The influence of emotion and observer characteristics on attention

by

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I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

For decades, emotion researchers have debated a series of issues related to the influence of emotionally laden information on the way in which people process and remember information. The present investigation was designed to experimentally test both general (Experiment 1 and 2) and person-specific (Experiment 3) influences of emotionally laden words on attention and memory using a digit-parity task in which participants were asked to make a speeded judgement about the parity of two digits flanking a to-be-ignored, centrally presented word. In Experiment 1, when a sexual, threat, school, or neutral word was presented between the digits, only the sexual words, rated high in arousal value by study participants, disrupted digit-parity performance producing longer digit-parity response times relative to all other word categories. Sexual words were also recalled more often by study participants in a surprise free recall task. Mirroring attention and memory results, an evaluation of skin conductance responses (SCRs) demonstrated that participants showed enhanced SCRs for the sexual words relative to all other word categories. Furthermore, when the sexual words were parsed into positive and negative word categories (Experiment 2), trials in which a sex-negative word was presented between the digits produced the longest digit-parity response times. Participants recalled more sex-negative words than any other word category. Importantly, participants' taboo ratings predicted attention and memory results. Finally, when words relevant to participants' fears were presented between the digits, digit-parity response times slowed relative to when a fear-irrelevant word was presented between the digits. Memory and skin conductance data provide converging evidence – participants recalled and produced larger skin conductance responses for fear-relevant words compared to fear irrelevant words.

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The influence of emotion and observer characteristics on attention

Emotion pervades our human experience. From Darwin and James (1872, 1884) onward, researchers have been captivated by emotional phenomena. Despite efforts to define emotion, to determine the structure of emotional experience, and to capture the behavioural, verbal, and physiological concomitants of emotion, it continues to remain elusive. One area which has received growing interest in past decades is the influence of emotion on visual attention.

Anecdotally, it stands to reason that noticing a rapidly approaching oncoming car should take precedence over noticing the flowers growing alongside the roadway. Indeed, we live in an information-rich environment, where we are constantly being bombarded with stimuli competing for our attention. Given the constraint that attention operates within a limited-capacity system where only some information can be selected for further processing, it is adaptive to prioritize those stimuli that have relevance for our survival and behavioural goals. While many factors can influence the likelihood that one particular stimulus is attended to over another, the overarching goal of this dissertation is to examine how affectively significant visual stimuli can capture attention. In pursuit of this goal I will show that affective significance is in the eye of the beholder. What may be of mere passing interest to some may be of great importance to others depending on the individual characteristics of the observer.

Emotion and Attention: The role of stimulus valence

Much of the literature examining the influence of emotion on attention has emphasized the role of stimulus valence, and in particular threat (e.g., Dijksterhuis & Aarts, 2003). Research examining the potentially attention-capturing effect of threatening stimuli is born out of the evolutionary threat hypothesis – the detection of threatening information has more adaptive value from a survival standpoint than the detection of other information. In a seminal study, Hansen and Hansen (1988) tested the hypothesis that humans preferentially orient their attention to threatening information. Using a visual search design, participants were presented with a matrix of friendly or angry faces. Embedded within these matrices were singleton faces of the opposite valance (e.g., a single angry face amongst friendly faces, and vice versa). Participants were asked to detect the singleton face as quickly as possible. Results indicated that participants were faster and more accurate at detecting an angry face among friendly faces compared to detecting a friendly face among angry faces, suggesting that humans are faster and more accurate to detect angry or negatively valenced faces than friendly or positively valence faces. These results were later replicated by Öhman, Ludqvist, and Esteves (2001). Interestingly, Öhman and colleagues' (2001) results also indicated that angry faces were more quickly and accurately located among friendly faces than were other negatively valenced faces (sad or scheming). The fact that angry faces were faster to locate than sad or scheming faces led investigators to conclude that threatening stimuli may be particularly potent capturers of attention – superior to other classes of stimuli with a negative valence. Providing further support for the evolutionary threat hypothesis, Öhman, Flykt, and Esteves (2001), showed that participants were faster to locate fear-relevant stimuli – snakes and spiders – amongst fear-irrelevant stimuli – mushrooms and flowers – than they were at locating fear-irrelevant stimuli – mushrooms and flowers – amongst fear-relevant stimuli.

The putative ability of threatening stimuli to capture attention may not be limited to faces and pictures of fear-inducing creatures like snakes and spiders. Dijksterhuis and Aarts (2003) showed that a threat advantage could also be detected using word stimuli. In a series of three studies, they exposed participants to subliminally presented positive or threatening words. In study one, participants were presented with either a positive word, a negative word, or no word. After each trial participants were asked to indicate whether they thought a word had appeared or not. In study two, half the trials contained positive words with the other half containing negative words. Participants were asked to indicate whether the word presented was positive or negative. In the final study, in addition to making an evaluative judgment (is the word positive or negative?), participants were asked to indicate which of two words was a synonym of the presented word (i.e., participants were asked to make a semantic judgment regarding the nature of the word). Across all studies, participants were able to detect, as well as correctly categorize (make a positive vs. threatening distinction), subliminally presented threatening words with greater accuracy.

The attention capturing capability of threatening words has also been found in studies employing variants of the Stroop colour-naming task; naming the font colour of a word is slowed when the word is threat-relevant relative to when the word is positive or neutral (McKenna and Sharma, 1995), even though emotion is irrelevant to the task. Results suggest that participants' inability to ignore the emotional content of the word interferes with their ability to name the font colour of the word, increasing colour-naming times. Thus, it is reasoned that the emotional content of the word momentarily captures attention, resulting in slower colour naming times for threat-relevant words as compared to neutral or positive words. Similar effects have been shown in studies employing socially threatening stimuli. As an example, Pratto and John (1991) found longer colour-naming response times for adjectives describing undesirable personality traits relative to socially desirable personality traits.

In concert, these findings demonstrate that humans are faster and more accurate when detecting threatening information than positive or neutral information, and that threatening stimuli interferes more with colour-naming in Stroop-type tasks than non-threatening information. However, closer examination of Ohman and colleague's (2001) results suggest that there appears to be something "special" about threatening information that cannot be explained by negative valence alone. Presumably, if negative valence accounted for participants' abilities to more quickly locate threatening information then we would expect other negative information to be located equally quickly. However, this is not the case. The inability of sad or scheming faces to preferentially capture attention suggests that negative valence alone is insufficient in explaining the attention grabbing quality of threatening stimuli. Moreover, some studies have even failed to show differences between threatening stimuli relative to neutral stimuli (e.g., Harris and Pashler, 2004) or positive stimuli (e.g., Constantine, McNally, & Hornig, 2001). Thus there is reason to suspect that only considering the influence of negative valence on attention leaves the story incomplete.

Mogg and colleagues (2000) found that the more extremely negative an image, the more likely it would attract attention; mild negative pictures, despite being negative in valence, did not attract more attention than positive pictures. Notably, other studies have found that positive stimuli (erotic stimuli) attract attention to a greater degree than negative stimuli (e.g., Anderson, 2005; Most, Smith, Cooter, Levy, & Zald, 2007). Still others have found that the attention-grabbing quality of negative valence stimuli disappears when positive valance, arousing stimuli (e.g., kissing) are included (e.g., Pratto, 1994). Collectively, results seem to highlight the potential influence of emotional *intensity* or *arousal* on attention. Indeed, a competing line of research suggests that threatening stimuli and some positive stimuli (e.g., erotica) tend to be associated with greater arousal responses relative to their neutral counterparts (e.g., Lang, Greenwald, Bradley, & Hamm, 1993), and it is the arousal value of stimuli that may account for the discrepant results concerning the attention-capturing capabilities of stimuli of differing valence (Anderson, 2005; Aquino & Arnell, 2007; Vogt, De Houwer, Koster, Van Damme, & Crombez, 2008).

Emotion and Attention: The role of stimulus arousal

Evidence supporting attention capture based on the arousal-inducing properties of stimuli has been demonstrated in a variety of tasks. These include the Stroop task, (e.g., MacKay, Shafto, Taylor, Marian, Abrams, and Dyer, 2004), affective priming (e.g., Robinson & Compton, 2006), and the attentional blink paradigm (Anderson, 2005; Arnell, Killman, & Fijavz, 2007, Mathewson, Arnell, & Mansfield, 2008). Replicating the results of Mogg et al. (2000), Schimmack (2005) provided further support for the importance of arousal in predicting performance on an attentional task. In this study, one set of participants rated a series of pictures for their valence and arousal properties. A second set of participants had to solve simple math problems that were presented in the middle of these pictures. The pattern of problem solving response times revealed that strongly arousing pictures (such as a gun pointed at the viewer) produced longer delays than moderately arousing pictures (e.g., a gun pointing away from the viewer) or mildly arousing pictures (e.g., a crying boy). Importantly, sexual pictures (e.g., opposite-sex models) produced a strong effect that matched the effect of the highly arousing unpleasant pictures. Thus, both negatively valenced as well as positively valenced pictures produced marked delays in solving the arithmetic problems - it was the degree of arousal triggered by the picture that appeared to determine response times.

Aquino and Arnell (2007) presented further evidence that the arousal level elicited by emotional stimuli may affect the attention-capturing capability of such stimuli. In this study participants were asked to make a speeded judgment about the parity of two digits flanking a centrally presented word. The to-be-ignored words were drawn from four different categories: threat-relevant, school-relevant, neutral, and sexually explicit. Self-report ratings of valence and arousal were garnered for each word. It was assumed that the more the word captured attention, the longer participant's response times would be for making the parity judgment. Results indicated that arousal ratings, but not valence ratings, predicted digit-parity response times, suggesting that the more arousing the word the more likely it would capture participants' attention and interfere with their ability to make these simple parity judgments.

Emotion and Attention: Implications for Memory

The ability to attend to and perceive stimuli is typically a prerequisite for remembering information. If arousal is related to attention capture, then participants should better remember emotionally arousing stimuli. Indeed, early studies relating memory and arousal provide support for the notion that high arousal facilitates immediate recall (e.g., for a review see, Eysenck, 1976).

In his cue-utilization theory, Easterbrook (1959) posited that emotional arousal would decrease the attentional resources available for information processing, narrowing one's focus of attention to the arousal-eliciting stimulus. As such, he predicted that information central to the source of the emotional arousal would be preferentially encoded and better remembered, whereas peripheral details would be less well encoded and hence, be poorly remembered. Enhanced detail for information central to the source of the emotional arousal has been termed the “weapon focus” effect in eye-witness testimony research (Loftus, 1979). Weapon focus refers to the visual attention that eye witnesses give to a perpetrator’s weapon during the course of a crime (for a review see Steblay, 1992). The weapon appears to draw attention to itself and in so doing decreases the ability of the eyewitness to adequately encode and later recall peripheral details. For example, if held at gun-point, witnesses will often remember details about the gun, at the expense of peripheral (yet important) details, such as the perpetrator’s clothing or facial features. Indeed, the data show that both lineup identification accuracy and feature accuracy (e.g., perpetrator’s clothing or facial features) are degraded by the weapon focus effect. More broadly, emotionally arousing scene components have been shown to reduce the likelihood that the details of other, non-emotionally arousing components are remembered (e.g., Christianson & Loftus, 1991).

Arousal has also been shown to influence memory for word stimuli. Enhanced memory, as indexed by a surprise recognition test where participants are asked to check off as many words as they remember, has been demonstrated for arousing words (e.g., sexual words) relative to neutral, positive, and negative words (e.g., Arnell, Killman, & Fijavz, 2007; Mathweson, Arnell, & Mansfield, 2008), as well as other potentially salient yet less arousing word stimuli (e.g., Aquino and Arnell, 2007). MacKay et al. (2004), demonstrated superior recall for taboo words (high in arousal value) relative to neutral words in a surprise recognition test. Furthermore, results showed better memory for font colours associated with highly arousing words relative to neutral words. Authors concluded that the activation of the meaning of the taboo words facilitated the binding of meaning to other contextual information of the words, such as font colour.

In “remember versus know” paradigms participants are presented with either novel or previously presented words. For each word they are asked whether they remembered the word being previously presented, or simply had the feeling (i.e., “knew”) that the word was familiar and therefore believed it had been previously presented, or alternatively thought the word was new. Kensinger and Corkin (2003), showed that participants gave a greater proportion of remember responses for negative words that were also high in arousal value than neutral words. In a follow-up experiment, the magnitude of the memory enhancement effect for emotional words was greater for words evoking high arousal (see Experiments 3-6).

Similar results have also been demonstrated in studies employing free recall paradigms. LaBar and Phelps (1998) conducted a memory study on temporal lobectomy patients and control participants. Of interest here is the performance of the control participants, who showed better memory for taboo relative to neutral words both immediately after the completion of study procedures and after a one-hour interval.

Biased Information Processing in Anxiety

As previously mentioned, emotional salience is often in the eye of the beholder. Research supporting information processing biases for emotional stimuli has important implications for individuals suffering from emotional disorders. Indeed, cognitive theories posit that an important factor underlying vulnerability to and maintenance of emotional disorders is biased information processing (for a review see Mathews and MacLeod, 2005).

There is now robust evidence that anxious individuals show preferential attention to threat cues relative to their non-anxious counterparts. Anxious participants show greater Stroop interference effects for threat-relevant words relative to positive or neutral words compared to non-anxious controls (Mathews & MacLeod, 1985). Importantly, these authors also showed that the particular form of a given person's anxiety, may determine just how threatening a specific cue is. When the investigators asked participants whether they characteristically worry about physical danger or social danger, participants who endorsed worrying about physical danger showed longer colour-naming times for physical threat relevant words relative to social threat relevant words in an emotional Stroop task. These results were replicated by Mogg, Mathews, & Weiman, (1989), and showed even clearer evidence that what is threating is in the eye of the beholder. Here, participants who reported experiencing more physical threat worries showed longer colour-naming time for physical threat words relative to social threat words. In contrast, participants who reported experiencing more social threat worries showed longer colour-naming times for social threat words relative to physical threat words. Similarly, spider-phobic participants showed little Stroop interference for general emotional words (e.g., fear, death, grief), but they showed large Stroop interference effects for spider-related words (Watts, McKenna, Sharrock, & Trezise, 1986).

In probe tasks, multiple stimuli are briefly presented (e.g., two faces). Following the offset of these stimuli, a probe is presented (a dot). Participants must respond to the onset of the probe as quickly as possible. Typically the probe is presented in the same location as one of the preceding stimuli. In probe tasks, if one of the leading stimuli preferentially captures attention, then RTs for probe detection are faster when the probe falls in the same location as the attention-capturing stimulus, compared to when the probe falls in the other location. Participants completing probe detection tasks are typically more influenced by threatening faces, relative to neutral faces (Bradley, Mogg, & Millar, 2000). Importantly, the influence of the threatening faces was significantly larger for participants with moderate and high state anxiety (as ascertained by self-report measures) compared to those with low state anxiety. In a variant of this study Mathews and colleagues used fearful or neutral faces in a dot-probe task (Mathews, Fox, Yiend, & Calder, 2003). This variant involved faces that were either looking straight ahead or had an averted gaze (the face looked to the left or right). The probes appeared beside the location of the face. Thus the probes appeared either in the “gazed at” location or in a “non-gazed at” location. For highly anxious participants, probes were detected fastest when they occurred in the location gazed at by a fearful face. In non-anxious participants, for the fearful faces there was no difference in probe-detection times between the gazed at and non-gazed at locations. Results suggest that attention is more likely to be guided to locations gazed at by fearful faces, but only for anxiety-prone individuals.

Although evidence has accrued for attentional biases for threatening information among anxious individuals, much of this evidence has been based on response-time tasks. Showing the predicted information processing biases using memory tasks has proven to be more elusive. Some researchers have shown memory biases in anxious individuals (e.g., MacLeod & McLauglin, 1995) but others have not (e.g., Russo, Fox, Bowles, 1999). Despite the finding that anxious individuals show greater Stroop interference effects for word stimuli consistent with the content of their worries, there was no evidence of a corresponding bias in recognition memory, suggesting that threatening stimuli, though capable of capturing attention, may not be processed extensively enough to result in memory biases (Mathews & MacLeod, 1985; Mogg, Mathews, & Weinman, 1989). One explanation of these results is that anxious individuals automatically orient their attention toward threat, (as evidenced by greater Stroop interference effects), but then actively avoid thinking about this threatening material. Avoiding elaborative processing of this threatening material would in turn, lead to poorer memory for this oriented-to, but not elaborated on, material (Mogg, Mathews, & Weinman, 1989). Using an incidental learning paradigm, participants diagnosed with generalized anxiety disorder (GAD), social phobia (SP) (with a particular fear of giving speeches), and controls were asked to create a visual scene combining either GAD-relevant (e.g., injury, death), speech-relevant (e.g., blank, embarrassment), pleasant (e.g., baby, love), or neutral words (e.g., dry, chin). Following scene creation, participants were instructed to write down all words they had imagined during the learning task. Free recall results failed to show a memory bias for either the GAD or SP participants (Becker, Roth, Andrich, & Margraf, 1999). When participants diagnosed with panic disorder with agoraphobia (PD) were included in a second experiment, evidence of memory biases were found – PD participants recalled a greater percentage of PD-relevant words than control participants. Interestingly, three groups of PD-relevant words were added in the second experiment, situational words (e.g., malls, crowds), symptom-relevant words (e.g., palpitation, dizziness), and words reflecting catastrophic cognitions (e.g., helplessness, crazy). Only the symptom-relevant words yielded differences in percentage of words recalled relative to control participants.

Differences in the types of memory paradigm employed (explicit versus implicit) has also been implicated in explaining discrepant findings in the literature. In a recent review, Coles and

Heimberg (2002) found, with the exception of individuals with PD, little support for explicit memory biases for threat-relevant information and only modest support (approximately 40% of all studies reviewed) for implicit memory biases. Therefore, as with the response-time measures, the effects may be dependent on the source of and type of anxiety (e.g., strong memory effects have been shown for those with panic disorder when asked to remember content related to the triggers for their anxiety). For an additional review of these memory studies see MacLeod & Matthew, (2004).

Emotion and Psychophysiology

The psychological dimensions of valence and arousal have been shown to be associated with specific physiological events (for a review see, Lang, 1995). For example, factor analytic studies of emotion reveal a strong two-factor solution, with heart rate, pleasantness ratings, and facial muscles loading highly on one factor (valence), and arousal ratings, viewing time, and skin conductance responses loading highly on a second factor (arousal). Event related skin conductance responses (SCRs) are directly related to the sympathetic nervous system activity that leads to arousal (Dawson, Schell, and Filion, 2000). When we encounter stimuli of emotional significance, SCRs are elicited. Indeed, SCRs have been shown to be linearly related to ratings of arousal – the higher the arousal rating, the larger the skin conductance response (Lang, 1995). With respect to heart rate responses to affective stimuli, the relationship may depend on whether tonic or phasic measures are employed. In terms of phasic measures, heart rate deceleration (HRD) is emerging as a non-invasive marker of emotional reactivity (Osumi and Ohira, 2009). HRD refers to a temporary slowing of heart rate in the first few heart-beats following the presentation of an emotionally laden stimulus. Typically, researchers present the stimulus, measure changes in the temporal distance between successive heart beats (the inter-beat interval [IBI]), and look for a temporary increase in inter-beat intervals, followed by an acceleration phase where IBIs become shorter. Studies using HRD as a marker of physiological reactivity have suggested a somewhat complex relationship between HRD and emotional stimuli. For example, HRD is associated with attention capture of female nude pictures, when viewed by male participants (Greenwald et al., 1989), but HRD responses have also been shown in participants exposed to pictures of mutilated bodies and gruesome homicide victims (Greenwald et al., 1989). In a review of the literature, Osumi and Ohira (2009) note that while some studies show HRD in response to pleasant pictures, others have not. With respect to studies using word stimuli, Thayer, Friedman, Borkovec, Johnsen, and Molina (2000) found evidence for HRD following threat words in unselected participants. In sum, although researchers document the lengthening in the first few IBIs following an emotional stimulus, it remains unclear what is meant by "emotional." In terms of pure arousal, however, the gold standard physiological marker would be skin conductance responses.

Summary and dissertation plan

For decades, emotion researchers have debated a series of issues related to the influence of emotionally laden information on information processing. Much of this research has paid specific consideration to the role of valence and in particular the threat value of emotional stimuli. It seems reasonable to assume that being able to detect stimuli conferring potential threat or danger as fast as possible is highly functional from a survival standpoint; whereas this may seem to be less important for positive stimuli. Thus, there is a plethora of research showing attention attention-capture effects by motivationally relevant stimuli (i.e., threat) in unselected participants. However, the postulate that such attention-capture effects are driven by the negative valence of the material remains questionable. As mentioned before, studies incorporating both emotionally threatening and emotionally appealing stimuli in the form of erotic or sexual stimuli (which is also assumed to be motivationally relevant in unselected participants), have been found to influence information processing in a similar manner. Furthermore, when positive and negative stimuli are equally related to an individual's current concerns they show similar attention capture capabilities (Riemann & McNally, 1995), leading many to highlight the important contribution of the arousal value of emotional stimuli.

In addition, studies that induce arousal by varying participant's goals, that is, studies that keep the stimuli constant but vary the emotional significance of the stimuli to the individual, have shown greater interference effects on a cognitive task and better memory for stimuli consistent with their motivational goals. For example, hungry participants perform worse on a tone-discrimination task when tones are paired with pictures of food than pictures of clothing compared to sated participants (Talmi, Ziegler, Hawksworth, Lalani, Herman, & Moscovitch, 2012).

In summary, arousal has been shown to operate at both ends of the motivational spectrum – objects or situations we might wish to approach (e.g., kissing) trigger arousal, as do threatening objects we wish to avoid. Furthermore, what is considered arousing may be due, in part, to the psychological make-up of the individual. Accordingly, cues representing punishment or threat have the potential to preferentially capture attention in an anxious population because they are particularly arousing to a system motivated to avoid punishment and not simply because they are negative in valence. Thus, the overarching goal of my dissertation will be to experimentally test the influence of emotion on information processing in participants drawn from an unselected population, and then to show person-specific effects among anxious individuals, with the degree of attentional and memory effects depending on whether what is seen (and what is to be remembered) relates to the source of a given person's anxiety.

