Blinded by Emotion: Target Misses Follow Attention Capture by Arousing Distractors in RSVP

Karen M. Arnell
Kassandra V. Killman
&
David Fijavz
Brock University

Participants are usually able to search rapid serial visual presentation (RSVP) streams and report a single target, given that RSVP distractors do not typically deplete attention required for target identification. Here, participants performed single target search, but the target was preceded by a to-be-ignored distractor varying in valence and arousal. When the critical distractor was a sexual word, lower target accuracy was observed, particularly at short distractor-target SOAs, even when participants were shown the critical distractors beforehand and told to ignore them. No reduction in target accuracy was evidenced when the critical distractor was negative, positive, threatening or emotionally neutral. Target accuracy was predicted by participants' arousal ratings to the critical distractor words, and by their memory for them, but not by their valence ratings. Memory for critical distractors mediated the relationship between arousal and target accuracy. The results provide evidence that arousing sexual words involuntarily capture attention and enter awareness at the expense of goal-driven targets, at least in the context of laboratory experiments performed by young university participants for whom sexual material might have high impact and relevance.

In rapid serial visual presentation (RSVP) items are presented one-at-a-time in the same spatial location at a high rate of speed (often 10 per second). When participants search RSVP streams for two targets, report accuracy for the first target (T1) is typically high, while accuracy for the second target (T2) suffers if it is presented less than 500 ms after the first target (an attentional blink or AB, Raymond, Shapiro, & Arnell, 1992). In contrast, when participants search RSVP streams for a single target, report is uniformly high, given that RSVP distractors do not typically deplete the attentional resources needed to perform the target task (Raymond et al., 1992). However, recently researchers have demonstrated that a to-be-ignored RSVP distractor can act as a T1 and set off an attentional blink (AB) provided that it matches the target search template sufficiently or is visually novel. For example, Barnard, Scott, Taylor, May, and Knightley (2004) showed that distractor words that were conceptually similar to the target search category (e.g., presenting "volunteer" as a distractor when the target search category is "a paid occupation") initiated an AB for subsequent target words. Folk, Leber and Egeth (2002) showed that a peripherally presented color singleton set-off an AB for a centrally presented RSVP target defined by the same color. Marios, Todd, and Gilbert (2003) showed that an RSVP distractor that was visually novel compared to the other stream items impaired target accuracy, but only for the first three or four trials on which the novel distractor was presented. The AB is typically explained in terms of T1

consuming attentional processing resources for a period of about 500 ms, so that a T2 presented during this interval does not receive sufficient attention to be consolidated in working memory prior to the decay or overwriting of its perceptual representation (e.g., Chun & Potter, 1995, Jolicoeur, 1998, 1999; Shapiro, Arnell, & Raymond, 1997). Results such as those of Barnard et al. (2004) and Marios et al. (2003) suggest that under some conditions attentional resources can also be captured by distractors (which act as a sort of involuntary T1), and this attentional capture has the same effect of limiting attentional resources for the subsequent target— in effect setting of an involuntary AB (involuntary in the sense that T1 processing was not task driven).

Emotionally salient material

The role of attention is to sift through the myriad of stimuli we are exposed to at any one time, selecting the most important stimuli for further processing and awareness. Many researchers have argued that emotion-related preattentive processing can influence the importance rating a stimulus receives and therefore has the power to guide attentional selection such that stimuli with greater emotional significance receive more limited-capacity processing (e.g., Compton, 2003; Lang, Bradley, & Cuthbert, 1997, Robinson, 1998). If this is the case, then one might expect that emotional words presented as distractors in RSVP streams would receive preferential attentional processing, possibly at the expense of accuracy for subsequent targets. In the present study we examine whether emotional word distractors varying in valence and arousal will capture attention involuntarily in RSVP.

There is reason to expect that emotionally salient words might capture attention at the expense of accuracy for subsequent targets in RSVP. Anderson

(2005) and Keil & Ihssen (2004) have recently shown that the AB of participants is dramatically reduced when *T2* is an emotionally arousing word, suggesting that such words receive preferential attentional processing in RSVP. The fact that the attenuated AB for emotionally arousing T2s was not observed in individuals with their left amygdala resected (Anderson & Phelps, 2001) further strengthens the claim that the AB attenuation with unselected participants was due to the emotionally salient nature of the stimuli given the important role of the amygdala with respect to emotion. Mathewson, Arnell and Mansfield (submitted) have also observed that the magnitude of the AB is increased when *T1* is a taboo or sexual word relative to positive, negative, and neutral T1 words. Each of the above RSVP studies found that the arousal level of the emotional target, not its valence predicted the AB modulation, suggesting that arousing targets receive more than their share of attentional resources in RSVP. Furthermore, Most, Chun, Widders and Zald (2005) used an RSVP stream of pictures and reported that when a negative distractor picture primarily evoking disgust (e.g., a picture of gory mutilated bodies) was presented as a critical distractor, an AB was observed for subsequent targets. Most, Smith, Cooter, Levy and Zald (submitted) recently demonstrated that erotic pictures were also capable of producing an involuntary AB when presented as critical distractors, and that this effect was even more robust than that observed with the negative pictures.

However, recently Barnard, Ramponi and Battye (2005) presented either a threat word or a non-emotional word as a critical distractor prior to the target word and found that the threatening distractor captured attention only for those participants who were high in both state and trait anxiety. Their results are consistent with

several studies showing that emotional stimuli can capture the attention of participants whose psychopathology is consistent with the presented words in paradigms such as emotional Stroop (e.g., Williams & Nulty, 1986) and dot probe (e.g., Mogg, Bradley, & Williams, 1995), but that participants not having any word congruent psychopathology do not (see Williams, Mathews & MacLeod, 1996 for a review). It may be that pictures, but not words ,presented in RSVP can capture the attention of unselected participants due the fact that information is more directly available from a picture for early information processing, whereas a word is a more indirect representation of the emotion. However, it may also be the case that emotional words can capture the attention of unselected participants when presented in RSVP, but that threatening words are not as effective as the taboo and sexual words used as T2 by Anderson (2005) and as T1 (Mathewson et al., submitted).

In the present study we examine whether critical distractor words presented in RSVP are capable of capturing the attention of unselected university students and impairing their accuracy on subsequent targets. Across experiments we examine this capture effect for a variety of critical distractor words (emotionally neutral, positive, negative, sexual, threatening, and anxious), and test whether the stimulus dimensions of arousal and/or valence can explain why some words capture attention but others do not. To elucidate the mechanism underlying the effect we also examine whether participants' reports of whether or not the critical distractor was remembered can predict the amount of attention capture.

