotional interference, \( r(58) = -.14, p = .277 \) (see Figure 2b). No other main effect or interaction was significant (no \( p \) value < .150). Notably, neither the main effect of phonological-loop capacity nor that of central-executive efficiency was significant, respectively, \( F(1,53) = 0.15, p = .902, \eta_p^2 = .001 \), and \( F(1,53) = 0.76, p = .387, \eta_p^2 = .014 \). In addition, neither the interaction between phonological-loop capacity and semantic content nor that between central-executive efficiency and semantic content was significant, respectively, \( F(1,53) = 0.15, p = .700, \eta_p^2 = .003 \) and \( F(1,53) = 0.46, p = .479, \eta_p^2 = .009 \). This showed that phonological-loop capacity and central-executive efficiency did not predict Emotional Stroop interference (see Figures 2c and 2d depicting this absence of relationship).

4. Discussion

In this study, we contrasted a cognitive and an emotional account for the origin of Emotional Stroop interference. We measured interference generated by sexual-abuse content in participants who had a varying experience of sexual abuse, from no abuse to high-severity abuse, and we tested the effect on this interference of (1) severity of sexual-abuse experience, (2) subjective emotionality, and (3) two indices of working-memory efficacy, namely, phonological-loop capacity and central-executive efficiency.

Participants who had experienced more severe abuse showed greater sexual-abuse interference. Given that relevance is posited to increase with severity, this finding was consistent with the idea that Emotional Stroop interference strongly relies on experience relevance (e.g., Williams et al., 1996). Emotionality ratings for sexual-abuse content were also positively related to severity, suggesting that the more relevant an experience was, the more emotional it was. Finally, greater emotionality ratings for sexual-abuse content predicted stronger sexual-abuse interference. This finding was consistent with an emotional account for Emotional Stroop interference (e.g., Richards & Blanchette, 2004); words reminiscent of past emotional experiences trigger emotional reactions (e.g.,
increases in arousal levels; Dresler et al., 2009) that interfere with the primary colour-naming task.

Figure 2. Emotional Stroop task. Relationship between relative emotionality ratings for abuse-related words (min. 0, max. 4) and (2a) interference with abuse-related words
(ms), and (2b) interference with generally emotional words (ms). Relationship between interference with abuse-related words (ms) and (2c) phonological-loop capacity (min. 0, max. 4.5), and (2d) central-executive efficiency (min. 0, max 1). Relationship between interference with generally emotional words (ms) and (2e) phonological-loop capacity (min. 0, max. 4.5), and (2f) central-executive efficiency (min. 0, max 1). Each dot represents the data of one participant.

Unlike emotionality ratings, neither phonological-loop capacity nor central-executive efficiency predicted sexual-abuse interference. Thus, unlike Cognitive Stroop interference (Long & Prat, 2002; Kane & Engle, 2003; Kiefer et al., 2005), Emotional Stroop interference was not related to working memory. This null-effect was observed despite the fact that participants who had experienced more severe sexual abuse had a lower phonological-loop capacity. Thus, the positive relationship between severity and sexual-abuse interference, on the one hand, and the negative relationship between severity and phonological-loop capacity, on the other, appeared to be orthogonal. In sum, the present findings did not provide support for the cognitive account for Emotional Stroop interference.

It is noteworthy that, because the running-span task was always performed after the Emotional Stroop task, the lower phonological-loop capacity observed in high-severity participants might have resulted from a stronger impact of the Emotional Stroop task in these participants (e.g., a stronger increase in arousal). If this is true, lower phonological-loop capacity in these participants would have been only temporary. However, this suggestion is inconsistent with previous findings showing lower working-memory capacity in victims of sexual abuse (compared to no-abuse controls) even in the absence of a task that promotes trauma-related thoughts (Stein et al., 2002). In any case, reduced phonological loop capacity in high-severity participants could account neither for the presence of a relationship between emotionality ratings and interference, nor for the absence of such relationship between working-memory measures and interference. It is interesting to note that, in the present study, participants exposed to abuse did not show lower central-executive efficiency. This finding is somehow at odds with the idea that trauma impairs executive functioning (Stein et al., 2002).

The last finding that we discuss concerns interference generated by generally emotional content. Generally emotional interference was not related to emotionality ratings for generally emotional words. This null effect might have been due to the low relevance of generally emotional words (Becker et al., 2001; Blanchette & Richards, 2012) and/or to the tighter distribution of ratings (SD = 0.9 for generally emotional ratings vs. SD = 1.2 for sexual-abuse ratings). Another possibility is linked to task order. Participants always filled questionnaires before performing the Stroop task. This might have primed emotions and memories in participants who have previously experienced
abuse, thus potentiating abuse-related interference and strengthening the relationship between abuse-related interference and emotionality ratings for abuse-related words. Such effect would not have occurred for generally emotional interference.

In conclusion, the present findings show that relevant emotional stimuli, which are central to participants’ core beliefs and identity, are more difficult to ignore and that they impact performance on a simple perceptual task. This effect on participants’ attention and voluntary control involves emotional processes, and not only cognitive processes. These results are good news given all the studies which have assumed, despite the absence of much evidence, that the Emotional Stroop task measures processes which are emotion specific and which are to a certain extent distinct from the processes measured in the Cognitive Stroop task, at least in their origin. Because this study was performed on a particular population with a specific trauma – students with an experience of sexual abuse – it will be important to replicate its findings with other populations (e.g., clinical) and other types of trauma (e.g., political violence). In any case, however, the results suggest that the Emotional Stroop task can be used as an index of emotional filtering efficiency.

More work is needed to understand fully the mechanisms underlying Emotional Stroop interference. Even though cognitive and emotional processes are not mutually exclusive and are in fact strongly connected (as illustrated by the overlap in brain regions activated by Emotional and Cognitive Stroop tasks; Whalen et al., 1998), it should be possible to isolate their relative contribution.

5. References