In short, my goals are twofold: **First, I will show that highly arousing stimuli are capable of producing interference effects in a primary cognitive task. Second I will show that for threatening stimuli, threat is in the eye of the beholder.** What may be threatening to some, may be innocuous to others. In the first two experiments I examined whether sexually explicit words high in arousal value would capture attention and derail the performance on a simple digit-parity task and would be better remembered in a surprise recall task. In the final study I investigated participant populations with different psychological histories. For one group of participants (those with a fear of flying), specific stimuli (flying words) were predicted to be particularly arousing because they are related to the source of their anxiety. If such words were particularly arousing, then they should be better remembered, and show greater disruptive effects in a digit parity task. For another group of participants (those with math anxiety), different triggers (math words) were predicted to be preferentially arousing, and hence better remembered and more disruptive to an on-going unrelated task. By contrasting the two groups, I hoped to show that emotional salience, is indeed in the eye of the beholder – what is arousing for one group might be of only passing interest to the other group. If so, then whether one sees disruptive effects on attention (and facilitative effects on memory) depends completely on the psychological makeup of the individual. Taken together, I hoped to show, both general and person-specific influences of emotionally laden stimuli on attention and memory.

Experiment 1

The first series of experiments had two objectives. First, I sought to replicate previous research showing the attention-capturing capability of arousing stimuli. Sexually explicit, threat-relevant, school-relevant, and neutral words were presented as distractors during a digit-parity task in order to see if response times would be influenced by the arousing properties of sexually explicit words. Following the response time task, I sought to show that highly arousing sexually explicit words would be better recalled in a surprise free-recall task. The second objective was to better understand exactly how and why sexually explicit words affect response times and memory in tasks like these. Emotion researchers are increasingly recognizing the importance of including both subjective and objective measures of affect in order to improve the reliability and validity of emotional assessment (e.g., Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005). Thus, SCR data as well as HRD data were collected, along with self-report valence and arousal ratings for the to-be-ignored words used in the digit parity task, allowing for converging evidence for the relation between psychophysiological markers and attention-capturing effects of stimuli differing on valence and arousal.

Predictions

First, I predicted that sexual words would be associated with greater self-reports of arousal than words from any other category (including threat words). Second, given this relation between sex words and arousal we expect longer digit-parity response times (RTs) when sexual words are presented between the digits, relative to all other word categories. Finally, I predicted that participants would show greater memory for the sexual words relative to all other word categories.

Based on previous evidence of an association between self-report arousal ratings and SCRs, I predicted that since sexual words engender the highest self-report ratings of arousal, then skin conductance responses would be highest for the sex words. If, in line with Greenwald and colleagues' (1989) findings, erotic pictures preferentially elicit HRD, we would expect the sexual words to produce greater HRD than other types of words. However, if HRD is preferentially associated with negative valence (as opposed to arousal), then the greatest HRD should be associated with threat words since they are uniformly negative in their valence.

Method

Participants

Fifteen University of Waterloo male (*n*=7) and female (*n*=8) undergraduate students participated for course credit. Ages ranged from 18 to 24, with a mean age of 20.2 years. All participants had normal or corrected-to-normal vision, were right-handed, had learned English by the age of eight, and had no history of medical, neurological, or psychiatric disorder. The data from one female participant was not included in the totals above, given that the participant had been up all night studying and had not yet slept.

Word stimuli

Previous research has suggested that the attention capturing capability of emotional stimuli may not be the result of the emotionality of the stimuli per se, but because emotional stimuli tend to form a cohesive word category (McKenna & Sharma, 1995). Here the argument is that emotion words form a cohesive category, whereas the control words to which they are often compared have no categorical affiliation, and it is the category membership that in part leads to attention capture. To address this issue, as well as the literature suggesting that concern-relevant stimuli may be particularly potent attention capturers (Dalgleish, 1995; Williams et al., 1996), I added a control category of school words in Experiment 1, which not only form a single category but could be considered concern-relevant to young University students. Therefore, one hundred word stimuli drawn from four word categories were included in the digit-parity task: 25 neutral (e.g., bread, autumn), 25 school-relevant (e.g., binder, read), 25 sexual (e.g., orgy, rape), and 25 threat-relevant (e.g., fear, murder). All word stimuli appear in Appendix A. Digits and words were presented in a black 48-point Lucida Grande font (against a white background) and all words were capitalized. The words were 4 to 8 letters long.

Digit-parity task

The experiment was controlled using SuperLab Pro 4 software (Version 4.0.7b; Abboud, Schultz, and Zeitlin, 2008) running on an iMac desktop computer. As can be seen in Appendix B, digit-parity displays always consisted of two different digits flanking a centrally presented word, with the word and digits presented simultaneously. Only the digits 2, 3, 5, and 8 were used as stimuli. The digits were randomly paired with the constraint that the pair consisted of different digits, and that on half of the trials the pair of digits had the same parity (e.g., both digits were "even" numbers). Participants were presented with two blocks of 100 digit-parity trials (25 of each type). The 100 trials in each block were presented in random order and there was no break given between blocks. Each digit-parity trial began with a cross presented in the center of fixation for 250ms. This was followed, after a 500ms blank screen, by a word with a digit to the left and right of it. The word and digit pairing remained on the computer screen for 150 msec. A 5000 msec inter-trial interval separated successive trials. Prior to block 1, 20 practice trials were presented using neutral words (different from the neutral words presented in the experiment proper).

Skin Conductance Responses and Heart Rate Inter-beat Intervals

Skin conductance responses (SCRs) and heart rate inter-beat intervals (IBIs) were measured using an eight-channel ADinstruments Powerlab (model 8/30) and were recorded continuously and simultaneously on a separate computer throughout the digit-parity task. SCRs were recorded using non-gelled electrodes attached to the distal phalanges of the index and ring fingers of the participant’s non-dominant hand. With respect to HR, the Powerlab system amplified the signal from three reusable clamp-on HR electrodes that were attached to the left and right biceps and the left ankle (ground). Upon presentation of each simultaneously presented word and digit pair, a digital marker was sent to an open channel of the Chart software, enabling the time locking of the digit-parity and word stimuli to any changes in SCRs and IBIs.

Word Ratings Task

Using a 7-point Likert scale, each of the 100 word stimuli were rated on dimensions of valence and arousal. Ratings were made using the 1 to 7 number keys on a computer keyboard. The valence scale ranged from negative to positive, with 1 being the most negative, 4 being neutral, and 7 being the most positive. The arousal scale ranged from low to high, anchored by low for the 1 response, neutral for the 4 response, and high for the 7 response. Participants were asked to make the valence and arousal ratings independently and encouraged to use the entire scale while staying true to their impression of the words. In addition, participants were encouraged to make their ratings based on their first reaction to the word and to avoid spending too much time deliberating on each word. The concept of arousal was further framed by two examples. Participants were told that being chased by a dog, or winning the lottery could represent situations that were highly arousing. Finally, when considering the sexual words, participants were told that they should not rate how “turned on” or sexually aroused they were by the word, but rather the level of arousal triggered by the word. For the valence ratings, coincident with the onset of each word was the prompt “Valence?” which remained on the screen until a valence rating was given. Once valence ratings were complete, the prompt changed to “Arousal?” Participants completed valence and arousal ratings for all word stimuli, presented in random order.

Procedure

The materials and experimental protocol were approved for use with human participants by the Office of Research Ethics of the University of Waterloo. All participants were tested individually. Following an informed consent procedure, participants were asked to wash their hands with Ivory soap and water in preparation for attaching the SCR electrodes. Participants were then seated approximately 50 cm from a computer screen and fitted with the heart rate and SCR electrodes. Each trial began with the presentation of a fixation cross presented in the center of screen followed by a word that had a number to the left and right of it. Using a button box and the index finger of their dominant hand, participants were instructed to press the right button if the digits matched in parity (i.e., were both odd, or were both even), and to press the left button if the digits mismatched (i.e., one odd and the other even). Participants were asked to respond as quickly as possible while being accurate and to ignore the centrally presented words. No indication was given that participants would be asked to recall any of the to-be-ignored words. Immediately following the digit-parity task, participants were given a blank piece of paper and asked to write down (in any order) as many of the words as they could remember from the digit-parity task. Finally, participants rated the valence and arousal of each of the 100 words from the digit-parity task. The ratings scales were provided on a piece of paper located in front of the participant (see Appendix C for rating scales). Participants made their word ratings using the 1 to 7 keys of a computer keyboard.

Results

Data Analytic Strategy

All statistics were conducted with the statistical package SPSS (v.21). First, to determine the affective profiles of each word category, one-way analyses of variance (ANOVA) using word as the unit of analysis were conducted with separate ANOVAs performed on mean arousal and mean valence word ratings, with a Bonferonni adjustment for multiple comparisons. To address whether word category had any effect on digit-parity RTs, memory, SCRs, and IBIs, repeated measures analyses of variance (ANOVAs) using participant's means for the different word categories as the unit of analysis were conducted with separate ANOVAs on mean digit-parity RTs, digit-parity errors, number of words recalled, SCRs and IBIs. For these analyses, when necessary, the degrees of freedom were adjusted using the Greenhouse-Geisser sphericity correction.

Word Ratings

Each of the 15 participants rated each word, yielding 15 arousal ratings and 15 valence ratings per word. These 15 word ratings were then averaged, yielding 100 average arousal ratings (one for each word) and 100 average valence ratings (one for each word). Thus, mean arousal and valence ratings were calculated for each word by averaging the arousal and valence ratings of the 15 participants.

The one-way ANOVA performed on mean arousal ratings showed that mean arousal ratings differed across word categories, $F(3, 96) = 180.6$, $p < .001$. Bonferroni *post-hoc* tests showed that sexual words ($M = 4.82$) were rated as significantly more arousing than the threat-related words ($M = 3.90$), school words ($M = 2.55$), and neutral words ($M = 2.52$), all p's < .01. Threat-related words were rated as significantly more arousing than the school and the neutral words (both, p's < .05), but school and neutral words did not differ.

The one-way ANOVA performed on mean valence ratings showed that mean valence ratings differed across word categories, $F(3,96) = 50.70$, $p < .001$. Bonferroni post hoc tests showed that the threat-related words ($M = 2.33$) were rated as significantly more negative than the sexual words ($M = 3.72$), school words ($M = 4.30$), and neutral words ($M = 4.34$), all p's < .01. Sex words were rated as significantly more negative than the neutral words and school words ($p < .05$). The school and neutral words did not differ.

Thus, based on participant's self-report ratings the sexual words represent the most arousing word category, while the threat-relevant words represent the most negative word category.

Digit-parity Response Times

Only digit-parity response times (RTs) for correct responses were analyzed. For each participant a total of four digit parity means were calculated (one for sex words, school words, threat words and neutral words). These means were calculated by averaging the (correct) RTs for each word in a given word group (e.g., if a person had made two errors on sex words their mean for this condition would be based on the remaining 23 correct responses). Prior to calculating these digit-parity cell means, raw digit-parity RTs were subjected to an outlier removal procedure as recommended by Van Selst and Jolicoeur (1994) in which the criteria for removal is *modified* as a function of the number of observations on which means were based. Van Selst and Jolicoeur (1994) demonstrated that with small sample sizes, the commonly used outlier elimination procedures (i.e., a simple non-recursive procedure with a criterion cut-off of 2.5 *SD*), can have an undesirable propensity to reject as outliers valid data points. Thus, adjusting the cut-off criterion required for outlier removal as a function of sample size can produce results that are unbiased by the number of observations (Van Selst, Jolicoeur, 1994). As a result, no single cut off criterion for outlier removal was used, rather the criterion varies as a function of the number of correct digit-parity RTs that contributed to a given cell mean for that participant. For instance, if a participant made 15 digit-parity errors in a given cell, this would leave only 10 correct observations and a 2.173 *SD* cut off criterion would be employed; if a participant made no errors, the mean would be based on 25 observations and a 2.410 *SD* cut-off criterion would be used. For sample sizes not provided, a linear interpolation is used. A total of 3.1% of all trials were removed using this procedure.

Figure 1 shows the mean response times (msec) for the digit-parity task for each word category as a function of block. The analysis revealed a main effect of block $F(1, 14) = 21.8$, $p < 0.01$. Bonferroni post-hoc tests revealed that digit-parity RTs were longer in block 1 ($M = 972$ msec) relative to block 2 ($M = 875$ msec), $p < 0.01$. The ANOVA revealed a main effect of word category $F(1.2, 16.9) = 14.43$, $p < 0.01$, with significantly longer RTs for the sex word category

(M =999 msec) relative to all other word categories (threat, M = 901 msec; school, M = 899 msec; neutral, M = 895 msec, all p's < 0.05). There were no other significant differences between word categories. The analysis also revealed a significant block by word category interaction, $F(1.2, 17.6) = 5.48$, $p < 0.05$. This interaction can be understood by looking at the differences between block 1 and block 2 RTs in each condition. Whereas there were only small decreases in RT from block 1 to block 2 for neutral, school and threat words, there were more pronounced decreases in RTs from block 1 to block 2 for the sex words. My interpretation of this interaction is that the very slow RTs for the sexual words in block 1 afforded greater room to improve in block 2. Despite this interaction, there were still marked differences between the word categories in both blocks. For Block 1, simple main effects analyses showed a significant word category effect, $F(1.2, 16.8) = 12.23$, $p < 0.01$, with Bonferroni tests showing longer RTs for the sex words relative to all other word categories; no difference in RTs for threat, neutral, or school words reached significance. For block 2, the simple main effect of word category was again significant $F(1.7, 24.3) = 7.74$, $p < 0.01$. Bonferroni tests once again showed significant differences between the sex words and all other word categories (all p's < .05) with no other significant differences.

Accuracy

One concern regarding RTs is the potential of a speed-accuracy trade off (e.g., RTs that are shorter for a particular word category because participants emphasize speed at the expense of accuracy). To examine this possibility, error rates were examined for each word category. Errors occurred on 4.2% of all trials. A 4 x 2 repeated measures analysis of variance was performed on error rates with word category (sex, threat, school, neutral) and block (block 1 and block 2) as within-participant variables (see Table 1). The analysis revealed no main effect of word category, $F(3, 42) = 0.72$, $p > 0.54$, no main effect block, $F(1, 14) = 1.80$, $p > 0.20$, but a word category by block interaction $F(2.1, 13.3) = 3.35$, $p < 0.05$. This interaction was caused by fewer erroneous digit-parity responses while ignoring threat words in block 2. If a speed accuracy trade-off did influence digit-parity results, I would expect participants to make more errors for the threat word group (i.e., they are trading speed for accuracy), not fewer. This pattern of errors, and the fact that the sexual word category was not the source of the block by word category interaction, indicates that the pattern of digit-parity RTs could not be explained by a speed-accuracy trade off.

Free Recall

Table 2 shows the mean number of words recalled during the free recall task as a function of word category across participants. The ANOVA confirmed that memory performance differed significantly across word categories, $F(3, 42) = 64.05$, $p < .001$. Bonferroni tests showed superior recall for sexual words (M =7.9) relative to threat words (M = 1.5), school words (M = 3.0), and neutral words (M = 0.9) (all p's< 0.05). School words were recalled significantly more often than the neutral words. No other comparisons reached significance.

Skin Conductance Responses

A skin conductance response is a discrete and short fluctuation in skin conductance that lasts several seconds and can be reported in magnitude or amplitude units (Dawson, Schell, & Filion, 2007). Magnitude refers to the mean value computed across all stimulus presentations including those without a measurable response, while amplitude refers to the mean value computed across only those trials on which a measurable or non-zero response occurred

(Humphreys, 1943). SCRs have commonly been reported in magnitude units, despite the fact that many psychophysiology researchers have argued against the use of magnitude measures given the potential confound between frequency and amplitude (see Prokasy & Kumpher, 1973; Dawson, Schell, & Filion, 2007). In an attempt to resolve the magnitude versus amplitude debate, researchers recommend separate assessments of amplitude and frequency rather than magnitude alone. A potential further complication inherent in SCR research is the finding that not all SCRs are directly related to an observable stimulus. Indeed, skin conductance responses have been shown to occur during periods of rest, in the absence of any identifiable stimulus. These SCRs are commonly known as “spontaneous” or “nonspecific” SCRs (Dawson, Schell, & Filion, 2007). To reduce the likelihood that nonspecific SCRs will be counted as elicited SCRs, authors recommend using latency windows of less than 4 seconds (Levinson, Edelberg, & Bridger, 1984). For the present investigation skin conductance response amplitudes were calculated by first defining a three second window, beginning one second after the presentation of the digit-parity stimuli (see Appendix D). Skin conductance response amplitudes were then calculated taking the maximum skin conductance level within the window, and subtracting the skin conductance level at the very beginning of the window. Only SCRs greater than 0.01 were considered a measureable response. As recommended by Dawson, Schell, and Filion (2000), a square root transformation was applied to the SCR data to reduce skewness of the SCR distribution prior to analyzing the data. Of note, the SCR data from one participant was not obtained due to technical difficulties.

Figure 2 shows mean SCR amplitudes as a function of word category and block. The analysis revealed a main of effect of word category $F(3, 39) = 3.15$, $p < 0.05$, with significantly larger SCRs for sexual words (*M* = 0.76μS) relative to all other word categories (threat, *M* = 0.65μS; school, *M* = 0.64μS; neutral, *M* = 0.64μS), but no other significant differences between word categories. The ANOVA produced no main effect of block, $F(1, 13) = 0.89$, $p = 0.36$, and no word category by block interaction, $F(3, 39) = 1.19$, $p = 0.33$. Next, mean SCR frequencies were subjected to the same analysis as noted above. The analysis revealed a main effect of word category, $F(3, 39) = 10.61$, $p < 0.01$, with significantly more measurable SCRs produced for sexual words (*M* =13.12) relative to threat (*M* = 10.04), school (*M* = 9.14), and neutral (*M* = 9.29), but no other significant differences between word categories. The ANOVA also produced a main effect of block, $F(1, 13) = 5.20$, $p < 0.01$, with a greater number of SCR frequencies produced in block 1 (*M* = 11.34) than block 2 (*M* = 9.45). The analysis did not produce a significant word category by block interaction, $F(3, 39) = 1.75$, $p = 0.17$. Considering amplitudes and frequency together, the sexual words not only elicited larger SCRs when they appeared between the digits during the digit-parity task relative to all other word categories, but also produced more frequent measurable SCRs.

Inter-beat Intervals

Inter-beat intervals (IBIs) represent the temporal distance (in msec) between each R-wave of consecutive heartbeats. For each word category six IBIs were calculated, with the first IBI beginning just prior to the presentation of the digit-parity stimuli. A low pass filter was applied to the heart beat trains to maximize the difference between r-waves and other electrocardiogram signals (e.g., q, s and t waves). Artifacts were then detected using the default settings of the Heart Rate Variability module of Chart 7.0, an ADinstruments analysis program.

Statistically defined artifacts were removed, valid R-waves were then labelled and inter-beat intervals were calculated.

For every participant these values were averaged to yield 6 IBIs for each of the sexual, threat, school, and neutral word categories (IBI 1 = the temporal distance between beat 1 and beat 2, IBI 2 = the temporal distance between beat 2 and beat 3, etc.). Prior to calculating these averages, raw IBI values were submitted to the Van Selst and Jolicoeur (1994) observation-dependent outlier elimination procedure, ensuring that any artifacts not detected by the scanning procedure were detected prior to the main analysis. As a result, 1.3% of all IBIs were eliminated using this procedure.

A word category (sex, threat, school, neutral), by block (1 and 2), by IBI (ibi1, ibi2, ibi3, ibi4, ibi5, ibi6) repeated measures ANOVA revealed only a significant main effect of IBI, $F(2.3, 27.1) = 13.59$, $p < 0.01$, indicative of heart rate acceleration. The predicted IBI by word category interaction (which would have been caused by the sex words having the greatest predicted HRD) was not significant $F(15, 180) = 0.79$, $p = 0.69$.

Discussion

The present investigation had two primary aims: (1) replicate previous research examining the attention-capturing effect of arousing stimuli and (2) extend previous research by examining the psychophysiological sequela of exposure to these arousing stimuli. With respect to the first aim the results can be summarized as follows: First, according to participants' self-report ratings, the sexual words represented the most arousing word category whereas the threat words represented the most negatively valenced word category. Second, when a sexual word was presented between the digits, responses to the digits were significantly slowed relative to all other word categories (threat, school, and neutral). Of interest, these differences were the most pronounced when participants were initially exposed to the sex words (i.e., in block 1), with the effect diminishing upon repeated exposure. Finally, the sexual words were recalled more often relative to all other word categories in a surprise free recall task.

The second aim was to extend previous research by including physiological measures of arousal in addition to more traditional self-report ratings. The results demonstrated that participants showed enhanced SCRs for the sexual words relative to all other word categories. Indeed, SCR results exactly mirrored digit-parity response times, with the largest SCR amplitudes occurring for the sexual words relative to all other word categories. Furthermore, the sexual words also produced more frequent measureable SCRs relative to all other word categories. Interestingly, with respect to heart rate deceleration we found no effect of word group. In fact, our IBI analysis showed heart rate *acceleration* for all word categories. Previous research has found evidence for HRD following the presentation of threat words using unselected populations (e.g., Thayer, 2000); however only threat and neutral words were used as stimuli. It is possible that, due to context effects, the presence of the sexual words in our experiment reduced the saliency of the threat words, given that the context in which specific words are shown (i.e., what other words are presented when, and how often) may play a role in determining which words capture attention and for how long. It is also possible that the phasic increases in heart rate noted in all conditions reflects the cognitive load imposed by having to determine if both digits were odd, even or mismatched in parity.

Although heart rate changes may have reflected the performance of the parity judgements, both SCRs and digit-parity judgement response times appeared to track how difficult it was to ignore the centrally presented words. If negative valence is preferentially associated with attention-capturing qualities, then threat-relevant words should have produced the longest digit-parity response times in this task. This was clearly not the case. Only the presentation of the sexual distractor words led to a marked increase in digit-parity response times.

Although the present experiment replicates and extends the previous work by Aquino and Arnell (2007), questions concerning why sex words are so attention capturing remain. In the present investigation the sexual word group was composed of words that were both negatively- (e.g., whore, incest) and positively- (e.g., kissing, foreplay) valenced. It is possible then, that digit-parity response times were preferentially slowed by stimuli that were both arousing AND negative in valence. If it is the negative valence that is critical then there might be minimal effects for the positively valenced sex words, even though they are more arousing than other classes of words.