In Experiment 1 positive, negative, arousing and neutral words were presented as distractors in RSVP streams at various lags before task-defined targets (words of color names). Participants were not told of the emotionally charged words, and were asked to simply report the color name appearing on each trial. In order to determine which of the emotional words were attended and encoded into awareness, participants were given a surprise list of the positive, negative, arousing, and neutral words after the RSVP task, and asked to check off which words they remember seeing in the RSVP streams. Participants were then asked to rate the arousal and valence of each of the emotion words. Based on the results of Anderson (2005) and Keil & Ihssen (2004) who observed that arousing words, regardless of their valence, were the only words to show a reduced AB when presented as T2, we predicted that target accuracy would be lower at short lags when arousal words are presented as distractors prior to the target. Further, we predicted that the arousal ratings, but not the valence ratings, of the emotional words would be related to target accuracy in that words rated higher in arousal would capture attention more readily, resulting in poorer accuracy for targets that followed. If arousing words were more likely to be encoded into awareness instead of the target, then we predicted greater memory for arousing words than other words, and a negative relationship between the number of times a word was remembered and target accuracy on trials where that word is presented.

Experiment 1

Methods

Participants

Participants were 18 (12 female) Brock University undergraduate students ranging in age from 18 to 38 years (mean 22 years). In this and all experiments reported here, the participants reported normal (or corrected to normal) visual acuity, and participated individually in a single session lasting under two hours. All participants

received course credit or a small monetary payment.

Design

The design of this experiment was a 5 (nature of critical distractor) X 6 (critical distractor - target lag) factorial. The critical distractor words lists were adapted from stimuli used by Anderson (2005), and were chosen to be neutral, positive, negative, or arousing (see Appendix A)[1]. There were also trials where no critical distractor word was presented in the stream. When present, the critical distractor appeared 1, 2, 3, 4, 5, or 8 words before the target color word (corresponding to 110, 220, 330, 440, 550, or 880 ms of separation). The levels of each factor varied randomly for each participant, with the constraint that each possible combination of the factors occurred twice every 60 trials. Each participant performed 240 trials in a single session.

Apparatus and Stimuli

Experiments were controlled using E-Prime software (Schneider, Eschman, & Zuccolotto, 2002) running on a Sony VIAO desktop computer, with 17" CRT color monitor. Participants made responses using the computer keyboard.

Eighteen items were presented in each RSVP stream. Streams with a critical distractor word (neutral, positive, negative, or arousing) contained 16 distractor words, one critical distractor word, and one color target word (see Figure 1). Trials where no critical distractor was presented contained 17 distractor words and one color target word. Distractor stimuli for the RSVP task were created a priori to be 60 neutral valence and low arousal words from four to seven letters in length. For presentation, distractor words were chosen randomly without replacement for each trial. Ten color words served as the word targets for the RSVP task (black, blue, brown, green, orange, pink, purple, silver, white, yellow). The identity of the target color word was chosen randomly by the computer with the constraint that each word be used once every 10 trials. When present, the critical distractor was presented in stream position 5 or 8 (each position was used equally often for each combination of critical distractor type and lag). The identity of the critical distractor word was chosen randomly within each critical distractor condition with the constraint that each word was shown once in the first 120 trials, and once in the second 120 trials. The critical distractor word was presented 1, 2, 3, 4, 5, or 8 items before the color word, placing it in stream positions 6 to 16.

All words were capitalized, and presented in 18 point bold Courier New font. The letters subtended approximately 1.4° of visual angle in height and 3.6° to 7.2° in width at an unfixed binocular viewing distance of approximately 40 cm. All words were presented in black using rapid serial visual presentation (RSVP), where each stimulus is presented one-at-a-time in the same spatial location. Each word was presented in the center of a uniform gray screen for 110 ms with no inter-stimulus interval between words.

Procedure

The experiment consisted of three parts: 1) the RSVP task, 2) a checklist task where participants were asked to check-off any critical distractor words that they recalled seeing in the RSVP task, and 3) a rating task where participants rated the arousal and valence of each of the critical distractor words.

For the RSVP task, participants were instructed to identify the color word on each trial, guessing if necessary, and to ignore all other words in the stream. They were shown the ten color words, and informed that the target would always be from this set, and only these responses would be allowed. Participants were unaware that emotional words would be presented amongst the

distractors. Approximately 5 practice RSVP trials preceded the experimental trials. Each trial began with the presentation of a black fixation cross in the center of the screen for 500 ms, followed by a 500 ms blank interval before the start of the RSVP stream. Immediately after each stream participants were prompted by a sentence on the computer screen to press the key matching the identity of the target (color names were affixed to 10 keys). Accuracy was stressed and responses were not speeded. Two seconds after their button press the fixation cross for the next trial appeared.

Immediately after completion of the RSVP task, participants were given a piece of paper containing a list of all 96 critical distractor words presented in alphabetical order. Participants were told that some of the words on the list were presented as distractors in the RSVP streams, and that they should check off the words that they remember seeing from the RSVP task. (In fact, all of the words on the list were critical distractors and had each been presented twice during the RSVP experiment.) Participants were allowed to go through the list in any order with no time constraints. There was no upper or lower limit on the number of checks.

Participants then received the word rating task. On each trial one of the 96 critical distractor words was presented in the center of the screen. The word stayed on the screen until the participant gave the word a valence rating and an arousal rating, using a 7 point Likert scale for each rating. The valence scale was anchored by "unpleasant" for the 1 response and "pleasant" for the 7 response. The arousal scale was anchored by "low" for the 1 response and "high" for the 7 response. Participants were asked to make the valence and arousal ratings independently, and to try to use the whole scale. Participants were encouraged to take their time and provide accurate ratings based

on their own personal views about the emotion of the word. Coincident with the onset of each word was the prompt "Valence?" which remained on the screen until a valence response was entered using the keys 1 to 7. Once the valence response had been given, the prompt changed to "Arousal?" which remained on the screen until an arousal response was entered using the keys 1 to 7. The 96 critical distractor words were each presented once in random order.

Results

RSVP Target Identification

Figure 2 shows the mean target accuracy (% correct) for each critical distractor condition as a function of the lag between the critical distractor and the target. A clear deficit in target identification accuracy can be observed for the arousal condition. An Analysis of Variance (ANOVA) was performed on target accuracy rates with critical distractor emotion and lag as repeated measures. The analysis revealed a significant main effect of critical distractor emotion, $F(4,68) = 11.92$, $p < .001$, no main effect of lag, $F(5,85) = 1.50$, $p > .19$, and no significant emotion by lag interaction, $F < 1$. Pairwise comparisons using Tukey HSD tests revealed lower overall target accuracy in the arousal condition relative to each of the other four critical distractor conditions, all p's $< .01$. No other comparisons approached significance (all p's $> .30$).

Word Ratings and Target Identification

The above results suggest that the arousal, not valence, of the critical distractor influenced subsequent target identification accuracy. However, it may be that participants would not agree with our groupings, and therefore it may not be arousal per se that was the cause the of the reduced target accuracy in the above analysis. Figure 3 presents a two-factor plot of the mean arousal and valence ratings

collapsed across participants where each of the critical distractor words is represented by a symbol indicating its condition membership. In general, participants' ratings of the words agreed with our own experimental grouping of the words.