Further complicating the matter, some sexual words tend to be socially unacceptable or taboo; therefore, it may be the taboo quality of sexual words that is associated with their attention-capturing effects. Consistent with this hypothesis are findings of longer colour-naming times for taboo words relative to neutral words in Stroop-type tasks (see MacKay et al., 2004; Siegrist, 1995) and reduced accuracy on subsequent targets when taboo words, relative to anxiety and threat words, are presented as distractors in rapid serial presentation (Arnell, Killman, & Fijvaz, 2007). Similar attention-capturing results for taboo stimuli have also been found using pictures (Most, Smith, Cooter, Levy, & Zald, 2007). More recently, Feng, Wang, Wang, Gu, and Luo (2012) found that erotic pictures selectively captured participants' attention at both early and late stages of processing relative to non-erotic pictures that were equally arousing and positive. These results suggest that the attention-capturing capability of erotica are different from those of other affective stimuli, but it is unclear what role the taboo nature of some erotic stimuli play in this relationship. Thus, the addition of a taboo rating for each word in our word sets could help further elucidate the attention-capturing effects of emotional stimuli. In Experiment 2, we addressed these issues by including both sex-positive and sex-negative word categories and having participants not only rate the arousal- and valence-level of the to-be-ignored words, but also the taboo-level of the words in each word category.

Experiment 2

To help clarify the reasons for the preferential attention-capturing effects of sexual words, I parsed the sex words into positively-valenced and negatively-valenced categories, and compared their attention-capturing properties to the threat and neutral word categories from the previous experiment[1]. I once again sought to assess whether the attention-capturing effects of specific words would be greatest when participants first were exposed to these words, and would dissipate with repeated exposure. Given the taboo quality of the sexual words, along with the arousal and valence ratings from Experiment 1, participants were also asked to rate the taboo-level of each word.

Method

Participants

Thirty-one University of Waterloo male (*n*=17) and female (*n*=14) undergraduate students participated for course credit. Ages ranged from 18 to 23, with a mean age of 19.7 years. All participants had normal or corrected-to-normal vision, were right-handed, had learned English by the age of eight, and had no history of medical, neurological, or psychiatric disorder. The data from one male participant is not included in the totals above because his cell phone rang during digit-parity task, jeopardizing the validity of digit-parity results. In addition, three female participants were not included in the totals above due to current psychiatric

[1] Experiment 1 results show longer digit-parity response times for sexual but not school words suggesting that concern relevance cannot explain the pattern of results. Thus, to minimize the potential impact that participant fatigue may have on our attentional task, we removed the school word category in experiment 2, limiting the number of trials each participant completed.

diagnoses and psychotropic medication use[2]. Approximately sixty percent of participants identified themselves as White/Caucasian (*n*=19, 61.3%), approximately 10 % as East Indian (*n*=3,9.7%), approximately 10% as Black/African (*n*=3, 9.7%), approximately 6% as Chinese (*n*=2, 6.5%), approximately 3% as Korean (*n*=1, 3.2%), approximately 6% as other Asian (Filipino) (*n*=2, 6.5%), and approximately 3% as other (*n*=1, 3.2%). As can be seen in Table 3, participants' depression, anxiety, and stress scores fell within the normal range[3].

Word stimuli

To limit the possibility that the attention capture of the sex-negative words and their subsequent superior recall is due to the fact that participants notice that a particular percentage of the words belong to a specific category (resulting in longer response times on trials containing those stimuli), I chose musical instrument words for their high category cohesiveness. In addition, musical instruments were chosen for their low written frequency, to match the low written frequency of the sexual words. Therefore, the neutral category of musical instrument words allowed us to control for possible word frequency and category cohesiveness effects. Thus, forty word stimuli from four word categories were included in the digit-parity task: 10 sex-negative, 10 sex-positive, 10 threat, and 10 neutral words. All word stimuli are presented in Appendix F. Digits and words were presented in black, 48-point Lucida

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[2] Our goal was to gauge the attention capturing capability of sexual words in a sample of healthy participants. To ensure that this sample was free from mental health conditions such as depression, or extreme anxiety or stress, we screened for these conditions using a general demographics questionnaire as well as an empirically validated self-report measure to assess participant's depression, anxiety and stress levels (see Appendix E for demographic questionnaire).

[3] The following severity rating guidelines are offered by the DASS questionnaire creators: "normal" depression scores range from 0-9, anxiety 0-7, stress 0-14; "mild" depression scores range from 10-13, anxiety 8-9, stress 15-18; "moderate" depression scores range from 14-20, anxiety 10-14; stress 19-25; "severe" depression scores range from 21-27, anxiety 15-19, stress 26-33; and "extremely severe" depression scores 28+, anxiety 20+, stress 34+.

Grande font against a white background and all words were capitalized. The words were 4 to 8 letters long.

Digit-parity Task

Participants were presented with three blocks of 40 digit-parity trials (10 of each type). The 40 trials in each block were presented in random order. Each digit-parity trial began with a centrally presented fixation cross presented for 250ms; after a 500ms blank screen, the to-be-ignored word was presented flanked by the digits on which parity judgements were to be made. A 5000 msec inter-trial interval separated successive trials. Once again, only the digits 2, 3, 5, and 8 were used as stimuli. Prior to block 1, 20 practice trials were presented using neutral words (different from the neutral words presented in the experiment proper).

Skin Conductance Responses and Inter-beat Intervals

As in Experiment 1, SCRs and IBIs were acquired using an eight-channel ADinstruments Powerlab (model 8/30) and were recorded continuously throughout the digit-parity task. SCRs were recorded using non-gelled electrodes attached to the distal phalanges of the left index and ring fingers of the participant’s non-dominant hand. Unlike Experiment 1, which used arm clamp electrodes, the Powerlab system amplified the signal from disposable HR electrodes that were attached below each collar bone and above the left hip (ground) (see Appendix G for HR electrode placement). Upon presentation of each trial, a digital marker was sent to an open channel of the Chart software, enabling the time locking of the distractor word to any changes in skin conductance level and heart rate.

Word ratings

Participants rated their emotional experience of each word on scales of valence, arousal, and tabooness. In Experiment 1, the valence scale ranged from negative to positive, with 1 being the most negative, 4 being neutral, and 7 being the most positive. In Experiment 1, to maintain consistency with the valence scale, the arousal scale also ranged from low to high, anchored by low for the 1 response, neutral for the 4 response, and high for the 7 response. However, by doing so, measurement error may have been unintentionally introduced. Conceptually, "neutral" does not fall in the middle of low and high. It is unclear then, if participants should enter a value of 1 or 4 if they believe the word to be low in arousal value. Therefore, in Experiment 2 valence and arousal ratings were assessed using a modified version of the Self-Assessment Manikin (SAM; Lang, 1980). The SAM is a non-verbal pictorial assessment technique that directly measures the pleasure, arousal, and dominance associated with an individual's affective reaction to a wide variety of word and pictorial stimuli (Bradley, Lang, 1994). For the purposes of the current experiment the dominance rating was not used. In order to be consistent with the Affective Norms for English Words (ANEW) , a popular rating system used in the vast majority of experimental designs using affective word stimuli, the valence and arousal ratings ranged from 1 to 9; with larger numbers indicative of positive valence and high arousal. Ratings were made using the 1 to 9 number keys on a computer keyboard. Valence was defined as the extent to which a participant found the word positive or negative; with 1 being the most negative, 5 being neither positive nor negative, and 9 being the most positive. Arousal was defined as the extent to which participants had an emotion reaction to the word; with 1 being low (or calm) and 9 as high (excited). Tabooness was defined as the extent to which participants viewed the word as offensive or socially unacceptable; from 1 (not at all taboo) to 9 (extremely taboo). Participants completed valence, arousal, and taboo ratings for all word stimuli, presented in random order. Word rating scales can be found in Appendix H.

Questionnaires

Depression, Anxiety, and Stress Scale – 21 (DASS-21, Lovibond and Lovibond, 1995). The DASS-21 is a 21 item self-report measure designed to measure the negative emotional states of depression, anxiety, and stress. Each subscale (depression, anxiety, and stress) is composed of 7 items. The Depression scale assesses dysphoria, hopelessness, devaluation of life, self-deprecation, lack of interest/involvement, anhedonia, and inertia. The Anxiety scale assesses autonomic arousal, skeletal muscle effects, situational anxiety, and subjective experience of anxious affect. The Stress scale is sensitive to levels of chronic non-specific arousal. It assesses difficulty relaxing, nervous arousal, and being easily upset/agitated, irritable/over-reactive and impatient.

Procedure

The procedure was identical to the procedure in Experiment 1, except for the addition of the taboo rating – participants first completed the digit-parity task, followed by the surprise recall task, and then completed the word ratings. In addition, prior to completing the digit-parity task, participants completed a general demographic questionnaire as well as the DASS-21.

Results

Data Analytic Strategy

Like Experiment 1, all statistics were conducted with the statistical package SPSS (v.21). First, to determine the affective profiles of each word category, one-way analyses of variance (ANOVA) using word as the unit of analysis were conducted with separate ANOVAs performed on mean arousal, valence, and taboo word ratings. Bonferonni adjustments for multiple comparisons were applied when contrasting word categories. Next, to answer the question of whether word category had any effect on digit-parity RTs, memory, SCRs or IBIs, repeated measures analyses of variance (ANOVAs) were conducted with separate ANOVAs on mean digit-parity RTs, digit-parity errors, number of words recalled, SCRs and IBIs. For these analyses, the degrees of freedom were adjusted according to Greenhouse-Geisser, as appropriate.

Next, Pearson correlations were calculated to examine the relationship between word ratings (arousal, valence, and taboo), digit-parity RTs, memory, and SCRs using word as the unit of analysis – thus, a new dataset with word (*N*=40) as the unit of analysis was created. For the word-level analyses, each digit-parity distractor word comprised a row in the data set. Therefore, the data was aggregated across participants for each word. To illustrate, consider the word KISSING. For each participant (*N*=31) the RTs associated with correct digit-parity judgements when the word KISSING was presented between the digits was calculated. An average RT was then calculated for the 31 participants and this average RT was assigned to the word KISSING. For recall, the number of participants who recalled KISSING in the surprise recall were tabulated (memory scores could thus range from 0 to 31). This memory score was assigned to the word KISSING. For SCRs, the SCRs associated with correct digit-parity RTs when the word KISSING was presented between the digits was calculated. An average SCR was then calculated for the 31 participants and this average SCR was assigned to the word KISSING. Thus, mean digit-parity RTs, mean number of words recalled, and mean SCRs were calculated for each word across participants. Dummy codes were created to represent each word category: sex-negative (1,0,0), sex-positive (0,1,0), and threat (0,0,1), with neutral coded (0,0,0). Therefore, word category was coded so that when the three dummy variables were entered into a multiple regression, the regression coefficients for the individual word categories (sex-negative, sex-positive, and threat) could be interpreted as the difference between each word category and the neutral word category (i.e., the contrast of each of the three experimental conditions versus the control). The three dummy-coded variables served as predictor variables in the following analyses.

Finally, to better understand the contribution of the affective ratings (arousal, valence, and taboo) on the relationship between our predictor variable, word category, and main outcome variables, digit-parity RTs and memory, mediation analyses with bootstrapping were conducted using the PROCESS computation procedure macro for SPSS described by Hayes (2013). Specifically, following suggestions by Preacher and Hayes (2004) the current experiment used the Preacher and Hayes SPSS macro to estimate the indirect effect and bias-corrected 95% confidence interval in simple mediation models for each mediation model depicted in Figure 3 based on 1000 bootstrap samples. In this analysis, mediation is significant if the 95% bias-corrected confidence interval for the indirect effect does not include zero.

Word Ratings

Each of the 31 participants rated each word, yielding 31 arousal ratings, 31 valence ratings, and 31 taboo ratings per word. These 31 word ratings were then averaged, yielding 40 average arousal ratings, 40 average valence ratings, and 40 average taboo ratings (one per word). Thus, mean arousal, valence, and taboo ratings were calculated for each word averaged across participants. The arousal ratings from one male participant were removed prior to data analysis procedures as he reported using the rating scale incorrectly.[4]

Mean arousal ratings differed across word categories, $F(3, 36) = 41.90$, $p < .001$. Bonferroni *post-hoc* comparisons showed that sex-negative words ($M = 5.61$) were rated as significantly more arousing than both the sex-positive words ($M = 4.38$), and neutral words ($M = 1.86$), both p's < .05. The sex-negative and the threat words ($M = 4.76$) words did not differ, nor did the sex-positive and the threat words, but both were rated as more arousing than the neutral words.

Mean valence ratings differed across word categories, $F(3, 36) = 105.69$, $p < .001$. Bonferroni *post-hoc* comparisons showed that sex-negative words ($M = 2.78$) did not differ from threat words ($M = 2.55$), but both were rated as significantly more negative than the sex-positive ($M = 7.05$) and neutral ($M = 5.81$) words. In addition the sex-positive words were rated as significantly more positive than the neutral words.

Finally, mean taboo ratings differed across word categories, $F(3, 36) = 46.33$, $p < .001$. Bonferroni *post-hoc* comparisons showed that the sex-negative words ($M = 6.03$) were rated as

[4] After completing the ratings task, a male participant reported using the arousal scale in an opposite manner than intended by experiment investigators. That is, he reversed the scale, with a rating of 1 representing high arousal and a score of 9 representing low arousal. To maximize the representativeness of our arousal ratings his ratings were removed from any further analyses.

significantly more taboo than the sex-positive words ($M = 2.33$), threat words ($M = 3.95$), and neutral ($M = 1.25$), all *p*'s <.05. Threat words were rated as significantly more taboo than the sex-positive and neutral word groups, and sex-positive words were rated as significantly more taboo than the neutral words.

Thus, based on participant's self-report ratings, the sex-negative words represent the most taboo word category. Along with the threat words, the sex-negative words were also rated as the most arousing and negative in valance.

Digit-parity Response Times

Only digit-parity Response Times (RTs) for correct responses were analyzed. Prior to calculating these means, raw digit-parity RTs were subjected to an outlier removal procedure as recommended by Van Selst and Jolicoeur (1994). As a result, 2.6% of all trials were removed using this procedure. The analysis revealed a main effect of block $F(1.2, 35.2) = 14.11$, $p < 0.01$. Bonferroni post-hoc tests revealed that digit-parity RTs were longer in block 1 ($M = 1155$ msec) relative to block 2 ($M = 1044$ msec), and block 3 ($M = 967$ msec); and block 2 RTs were longer than block 3, all p's < 0.01. The ANOVA revealed a main effect of word category $F(2.3, 68.3) = 7.57$, $p < 0.01$, with significantly longer RTs for sex-negative words (M =1088) and sex-positive words (M =1072), relative to the other two word categories (threat, M =1035; neutral, M = 1025, both *p*'s <0.05), but no other significant differences between word categories. Finally, the analysis revealed a significant block by word category interaction $F(3.4, 102.2) = 2.8$, $p < 0.04$. The interaction was due to relatively long RTs for sex words in block 1, affording greater improvements in RT performance for the sexual word categories in blocks 2 and 3. To test whether parsing the sexual words into two separate categories according to their valence (i.e., sex-negative versus sex-positive) had any effect on block 1 digit-parity RTs, I used a direct contrast between the sex-negative and sex-positive words. The direct comparison between the sex-negative words and sex-positive words showed that the sex-negative words (*M* =1237) lead to longer digit-parity RTs relative to the sex-positive words (*M* =1153), $t(30) = 2.97$, $p < 0.05$. To test whether the sex-negative words had any effect on digit-parity RTs relative to the threat words (which according to participants' self-report ratings were equal in valence and arousal value to the sex-negative words), I used a direct contrast between the sex-negative words and threat words. The direct comparison between the sex-negative words and threat words in block 1 showed that the sex-negative words (*M* = 1237) led to longer digit-parity RTs relative to the threat words (*M* =1115), $t(30) = 2.97$, $p < 0.01$ (see Figure 4). In Block 2, the direct comparison between the sex-negative words and sex-positive words did not reach significance, nor did the direct comparison between the sex-negative words and threat words, but both the sex-negative words (*M* =1065) and sex-positive words (*M* =1056) produced longer RTs than the neutral category (*M* =1006), $p < .01$. In block 3, no comparisons reached significance.

Accuracy

Errors occurred on 3.7% of all trials. A 4 x 3 repeated measures analysis of variance was performed on error rates with word category (sex-negative, sex-positive, threat, and neutral) and block (block 1, block 2, and block 3) as within-participant variables. The analysis revealed no main effect of word category, $F(2.4, 74.1) = 0.49$, $p > 0.65$, no main effect of block, $F(2, 60) = 2.573$, $p > 0.08$, and no block by word category interaction, $F(6, 180) = 0.16$, $p > 0.98$ (see Table 4). As such the differing patterns of response times for the different word categories cannot be due to a speed-accuracy tradeoff.

Free Recall

Table 5 shows the mean number of words recalled during the surprise free recall task as a function of word category across participants. The ANOVA confirmed that memory performance differed significantly across word category, $F(3, 90) = 18.48$, $p < 0.01$. Bonferroni tests showed better memory for sex-negative words ($M = 4.3$) relative to sex-positive ($M = 2.3$), threat ($M = 1.7$), and neutral words ($M = 2.6$), all p's < 0.05; neutral words were also recalled significantly more often than threat words. No other comparisons reached significance.

Skin Conductance Responses

Skin conductance response amplitudes were calculated using a three-second window, beginning one second after the simultaneous presentation of the to-be-ignored words and flanking digits. The skin conductance level at the exact beginning of the window was subtracted from the maximum skin conductance level within the window to obtain the SCR for that trial. As recommended by Dawson, Schell, and Filion (2000), a square root transformation was applied to the SCR data to reduce skewness of the SCR distribution prior to analyzing the data.

Figure 5 shows mean SCR amplitudes as a function of word category and block. The analysis revealed a main of effect of word category $F(3, 72) = 4.10$, $p < .05$. The sex-negative words ($M = 0.96$ μS) did not significantly differ from the threat words ($M = 0.88$ μS, $p = 0.11$) but were significantly different from the sex-positive ($M = 0.86$ μS) and neutral words ($M = 0.83$ μS). The ANOVA produced no main effect of block, $F < 1.0$, $p > 0.95$, and no block by word interaction, $F < 1.0$, $p > 0.53$. Next, mean SCR frequencies were subjected to the same analysis as noted above. The ANOVA did not produce a significant main effect of word category, $F(3, 90) = 1.38$, $p = 0.26$, but did produce a main effect of block, $F(2, 60) = 13.09$, $p <0.01$, with a greater number of SCRs produced in block 1 (*M* = 5.94), relative to block 2 (*M* = 5.07), and block 3 (*M* = 4.73). Finally, the ANOVA did not produce a significant word category by block interaction, $F < 1.0$, $p = 0.64$. Thus, despite the fact that each word category produced a similar number of SCRs, when a sex-negative word was presented between the digits during the digit-parity task, larger SCR amplitudes were produced relative to the sex-positive and neutral word categories.

Inter-beat Intervals

For each word category six IBIs were calculated, with the first IBI beginning just prior to the presentation of the digit-parity stimuli. A low pass filter was applied to the heart beat trains to maximize the difference between r-waves and other electrocardiam signals (e.g., q s and t waves). Artifacts were then detected using the default settings Heart Rate Variability module of Chart 7.0, an ADinstruments analysis program. Statistically defined artifacts were removed, valid R-waves were then labelled and inter-beat intervals were calculated. For every participant these values were averaged to yield 6 IBIs for the sex-negative, sex-positive, threat, and neutral word categories (IBI 1 = the temporal distance between beat 1 and beat 2, IBI 2 = the temporal distance between beat 2 and beat 3, etc.). Prior to calculating these averages, raw IBI values were submitted to the Van Selst and Jolicoeur (1994) observation-dependent outlier elimination procedure, ensuring that any artifacts not detected by the scanning procedure were detected prior to the main analysis. Trimming using the Van Selst and Jolicoeur procedure resulted in elimination of 1.3% of the data.

The ANOVA revealed only a significant main effect of block, $F(2, 40) = 6.54$, $p < 0.001$, indicative of tonic changes in arousal likely due to repetition of the words and increased ease with digit-parity task with practice, and a main effect of IBI, $F(2, 41) = 23.99$, $p < 0.001$, indicative of heart rate acceleration (IBI 1 was longer than IBI 2, which was longer than IBI 3). As in experiment 1, the predicted IBI by word category interaction (caused by the sex words having the greatest HRD) was not significant $F(5, 126) = 0.77$, $p = 0.58$.

Correlational findings

Prior to conducting mediational analyses, the relationship between word ratings (arousal, valence, and taboo), digit-parity RTs[5], memory, and SCRs[6] were examined (see Table 6). Arousal ratings were correlated with taboo ratings, where higher arousal ratings were associated with higher taboo ratings. Arousal ratings were also correlated with valence ratings, where higher arousal ratings were associated with negative valence. Finally, taboo ratings were correlated with valence ratings, where higher taboo ratings were associated with negative valence. Only taboo ratings were significantly related to digit-parity RTs, with higher taboo ratings having longer digit-parity RTs. In a similar fashion, only taboo word ratings significantly related to the number of words recalled, where higher word taboo ratings were associated with better recall. When each of the affective ratings were correlated with SCRs, both word arousal ratings and word taboo ratings were significantly related to SCRs, where higher word arousal ratings were associated with larger SCRs. This was true even when the variability due to taboo ratings was partialed out (semiparital $r = 0.34$, $p = 0.05$). Though taboo ratings significantly predicted SCRs, this relationship did not hold true when the variability due to arousal ratings was partialed out ($r = 0.13$, $p = 0.44$).

[5] Given the significant block by word interaction, only block 1 RTs were included.
[6] Given the non-significant block by word interaction, SCRs were collapsed across blocks

Mediational Analyses

Digit-parity RTs. To investigate whether word category was related to digit-parity RTs, I first examined the total effects (*c*) of word category and digit-parity RTs. Total effects indicated a significant relationship between the contrast of the sex-negative words to the neutral words and digit-parity RTs, with words in the sex-negative word category having longer digit-parity RTs ($\beta = 132.8$, $SE = 55.6$, $p = 0.02$). The indirect effect of the contrast of the sex-negative words to neutral words and digit-parity RTs, through taboo ratings, was positive and statistically different from zero based on 1000 bootstrap samples, ($\beta = 204.7$, $SE = 101.6$, $p < 0.05$, the 95% bias-corrected confidence interval for this mediated effect was 2.4 to 417.3). The direct effect (*c'*) of the contrast between the sex-negative word category and the neutral word category no longer predicted digit-parity RTs once taboo ratings were included in the model ($p = 0.52$). These results support the hypothesis that the relationship of the sex-negative word category to digit-parity response times is mediated by the greater tabooness of these words.

Memory. To investigate whether word category was related to memory, I first examined the total effects (*c*) of word category and memory. Total effects indicated a significant relationship between the contrast of the sex-negative words to the neutral words and memory performance, reflecting better recall for words within the sex-negative word category ($\beta = 4.7$, $SE = 2.0$ $p = 0.03$). The indirect effect of the contrast of the sex-negative words to neutral words and memory performance, through taboo ratings, was positive and statistically different from zero based on 1000 bootstrap samples, ($\beta = 26.1$, SE = 4.2, $p < 0.05$, the 95% bias-corrected confidence interval for this mediated effect was 17.1 to 34.6). The direct effect (c') of the contrast between the sex-negative word category and the neutral word category no longer predicted memory performance once taboo ratings were included in the model ($p = 0.19$). These results support the hypothesis that the relationship of the sex-negative word category to memory performance is mediated by the greater tabooness of these words.

Discussion

The primary aim of the present investigation was to further clarify the attention-capturing effect of sexual words by parsing the sexual words into clearly positive and negative word groups while maintaining their arousing properties. As expected, according to participants' self-report word ratings, the sex-negative words were rated as more negative than the sex-positive words. However, the sex-negative words were also rated by participants as more arousing than the sex-positive words. Interestingly, the sex-negative words were rated as equally negative and equally arousing as the threat words. One aspect that appeared to differentiate the sex-negative and threat words was the taboo value of the sex-negative words. The sex-negative words were rated by participants as more taboo than the threat words, and indeed more taboo than any other word category. To summarize, based on participant's self-report ratings the sex-negative words represented the most taboo word category. Along with the threat words, the sex-negative words were also rated as the most arousing and negative in valance.

With respect to digit-parity RTs, we found longer response times for the sex-negative words relative to all other word categories (sex-positive, threat, neutral) for the first presentation of the words (i.e., in block 1). By the second presentation of each word (i.e., in block 2), only the sexual words (both the sex-negative and sex-positive words) produced longer digit-parity response times than the neutral words. Importantly, despite the fact that the threat words were rated as equally arousing and negative as the sex-negative words, only the sex-negative words predicted digit-parity response times in block 1. Taken together, it would seem that the attention-capturing effects of the sex-negative words may be due to their taboo nature. Mediation analysis confirmed these results – taboo ratings mediated the relationship between the sex-negative words and digit-parity response times, suggesting that participants' appraisal of the sex-negative words as socially unacceptable accounted for their attention capturing effects.

The memory data exactly replicated digit-parity response times, that is, participants recalled more of the sex-negative words relative to all other word categories. Like the observed pattern of digit-parity results, taboo ratings mediated the relationship between the sex-negative words and memory performance. Once again, results suggest that participants' evaluation of the sex-negative words as socially unacceptable explained why they are better remembered than equally arousing (e.g., threat words) words.

Finally, participants produced larger SCRs for the sex-negative words relative to the sex-positive and neutral words. The sex-negative and threat words elicited equally large SCRs. This may not be surprising, given that the sex-negative words were rated as equally as arousing as the threat words, and SCRs are particularly adept at tracking arousal. In support of this conjecture, the word level analyses demonstrated that the higher the word arousal rating the larger the size of the SCRs produced, replicating previous research showing a positive relationship between arousal ratings and SCRs (e.g., Lang et al, 1993; Lang, 1995).

It is worth noting that in the present investigation the observed correlations between arousal and SCRs are relatively modest in comparison to those previously reported by others (see Lang et al., 1993; Lang, 1995). This modest correlation may, at least in part, be due to the fact that word ratings were recorded after multiple presentations of the words during the course of the parity task. Assessing participants' emotional experience to the words after multiple exposures to these words may have led to measurement error. If participants poll their reactions to these words in order to subjectively rate these words on arousal they are polling reactions that may have been attenuated by multiple exposures to the presented word in the course of the digit parity task.

In terms of the heart rate data, again, our IBI analysis showed heart rate *acceleration* for all conditions. One may interpret these effects as in increase in heart rate associated with making the button press response to indicate the parity decision, since even neutral words showed this heart rate acceleration. It is possible that this cognitive load associated with making the parity decision masked any potential phasic heart rate deceleration. To minimize movement artifacts Flykt (2005) included an experiment where participants were asked to simply view search displays consisting of affective pictures without making any button-pressing responses. Flykt was able to show heart rate deceleration for emotionally salient pictures relative to neutral pictures. In Experiment 2b, I followed Flyke's approach, and measured phasic heart rate changes in the absence of parity decisions and their ensuing button-press responses. In the absence of the cognitive load imposed by making parity decisions, I hoped to show greater heart rate deceleration effects for the sex negative words – a finding that would provide converging evidence that this category has special effects on attention.

Experiment 2b

Although emotional stimuli have been shown to elicit HRD in previous research, one concern with the current investigation is that there were large cognitive demands placed on participants when making the parity decisions. To make a parity decision, participants had to attend to the digits, store them in short-term memory, compare them to each other, and then make a motor response. It is possible that cognitive demands of the digit–parity judgements in this task as well as making a motor response could mask any potential heart rate deceleration. Indeed, in a task with minimal cognitive requirements (simply reading words as they appear on a computer screen) HRD has been found for threat words (Thayer, Friedman, Borkovec, Johnsen, & Molina, 2000). Therefore, to help eliminate the possibility that the cognitive demands of computing digit parity interfered with our ability to detect HRD, we removed the parity decision and instead instructed participants to passively view the words (flanked by the digits). Specifically, participants were asked to view a word that, in line with the first experiment, would be surrounded by a digit to the left and right of it. No instructions were given regarding these digits.

Method

Participants

Eleven University of Waterloo male (*n*=3) and female (*n*=8) psychology graduate students were recruited from the University of Waterloo's graduate student list service to participate in the experiment. All participants had normal or corrected-to-normal vision and had learned English by the age of eight.

Apparatus and Stimuli

The same word stimuli were used as in Experiment 2.

Design

Participants were presented with one block of 40 digit-parity trials (10 words for each word category, sex-negative, sex-positive, threat, neutral) in random order. Each trial began with a cross presented in the center of fixation for 250ms; followed, after 500ms, by a word flanked by digits. A 10,000 msec inter-trial interval separated successive trials. Prior to the presentation of the experimental trials, 10 practice trials were presented using neutral words (different from the neutral words presented in the experiment proper).

Procedure

All participants were tested individually. After obtaining consent, participants were fitted with the heart rate electrodes. Each participant viewed the word stimuli while sitting quietly with their hands in their lap to avoid making gross upper body movements.

Results

Inter-beat Intervals

For each word category six IBIs were calculated, with the first IBI beginning just prior to the presentation of the word/digit stimuli. A low pass filter was applied to the heart beat trains to maximize the difference between r-waves and other electrocardiam signals (e.g., q, s and t waves). Artifacts were then detected using the default settings of the Heart Rate Variability module of Chart 7.0, an ADinstruments analysis program. Statistically defined artifacts were removed, valid R-waves were then labelled and inter-beat intervals were calculated. For every participant these values were averaged to yield 6 IBIs for each of the sex-negative, sex-positive, threat, and neutral word categories (IBI 1 = the temporal distance between beat 1 and beat 2, IBI 2 = the temporal distance between beat 2 and beat 3, etc.). Prior to calculating these averages, raw IBI values were submitted to the Van Selst and Jolicoeur (1994) observation-dependent outlier elimination procedure, ensuring that any artifacts not detected by the scanning procedure were detected prior to the main analysis. Trimming using the Van Selst and Jolicoeur procedure resulted in elimination of 1.6% of the data.

A 4 x 6 repeated measures ANOVA IBI was performed on HRD data with word category (sex-neg, sex-pos, threat, and neutral) and IBI (IBI1, IBI2, IBI3, IBI4, IBI5, IBI6) as repeated variables. The ANOVA revealed a significant main effect of word category, $F(3, 30) = 4.91$, $p < 0.01$, with overall longer IBIs for the sex-negative word category ($M = 0.903$) relative to sex-positive ($M = 0.887$), and threat ($M = 0.885$). The analysis also revealed a main effect of IBI, $F(5, 50) = 5.78$, $p < 0.01$, Bonferonni tests showed that IBI 2 was longer than IBI 5 and IBI 6. No other comparisons reached significance. Finally, the predicted IBI by word interaction was non-significant $F(15, 150) = 0.94$, $p = 0.42$.

The main effect of word category but absence of a word category by IBI interaction forces the interpretation of slower heart rates for the sex-negative words regardless of IBI. As can be seen in Figure 6, this is clearly not the case, all data points appear to be relatively similar prior to presenting the words at IBI-1 with the sex-negative and sex-positive words lying atop one another. Theoretically, it makes little sense to suppose that heart rate would be slowed for sex-negative words at IBI -1 since this IBI occurs *prior* to the exposure of the word. At subsequent IBIs (after the word and digits have been presented) heart rate is elevated for the sex-negative word category relative to all other word categories. Put another way, only the sex-negative words appear to show meaningful heart–rate deceleration (the rise in Inter-beat interval duration during the processing of the word). Therefore, because of the theoretical importance of this a priori predicted interaction between IBI and word category, simple main effects of word category were conducted at each inter-beat interval. As anticipated, there was no main effect of word category at IBI 1, (the IBI just prior to the first presentation of the word), $F < 1.0$, $p = 0.65$, but the main effect of word category was significant at IBI 2, $F(2, 15) = 3.36$, $p < 0.05$. This was caused by a significant deceleration of heart rate from IBI 1 to IBI 2 for the sex negative words – a deceleration that was absent for any other word category. As can be seen in the Figure 6, although the initial deceleration was followed by an acceleration period, the initial deceleration was so pronounced; heart rates for the sex-negative words remained high over IBIs 2 through 5, IBI 3, $F(3, 30) = 3.21$, $p < 0.05$; IBI 4, $F(3, 30) = 2.91$, $p < 0.05$; IBI 5, $F(3, 30) = 3.55$, $p < 0.05$. By IBI 6, the main effect of word category did not reach significance, $F(3, 30) = 2.34$, p=0.09.

In considering why the IBI by word category effect failed to reach significance, we looked at the individual data of the participants in this experiment. In this design, the interaction error term for the IBI by word category effect is the participants by IBI by word *MS* error term, suggesting that the likely sources creating the non-significant interaction are one or two participants who do not show the deceleration for the sex-negative words. Figure 7 shows that participants 4 and 6 do not show heart rate deceleration for the sex-negative word category but all the other participants do.

Discussion

Analyses of heart rate data showed that only words from the sex-negative word category triggered heart rate deceleration (in a majority of participants). These results suggest that the failure to find HRD in the context of the Experiments 1 and 2 was likely due to the masking of HRD by the cognitive load imposed by having to make the parity decision.

When participants viewed sex-negative words HR initially decelerated more than when participants viewed sex-positive, threat, or neutral words. These results are in line with previously reported HR deceleration in response to mutilated bodies, rated by study participants both high in arousal value and negative valence (Greenwald et al., 1998). Importantly, although in Experiment 2 participants rated the threat and sex-negative words as being equally negative in valence, only the sex-negative words elicited HR deceleration, suggesting that negative valence alone is not sufficient in eliciting HR deceleration. Instead, when participants are exposed to stimuli high in both arousal value and negative valence, deceleration occurs. With respect to previous research, when participant arousal and unpleasantness have been taken into consideration, HR deceleration is commonly observed. For example, under conditions that elicit frustration, such as when participants are offered disadvantageously unfair offers, heart rate initially decelerated more than when an offer was perceived as fair (Osumi, & Ohira, 2009).

Experiment 3

Individual differences in participants' anxiety level have been shown to influence the attention capturing capability of threat-relevant relative to emotionally neutral stimuli. In a recent meta-analysis, Bar-Haim, Lamy, Pergamin, Bakersmans-Kranenburg, & van IJzendoorn (2007) found evidence supporting attention capturing effects for threat-relevant stimuli across different types of anxious populations (e.g., generalized anxiety disorder, social phobia, panic disorder), with significant threat-related biases in clinically diagnosed participants as well as in participants with high self-reported anxiety. Interestingly, the smallest effect sizes were found for participants diagnosed with specific phobias. However, Bar-Haim and colleagues included only those studies comparing general threat-relevant words relative to neutral. It may be that for individuals diagnosed with specific phobias, general threat stimuli are not emotionally salient enough to elicit attention-capturing effects. For those with a particular phobia, it may be the case that attention-capture will be maximal only if the threatening stimuli are directly relevant to that person's specific phobia. Indeed, there is consistent evidence supporting Stroop interference effects for snake-relevant words among snake fearful participants relative to non-fearful participants (e.g., Kindt & Brosschot, 1998). Similar Stroop interference effects have also been found for spider-relevant stimuli relative to neutral stimuli for spider-phobic participants, regardless of type of stimulus employed, pictorial or linguistic (Kindt & Brosschot, 1997). Using a dot probe task, Mogg and Bradley (2004) found that participants who reported being fearful of spiders (high fear group) were faster to locate probes replacing pictures of spiders pictures relative to fear-irrelevant stimuli (i.e.. pictures of cats). This fear-relevant versus fear-irrelevant difference was significantly greater for participants with a spider phobia than for those who were not especially afraid of spiders (low fear group). The fact that the differences between spider phobics and the low fear group were maximal at short exposure durations suggests that high fear is associated with rapid detection of fear-relevant stimuli (i.e., stimuli exposure durations of only 200 *msec*).

Rapid detection of feared stimuli in fearful participants has also been found in studies employing visual search tasks (e.g., Öhman, Flykt, & Esteves, 2001). However, Wenzel and Holt (1999) failed to find evidence of attention capture of phobia-relevant stimuli. Closer examination of study procedures suggest that longer stimuli exposure duration (500msec) employed by study investigators may account for the discrepant results. Indeed, dot-probe experiments employing relatively short exposure durations yield a significantly larger effect than those employing longer exposure durations (Bar-Haim at al., 2007).

Fear-relevant memory effects have also been shown to occur in phobic populations. Participants who were either blood phobic, injection phobic, or injury phobic were exposed to medical (e.g., blood, injection), disgusting (e.g., vomit, excrement), negative (e.g., lonely, miserable), and neutral (e.g., spoon, toaster) words. Afterwards, when participants were then asked to complete word-stems with the first word that came to mind, phobic participants produced significantly more medical and disgust word-stems than non-phobics; in contrast, the two groups did not differ on negative or neutral word-stems (Sawchuk, Lohr, Lee, & Tolin, 1999).

In addition to attention and memory effects, decades of research using electrodermal activity, specifically skin conductance responses, has shown elevated electrodermal responses to emotionally salient stimuli in anxious populations. For example, self-reported spider phobics produce larger SCRs when viewing pictures of spiders relative to control pictures (Wilson, 1967). In addition, the pioneering work of Öhman and colleagues has suggested that physiological responses to emotionally salient information are often set in motion before conscious perception of the stimuli. That is, SCRs to emotionally relevant stimuli could be elicited even with very brief stimulus presentations that preclude conscious awareness. For example, Öhman and Soares (1994) measured SCRs for subliminally presented snakes, spiders, or control stimuli (flowers and mushrooms). The participants were either snake- or spider-fearful individuals, or non-fearful individuals. Results indicated that snake-fearful participants produced larger SCRs for pictures of snakes compared to pictures of spiders or control pictures. Spider-fearful participants showed larger SCRs for pictures of spiders compared to pictures of snakes or control pictures (also see Öhman & Weins, 2003).

A key factor that appears to constrain the findings of the studies reviewed above is the extent to which the stimuli employed in cognitive paradigms accurately reflect the concerns of the individuals being studied. That is, information processing systems of anxious individuals may be distinctively sensitive to and biased in favour of stimuli that match their particular concerns. Thus, the degree to which one observes attention capture and memory effects may depend on the emotional significance that the word meaning holds for that individual. As noted above, a generally fearful object (a snake) may have large or small attention-capturing effects depending on how a given individual feels about snakes. For one who is terrified by snakes, attention capture effects may be profound; for one who finds snakes only mildly unpleasant, attention capture may be minimal.

Experiment 3 examined the role of person-specific influences of emotionally laden stimuli on attention and memory. Specifically, do stimuli consistent with participants' specific fears more greatly disrupt attention and impair their ability to perform a simple digit-parity task? In addition, I examined whether participants would show better surprise recall for stimuli consistent with their fears. Along with attention and memory effects, I examined whether fear-relevant stimuli would elicit larger SCRs than fear-irrelevant stimuli. In order to test these hypotheses, I recruited participants who either had a fear of flying or were math anxious. Included in the word stimuli were words that were consistent with each fear. Participants were presented with flying-relevant and math-relevant word distractors, as well as neutral words that were unrelated to either flying or math.

Predictions

First, I predicted that the fear of flying words would be associated with greater self-reports of arousal than fear-irrelevant words for participants with a fear of flying and the math-relevant words would be associated with greater self-reports of arousal than fear-irrelevant words for math anxious participants. Statistically, when word category (flying, math, neutral) and fear group (flying, math) were to be compared in an ANOVA context, there would be a significant word by fear group interaction.

Second, I predicted that participants with a fear of flying would show longer digit-parity RTs when flying-relevant words were presented between the digits relative to neutral and math-relevant words. Similarly, I predicted that math anxious participants would show longer digit-parity RTs for math-relevant words relative to neutral and flying-relevant words (again yielding a fear-group by word category interaction).

The third prediction was that participants in a surprise recall task would better remember words that are consistent with their fears. Specifically we predicted that participants with a fear of flying would recall more flying-relevant words relative to all other word categories, and math anxious participants would recall more math-relevant words relative to all other word categories (a fear-group by word category interaction).

Finally, I predicted that participants would produce larger SCRs for stimuli consistent with their fears. Thus, participants with a fear of flying should show the largest SCRs for flying-relevant words relative to neutral words, and math anxious participants should show the largest SCRs for math-relevant words, resulting in a fear-group by word category interaction.

Participants

Participants were recruited from a sample of approximately 6,800 University of Waterloo undergraduate and graduate students who received course credit for their completion of a mass testing screening session at the beginning of the Spring 2011, Fall 2011, Winter 2012, and Spring 2012 academic terms. Participants whose Abbreviated Math Anxiety Scale (AMAS) score was greater than 30[7], whose Fear of Flying Inventory (FOFI) score was less than 45, and who did not endorse having a fear of flying[8] at the time of screening were identified as "likely math anxious, but as not having a fear of flying." Participants whose AMAS score was less than 30, whose FOFI score was greater than 100[9], and who endorsed having a

[7] Cut-off scores were guided by previous research who selected participants with AMAS scores over 30 to constitute high math anxious and those with scores under 20 to constitute low math anxious (see Maloney, Ansari, & Fugelsang, 2011).
[8] Mass testing question: Do you have a fear of flying? Note that by answering 'yes' to this question one is saying that one experiences a considerable amount of fear or discomfort; more than the average person.
[9] Cut-off scores guided by previous research who found participants with diagnosed fear of flying had a mean pre-treatment FOFI of greater than 100 and a mean post treatment FOFI score of less than 45 (see Scott, 1987).

fear of flying at the time of screening were identified as "likely having a fear of flying, but not math anxious." Approximately three hundred and thirty (*N*=330) students were identified as meeting these study requirements (i.e., as belonging to one of the aforementioned groups). The Research Experience Group coordinator then sent an information synopsis to these targeted students allowing them the opportunity to participate.

Of that sample, fifty-six participants (*N*=56) agreed to participate in the study and were recruited to participate for additional course credit. Upon completion of study procedures, all participants again completed the self-report measures (e.g., AMAS and FOFI) to confirm group membership. Given that participants were administered self-report measures during a mass testing session that could have occurred up to 3 months prior to our experiment, if AMAS and FOFI scores no longer met the aforementioned study inclusion criteria at time of testing, participants' data were eliminated from further analysis. The second screening session revealed that twenty-four (*N*=30) participants no longer met study inclusion criteria. One participant (*N*=1) identified himself as having grapheme-colour synesthesia (the association of specific colours with numerical digits). Because the digit-parity task requires participants make speeded decisions about numerical digits, to eliminate the possibility that the associated colour experience with numerical digits produced the observed digit-parity interference effects, his data was excluded from further analyses. Finally, for one participant, upon arrival at the lab none of his demographic information (e.g., age, gender) matched his pre-screen information; therefore he was granted course credit, but did not participate in the experiment. The final sample comprised data from twenty-eight (*N*=28) individuals.

The math anxious group comprised of fifteen male (*n*=3) and female (*n*=11)[10] University of Waterloo undergraduate students ranging in age from 18 to 25 with a mean age of 19.7 years (*SD* =1.8). Approximately fifty percent of the MAG participants identified themselves as Caucasian (*n*=8; 53%), approximately seven percent as East Indian (*n*=1; 6.7%), approximately seven percent as Black/African (*n*=1; 6.7%), approximately seven percent as Chinese (n=1; 6.7%), approximately seven percent as other Asian (Filipino) (*n*=1; 6.7%), and approximately thirteen percent as Biracial (*n*=2; 13.3%). No MAG participants reported having a psychiatric disorder.

Thirteen University of Waterloo male (*n* =3) and female (*n*=10) undergraduate students ranging in age from 18 to 29 with a mean age of 20.8 years (*SD*=3.3) made up the fear of flying group (FFG)[11]. Approximately fifty percent of the FFG participants identified themselves as White/Caucasian (*n*=7, 53.8%), approximately fifteen percent as East Indian (*n*=2; 15.4%), approximately fifteen percent as Chinese (*n*=2; 15.4%), approximately seven percent as Middle Eastern (*n*=1; 7.7%), and approximately seven percent as Biracial (*n*=1). Four FFG participants reported being diagnosed with a psychiatric disorder (*n*=2, Major Depression Disorder; *n*=1, Panic Disorder; *n*=1, Generalized Anxiety Disorder).