The relationship between critical distractor valence, critical distractor arousal, and color target accuracy was assessed further using the participant's own valence and arousal ratings of the critical distractors instead of grouping the words into categories. Collapsing across participants, the mean arousal rating for each of the critical distractors and the mean valence rating for each of the critical distractors were correlated with the mean color target accuracy on trials where each of the critical distractors was presented (e.g., the arousal and valence ratings for "sad" and the target accuracy on trials where "sad" was presented as the critical distractor). Arousal ratings significantly predicted overall target identification accuracy, $r(93) = -.31$, $p<.002$, where higher arousal ratings were associated with lower color identification accuracy, even when valence ratings were partialed out (semi-partial $r = -.37$, $t(92) = 3.76$, $p < .001$). However, valence ratings did not significantly predict overall target identification accuracy, $r(93) = .07$, $p > .54$, despite the fact that arousal and valence ratings were positively correlated, $r(93) = .40$, $p <.001$. A hierarchical regression showed no significant increase in the variability explained when the arousal X valence interaction was added in a second step after arousal and valence scores (partial $r = .06$, $t<1$) indicating that the relationship between critical distractor arousal ratings and target accuracy was not modulated by valence. However, it may be that valence would have its greatest effect for very positive or very negative words, and that valence extremity (distance from neutral valence) would be a better predictor than valence rating per se. Valence extremity was calculated by taking the absolute difference between the valence rating and 4 (the midpoint on the valence scale). Valence extremity was not related significantly to target accuracy, $r(93) = .13$, $p > .21$, and arousal was a significant predictor of target accuracy even after the variability due to valence extremity was partialed out (semi-partial $r = -.39$, $p < .001$).

Word frequency estimates for the critical distractors were found using Kucera and Francis (1967). Word frequency estimates were not available for three of the arousal words, but ranged from 1 – 187 per million (M=25) for the remaining words. When the word frequency were correlated with target accuracy for each word, no significant relationship was observed, $r(90) = .13$, $p > .20$. Word length (number of letters) also failed to predict target accuracy, $r(93) = .05$, $p > .63$. Importantly, arousal ratings were still a significant predictor of target accuracy once the variability due to number of letters and word frequency was removed (semi-partial $r = -.33$, $p < 001$).

Checklist and Target Identification

If identification accuracy is reduced for color targets when they follow arousing words because attention is captured by the arousing stimulus, then the arousing word should be encoded into memory instead of the color target on that trial (assuming attention facilitates encoding into awareness which then supports future memory performance). Thus, arousing words should remembered more often than any other word type, and there should be a negative correlation between the number of times a critical distractor is checked and target identification accuracy. The mean number of checks for each word in each of the four critical distractor conditions was 0.83 for the neutral words, 1.47 for the positive words, 1.00 for the negative words, and 4.79 for the arousal words. A one-way ANOVA

comparing mean number of checks across emotion word conditions showed a significant main effect of word condition, $F(3,91) = 22.76$, $p < .001$. Tukey HSD tests showed that arousal words were checked significantly more than the other three word types, all p's <.001, but that the other three types did not differ from each other (all *p*'s > .65).

When the total number of checks across participants (maximum = N of 18) for each of the 95 critical distractors was correlated with the accuracy for the color target that followed each critical distractor a strong relationship was observed, $r(93) = -.52$, $p < .001$, where words that were checked off more often were associated with significantly lower target accuracy. This relationship provides clear evidence that on trials where the critical distractor enters conscious awareness, subsequent targets are less likely to be encoded into awareness, and supports the idea that arousing critical distractors captured attention at the expense of color target identification.

The number of checks a word received was predicted by its arousal rating, $r(93) = .55$, $p < .001$, but not by its valence rating, $r(93) = .14$, $p > .17$. Furthermore, a simultaneous regression where arousal ratings and number of checks were entered as predictors of target accuracy demonstrated that arousal ratings of the critical distractors no longer significantly predicted color target accuracy once the number of checks a critical distractor received was partialed out (partial $r = -.02$, $t(92) = .20$, $p > .84$). In contrast, the number of checks for critical distractors did significantly predict target accuracy when the critical distractors' arousal ratings were partialed out (partial $r = -.44$, $t(92) = 4.63$, $p < .001$). This pattern of relationships suggests a direct relationship between conscious encoding of the critical distractor and target accuracy, and an indirect relationship between arousal rating and target accuracy that is mediated by conscious encoding of the critical distractor.

Discussion

Although the vast majority of RSVP distractors do not receive attentional processing and are not encoded into awareness for later recall, the present results suggest that arousing words did capture attention when they were presented as distractors in an otherwise emotionally neutral RSVP stream, and that these arousing words were entered into awareness for later recall. Furthermore, encoding these words into awareness for later recall decreased the ability to accurately identify target words presented for several hundred milliseconds. Participants' arousal ratings of the words were found to uniquely predict target identification accuracy, where more arousing critical distractors led to poorer target color accuracy. However, arousal was shown to have an indirect effect via memory checks for the critical distractor. Highly arousing words were more likely to be attended and therefore remembered, but this came at a cost of less attention and awareness of subsequent targets. However, if high arousal words were not encoded into awareness for later recall (as indicated by the checklist), then there was no cost to target accuracy. This mediated effect suggests that the mere presence of high arousal words did not disrupt normal processing, for example, by shocking the system even when the participant remained unaware of the word. Note that emphasizing the importance of checklist performance as a mediator assumes that participants had no bias to check off some words over others on the checklist. Checklist performance was shown to predict target accuracy independently of arousal and valence ratings, so these dimensions could not underlie any potential bias, but one could

still exist. The issue of potential bias will be examined further in Experiment 2.

Another factor complicating interpretation of the above results is that the critical distractors were presented amongst non-critical distractors that were emotionally neutral words. It is therefore possible that the emotional words were more novel in the context of the streams, and that it was this novelty that allowed them to capture attention more than other words. For example, critical distractors that were neutral would not be novel at all with respect to the other distractors, whereas the other word types could be separated from the distractors on the basis of their emotionally laden nature alone. Therefore, it is possible that novelty in context could have influenced the results, at least in part.

Another complicating factor was the lack of an impressive effect of lag in the arousal condition. If arousing words captured attention, they would be expected to do so only for a limited time, resulting in decreased target accuracy at short lags but not long lags. The arousal category contained sexual words, curse words, and threat words. If some of these word categories captured attention, but others did not, then this could reduce the potential for lag effect to be seen. As such, it would be interesting to examine the attention capture for sexual, threatening, and anxious words separately and see the lag effect for each. Also, using lags of 1, 2, 3, 4, 5, and 8 meant that the majority of targets appeared in the earlier stream positions, perhaps biasing participants' attention away from later stream positions that rarely contained a target.