All participants (across both participant groups) had normal or corrected-to-normal vision, were right-handed, had learned English by the age of eight, and had no history of medical or neurological disorder.

[10] Gender information is missing for n=1 math anxious participant.
[11] Demographic information is missing for one (n=1) fear of flying participant.

Word stimuli

Thirty word stimuli from three word categories were included in the digit-parity task: 10 math-relevant, 10 flying-relevant words and 10 neutral words (see Appendix I). Digits and words were presented in black, 48-point Lucida Grande font against a white background and all words were capitalized. The words were 4 to 8 letters long.

Digit-parity Task

Participants were presented with four blocks of 30 digit-parity trials (10 math-relevant, 10 flying-relevant, 10 neutral). The 30 trials in each block were presented in random order. Each digit-parity trial began with a centrally presented fixation cross presented for 250ms; after a 500ms blank screen, the to-be-ignored word was presented flanked by digits on which parity judgements were to be made. A 5000 msec inter-trial interval separated successive trials. Prior to block 1, 20 practice trials were presented using neutral words (different from the neutral words presented in the experiment proper).

Skin Conductance Responses

As in studies 1 and 2, SCRs were measured using an eight-channel ADinstruments Powerlab (model 8/30) and were recorded continuously throughout the digit-parity task. SCRs were recorded using non-gelled electrodes attached to the distal phalanges of the left index and ring fingers of their non-dominant hand. Upon presentation of each trial, a digital marker was sent to an open channel of the Chart software, enabling the time locking of the presentation of the distractor word and any changes in skin conductance level.

Word ratings

Participants rated their emotional experience of each word on scales of valence and arousal. Valence and arousal ratings were rated in a similar manner as described in experiment 2 (i.e., using a modified version of the SAM). Participants completed valence and arousal ratings for all word stimuli, presented in random order.

Questionnaires

Depression, Anxiety, and Stress Scale – 21 (DASS-21, Lovibond and Lovibond, 1995). The DASS-21 is a 21 item self-report measure designed to measure the negative emotional states of depression, anxiety, and stress. Each subscale (depression, anxiety, and stress) is composed of 7 items. The Depression scale assesses dysphoria, hopelessness, devaluation of life, self-deprecation, lack of interest/involvement, anhedonia, and inertia. The Anxiety scale assesses autonomic arousal, skeletal muscle effects, situational anxiety, and subjective experience of anxious affect. The Stress scale is sensitive to levels of chronic non-specific arousal. It assesses difficulty relaxing, nervous arousal, and being easily upset/agitated, irritable/over-reactive and impatient.

Fear of flying inventory (FOFI) (Scott, 1987). The FOFI is a 33-item self-report questionnaire used to assess fear of flying. Respondents indicated on a nine-point Likert-like scale the extent to which they would be disturbed by, or anxious about, specified events related to air travel (e.g., taxiing down the runway, taking off, experiencing turbulence). For each item, the scale ranged from 0 (not at all) to 8 (very severely disturbing). Scores on the FOFI range from 0 to 264.

Abbreviated math anxiety scale (AMAS). The AMAS is a 9-item self-report questionnaire used to assess math anxiety in a general population. Respondents indicate using a five-point Likert-like scale how anxious they would feel during specified events (e.g., taking an exam in a math course; listening to a lecture in a math course). Scores on the AMAS range from 9-45.

State anxiety rating. Participants rated how anxious they felt during the experiment on a scale from 1 to 5, with 1 represented low levels of anxiety and 5 representing high levels of anxiety.

Procedure

The procedure was similar to the procedures used in Studies 1 and 2. Participants first completed the digit-parity task, followed by the surprise recall task, then the word rating task. Given the potential overlap between the content of the questionnaires and the words used in the experiment proper, to avoid potential priming effects, participants filled out the AMAS, FOFI, DASS-21, and state anxiety rating after completing the memory recall task, just prior to the word rating task.

Results

Data Analytic Strategy

All statistics were conducted with the statistical package SPSS (v.21). First, to determine whether scores on self-report measures of fear of flying, math anxiety, and negative affective states differed based participant's identified fear, independent samples t-tests were performed on FOFI, AMAS, and DASS-21 scores. Next, to determine the affective profiles of each word category, a 2x 3 mixed analysis of variance (ANOVA) was performed on mean arousal and valence word ratings with word category (math, flying, neutral) as the within-participant variable and participant's identified fear (math, flying) as the between-participant variable. To answer the question of whether word category had an effect on digit-parity RTs, memory, and SCRs, a mixed analysis of variance was performed on mean digit-parity RTs, memory, and SCRs. Degrees of freedom were adjusted according to Greenhouse-Geisser, where appropriate. For this study planned comparisons (t-tests) were employed, and one-tailed tests are reported.

Participant Characteristics

Demographic and clinical characteristics for the MAG and FOF participant groups are presented in Table 7. As expected, FFG participants scored higher on the FOFI than did the MAG participants, $t(25) = 12.41$, $p < 0.001$, indicating a greater level of fear of flying[12]. Math anxious participants showed higher scores on the AMAS than did the fear of flying participants, $t(26) = 7.56$, $p < 0.001$, indicating a greater level of math anxiety. No other self-report measures yielded significant results, all p's > 0.25.

[12] FOFI scores are missing for one FFG participant

State Anxiety Rating

Participants' subjective ratings of anxiety during the experiment was subjected to an independent samples t-test. Results indicate that state anxiety ratings for the FFG participants (M = 2.5; SD =1.3) did not differ from state anxiety ratings of the MAG participants (M = 2.1; SD = 1.2), $t(26) < 1.0$, $p = 0.42$.

Word Ratings

For both the arousal ratings and valence ratings a similar data-reduction procedure was conducted. For each of the 30 words (10 flying, 10 math, 10 musical instruments), two averages were calculated; one based on the ratings from the fear of flying group, and a second based on ratings of the math anxious group. These 60 data points were analyzed using a 2 x 3 mixed analysis of variance with word category (flying, math, music) as the within-participant variable and participants' identified fear (flying, math) as the between participant variable. The analysis revealed that mean arousal ratings differed across word categories, $F(2, 52) = 14.9$, $p < 0.001$, where both the flying words (M = 4.20) and math words (M = 4.01) were rated significantly more arousing that the neutral words (M = 2.23). This main effect, however, must be interpreted within the context of a higher-order interaction involving group. Consistent with our first prediction, the ANOVA revealed a significant word by identified fear group interaction, $F(2, 52) = 17.53$, $p < 0.001$. Paired samples t-tests showed that for those participants with flying as their identified fear, flying words (M = 5.03) were rated significantly more arousing than math words (M =2.95), $t(12) = 5.03$, $p < 0.001$ and neutral words (M = 2.23), $t(12) = 6.62$, $p < 0.001$. For participants with math as their identified fear, the math words (M = 5.64) were rated as significantly more arousing than the flying words (*M* = 2.93), $t(14) = 4.77$, $p < 0.001$ and neutral words (*M* = 2.23), $t(14) = 4.55$, $p < 0.001$.

Mean valence ratings differed across word categories, $F(2, 52) = 13.31$, $p < 0.001$; math words (*M* = 3.48) were rated as significantly more negative than the flying (*M* = 4.87) and neutral (*M* = 5.63) words. Again, this main effect must be interpreted within the context of a higher-order interaction involving group. The ANOVA produced a significant word by identified fear group interaction, $F(2, 32) = 11.4$, $p < 0.001$. Paired samples t-tests showed that for those participants with flying as their identified fear, flying words (*M* = 4.05) were rated as significantly more negative than the neutral words (*M* = 5.77), $t(12) = 2.23$, $p < 0.05$, but about equally as negative as the math words (*M* = 4.66), $t < 1$, $p = 0.42$. For participants with math as their identified fear, the math words (*M* =2.30) were rated as significantly more negative than the flying words (*M* =5.69), $t(14) = 7.78$, $p < 0.001$, and the neutral words (*M* =5.60), $t(14) = 6.15$, $p < 0.001$.

Thus, based on participant's self-report ratings, the flying words represented the most arousing word category for participants with a fear of flying, but were about equally as negative in valence as the math words. By contrast, the math words represented the most arousing and negative word category for participants who were math anxious. Thus, the flying words represented the most arousing words for the fear of flying participants, and the math words represented the most arousing and negative words for the math anxious participants.

Digit-parity Response Times

Only correct parity judgements were analyzed when calculating digit-parity response times (RTs). Prior to calculating these means, raw digit-parity RTs were subjected to the outlier removal procedure recommended by Van Selst and Jolicoeur (1994). A total of 2.1% of all trials were removed using this procedure.

Figure 8 shows the mean digit-parity RTs for each word category as a function of identified fear group. The analysis revealed a main effect of block $F(3, 37) = 5.83$, $p < 0.01$. Bonferroni post-hoc tests revealed that digit-parity RTs were longer in block 1 ($M = 1332$), block 2 ($M = 1270$) and block 3 ($M = 1257$) relative to block 4 ($M = 1177$), all p's < 0.05, with reduction in RT in block 4 likely due to practice effects. The ANOVA did not produced a main effect of word, $F(2, 52) = 1.60$, $p = 0.21$ but as predicted, did reveal a significant word x fear interaction, $F(2, 52) = 4.54$, $p < 0.05$. Testing whether participants with a fear of flying showed greater digit-parity interference effects for word stimuli consistent with their concerns (i.e., flying-relevant), the comparison between flying words and neutral words showed that, as predicted, flying words (M =1298) led to longer digit-parity RTs relative to neutral words (M =1249), $t(12)= 2.03$, $p < 0.05$. Mean digit-parity RTs for flying words (M =1298) were also significantly longer than math words (M =1228) for the fear of flying participants, $t(12) = 2.36$, $p < 0.05$. Testing whether math anxious participants showed greater digit-parity interference effects for word stimuli consistent with their concerns (i.e., math-relevant), the comparison between math words and neutral words showed that, as predicted, math words (M =1287) led to longer digit-parity RTs relative to neutral words (M =1239), $t(14)$ =1.69, $p < 0.05$. Mean digit-parity RTs for math words (M=1287) approached significance, but ultimately were not significantly longer than flying words (M =1253), $t(14)$ =1.43, $p = 0.08$.

Accuracy

Errors occurred on 5.7% of all trials. A 2 x 3 mixed ANOVA was performed on RT error rates with word category (math, flying, neutral) and block (block 1, block 2, block 3, block 4) as the within-participant variable and participant's identified fear (math, flying) as the between-participant variable. The analysis revealed no main effect of word category, $F < 1.0$, $p = 0.83$, no main effect of block, $F < 1.0$, $p = 0.46$, no main effect of participant's identified fear, $F < 1.0$, $p = 0.69$, no block by word interaction, $F < 1.0$, p=51 and no word by group interaction, $F < 1.0$, $p = 0.36$. As such, the differing patterns of response times for the different word categories as a function of identified fear group cannot be due to a speed-accuracy tradeoff.

Free Recall

Table 8 shows the mean number of words recalled during the free recall task as a function of word category and participant group. The ANOVA revealed a main effect of word, $F(2,32) = 4.42$ $p < 0.05$, with better recall for the flying words (M =3.11) relative to neutral words (M=2.04), but flying words did not differ from math words (M =2.69). Crucially, the ANOVA also revealed a significant word by identified fear group interaction, $F(2,52) = 9.71$, $p < 0.001$. Testing whether participants with a fear of flying recalled more words consistent with their concerns (i.e., flying-relevant), the planned comparison between the flying and neutral words was significant for the fear of flying participants, $t(12) = 4.47$, $p < 0.05$, with better recall for flying-relevant words (M =4.08) relative to neutral words (M =1.61). Participants with a fear of flying also had better recall for flying words relative to math words (M =2.6), $t(12) = 2.89$, $p < 0.01$. Likewise, math anxious participants recalled more math (M=3.40) words relative to neutral words (*M* =2.47), $t(14) = 2.82$, $p < 0.01$. Math anxious participants also had better recall for math words relative to flying words (*M* =2.13), $t(14) = 2.57$, $p < 0.01$.

Skin Conductance Responses

Skin conductance response amplitudes were calculated using a three second window, beginning one second after the simultaneous presentation of the to-be-ignored words and flanking digits. The skin conductance level at the exact beginning of the window was subtracted from the maximum skin conductance level within the window to obtain the SCR for that trial. As recommended by Dawson, Schell, and Filion (2000), a square root transformation was applied to the SCR data to reduce skewness of the SCR distribution prior to analyzing the data.

The ANOVA did not reveal a main effect of word $F(2,46) = 1.80$, $p = 0.18$, a main effect of fear $F < 1.0$, $p = 0.45$, or a word by fear interaction, $F < 1.0$, $p = 0.48$. Nonetheless, to test whether participants with a fear of flying produced larger SCRs for word stimuli consistent with their concerns (i.e., flying-relevant), I used a direct contrast between flying words and neutral words. The comparison between flying words and neutral words showed that, as predicted, flying words (*M* = 0.49µS) lead to larger SCRs relative to neutral words (*M* = 0.40µS), $t(10) = 2.42$, $p < 0.01$, for participants with a fear of flying. Mean SCRs for flying words were also significantly larger than math words (*M* = 0.38µS) for the fear of flying participants, $t(10) = 2.26$, $p < 0.01$. To test whether math anxious participants produced larger SCRs for word stimuli consistent with their concerns (i.e., math-relevant), I used a direct comparison between math words and neutral words. Counter to my prediction, the direct comparison between math words (0.47µS) and neutral words (0.49µS) did not reveal significant results, $t(14) < 1.0$, $p >$

0.05; nor did the direct comparison between math words (0.47µS) and flying words(0.49), $t(14) < 1.0$, $p > 0.05$.

Next, the same analysis was conducted using mean SCR frequency data. To test whether participants with a fear of flying produced a greater number of measurable SCRs for word stimuli consistent with their concerns, we used a direct comparison between the flying words and neutral words. A greater number of measureable SCRs were produced for flying words (M= 3.65) than neutral words (M = 3.10), $t(11) =1.87$, $p < 0.05$. In addition, a greater number of measureable SCRs were produced for flying words relative to math words (M = 2.30), $t(11) = 4.53$, $p < 0.05$. With respect to our math anxious participants, mirroring the SCR amplitude data, no significant differences were found between word categories, all p's > 0.05.

Discussion

The aim of the present investigation was to examine whether word stimuli matching a person's specific fears would elicit attention-capturing effects. Results can be summarized as follows: First, for individuals with a fear of flying, according to participant self-report ratings, the flying words represent the most arousing word category. For math anxious individuals the math words represent the most arousing and negatively valenced word category. Second, for participants with a fear of flying, when a flying word was presented between the digits, responses were significantly slowed relative to all other word categories (math and neutral). For math anxious individuals, when a math word was presented between the digits, responses were significantly slowed relative to neutral words. Although in the predicted direction, the math words did not produce significantly longer digit-parity response times relative to flying words.

The memory data also attest to the disruptive effects of words related to an individual's specific fears on a primary cognitive task. Individuals with a fear of flying recalled more flying words relative to all other word categories (neutral and math). Math anxious individuals recalled more math words relative to all other word categories (neutral and flying neutral).

Lastly, individuals with a fear of flying not only produced more measurable SCRs, but produced larger SCRs for flying words relative to neutral and math words. Unexpectedly, math anxious individuals did not produce larger SCRs for math words relative to neutral or to flying words.

When one considers the fear of flying group, there is strong support that words related to this specific fear are preferentially attended to and remembered. Results suggest that flying words momentarily captured participants' attention, disrupting digit parity judgements relative to neutral or math words. Flying words also triggered larger, and more frequent skin conductance responses than any other type of word for this group of participants. Flying words were better remembered by those with a fear of flying than any other word category. When one considers the math anxious group, the effects of words related to math were somewhat weaker. Although math words disrupted digit parity judgements relative to neutral words, they did not disrupt performance more than flying words. Math words did not trigger preferentially large SCRs relative to flying or neutral words. Math anxious participants did, however, remember math words better than any other word category. In sum, on a behavioural level, individuals with a fear of flying responded more so to flying words than individuals with math anxiety reacted to math-relevant words.

One possible account for this pattern of data is that the nature of the digit-parity task itself could have washed out any effect at the word level for the math anxious participants. That is, though the digit-parity task is intended to be a relatively simple cognitive task, the stimuli on which judgements were to be made (the digits) were not unrelated to the source of anxiety for the math anxious group. In other words, the digits themselves could have elevated anxiety among the math anxious. At first glance, the skin conductance response data may seem to support this conclusion. Whether a math-relevant, flying-relevant, or neutral word was presented between the digits, math anxious participants produced equivalently high SCRs, and an equivalent number of skin conductance responses.

However, the role played by digit exposure among the math anxious might be relatively subtle. It was not the case that the math anxious people had significantly larger SCRs relative to the fear-of-flying group regardless of word category (i.e., there was no main effect of fear group). As such, it is unlikely the case that the presence of digits elevated the SCRS for the math anxious on all trials. It is possible that the digits had more subtle effects in eliminating the *differences* between conditions. Consider the fear of flying group in the flying words versus math words condition. Here the contrast is between a fear-relevant condition and a fear-irrelevant condition – there is nothing in the math word stimuli that is related to fear of flying. Now consider the math anxious group in the math words versus flying words or neutral conditions. In the fear-irrelevant (math words or neutral conditions), there are still stimuli (the digits) that could be related to math anxiety, rendering the contrast between the conditions less pronounced. Such conjectures, of course, are in need of empirical verification (for example one could change the primary task from digit parity judgements to presenting flanking letters in either upper case, lowercase, or a mixture of cases and having participants make letter case judgements).

A final possibility that might help explain the relatively weaker effects of the math words for math anxious individuals compared to the flying words for flying anxious individuals is the frequency with which these concepts are cognitively activated in day-to-day life. Simply put, although it is easy to avoid airports, it is much harder to avoid mathematics (especially in a University setting). Although these students may avoid mathematics courses per se, they would still be exposed to many of these concepts while taking statistics as part of their psychology degrees. With repeated exposure, there is the possibility that math anxious participants adapt (i.e., habituate) to such stimuli. By contrast, those with a fear of flying would seldom encounter airport-related concepts in their day-to-day lives. Thus, when faced with words such as run-way or turbulence, they may react more than the math anxious when they are faced with words such as integer and exponent.

General Discussion

The overarching goal of my dissertation was to experimentally test both general and person-specific influences of emotionally laden stimuli on attention and memory. To this end, using a digit-parity task, unselected participants (Experiment 1 and 2) and participants with specific fears (Experiment 3) were asked to make speeded judgements about the parity of two digits flanking a to-be-ignored, centrally presented word. In experiment one, either a sexual, threat, school, or neutral word was randomly presented between the digits. The results indicated that, when a sexual word (rated highest in arousal value by study participants) was presented between the digits, digit-parity performance was disrupted, producing longer digit-parity response times relative to all other word categories. Study participants recalled more sexual words relative to all other word categories and produced the largest SCR amplitudes in response to the sexual words. In Experiment 2, when the sexual words were parsed into positive and negative word groups, the sex-negative words produced longer digit-parity response times compared to the sex-positive words. Of crucial importance, despite the fact that the sex-negative and the threat words were rated as equally arousing and equally negative in valence, only the sex-negative words predicted digit-parity response times. As such the arousal level of the words could not entirely account for the preferential attention-capturing abilities of the sex-negative words.

Distinguishing the sex-negative and threat word categories was the taboo level of the sex-negative words, suggesting that disruptions in digit-parity performance when a sex-negative word is presented between the digits may be due, at least in part, to the taboo nature of the words. Mediation analysis confirmed this conclusion – participants' taboo ratings mediated the relationship between the sex-negative word category and digit-parity response times. Like the observed pattern of digit-parity results, participants recalled more sex-negative words. Again the relationship between the sex-negative word category and digit-parity response times was mediated by participant taboo ratings. Finally, in Experiment 3, when a word matching a person's specific fear was presented between the digits, digit-parity responses were significantly slowed relative to fear-irrelevant words. However, the effect was more pronounced for individuals with a fear of flying than for those who are math anxious. Indeed, for the math anxious participants, there were only significant differences between the math words and the neutral words, not the math words and the flying words. Despite the fact that math words tended to be less attentionally disruptive for the math anxious group (relative to how profoundly disruptive flying words were for the fear-of-flying group) both fear groups recalled more fear-relevant words than fear-irrelevant words. With respect to SCRs, individuals with a fear of flying showed larger SCRs in response to digit-parity stimuli when a fear-relevant or flying word was presented between the digits, compared to a fear-irrelevant word (math words or neutral words). This effect was not true for our math anxious participants. I discuss the implications of these findings below.

The finding that emotionally laden stimuli are capable of capturing attention and disrupting performance on a primary cognitive task more so than emotionally neutral stimuli is not new. Decades of empirical findings support prominent information processing theories that emotionally laden stimuli are particularly advantaged in their ability to capture and hold attention (e.g., Anderson, 2005; Aquino & Arnell, 2007; Siegrist, 1995). Following from the predictions of evolutionary threat theory, much of this research has investigated the emotional experience of fear or threat upon cognitive processing (e.g., Hansen & Hansen, 1988; Öhman & Soares, 1993). Somewhat ignored in these evolutionary theories is the fact that positive stimuli (e.g., those signalling potential mating opportunities or feeding) have an obvious importance for species survival, and potentially greater motivational relevance in unselected populations (Derryberry & Rothbart, 1997). In Experiment 1, the finding that sexual words when presented as to-be-ignored distractors significantly slowed responses to simultaneously presented flanking digits more than threat-relevant words is in line with several lines of research investigating the attention capturing effects of sexual stimuli (e.g., Anderson, 2005; Aquino & Arnell, 2007; Most et al., 2007; Schimmack, 2005). What appeared to account for these results was the arousal level of the sexual words. Participants' self-report ratings of valence and arousal identified the sexual words as the most arousing and the threat words as the most negative in valence. If negative valence were associated with attention-capturing qualities, then threat-relevant words should have produced the longest digit-parity response times in this task. This was clearly not the case. Only the presentation of the sexual distractor words led to a marked increase in digit-parity response times. Results suggest that the presentation of the sexual word captured participant's attention, resulting in slower digit-parity decision making times.

A more fine-grained analysis of the sexual words used in Experiment 1 revealed that there were potentially different subcategories comprising the sexual word category. One category of words was negative in valence (e.g., whore, incest) whereas another category was positive in valence (e.g., kissing, foreplay). Previous research has shown that when stimuli conferring threat (e.g., blood/injury) and those conferring more appetite motivations (e.g., sex) are included in study designs, both motivational categories induce response time slowing in a cognitive task relative to neutral stimuli (Buodo et al., 2002; Schimmack, 2005). That is, attention is drawn to both positive and negative stimuli if they are equally arousing. Recently, Most et al. (2007) showed that participants are worse at detecting a target image when it follows an erotic (e.g., erotic pictures of male-female couples) or aversive (e.g., pictures depicting gore and violence) picture. This was true even when participants were given a sizable monetary incentive to ignore the emotional distractors and when given specific details about the to-be-detected target image. Ultimately, in Experiment 1 although sexual words clearly had an impact on attention and memory, it was unknown how the different subgroups of words that comprised the sexual word category may have differentially influenced attention capture, skin conductance and memory.

In addition, the sex words presented between the digits in Experiment 1 may not only differ in valence, but also in their taboo quality. Words such as ‘whore’, ‘incest’, ‘sodomize’ are not only negative in valence and potentially highly arousal, but also taboo or socially unacceptable. Though previous research has pointed toward the potential role the taboo level of sexual stimuli may play on the attention capturing capability of these stimuli (e.g., Most, Smith, Cooter, Levy, & Zald, 2007) to my knowledge no study to date has systematically tested this prediction.

Results from Experiment 2 add to and extend previous research showing the attention capturing effect of sexual stimuli in important ways. First, as mentioned above, when positive and negative stimuli are equated on arousal level, both types of stimuli have been shown to capture attention. Sexually explicit stimuli (e.g., nude bodies, couples in erotic poses) are typically employed to represent the positively arousing word category. Contrasted to that, aversive (e.g., mutilated bodies or animals) or threatening (e.g., gun pointed at viewer) stimuli are typically employed to represent the negative arousing word category. However, sexual stimuli can also be of a positive and negative nature. Therefore, it seems reasonable to assume that attention to sexually positive and sexually negative stimuli may differ in important ways. If it is the negative valence of arousing stimuli that is crucial, then there might be minimal effects for positively valenced, yet arousing sex words. In Experiment 2, we addressed this issue by parsing the sexual word category into both sex-positive and sex-negative word categories.

One key finding from Experiment 2 was that digit-parity response times were significantly slowed when sex-negative words served as the distractors relative to all other word categories *including the sex-positive words*. Although this effect was noted only for the first block of trials, this latter fact does not diminish its importance – participants may have habituated to the distracting capability of the words with repeated exposure. Notably, my analysis of participants' self-report valence and arousal ratings found that the sex-negative words were rated as more arousing than the sex-positive words. Sex negative words (not surprisingly) were rated as significantly more negative than sex positive words. Such differences confirm our intuition that sexual words in Experiment 1 were composed of two different subcategories. Based on these subjective ratings it might, at first glance be tempting to interpret the preferential disruption of attention by the sex-negative words as being attributable to their combination of high arousal and negative valence. However, according to participants' self-report ratings, threat words were just as negative in valence and just as arousing as the sex-negative words. As such, if it were simply the combination of high arousal and negative valence that leads to attention capture and disruption of parity judgements, then threat words should have been equally disruptive in the digit-parity task. The fact that sex-negative words were preferentially disruptive in the digit parity task, yet were equivalent to the threat words in rated valence and arousal, lead us to look for another aspect of the sex-negative words that may have accounted for their attention-capturing capability.

Rising to the top of potential candidates for what made the sex-negative words so disruptive was the taboo nature of these words. Participants rated the sex-negative words as more taboo or socially unacceptable than any other word category, including threat words. Mediation analyses confirmed these results – the tendency to interpret the sex-negative words as socially unacceptable mediated the relationship between the sex-negative words and digit-parity response times. Taken together, Experiment 2 suggests that the taboo nature of sex-negative words may be even more important than their combination of negative valence and arousal, at least when it comes to their disruptive, attention-capturing affects.

Results from Experiment 2 not only point to the importance of assessing participants' interpretations of the emotional stimuli employed in study designs, but certainly when employing sexually explicit or erotica as stimuli, taboo ratings appear to be the critical factor in determining their attention capturing capabilities. Indeed, our results suggest that arousal value may not be the key factor when considering the attention-capturing effects of sexual stimuli. The idea that the sex-negative words are socially unacceptable in the current research better accounts for their attention-capturing effects. Highlighting this point, the existing literature contains a number of findings that remain unaccounted for by arousal theories alone. For example, Bertels, Kolinsky, and Morais (2010) examined the influence of the affective content of speech on the spatial orienting of auditory attention using an auditory version of a dot-probe paradigm. In this study, two words were simultaneously presented to the left and right ear of study participants, followed by an auditory beep presented either on the left or right side. Participants were instructed to press the right key of a button box as quickly and accurately as possible with their dominant hand upon hearing the beep. Word pairs consisted of taboo, negative, positive, and neutral words. Importantly, participants responded faster to auditory probes when they followed a taboo word relative to all other word categories, despite the fact that in this study the negative words were rated *higher* in arousal value than the taboo words. If interference effects were due to the arousal value of affective stimuli, participants should have responded faster to auditory probes when they followed a negative word relative to a taboo word. Though study authors included taboo words in their study design they did not use participants' ratings of these words to test the prediction that it is the taboo nature of the words that predicted auditory probe results. Bertels, Kolinsky, and Morais (2010) finding closely mirrors Schimmack's (2005) finding that pictures of snakes had a significantly weaker effect on attention than predicted by the arousal ratings of snake pictures. Here the key aspect of the study may have been their choice of comparison stimuli (same-sex bodies in swimwear/underwear, pictures of battered women, and drug addicts with syringes). It could be argued, that although pictures of snakes are arousing they are not taboo. The comparison stimuli by contrast, may have contained some images that the majority of participants would have considered taboo – a situation which would have detracted from the ability to show preferential attention-capture of the snake pictures. Again though, taboo ratings were not incorporated into the study design.

In a similar vein, when participants are asked to name the colour of a frame surrounding either an erotic, or non-erotic picture matched in both valance and arousal to the erotic pictures, colour naming times were significantly longer for the erotic pictures (Feng et al., 2012). Here one wonders whether the erotic pictures would have received higher taboo ratings than the non-erotic pictures, had taboo been assessed. Furthermore, though not intentionally designed to assess the impact of taboo ratings on attention, taboo words (e.g., dick, fuck, queer) rated high in shock value – assessed by having participants rate words on a scale from 1 (normal) to 5 (very taboo, shocking) – were detected faster than negative (e.g., murder, death, fear) or positive words (e.g., romance, smile, treasure), suggesting that even if arousal is a crucial dimension, taboo words seem to have a particularly “shocking” quality that may account for their robust interference effects (Bertels, Kolinsky, Morais, 2012).

The interference effects elicited by the sex-negative word group is consistent with previous results from studies employing taboo variants of the Stroop task, in which it has been repeatedly shown that unselected participants take longer to name the ink colour of taboo words compared to neutral words (Bertels, Kolinsky, Morais, 2012; MacKay et al., 2004; Siegrist, 1995). It is worth commenting on the limited “staying power” of this effect in both Experiment 2 and previous studies. That is, it has previously been shown that the size of the taboo Stroop effect diminished upon repeated exposure to taboo words (MacKay et al., 2004). Results from Experiments 2 completely align with such findings. Namely, differences in digit-parity response times were most pronounced when participants were initially exposed to the sex words (i.e., in block 1), with the effect diminishing upon repeated exposure.

Experiments' 1 and 2 demonstrate that emotional stimuli are more likely than neutral stimuli to attract attention. If emotional stimuli are capable of capturing attention, it stands to reason that emotion should similarly enhance memory. That is, if attention is directed toward emotional stimuli, then emotional stimuli should be more likely to be encoded into memory, and better recalled. Non-emotional stimuli by contrast, which do not capture and hold attention, should be less likely to be encoded and hence recalled. Indeed, previous research shows that if participants are shown emotional and neutral stimuli, they will later recall or recognize a greater proportion of the emotional stimuli relative to the neutral stimuli, whether the stimuli employed are pictures, words, or sentences (see Hamann, 2001, and Levine & Edelstein, 2009, for reviews). In addition, participants' memories are also more detailed for emotional than neutral stimuli (Kensinger & Corkin, 2003). When participants were asked to recall previously viewed pictures varying on dimensions of valence and arousal, both immediately and one year later, pictures rated high in arousal value were more likely to be recalled relative to pictures rated low in arousal value (Bradley et al., 1992). Results from experiment 1 replicate these findings – sexual words, rated highest in arousal value by study participants were recalled more often relative to threat words, school words, and neutral words.

However, when taboo words are included with other more traditionally defined emotional words (e.g., negative words), memory effects were even greater for the taboo words. This suggests that taboo words show a more exaggerated version of the "memory for emotion" effect (Kensinger & Corkin, 2003, experiment 4). In Experiment 2 when the sex words were parsed into negative and positive word categories, memory data exactly mirrored digit-parity response times – participants recalled more sex-negative words relative to all other word categories. Once again, the combination of valence and arousal cannot account for these data – threat words were equivalent in both valence and arousal to the sex-negative words, yet threat words were not recalled nearly as often as the sex-negative words. As such, the taboo value of the sex-negative words appears to have profound implications for memory above and beyond arousal. The superior recall of sex-negative words is consistent with previous research showing better recall for taboo words relative to neutral words (Jay, Caldwell-Harris, & King, 2008; Buchanan, Etzel, Adolphs, & Tranel, 2006; MacKay et al., 2004). Our results are in line with many prominent psychological theories that view appraisal as an important mediator of emotion (Lazarus, 1991). That is, the reason the sex-negative words capture attention and are therefore remembered in a subsequent memory task may be due to participants' appraisal of the words as socially unacceptable or taboo. Others have argued that the reason colour-naming times are slowed for negative information is because when confronted with negative or threatening stimuli humans are motivated by the need to avoid the disturbing affect associated with particular stimuli or memories (see Holmes, 1974, for a review). According to this view, colour-naming times are greatest for negative stimuli because cognitive effort is required to keep the undesirable content out of consciousness. This account runs counter to our findings concerning how memorable the sex-negative words were. Cognitively defending against the content of the sex-negative words would predict *poorer* not better memory for those stimuli relative to less noxious stimuli.

The finding that the threat words were recalled less often than the neutral words in Experiment 2 requires further comment, as at first glance this finding may indeed suggest cognitive defences at play. However, one must remember that the neutral category in Experiment 2 was composed of the names of musical instruments. We selected musical instrument names as our non-emotional word category for two reasons. First, the musical instrument names have a relatively low psycholinguistic frequency – akin to the frequency of threat words. Second, previous research has suggested that the attention capture of emotional words may not be solely attributable to the emotionality of the stimuli per se, because emotional stimuli form a word *category*, whereas random neutral words do not (McKenna & Sharma, 1994). Thus we sought to choose a reasonably tight-knit semantic category. The threat words in Experiment 2, though all unified by their threatening quality, form a relatively loose category compared to the sex-negative, sex-positive, and neutral musical-instrument words. Therefore, it may not be surprising that threat words were recalled less often than the neutral words. Others have noted similar results (Buchanan et al., 2006). For example, Jay, Caldwell-Harris, and King (2008) found that participants were more likely to recall animal words that formed a tight-knit category relative to emotional words (composed of both positive and negative words).

The attentional systems of anxious individuals may be uniquely sensitive to and biased to process stimuli in their environment that are consistent with their fears. Indeed, biases in processing fear-related information have been assigned a prominent role in the development and maintenance of anxiety disorders (Beck, 1976; Mathews and MacLeod, 2005). In Experiment 3 I showed that what a person finds highly arousing may depend entirely on the characteristics of the observer. When participants with characteristically unique anxieties (flying versus math) are shown stimuli which reflect their concerns, digit-parity response times are significantly slowed relative to neutral stimuli. Results suggest that participants' attention was momentarily captured by the presence of the fear-relevant word, interfering with their ability to quickly identify the parity of two flanking digits. These finding are in line with previous literature investigating the attention capturing effects of fear-relevant stimuli in anxious populations (for a review see Bar-Haim et al., 2007). Here I again acknowledge that while strong support for this contention comes from the analysis of the fear of flying group (where flying words were more disruptive than math or neutral words) relatively weaker effects were shown amongst our math anxious participants - math anxious participants only showed digit-parity interference effects for math words relative to neutral words not to flying words.

One possible explanation for the relatively weaker interference effects demonstrated within the math anxious group is that the participants were not sufficiently math anxious. That is, the math words were not emotionally provocative enough to produce effects resembling the effects seen within the fear of flying participants. This explanation in unlikely, however, because according to participants' subjective self-report anxiety levels, the math anxious participants reported being as anxious as the fear of flying participants. It is possible that flying-relevant words are naturally powerful attention capturers given the potential catastrophic consequences should one be in a plane crash. For sake of argument, one could pose that while plane crashes are typically lethal, failure to solve a math problem has far less dire consequences. If this were the case, one would expect that both groups of participants would rate the flying words as being more negative than the neutral (musical instrument) words. Although this was certainly true for the fear-of-flying group, there was no difference between the neutral words and the flying words for the math anxious group (the flying words were nominally rated as being more positive!). Thus one must look for a different account for the relatively weaker disruptive effects of math words among the math anxious compared to the flying words among the fear-of-flying group.

In accounting for these effects, one is struck by differences in the frequencies with which math concepts and flying concepts are activated in everyday life. Given that our participants are composed of mostly psychology students who are likely taking statistics as part of their psychology degrees, it is likely that our math anxious participants are exposed to math concepts on a more regular basis than our fear of flying individuals are exposed to flying-related stimuli. With repeated exposure, there is the possibility that math anxious participants adapt (i.e., habituate) to such stimuli. By contrast, those with a fear of flying would seldom encounter airport related concepts in their day-to-day lives. Thus when faced with words such as “run-way” or “turbulence”, they react more than the math anxious when they are faced with words such as integer and exponent.

The finding that flying words disrupted digit-parity performance in participants with a fear of flying raises an interesting question: What accounts for this effect? According to participant self-report valence and arousal ratings, despite the fact that the math words were rated as negative as the flying words, only the flying words produced longer digit-parity response times. In line with various theories of emotion emphasizing the importance of arousal, the flying words were rated as more arousing that the math words for our fear of flying participants, suggesting that the arousal level of the flying words accounted for their attention capturing effects. The lack of a three way interaction involving word, block, and fear suggests that flying words showed their disruptive effects across four blocks of trials – making them more resistant to the habituation effects shown in Experiment 1 and 2. It is also interesting to look at the kind of flying-relevant words that captured fear-of-flying participants' attention. The majority of flying words used in Experiment 3 were closely related to what can be described as problem-free flying. Other than the word "turbulence", in general the flying words did not reflect threat-relevant words such as *crash, death,* or *panic*. In fact, the words were mild with regard to their threatening nature. Results suggest an important determinant of the attention capturing effects and corresponding larger SCRs was the *appraisal* of the words for our fear of flying participants. That is, these seemingly benign flying words (e.g., airport, boarding, wing) were deemed threatening, as evidence by participant arousal ratings, by our fear of flying participants. Indeed, the flying words were rated low in arousal value (2.23; with 1 representing low arousal and 9 representing high arousal) by our math anxious participants. Such a finding supports our assertion that arousal is in the eye of the beholder – what may be arousing for one person may not be arousing for another.

Not only do participants' show interference effects for stimuli that are consistent with their fears on a behavioural level, but they also show similar effects on a physiological level. That is, participants show strong physiological reactions, as evidenced by SCRs, only to stimuli consistent with their fears. As predicted, when a flying-relevant word was presented between the digits, participants with a fear of flying elicit larger SCRs relative to flying-irrelevant words. Thus, within the fear of flying participants, on both a behavioural and physiological level, our results seem to support coherence theories of emotions which predict coordinated emotion-specific changes in different emotion response domains. Though we show evidence of coherence amongst participants' subjective reports of emotion (e.g., word ratings), behavioural indices (e.g., digit-parity results), and physiological markers (e.g., SCRs), it is more difficult to disentangle what this coherence reflects. Previous research has shown that physiological markers such as SCR not only reflect subjective reports of fear, but also reflect processes such as attention (Öhman & Soares, 1994; Öhman & Weins, 2003), interest, and general emotional arousal (Lang, Bradley, & Cuthbert, 1997). Thus, the SCRs elicited for our fear of flying participants when confronted with a flying word seem to reflect the attention grabbing capability of the word as well as the simultaneously produced fear elicited by the words.

Interestingly, for our math anxious group, SCR results seem to reflect more of a general emotional arousal produced by having to determine whether the two flanking digits matched or mismatched with respect to their parity, irrespective of the nature of the word presented between the digits. That is, one could argue that the task of having to determine whether the parity of two digits matched or mismatched seemed to overload, on a physiological level, our math anxious participants. This explanation may also account for why the math words did not produce longer digit-parity response times relative to the flying words. Though the digit-parity task is intended to be a relatively simple cognitive task, making even simple parity discrimination decisions could have overwhelmed our math anxious participants, washing out any attention capturing effects of the math words. However, it was not the case that the math anxious participants had significantly larger SCRs relative to the fear of flying participants for all word categories. That is, if the role played by having to determine the parity of two flanking digits was physiologically overwhelming for the math anxious participants, I would have expected a main effect of fear group (which was non-significant). Of course, it is possible that making parity decisions had more subtle effects in eliminating the differences between conditions. Even when exposed to fear-irrelevant words, the math anxious group were still exposed to potentially fear-relevant stimuli – the digits flanking the words, rendering the contrast between the conditions less pronounced. In order to reduce the potential influence of having math anxious participants make decision that require mathematical comparisons, future studies could modify the digit-parity task so that stimuli other than digits were flanking the word stimuli.

Despite the fact that most psychological theories of anxiety disorders predict that anxious individuals will show enhanced memory for anxiety-relevant information (Beck et al., 1985; Bower, 1987), when different anxiety disorders are considered, the evidence is mixed (Coles & Heimberg, 2002; Williams, Watts, MacLeod, & Mathews, 1997). In addition when reviews are conducted examining the empirical support for memory biases in anxiety disorders, due to the limited research that has focused on individuals with specific phobias, this class of anxiety disorders is often not included (Coles & Heimberg, 2002). Thus, memory results from Experiment 3 add to the existing literature by showing the presence of memory biases in anxiety disorders in a rarely studied population – those with *specific* fears. Our results demonstrate that participants with a fear of flying as well as those who are math anxious recall more words that are consistent with their fears relative to words that are unrelated to their fears. The crossing over of these effects with fear-group (math anxious show better recall of math words than flying words, whereas flying anxious show better recall of flying words than math words) rules out the fact that recall differences were impacted by psycholinguistic differences between categories such as word frequency, concreteness etc. Rather, they imply that participants better remember items related to their specific fears. Similar results have been shown for participants with blood injection phobias (Sawchuk et al., 1999). Additionally, though participants with specific phobias are seldom included in study designs, a close kin to individuals with specific phobias may be participants with panic disorder. Panic disorder is characterized by recurrent and unexpected periods of intense fear and is often accompanied by a phobic-like avoidance of situations which may evoke panic. In this patient population, support for a memory bias has been relatively strong (Cole & Heimberg, 2002).

Though the amount of support for memory biases towards fear-relevant information varies greatly by disorder, a review of the relevant literature emphasizes the importance of using materials that are specifically relevant to the disorder under investigation. Thus, it may not be surprising that memory biases for participants with Generalized Anxiety Disorder (GAD) remain the most elusive. GAD individuals tend to worry about a rather wide and diverse selection of stimuli, and therefore, it is difficult to find words that are relevant to each patient's potentially idiosyncratic concerns. In addition, it is difficult to find words that are specific to only their concerns. Indeed, in a study in which GAD participants were included with individuals diagnosed with Social Anxiety Disorder (SAD), the words employed to be GAD-specific were rated as equally relevant to the SAD participants! This overlap could potentially account for why the two groups did not differ in terms of memory effects (Becker et al., 1999). When the same investigators included participants diagnosed with Panic Disorder (PD) and used stimuli that were rated as relevant to only those with PD, memory biases emerged (see experiment 2). Using participants with specific fears, as in the case of experiment 3, allowed the construction of appropriate and specific word lists for each fear-group under study. When the same lists are used as both the fear-inducers in one group, and the fear-irrelevant words in the other group, and cross-over effects are found (group by word list interactions as in Experiment 3) one can be confident that it is the person specific fear-inducing properties of the words that drives memory performance rather than other unrelated word properties.

Reviewing the literature, it would seem that, the type of memory encoding task employed appears to have an effect on whether memory biases are found. For example, several studies have found that incidental learning tasks and free recall tests optimize the chance of finding anxiety-congruent effects (e.g., Friedman, Thayer, Borkovec, 2000). Participants in our study were not explicitly instructed to remember the words used in the digit-parity task; in fact, they were explicitly told to ignore the words presented between the digits. Our results show that despite the instruction to ignore the words, when a word consistent with participants' specific fears was presented between the digits, digit-parity performance not only suffered, but participants were more likely to recall fear-relevant words than fear-irrelevant words after the completion of the parity task.

Memory results from Experiment 3 cannot be explained by the fact that the fear-relevant words formed a more cohesive category than fear-irrelevant words. As mentioned, previous research has shown that words that form a coherent category are more easily learned and remembered that words that do not form a coherent category (Klein & Kihlstrom, 1986). Given the fact that anxiety words may be more easily categorized by anxiety patients, Mogg, Kentish, and Bradley (1993) suggested that memory biases for threat-relevant words might be due to better categorization of these words rather than the matching of these words to participants concerns. However, this hypothesis does not explain our results. Participants in Experiment 3 consisted of individuals with a fear of flying and those who were math anxious.