Experiment 2

In Experiment 2 sadness (negative), positive and neutral word categories were used as in Experiment 1. Individual word categories were also created for sexual words, threat words, and anxiety-related words so that the ability of each to capture attention during the RSVP task could be compared. Each critical distractor was presented either 3 or 8 items before the color target to gather more data per lag, and so that participants did not have a bias to look for the target in earlier stream positions. The novelty-in-context issue was addressed by using non-words as distractors in the RSVP stream, instead of the emotionally neutral words used in Experiment 1. Because non-words have no associated semantics or emotional impact they provide a context where each critical distractor is equally novel with respect to the background. Of course, arousal words will still be more arousing than the background relative to neutral words, but the impact of this emotional difference is what is being tested (i.e. the ability of emotional stimuli to capture attention while performing an emotionally neutral task under otherwise emotionally neutral conditions). The use of non-words is also desirable in that they will still create an RSVP stream allowing masking of the critical distractors and targets, and will also allow the use the same color-word target identification task as in Experiment 1. An additional change was the use of foils on the memory checklist to examine whether checklist performance was a result of memory for the words or a bias to respond to certain types of words.

Method

Experiment 2 was the same as Experiment 1 with the following exceptions. Participants were 24 Brock University undergraduate students (16 female). None had participated in Experiment 1. There were six types of critical distractor words (positive, sadness, neutral, taboo-sexual, threat, and anxiety) with 26 words in each condition. The words from the positive, sadness, and neutral conditions were largely the same as those from Experiment 1. The vast majority of threat words were those

used by McKenna and Sharma (1995) in their threat condition. Both taboo and sexual words were used for the taboo-sexual word condition. Words used for the taboo-sexual and anxiety conditions were selected by the authors. A critical distractor was presented on every trial. Participants performed 624 total trials where each critical distractor was presented four times throughout the experiment, once every 156 trials. The critical distractor was presented in positions 5 or 8 in the RSVP stream (balanced across emotion condition and lag), and was situated three or eight items before the target color word. The non-critical distractors were changed from 60 neutral words to 60 non-words of the same length. The non-words obeyed all orthographic rules of English and included no pseudohomophones. Participants rated all 156 of the critical distractor words for valence and arousal. The memory checklist included all 156 critical distractors and 18 foils (3 from each emotion category, see Appendix A for all critical distractors and foils for Experiment 2) presented in alphabetic order. Participants performed the RSVP task, then the checklist task, and finally the rating task as in Experiment 1.

Results

RSVP Target Identification

Figure 4 shows the mean target accuracy (% correct) for the six critical distractor emotion conditions as a function of lag. A clear deficit in target identification accuracy can be observed at lag 3 for the taboo-sexual condition only. An ANOVA was performed on target accuracy rates with emotion condition and lag as repeated measures. The analysis revealed a significant main effect of critical distractor emotion, $F(5,115) = 9.69, p < .001$. Post-hoc tests using the Tukey HSD procedure revealed that target accuracy in the taboo-sexual distractor condition was lower than in all other conditions (all p's < .01) but that

overall target accuracy did not differ for the other five emotion conditions (all p's > 25). The main effect of lag was also significant, $F(1,23) = 20.89, p < .001$, with lower accuracy at lag 3 then lag 8. The distractor emotion by lag interaction also reached significance, $F(5,115) = 6.69, p < .001$, due to mostly to the large lag effect observed for taboo-sexual distractors compared to all other distractor types (all p's < .01 when comparing the difference in target accuracy at lag 8 and lag 3 for the taboo-sexual condition to all other emotion conditions). Planned comparisons showed a significant lag effect on trials with a sexual/taboo distractor, $t(23) = 5.50, p < .001$, and for trials with a sadness distractor $t(23) = 3.18 p < .01$. There was also a marginally significant lag effect for trials with a threat distractor, $t(23) = 2.01, p < .06$, but no lag effect for the other three emotion conditions (all p's > .15).

Word Ratings and Target Identification

As in Experiment 1, the arousal ratings, valence ratings, and valence extremity scores for each of the critical distractors were correlated with the mean color target accuracy on trials where that critical particular distractor was presented. Arousal ratings for the critical distractors again predicted accuracy for the targets that followed, $r(154) = -.24, p < .01$ where higher arousal ratings for a critical distractor were associated with lower target accuracy on trials where that distractor was presented. Arousal was a significant predictor of target accuracy even when the variability attributable to valence was partialed out (semi-partial $r = -.20, p < .05$), and when the variability attributable to valence extremity was partialed out (semi-partial $r = -.26, p < .001$). Neither valence nor valence extremity were significant predictors of target accuracy, $r(154) = -.12, p > .12$, and $r(154) = .10, p > .23$ respectively. Arousal ratings predicted accuracy for targets that followed

the critical distractor closely at lag 3, $r(154)$ = -.20, $p < .02$, but not later at lag 8, $r(154)$ = -.15, $p > .07$. Valence and valence extremity did not predict target accuracy at either lag (all p's > .11).

Word frequency ratings ranged from 1 to 807 per million (M=41.9), but were unavailable for seven of the taboo-sexual words. Word frequency was not related to target accuracy, $r(154) = -.01$, $p > .88$. However, number of letters did predict target accuracy, $r(154) = .19$, $p < .05$, where longer critical distractors were associated with higher target accuracy (perhaps due to the greater difficulty of reading the longer distractors in the fast RSVP stream). Importantly, however, number of letters did not vary as a function of the distractor emotion, $F(5,149) = 1.76$, $p > .12$, with less than a one letter mean difference between all conditions. Furthermore, both emotion condition and arousal were significant predictors of target accuracy even once the variability due to number of letters and word frequency was removed (semi-partial r = .17, $p < .02$, semi-partial r = -.23, $p < .005$ respectively).

Checklist and Target Identification

The mean number of checks for a word in each of the distractor emotion conditions is presented in Table 1 for both memory checklist targets and foils (maximum number of checks for both targets and foils is equal to the number of participants which was 24). Reliable memory was observed for all of the six distractor emotion conditions in that for each emotion condition the number of participants who checked a word was significantly greater for the targets (words presented during the RSVP task) than for the foils (words not presented during the RSVP task), all p's < .005. There was a significant effect of distractor emotion for target words, $F(5,150) = 22.21$, $p < .001$. Tukey HSD tests revealed that taboo-sexual words were checked more often than all other word types, all p's < .001, but the number of checks was the same for all other emotion conditions, all p's > .41. There was a marginally significant effect of distractor emotion for foil words, $F(5,12) = 2.93$, $p < .06$. Tukey HSD tests revealed a significant difference between taboo-sexual and neutral words only, $p < .05$, with no other differences approaching significance, all p's > .10. However, the slight difference in false alarm rate across distractor emotion conditions could not fully explain the large difference in the number of hits across emotion conditions. Indeed, when the number of checks for target words was corrected for the number of checks for word foils (hits – false alarms), a significant effect of emotion condition was still observed, $F(5,150) = 6.14$, $p < .001$. Tukey HSD tests performed on the corrected checks still showed a significant difference between sexual/taboo words and all other word types, all p's < .01, with no other significant differences amongst the emotion conditions, all p's > .80.

The number of checks a word received predicted overall target accuracy, $r(154) = -.49$, $p < .001$, where words that were checked more often were associated with significantly lower target accuracy as in Experiment 1. This relationship held even when the number of checks corrected for the false alarms was used as a predictor, $r(154) = -.41$, $p < .001$. The number of checks a word receive predicted reduced accuracy for targets presented at lag 3, $r(154) = -.50$, $p < .001$, but not lag 8, $r(154) = -.14$, $p > .14$. Number of checks was again related to arousal ratings, $r(154) = .37$, $p < .001$, but not valence ratings, $r(154) = .08$, $p > .35$. When arousal ratings and number of checks were entered as simultaneous predictors of target accuracy, arousal ratings of the critical distractors no longer significantly predicted color target accuracy once the

number of checks a critical distractor received was partialed out (partial $r = -.07$, $t < 1$). In contrast, the number of checks for critical distractors did significantly predict target accuracy when critical distractors' arousal ratings were partialed out (partial $r = -.43$, $t(153) = 6.01$, $p < .001$). This pattern of relationships was the same as that observed in Experiment 1, and again suggests that the relationship between arousal ratings and target accuracy is mediated by encoding of the critical distractor into awareness.

Discussion

As in Experiment 1, taboo-sexual distractors in the present experiment captured the attention of participants and were encoded into awareness at the expense of encoding the subsequent target. The present experiment also shows that this attention capture was not observed for threat words or anxiety words, just as it was not observed for sadness related, positive, or neutral words in either experiment. The specificity of the attention capture effect for taboo-sexual words will be examined in the General Discussion.

The present results also provide the first compelling lag effect (a significant 12% difference across lags) for target accuracy in the taboo-sexual condition. Target accuracy in the taboo-sexual condition was lower than the average of the other conditions by 10.4% at lag 3, but only 1.2% at lag 8. As with the AB, the presence of a lag effect for taboo-sexual distractors suggests that the taboo-sexual word held attention for only a few hundred milliseconds at most. Indeed, arousal ratings and memory checks predicted accuracy for targets presented at lag 3 but not at lag 8. The present pattern of results suggests that the encoding of the critical taboo-sexual distractor sets off an involuntary AB (involuntary in that the taboo-sexual word is not a goal-driven target). Small but significant lag effects were also observed for sadness and

threatening critical distractors, however, in both cases this resulted more from increased accuracy at lag 8 than from reduced accuracy at lag 3. Furthermore, the overall target accuracy was reduced only for taboo-sexual words, not for any other word type.

The present experiment also suggests that the novelty of the critical distractor with respect to the other distractor words was not a key factor underlying the results of Experiment 1 given that all words were presented amongst non-word distractors in Experiment 2 and thus were equally novel. Together Experiments 1 and 2 suggest that attention capture for arousing distractors can be observed with word or non-word distractors that are emotionally neutral. However, although all of the critical distractors differed from the background of non-word distractors in Experiment 2, the relative ratio of trials with taboo-sexual words to trials without such words was still 1:5. Thus, it is possible that taboo-sexual words were considered by participants to be more novel simply because they were more rare than non-taboo-sexual words across the set of trials. This issue is examined in Experiment 3.

Experiment 3

To address the issue of the relative novelty of taboo-sexual critical distractors with respect to the entire distractor set, in the present experiment critical distractors were presented equally often from only two conditions (neutral and taboo-sexual). The two conditions were created so that both formed a semantic grouping or theme as it is possible that word conditions that form a tighter semantic group may better prime each other across trials, thereby increasing the potential for attention capture and encoding (McKenna & Sharma, 1995).

Also, Experiments 1 and 2 were not well suited to examining whether the attention capture effect for taboo-sexual words changed across several repeated

presentations of the words. Harris and Pashler (2004) have suggested that emotionally laden words may capture attention the first or second time they are presented, but not thereafter. They argue that the capture is simply due to a temporary surprise reaction by the participant that wears off after one or two presentations. In the present experiment the size of the attention capture effect will be examined across 10 blocks (10 presentations of each word).

To equate the semantic relatedness of the critical distractor groups in the present experiment, two types of critical distractor words were used: a neutral word group that consisted of words loosely organized around a music theme, and taboo-sexual word group that consisted of words loosely organized around a sexual theme. Each critical distractor from these two groups was presented once in each of ten blocks so that the size of any attention capture effect could be compared across blocks. The lag between the critical distractor and the target was held constant at 3 (the lag where large effects of emotion condition were observed in Experiment 2) so that the effect of block could be examined without variability due to lag. The extent to which a surprise reaction is important to the attention capture of sexual words was also examined by having half of the participants perform the RSVP trials without being told of the sexual and music distractors, and the other half perform the RSVP trials after being shown the sexual and music words and told to ignore them during the RSVP task.

Methods

Experiment 3 was the same as Experiment 2 with the following exceptions. Participants were 43 Brock University undergraduate students (29 female). None had participated in Experiments 1 or 2. Only neutral and taboo-sexual critical distractors were used. The neutral critical distractors

consisted of twelve words loosely organized around a music theme (AUDIENCE, BAND, DANCE, DRUM, JAZZ, LISTEN, PIANO, PLAY, SING, STRUMMING, TROMBONE, WOODWIND). The taboo-sexual critical distractors consisted of twelve words loosely organized around a sexual theme (BITCH, CLITORIS, DILDO, EROTIC, FUCK, LESBIANS, NIPPLES, ORGASM, ORGY, PENIS, PISS, SEXUAL). Twenty-two of the participants WERE NOT told of the music and sexual word distractors prior to performing the RSVP trials. Twenty-one of the participants WERE shown all of the music and sexual words used as critical distractors immediately before beginning the RSVP trials. These participants were told that these words would be presented in the RSVP streams, but to ignore the music and sexual words and focus only on identifying the color targets. For both groups of participants each critical distractor was presented once per block in random order, resulting in 24 trials per block. The experiment consisted of ten of these blocks performed back to back with no break between the blocks for a total of 240 trials. The critical distractor was presented in positions 5 or 8 in the RSVP stream (balanced across emotion condition and block), and always occurred three items before the target color word.

Results

RSVP Target Identification

Figure 5 shows the mean target accuracy (% correct) for the sexual and music conditions as a function of block and whether or not the participant was informed about the critical distractors. For both informed and uninformed participants, a clear deficit in target identification accuracy can be observed for the sexual condition in all but the last block. A 2 X 10 X 2 ANOVA was performed on target accuracy rates with sexual/music and block as repeated measures and informed/uninformed as a

between participant variable. The analysis revealed a significant main effect of critical distractor emotion, $F(1,41) = 72.39$, $p < .001$, with lower target accuracy when targets were preceded by sexual words compared to when targets were preceded by music words. The main effect of block was also significant, $F(9,369) = 2.09$, $p < .05$ with accuracy increasing slightly across blocks. The emotion by block interaction was also significant, $F(9,369) = 2.51$, $p < .01$, as the difference in target accuracy for sexual and music words decreased across blocks. Planned comparisons using the Tukey HSD procedure showed a significant reduction in target accuracy for sexual words compared to music words for all but the last block (all p's $< .05$). Interestingly, there was no main effect of whether or not the participants were shown the critical distractors before performing the RSVP trials, $F(1,41) = 1.74$, $p > .19$, and this factor did not enter into any interactions, all F's < 1, providing evidence that knowing about the nature and presence of the distractors beforehand did not influence the attention capture effect.