Words employed consisted of flying-relevant words, math-relevant words, and neutral words that were specially selected to form a tight-knit, cohesive semantic category, namely musical instruments. Therefore, not only do the words chosen to be relevant to a participant's particular fear form a cohesive category, but each of the fear-irrelevant word groups also form cohesive categories. If ease of categorization was responsible for memory bias for threat-relevant words in anxious populations, math words, musical instrument words and flying words should have been recalled equally often by all participants. Of course this was not the case; memory biases were found only for words that related to the tested individual's specific fears (flying words for the fear-of-flying group, math words for the math-anxious group).

Although the results of our experiment fit well with an albeit small literature investigating memory biases for specific phobias, at first glance they are potentially hard to explain on the basis of popular vigilance-avoidance models of anxiety disorders (Williams, 1988; Foa & Kozak, 1986). Incorporating the robust finding of attentional biases for threat-relevant material in anxious patient populations with the relatively mixed memory bias within the same populations suggests that anxious individuals are characterized by a pattern of initial vigilance to threat followed by avoidance of further elaboration of this material, making threatening information potentially more accessible for perception but less retrievable in memory (Coles & Heimberg, 2002). The predicted vigilance-avoidance pattern of processing in anxiety (e.g., Foa & Kozak, 1986), is consistent with Mathews and colleagues (1989), who showed that clinically anxious participants did not recall more threatening words than neutral words relative to control participants. Vigilance avoidance theories are also consistent with the work of Mogg, Mathews, and Weinman (1989), who found poorer memory for threatening than non-threatening material despite evidence for greater attentional bias towards threat compared to non-threat in anxious individuals. However, in the current experiment, we found evidence for attention-capture of fear-relevant stimuli, as evidenced by longer digit-parity response times for fear-relevant words, followed by *better* memory for such material. In an attempt to account for the seemingly discrepant results, methodological differences in study design must be examined. In our design, participants were not told to remember any words, rather they were specifically instructed to ignore the words presented between the digits. One could even argue that the cognitive load associated with making the digit-parity decision could have created the conditions necessary to produce memory results. In other words, it is likely that participants in our study did not have time to employ avoidant coping strategies typically characteristic of anxious individuals. Indeed, when participants are prevented from using avoidant coping techniques and asked to elaborate on or image scenes involving themselves and the relevant word stimuli, memory biases occur (Nunn, Stevenson, & Whalan, 1984).

Conclusions

This dissertation presents evidence that highly arousing stimuli are capable of producing interference effects in a primary cognitive task and that what a person finds highly arousing may depend crucially on the characteristics of the observer. Importantly, there is also evidence to suggest that sexual stimuli may represent a particularly robust class of stimuli capable of capturing attention in unselected participants. Our fine-grained analysis of this class of words suggests that attention capture is likely linked to the socially unacceptable or taboo nature of such stimuli. Although we add to the literature by showing that the taboo aspects of certain sexual words accounts for attention capture even better than arousal, in general, highly arousing stimuli (such as flying words to one with a fear of flying) will capture attention and derail performance on a simple digit-parity task, but also that these stimuli are also more often recalled on a surprise memory task. Finally, years of previous research highlight the importance of determining the extent to which response systems (e.g., physiological, behavioural, experiential) come together. In the present dissertation, we found support for the association between participant's self-report ratings of arousal (experiential), SCRs (physiological), and digit-parity response times and recall (behavioural).

Given that we live in an information-rich world where we are constantly being bombarded with diverse stimuli, it is important to understand the factors that determine what stimuli afford priority processing. As pointed out by Robinson (1989), knowing the valence of a situation – whether something is good or bad – may not provide individuals with enough information to spring into action. Instead, an additional appraisal that is closely linked with arousal may be of paramount importance.

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Appendix A: Word stimuli for Experiment 1

Sexual list	**Threat list**	**School list**	**Neutral list**
BLOWJOB	AFRIAD	ARTICLE	ANCHOR
BREAST	ANGRY	BINDER	AUTUMN
CLIMAX	BEATEN	BOOK	BRANCH
CLITORIS	BURNED	BRAINY	BREAD
COCK	DANGER	CLASS	CALL
CONDOM	DEATH	COFFEE	CORE
DILDO	DOOM	COMPUTER	CURVE
EROTIC	ENEMY	DESK	EXCEED
FOREPLAY	EVIL	ERASER	FIELD
FUCK	FATAL	FACT	FOOT
INCEST	FEAR	LECTURED	GATE
KISSING	GRIEF	LETTER	LAYER
LESBIAN	HARSH	LIBRARY	LEAGUE
NIPPLE	HORROR	LUNCH	LEVER
ORGASM	HURT	NOTE	LINK
ORGY	KILL	PAPER	PARK
PENIS	MISERY	PENCIL	PATROL
PUSSY	MURDER	PUPIL	PLATE
RAPE	PAIN	READ	POTATO
SCROTUM	SCREAM	REPORT	SEND
SLUT	SORROW	SCHOOL	SENIOR
TESTICLE	SUFFER	SPEAKER	SOLAR
VAGINA	TENSE	STAPLE	THUMB
VIRGIN	WEEP	STUDYING	WAGON
WHORE	WORRY	TEACHER	WILLOW

Appendix B: Schematic depiction of digit-parity task.

Appendix C: Affective Rating Scales for Experiment 1

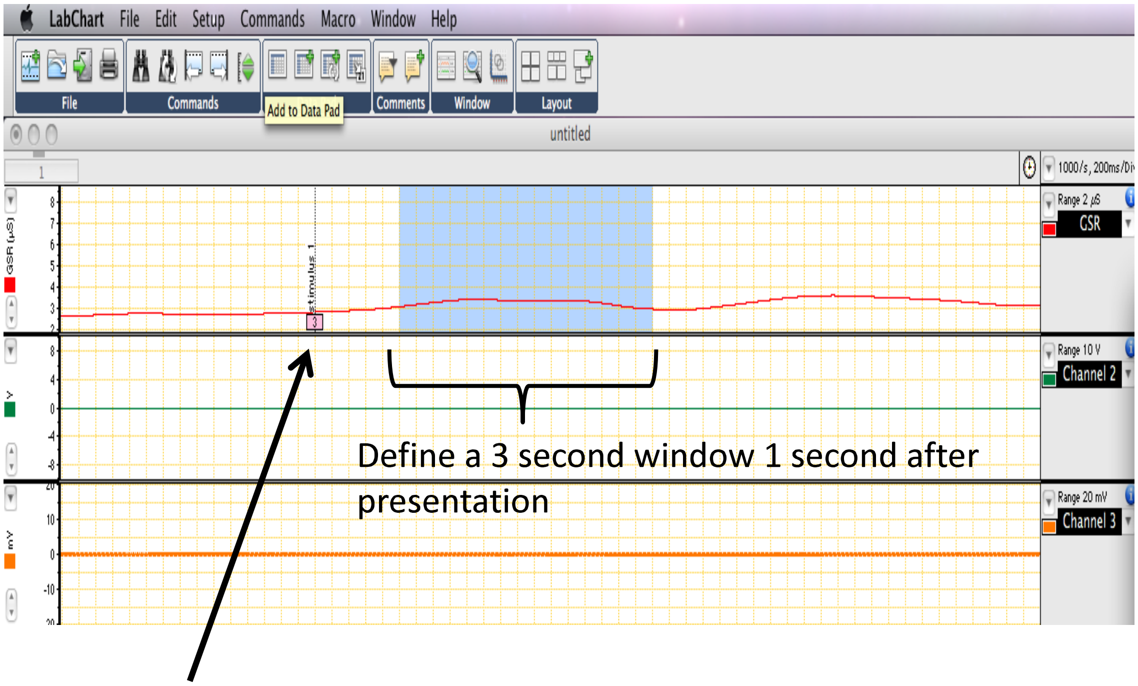
Valence

1	2	3	4	5	6	7
negative			neutral			positive

Arousal

1	2	3	4	5	6	7
low			neutral			high

Appendix D: Schematic depiction of SCR data collection



Time-locked presentation of digit-parity stimuli

Appendix E: Demographics Questionnaire

Age: _______________

Gender:_____________

1. (handedness) With which hand do you write? Please circle one.
    a. Right hand
    b. Left hand
    c. Both hands (ambidextrous)
2. Do you have a skin allergy to rubbing alcohol?
    a. Yes
    b. NO
3. Is English your most fluent language? Please circle one.
    a. Does not apply to me, English is my FIRST or ONLY language
    b. Yes
    c. No
4. Can you speak English fluently? Please circle one.
    a. Does not apply to me, English is my FIRST or ONLY language
    b. Yes
    c. No
5. Can you read and write English fluently? Please circle one.
    a. Does not apply to me, English is my FIRST or ONLY language
    b. Yes
    c. No
6. Do you have any neurological conditions, psychological disorders or brain lesion? Please circle one.
    a. Yes
    b. No
7. Are you taking antidepressant or antipsychotic drugs? Please circle one.
    a. Yes
    b. No
8. Have you ever been diagnosed with clinical depression? Please circle one.
    a. Yes

b. No

9. Have you ever been diagnosed with clinical anxiety? Please circle one.
    a. Yes
    b. No

10. Are you currently being treated for anxiety (i.e., taking medication or undergoing therapy)? Please circle one.
    a. Yes
    b. No

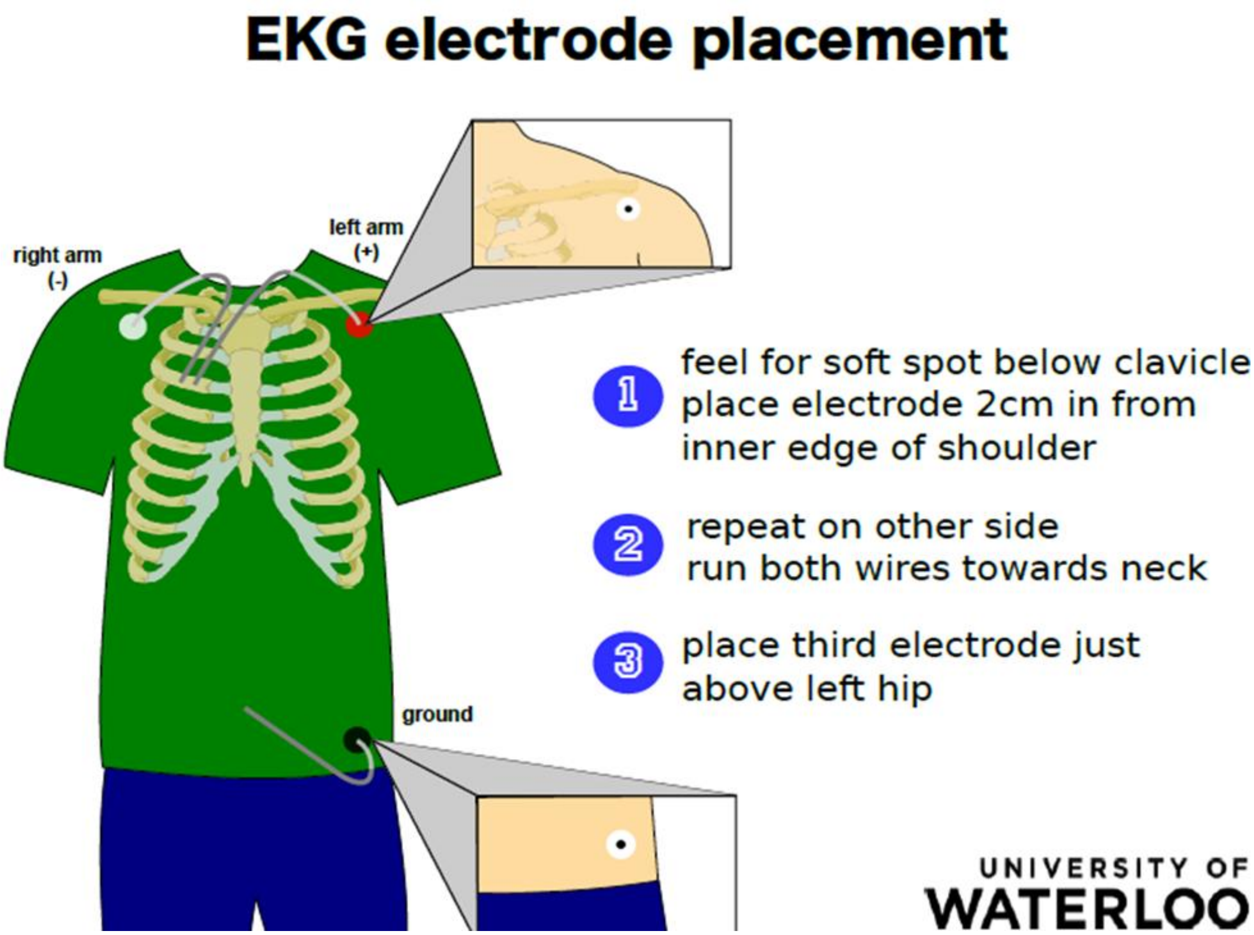
11. Do you have a heart condition and/or are you currently taking any medication that could interfere with the recording of your heart rate? Please circle one.
    a. Yes
    b. No

12. What is your ethnic background? Please circle one.
    a. Chinese (including Hong Kong Chinese & Taiwanese)
    b. Korean
    c. Other Asian groups (including Filipino)
    d. Black/African
    e. Aboriginal/Native
    f. Middle Eastern
    g. East Indian
    h. White/Caucasian
    i. Other: _____________________

Appendix F: Word stimuli for Experiment 2

Sex-negative	Sex-positive	Neutral list	Threat list
COCK	CARESS	BANJO	ANGRY
CUNT	CLIMAX	BONGOS	ASSAULT
FUCKED	FLIRT	COWBELL	DESTROY
HERPES	FOREPLAY	DRUM	FEAR
HOOKER	HUGS	GUITAR	HORROR
INCEST	KISSING	MANDOLIN	KILL
OBSCENE	LOVE	PICCOLO	MURDERED
PUSSY	MASSAGE	TRUMPET	SUFFER
SODOMIZE	ORGASM	TUBA	TORTURE
WHORE	SNUGGLE	VIOLIN	TRAUMA

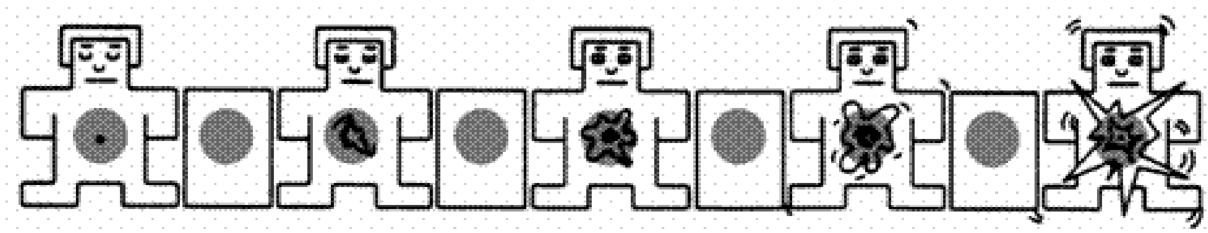
Appendix G: Heart rate electrode placement schematic



Appendix H: Affective Rating Scales for Experiment 2

In this study we are interested in how people perceive words. You will be given a list of words—your task is to rate each word according to the scales that are presented on this page. Please be as honest as possible in your judgments; they are very important to us! Work at a rapid pace and don't spend too much time on each word. Make your ratings based on your first reaction to the word. **Please note, that when considering the sex words we are *not* asking you to rate how "turned on" or sexually aroused you are by the words.**

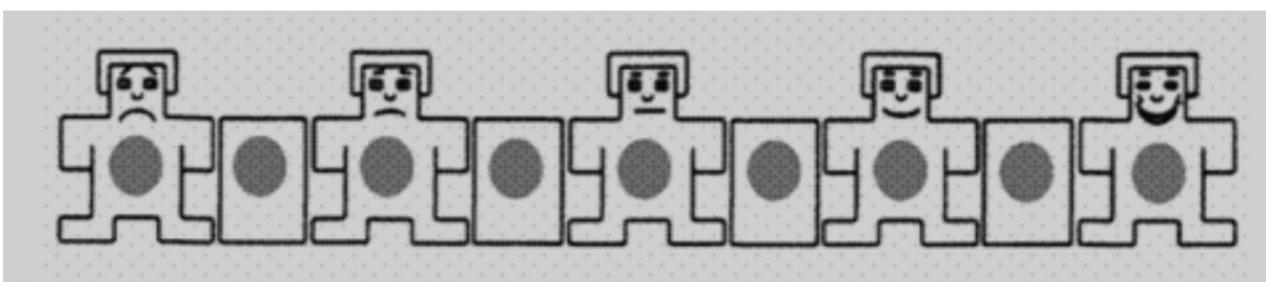
Please rate your emotional reaction to the word.



1 2 3 4 5 6 7 8 9

Calm (low) Excited (high)

Please rate how positive or negative the word is



1 2 3 4 5 6 7 8 9

Negative Neither positive or negative Positive

Please rate how taboo or socially unacceptable the word is

1 2 3 4 5 6 7 8 9

Not at all taboo very taboo

Appendix I: Word stimuli for Experiment 3

Math	**Flying**	**Neutral**
ALGEBRA	AIRPORT	TIMPAMI
ARITHMETIC	TURBULENCE	ACCORDION
EQUATION	PROPELLER	EUPHONIUM
FRACTIONS	AIRPLANE	XYLOPHONE
GEOMETRY	DEPARTURE	RECORDER
INTEGER	FLYING	TRUMPET
MATH	WING	TUBA
DIVISION	BOARDING	KEYBOARD
EXPONENT	TAKEOFF	TROMBONE
CALCULUS	COCKPIT	CLARINET

Figure 1. Mean digit-parity response times for each word category as a function of block. Error bars represent 95% confidence intervals for each mean (Experiment 1).

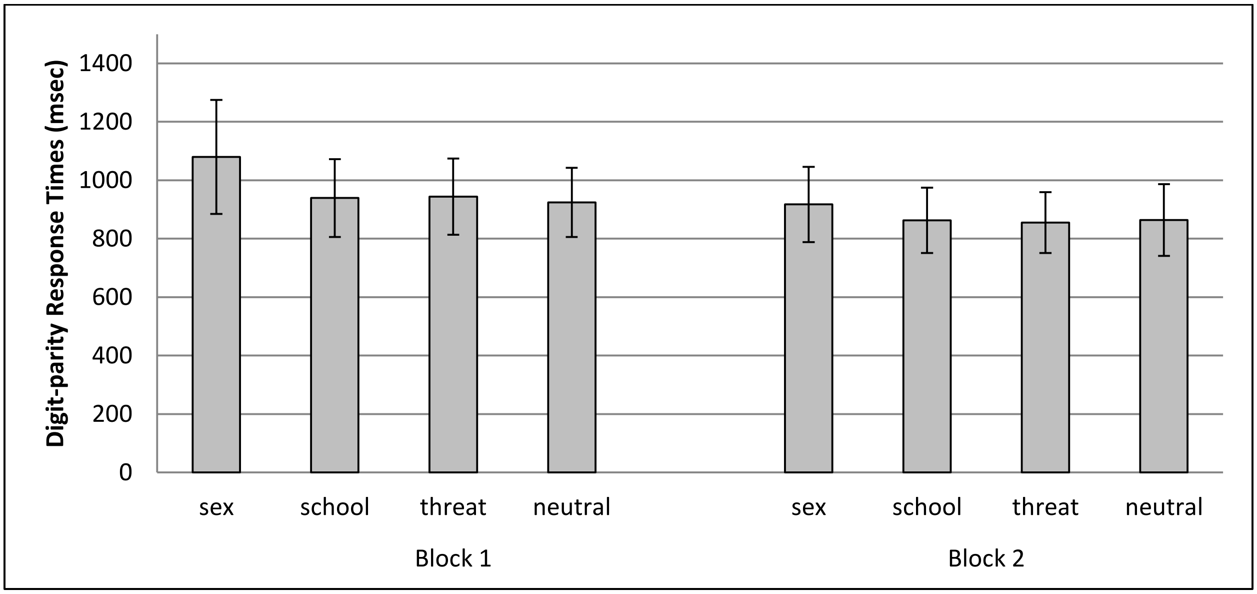


Figure 2. Mean skin conductance response amplitudes for each word category as a function of block. Error bars represent 95% confidence intervals for each mean (Experiment 1).

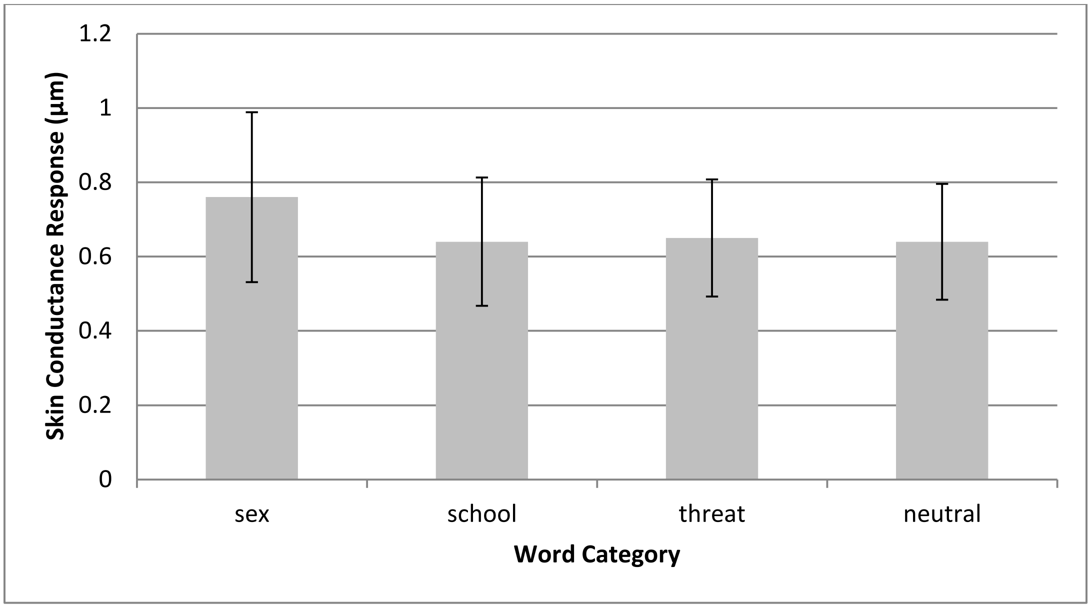


Figure 3. Mediation Models (Experiment 2).