Word Ratings and Target Identification

The arousal ratings, valence ratings, and valence extremity scores for each of the critical distractors were calculated using all participants (both those informed and those uninformed about the critical distractors), and these ratings were correlated with the mean target accuracy on trials where that critical distractor was presented. Arousal ratings for the critical distractors again predicted accuracy for the targets that followed, $r(22) = -.67$, $p < .001$ where higher arousal ratings for the critical distractor were associated with lower target accuracy on trials where that distractor was presented. Neither valence nor valence extremity were significant predictors of target accuracy ($r(22) = .27$, $p > .19$, $r(22) = -.20$, $p > .34$ respectively). Arousal was a

significant predictor of target accuracy even when the variability attributable to valence was partialed out (semi-partial $r = -.64$, $p < .001$), and when the variability attributable to valence extremity was partialed out (semi-partial $r = -.65$, $p < .001$).

Word frequency ratings ranged from 1 to 200 per million (M=37.3), but were unavailable for three of the arousal words. Neither word frequency nor word length were significant predictors of target accuracy ($r(22) = .31$, $p > .17$, $r(22) = .27$, $p > .20$ respectively). Arousal ratings and distractor emotion condition also predicted target accuracy even once variability attributed to frequency and length had been partialed out (semi-partial $r = -.64$, $p < .001$, semi-partial $r = -.55$, $p < .01$ respectively).

Checklist and Target Identification

The mean number of checks was significantly greater for sexual words (M=25.17) than for music words (M=20.42), $t(22) = 2.22$, $p < .05$. Number of checks again predicted target accuracy, $r(22) = -.65$, $p < .002$ where words that received more checks were associated with lower target accuracy on trials where they were presented. In contrast to Experiments 1 and 2, the correlation between arousal and the number of checks did not reach significance, $r(22) = .34$, $p < .10$. Arousal was a significant predictor of target accuracy over and above number of checks when both were used as simultaneous predictors (semi-partial $r = -.47$, $p < .001$), providing evidence that checklist performance did not fully mediate the effect between arousal and target accuracy. Nonetheless, the predictive effect of arousal was attenuated by approximately 30% after controlling for the number of checks, providing evidence of partial mediation.

Discussion

Results from the present experiment showed clearly that sexual words captured attention relative to music-related words.

This result suggests strongly that this attention capture effect for sexual words does not result from the relative novelty of sexual words across the trials. One half of the trials contained a sexual word as the critical distractor and the other half contained a musical word as the critical distractor. Thus sexual words were not more novel in the context of the experiment than were music words, yet target accuracy on sexual words was much lower than for music words. The results from this experiment also provide evidence that it was not the semantic grouping that results in the capture effect for sexual words, as both arousing and neutral word conditions were organized around a semantic theme (sex and music) in the present experiment.

The results also show that the attention capture effect is not the result of a fleeting surprise reaction on the first few trials as has been demonstrated with some paradigms and stimuli (e.g., Harris & Pashler, 2004, Marois et al., 2003). The attention capture of sexual words lasted for nine presentations of each sexual word, and over 100 presentations of the group sexual words – far longer than the one or two trials that theories of momentary surprise would predict. Furthermore, the attention capture by sexual words was found to the same degree whether participants were shown the critical distractors before performing the RSVP trials, or given no information about the existence of the critical distractors. If a momentary surprise reaction at the appearance of sexual words were responsible for the attention capture, then we would expect less capture for those participants who were informed about the sexual words than those that were not (at least in the first block or two), but this difference was not present. For both informed and uninformed participants there was no attention capture effect for the last block (block 10), suggesting that despite the fact that the attention capture by sexual words lasts over 100 trials, that sexual words do eventually lose their power to capture attention in RSVP. In this experiment the lag between the critical distractor and target color was fixed at 3 for all trials. The predictable lag may have allowed participants to override the capture effect to some extent. It is possible that the reduced accuracy for target trailing sexual words may have lasted for even more than nine blocks if a variety of lags had been used.

Unlike Experiments 1 and 2, checklist performance did not fully mediate the relationship between arousal and target accuracy in the present experiment. This is likely because the checks become less useful when critical distractors are presented several times. Multiple presentations of a given word provide multiple opportunities to become aware of the word, yet the checklist does not discriminate between those words that have been attended several times and those attended just once or twice[2]. Also, even low arousal words could be expected to be attended by some participants on some trials, thereby reducing the relationship between arousal and checks with an increasing number of presentations for each word.

General Discussion

Sexual words, but not threat words, anxiety words, positive, negative, or neutral words were shown to capture attention when presented to unselected undergraduate participants as distractors during RSVP. This involuntary attention capture was at the expense of performance on a target presented within a few hundred milliseconds of the sexual word, and was predicted by the arousal, but not the valence ratings given to the distractors. This attention capture by sexual words was observed when both neutral words and non-words acted as RSVP fillers, when sexual words were relatively novel and when they were not, and occurred

regardless of whether or not participants were warned about the critical distractors beforehand. Although the sexual distractor held attention for only a few hundred ms (resulting in a lag dependent capture effect), the capture effect was shown to span over 100 presentations of sexual words, and nine presentations of the same word before habituating. Furthermore, memory for the critical distractors negatively predicted accuracy for targets that followed, suggesting that encoding the critical distractor into awareness interfered with encoding the target into awareness on some trials. Indeed, arousal ratings no longer predicted target accuracy once memory for the critical distractor was accounted for, suggesting that the arousal of the critical distractor influences target accuracy via encoding of the critical distractor (i.e. arousing distractors have no effect on target accuracy unless they are encoded into awareness).

Emotion Capture and the AB

A lag-dependent accuracy deficit resembling the AB was observed for sexually explicit words, suggesting that these words acted as a first target and set-off an involuntary AB. The negative relationship between the number of times a words was remembered from the RSVP streams and the number of target errors suggests that sexual words are more likely to be encoded into conscious awareness at the expense of the targets that follow them. If the sexual word is encoded into awareness, even involuntarily (against the participants' goals), the attention taken to encode this word will reduce the attention available to process the subsequent target. This notion is broadly consistent with models of the AB which generally agree that attending to and encoding a first target reduces the attentional resources required to encode a second target into conscious awareness (Chun & Potter, 1995; Jolicoeur, 1998; Shapiro et al., 1997),

although in the AB the first target is voluntarily encoded to meet task demands. Therefore, if an RSVP item is encoded into awareness, regardless of whether the encoding reflected task instructions (as in the typical AB paradigm) or not (as in the present study), a deficit in identification of a subsequent target appearing within about half a second can be observed.

The present results are also consistent with the results of Anderson (2005), and Keil and Ihssen (2004), who found that the AB is dramatically reduced when the second target is an arousing word (many of these words were also sexually explicit), and that the arousal quality of the word is a better predictor of the AB modulation than is the valence. The affective nature of the second target is implicated specifically given that the AB reduction for emotionally valenced second targets was not observed in individuals with their left amygdala resected (Anderson & Phelps, 2001). Thus, arousing targets not only appear to capture attention when presented as distractors, but also appear to overcome attentional limitations when presented during the AB. Both results suggest that arousing stimuli are not subject to the usual rules of target search in RSVP. Furthermore, Mathewson et al.(submitted) have observed a larger AB when sexually explicit words were presented as T1s in an otherwise typical AB task. These same words were also found to produce larger amplitude P3 event-related brain potentials (ERPs) than negative, positive, neutral, threatening, or anxiety-related words, and the magnitude of the P3 outside of the RSVP task was found to predict the AB size when the emotion words were presented as T1s during the AB task (Arnell & MacLeod, in preparation). The capture of attention by task irrelevant distractors that was observed in the present study also fits nicely with the results of Most et al. (submitted) who

reported that erotic distractor pictures initiated an involuntary AB for subsequent picture targets. Most et al. also reported that the erotic distractor pictures resulted in a more robust involuntary AB than did gory pictures in that the AB produced by erotic pictures was resistant to participant strategies shown to reduce the AB observed with gory pictures. Collectively, the above findings provide evidence that sexually explicit words and pictures receive more than their share of attentional resources in RSVP and are preferentially encoded into awareness.

Arousal, Relevance and Attention

In the present study, sexual words received higher arousal ratings than any other word group, suggesting that sexually explicit words may be particularly effective at capturing attention because they are seen as more arousing than threat or anxiety-related words by young, unselected university undergraduate students. The ability of sexually explicit words to reliably capture the attention of unselected undergraduates appears to stand in contrast to the weaker and inconsistent attention capture effects observed for threat, anxiety, or sadness-related words in a variety of paradigms using unselected undergraduate students. For example, MacKay, Shafto, Taylor, Marian, Abrams, & Dyer (2004) observed elevated Stroop color naming times when taboo words (sexually explicit words and racial slurs) were used as Stroop words, compared to RTs with emotionally neutral words. However, anxiety, threat, and sadness related words have often failed to produce an increase in Stroop color naming RTs when shown to unselected participants, or to controls with no psychopathology (see Williams et al.,1996 for a review). This is despite the fact that clinical participants demonstrate a compelling bias to attend to these same threat, anxiety or sadness words if they are consistent with the participant's

psychopathology (see Williams et al., 1996). Aquino and Arnell (in press) have also shown that sexually explicit words, but not threat words, presented between two digits produced elevated response times on a digit parity task performed by unselected undergraduate students (see also Harris & Pashler, 2004).

It is also possible that the attention of young university students may be particularly prone to capture by taboo and sexually explicit material that may be viewed as concern relevant. Concern relevance recently received some support from Most et al. (2005) who showed increased attentional capture for pictures of disgusting or dangerous situations by participants who were high in harm avoidance. Indeed, personal relevance or impact (which is only partially captured by arousal ratings) may explain why some critical distractors were more effective at capturing attention than were others with similar arousal ratings.

According to arousal theories of attention sexually or taboo material may capture attention more readily than other material because arousal controls the amount of attention that is voluntarily (e.g., Lang, Greenwald, Bradley, & Hamm, 1993) or involuntarily (e.g., Gronau, Cohen, Ben-Shakhar, 2003) given to stimuli (Schimmack, 2005). Schimmack (2005) examined the interference of emotional pictures while participants solved math problems or detected the location of a line. Both strongly unpleasant pictures and pictures of scantily clad opposite-sex models captured attention, whereas pictures of snakes, and mildly negative pictures did not capture attention. Schimmack interpreted the results in terms of support for the arousal theory of attention in that the more arousing the stimuli, the more they interfered. Schimmack further suggested that arousal influenced an initial "relevance check" that

determined the amount of attentional allocation, and that this check was performed prior to the processing of valence and other stimulus dimensions. Consistent with this proposal, Scherer's (2001) sequential evaluation check (SEC) model postulates that an initial relevance check is responsible for the regulation of further attention such that stimuli deemed relevant receive more processing capacity.

The present results are also consistent with the binding hypothesis of MacKay et al. (2004) which suggests that activation of highly arousing meanings (e.g. to taboo words) facilitates the binding of the meaning to other contextual features of the word such as its location, color etc. Because attention is needed for binding (Treisman & Gelade, 1980), a facilitation in binding for features of taboo words would also require attentional engagement of the taboo word, thus leaving less attention for subsequent targets. As discussed by MacKay et al., a facilitation in binding would also provide more retrieval cues for these words, and thus lead to superior memory for these high arousing words in a subsequent surprise memory task. Taboo words are assumed to receive superior binding by triggering emotional reactions via the amygdala which then triggers the hippocampus to activate attention to bind the arousing stimuli to their context, thus enabling superior retrieval (MacKay et al., 2004). These models are also compatible with each other, as Scherer and Schimmack's relevance check that purportedly triggers greater attentional capacity may well be the same as MacKay et al.'s amygdala activation that results in greater binding.

Conclusions

Sexually explicit distractor words can capture attention in RSVP streams, and do so at the expense of identification performance for subsequent neutral targets. The present results provide a mechanism for this effect by showing that target accuracy suffers only when the emotional distractor has been encoded into awareness for later memory recognition. These results are consistent with previous results showing preferential processing of emotional targets in RSVP (e.g., Anderson, 2005; Keil & Ihssen, 2004; Mathewson et al., submitted), and with arousal theories of attentional allocation (e.g., MacKay et al., 2004; Scherer, 2001).

References

Anderson, A. K. (2005). Affective influences on the attentional dynamics supporting awareness. *Journal of Experimental Psychology: General*, *134*, 258-281.

Anderson, A. K., & Phelps, E. A. (2001). Lesions of the human amgdala impair enhanced perception of emotionally salient events. *Nature, 411*, 305-309.

Aquino, J. M. & Arnell, K. M. (in press). Attention and the processing of emotional words: Dissociating the effects of arousal words. *Psychonomic Bulletin and Review*.

Arnell, K. M. & MacLeod, J. *Electrophysiological evidence for enhanced on-line processing of sexual words during rapid serial visual presentation.* Manuscript in preparation.

Barnard, P. J., Ramponi, C., & Battye, G. (2005). Anxiety and the deployment of visual attention over time. *Visual Cognition, 12*, 181-211.

Barnard, P., Scott, S. K., Taylor, J., May, J., & Knightley, W. (2004). Paying attention to meaning. *Psychological Sciences, 15*, 179-186.

Chun, M. M., & Potter, M. C. (1995). A two-stage model for multiple target detection in rapid serial visual presentation. *Journal of Experimental Psychology: Human Perception & Performance*, *21*, 109-127.

Compton, R. J. (2003). The interface between emotion and attention: A review of evidence from psychology and neuroscience. *Behavioral and Cognitive Neuroscience Reviews, 2*, 115-129.

Folk, C. L., Leber, A. B., & Egeth, H. E. (2002). Made you blink! Contingent attentional capture produces a spatial blink. *Perception and Psychophysics, 64*, 741-753.