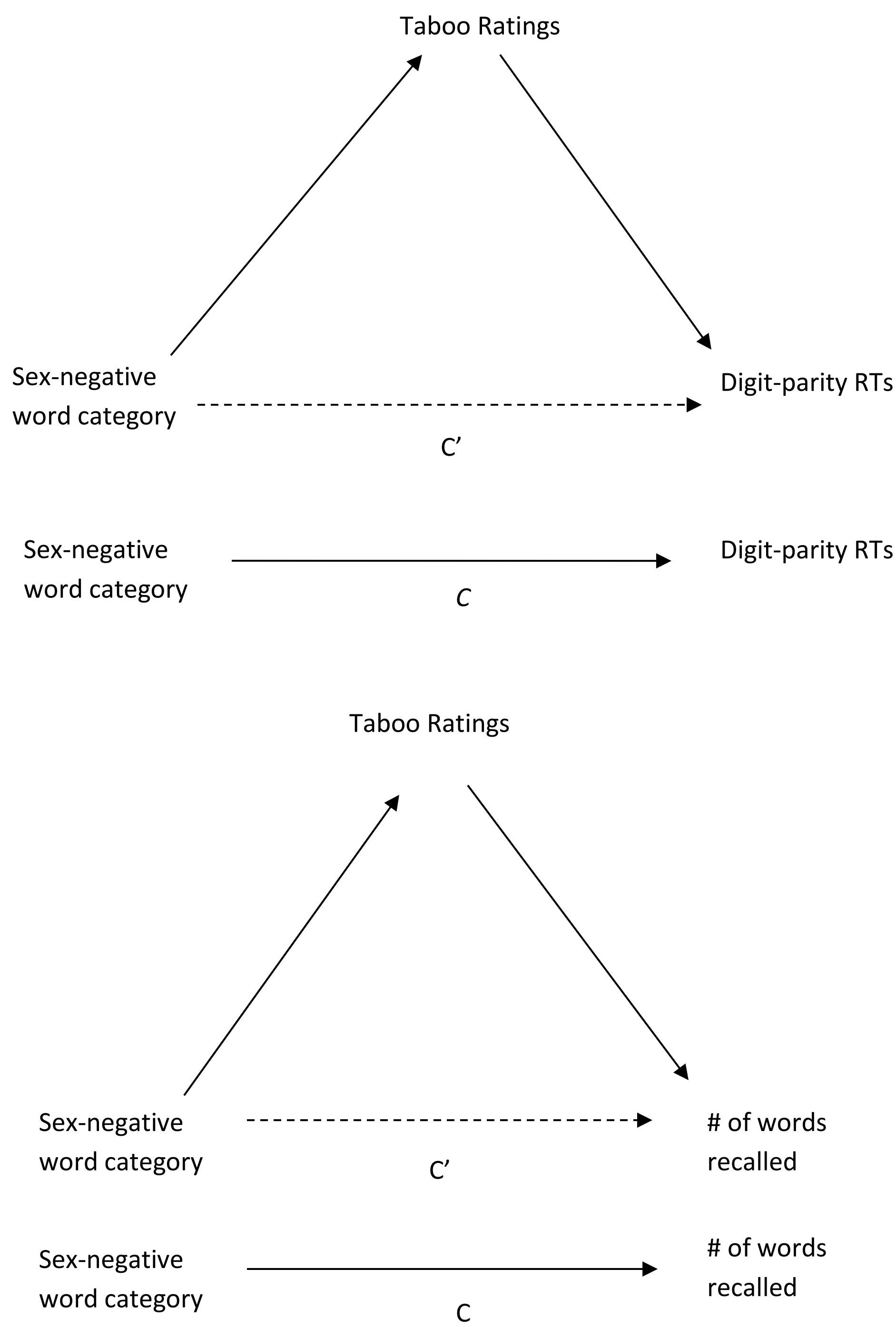


Figure 4. Mean digit-parity response times in Block 1 for each word category. Error bars represent 95% confidence intervals for each mean (Experiment 2).

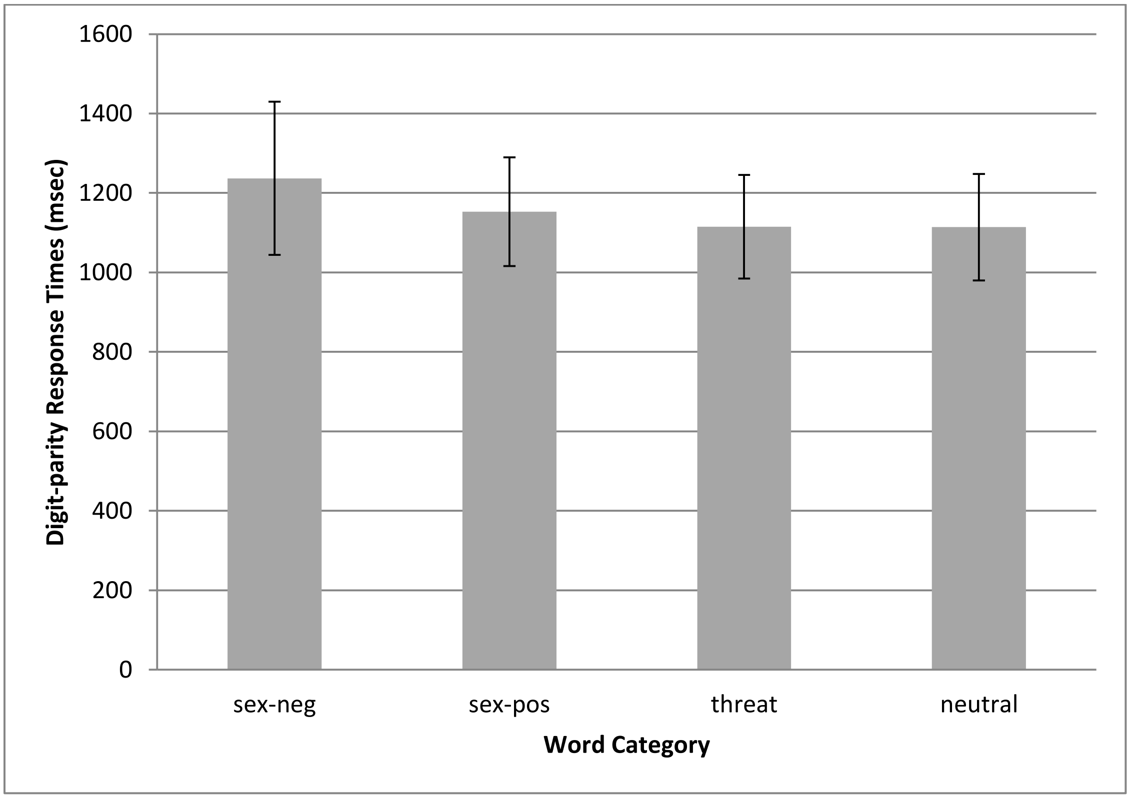


Figure 5. Mean skin conductance response amplitudes for each word category as a function of block. Error bars represent 95% confidence intervals for each mean (Experiment 2).

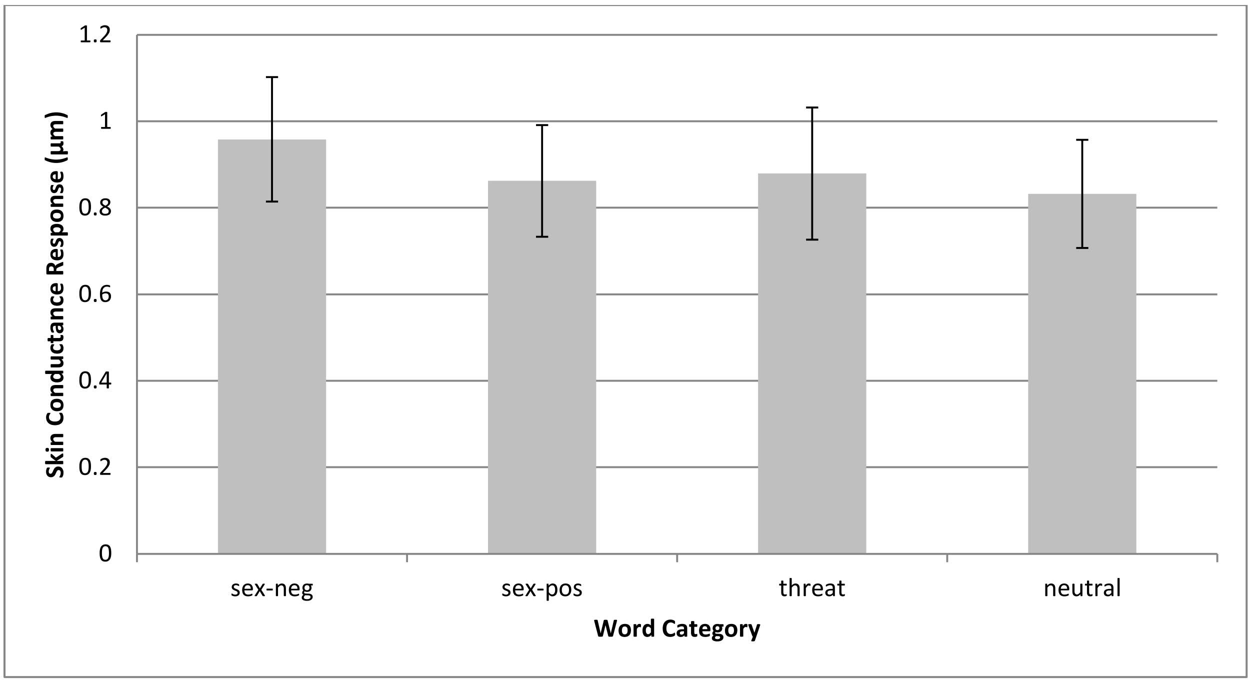


Figure 6. Mean inter-beat interval durations across word categories (Experiment 2b).

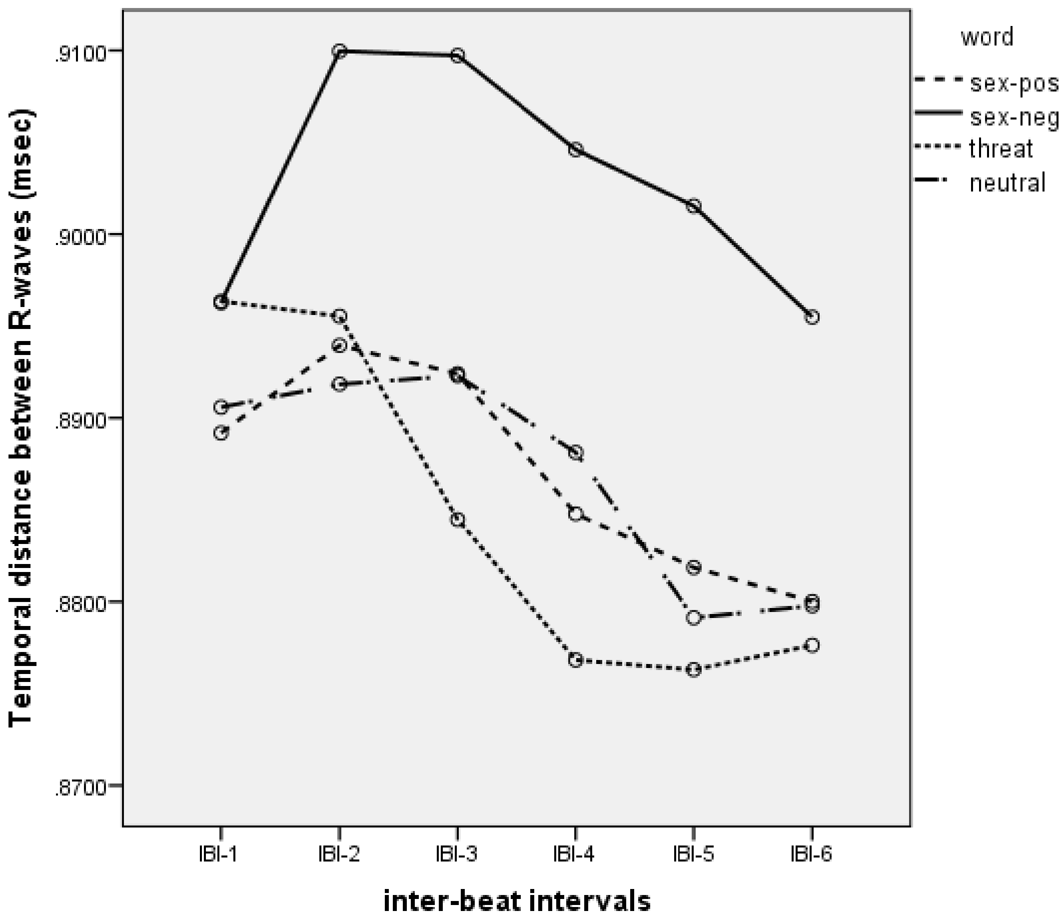


Figure 7. Mean inter-beat interval durations for the sex-negative word category for each participant (Experiment 2b).

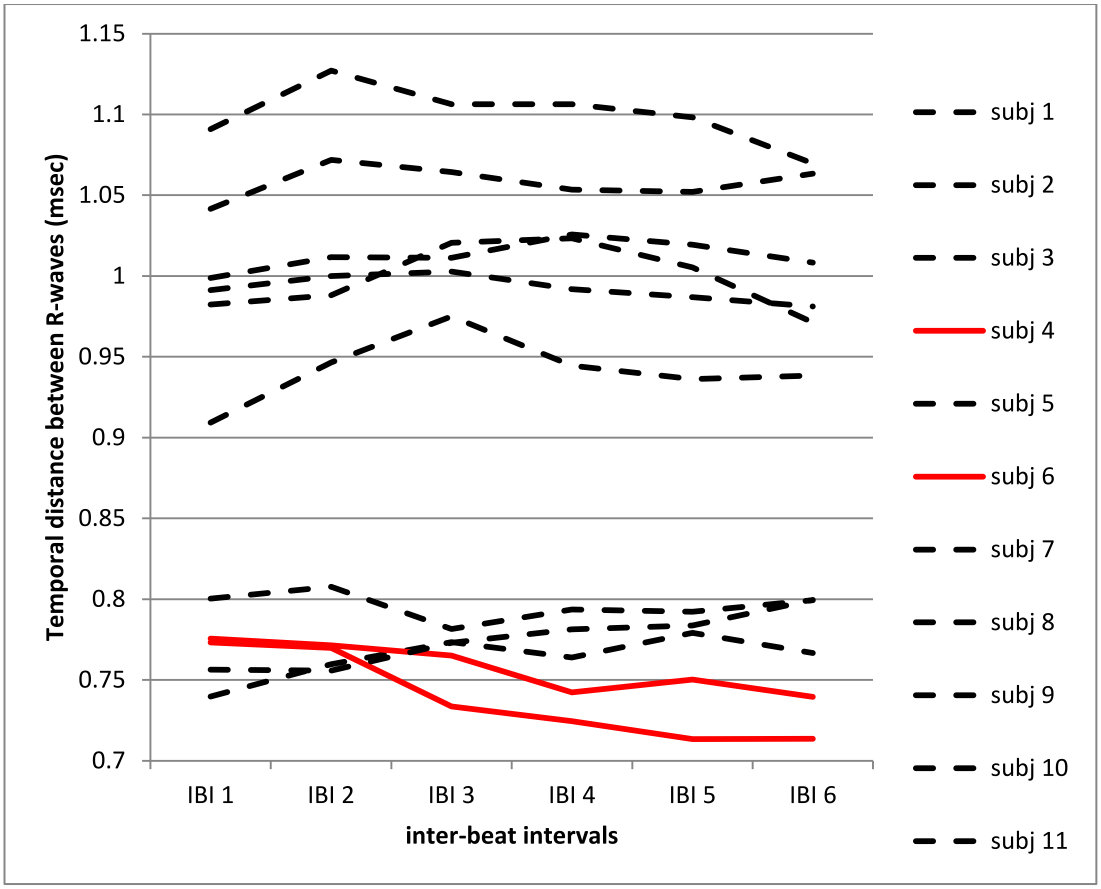


Figure 8. Mean digit-parity RTs for each word category as a function of identified fear group. Error bars represent 95% intervals for each mean collapsed across blocks (Experiment 3).

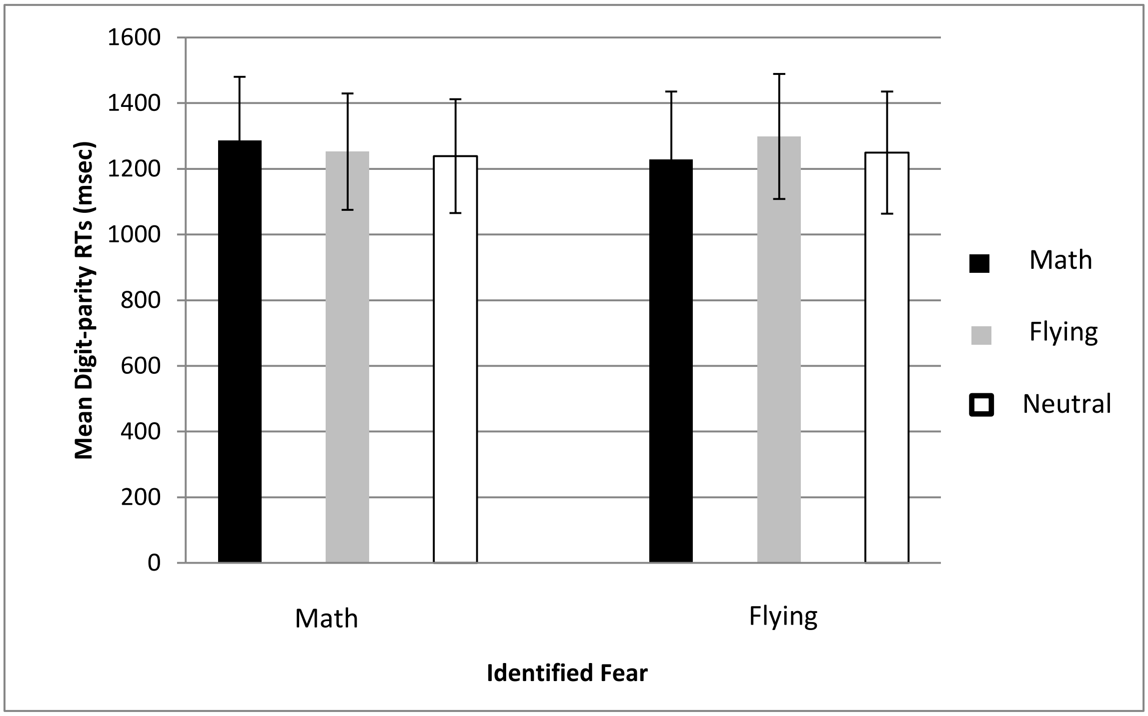


Table 1.

% errors made as a function of word category and block for Experiment 1 (standard deviations are in parentheses).

Word Category	% errors	
	Block 1	Block 2
Sex	1.4 (1.5)	1.2 (1.3)
School	0.9 (1.9)	1.1 (1.6)
Threat	1.3 (2.1)	0.7 (1.2)
Neutral	1.2 (1.8)	0.7 (1.1)

Table 2.

Mean number of words recalled as a function of word category for Experiment 1 (standard deviations are in parentheses).

Word Category	Number of words recalled
Sex	7.9 (0.6)
Threat	1.5 (0.4)
School	3.0 (0.4)
Neutral	0.9 (0.2)

Table 3.

Mean scores obtained on the DASS-21 for Experiment 2 (standard deviations are in parentheses).

	n =31
DASS_D	6.97 (6.4)
DASS_A	4.71 (4.9)
DASS_S	9.81 (6.6)

Table 4.

% errors made as a function of word category and block for Experiment 2 (standard deviations are in parentheses).

Word Category	% errors		
	Block 1	Block 2	Block 3
Sex-negative	4.8 (7.2)	3.9 (6.1)	2.9 (6.4)
Sex-positive	4.5 (8.9)	4.8 (7.2)	2.9 (5.3)
Threat	3.2 (7.0)	3.6 (7.1)	2.3 (5.0)
Neutral	3.9 (6.1)	4.2 (8.5)	2.9 (6.4)

Table 5.

Mean number of words recalled as a function of word category for Experiment 2 (standard deviations are in parentheses).

Word Category	Number of words recalled
Sex-negative	4.3 (0.3)
Sex-positive	2.3 (0.3)
Threat	1.7 (0.3)
Neutral	2.6 (0.3)

Table 6.

Pearson correlations among dependant variables for Experiment 2.

	ARO	VAL	RTs	MEM	SCRs
ARO	-				
VAL	-.448**	-			
RTs	.260	-.195	-		
MEM	-.009	-.066	.254	-	
SCRs	.514**	-.168	.294	.292	-
TAB	.731**	-.762**	.438**	.383*	.450**

Note. ARO = standardized arousal rating; VAL = standardized valence rating; RT = mean digit-parity RT for block 1, SCR = mean SCR amplitudes collapsed across blocks; Memory = mean number of words recalled; TAB = standardized taboo rating.

Table 7.

Demographic and clinical characteristics of the two participant groups (Experiment 3).

	Group			
Variable	FOF	MAG	*t*	*p*
N	13	15		
Age	20.8 (3.3)	19.7 (1.8)	3.35	0.08
FOFI	146 (30.4)	27 (18.6)	12.41	<0.001
AMAS	20 (5.6)	34.0 (4.4)	7.56	<0.001
DASS_S	12.9 (5.6)	14.4 (9.1)	< 1.0	0.62
DASS_A	9.2 (6.4)	6.3 (6.8)	1.18	0.25
DASS_D	8.6 (9.3)	9.1 (6.0)	< 1.0	0.88

Table 8.

Mean number of words recalled by participant group (standard deviations are in parentheses) (Experiment 3).

	Group	
Word Category	FOF	MAG
Flying	4.08 (2.5)	2.13 (1.5)
Math	2.31 (0.8)	3.40 (1.7)
Neutral	1.61 (1.8)	2.47 (1.7)