Gronau, N., Cohen, A., & Ben-Shakhar, G. (2003). Dissociations of personally significant and task-relevant distractors inside and outside the focus of attention: A combined behavioral and psychophysiological study. *Journal of Experimental Psychology: General, 132*, 512-529.

Harris, C. R., & Pashler, H. (2004). Attention and the processing of emotional words and names: Not so special after all. *Psychological Science, 15*, 171-178.

Jolicoeur, P. (1998) Modulation of the attentional blink by on-line response selection: Evidence from speeded and unspeeded Task 1 decisions. *Memory and Cognition*, *26*, 1014-1032.

Jolicoeur, P. (1999). Concurrent response selection demands modulate the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance*, *25,* 1097-1113.

Keil, A., & Ihssen, N. (2004). Identification facilitation for emotionally arousing verbs during the attentional blink. *Emotion, 4*, 23-35.

Kucera, H., & Francis, W. N. (1967). *Computational analysis of present-day American English.* Brown University Press, Providence.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). Motivated attention: Affect, activation, and action. In P. J. Lang R. F. Simons, & M. T. Balaban (Eds*.), Attention and orienting: Sensory and motivational processes* (pp. 97-135). Mahwah, NJ: Lawrence Erlbaum.

Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. O. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology, 30*, 261-273.

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

Marios, R., Todd, J. J., & Gilbert, C. M. (2003, May*). Surprise blindness: A distinct form of attentional limit to explicit perception.* Poster presented at the 3rd Annual Meeting of the Vision Sciences Society, Sarasota, FL.

Mathewson, K. J., Arnell, K. M., & Mansfield, C. A. *Capturing and holding attention: The impact of emotional words in rapid serial visual presentation.* Manuscript submitted for publication.

McKenna, F. P, & Sharma, D. (1995). Intrusive cognitions: An investigation of the emotional Stroop task. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 21*, 1595-1607.

Mogg, K., Bradley, B. P., & Williams, R. (1995). Attentional bias in anxiety and depression: The role of awareness. *British Journal of Clinical Psychology*, 34, 17-36.

Most, S. B., Chun, M. M., Widders, D. M., & Zald, D. H. (2005). Attentional Rubbernecking: Cognitive control and personality in emotion induced blindness. *Psychonomic Bulletin & Review*, *12*, 654-661.

Most, S. B., Smith, S. D., Cooter, A. B., Levy, B. N., & Zald, D. H. *The naked truth: Appetitive, arousing distractors*

impair rapid target perception. Manuscript submitted for publication.

Raymond, J. E., Shapiro, K. L., & Arnell, K. M. (1992). Temporary suppression of visual processing in an RSVP task: An attentional blink? *Journal of Experimental Psychology: Human Perception & Performance, 18*, 849-860.

Robinson, M. D. (1998). Running from William James' bear: A review of preattentive mechanisms and their contributions to emotional experience. *Cognition and Emotion*, 12, 667-696.

Scherer, K. R. (2001). Appraisal considered as a process of multilevel sequential checking. In K. R. Scherer, A. Schorr, & T. Johnstone (Eds.), *Appraisal processes in emotion* (pp. 92-120). Oxford, England: Oxford University Press.

Schimmack, U. (2005). Attentional interference effects of emotional pictures: Threat, negativity, or arousal? *Emotion, 5*, 55-66.

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). *E-Prime User's Guide*. Pittsburgh: Psychology Software Tools Inc.

Shapiro, K. L., Arnell, K. M., & Raymond, J. E. (1997). The attentional blink. *Trends in Cognitive Science, 1(8),* 291-296.

Treisman, A. M., & Gelade, G. (1980). A feature-integration theory of attention. *Cognitive Psychology, 12*, 97-136.

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

Williams, J. M. G., & Nulty, D. D. (1986). Construct accessibility, depression and the emotional Stroop task: Transient emotion or stable structure? *Personality and Individual Differences*, 7, 485-491.

Footnote

[1]Inadvertently, one of the critical distractors used in the positive list was the word "gold" which should not have been a critical distractor given that it too is a color word (although not one of the ten target color words used in the present study). Thus, the two trials for each participant where "gold" was presented as the critical distractor were removed from all of the above analyses. Interestingly, however, "gold" resulted in the third highest number of target errors among all critical distractors despite the fact that its mean arousal rating was not particularly high (4.67/7.00). Also, "gold" was checked on the checklist by 10 of the 18 participants, making it the second most checked critical distractor. These results suggest that "gold" readily captured attention due to its match with the target search template.

[2]Pilot data were collected where participants were asked to report the number of times they saw each word, rather than just indicating whether they saw the word or not. However, participants were not able to provide useful estimates during this task.

Table 1: Mean Number of Checks for Critical Distractors and Foils in Experiment 2 as a

Function of the Critical Distractor Emotion Condition. Standard deviations are in brackets.

	Mean Number of Checks per Word (/24)		
Emotion Condition	**Critical Distractors**	**Foils**	**Critical Distractors - Foils**
Sadness	2.80 (2.31)	1.33 (1.15)	1.47 (2.31)
Positive	3.69 (2.62)	2.00 (0.00)	1.69 (2.62)
Taboo-Sexual	9.19 (3.10)	4.33 (2.52)	4.86 (3.36)
Neutral	3.04 (2.13)	0.67 (0.58)	2.37 (2.13)
Threat	4.15 (2.68)	2.33 (0.58)	1.82 (2.68)
Anxiety	3.92 (2.41)	1.67 (1.15)	2.25 (2.42)

Figure Captions

Figure 1. Diagram of a trial in Experiment 1. In this example, the critical distractor is from the
arousal condition, the correct answer is "brown", and the lag between the critical distractor
and the target is 2. The critical distractor was positive, negative, arousing, or neutral. There
were 0, 1, 2, 3, 4, or 7 fillers between the critical distractor and color target. Four to eight
filler words preceded the critical distractor and 2 to 12 fillers words trailed the color target.

Figure 2. The group mean percentage of correct color target identification responses in
Experiment 1 as a function of critical distractor emotion category and the lag between the
critical distractor and the target. Error bars represent the standard error for each mean.

Figure 3. Two-factor plot of the mean arousal and mean valence ratings for the 96 critical
distractors in Experiment 1 (collapsed across participants). Words from the negative
condition are plotted as open squares, words from the positive condition as stars, words from
the arousal condition as open circles, and words from the neutral condition are plotted as
filled triangles.

Figure 4. The group mean percentage of correct color target identification responses in
Experiment 2 as a function of critical distractor emotion category and the lag between the
critical distractor and the target. Error bars represent the standard error for each mean.

Figure 5. The group mean percentage of correct color target identification responses in
Experiment 3 as a function of block and critical distractor emotion category (sexual/music).
Panel A shows data from participants who were not informed about the presence of the music
and sexual words before the RSVP trials.). Panel B shows data from participants who were
informed about the presence of the music and sexual words before the RSVP trials. Error
bars represent the standard error for each mean.

500 ms

500 ms

MANAGE — 110 ms for each word

INPUT
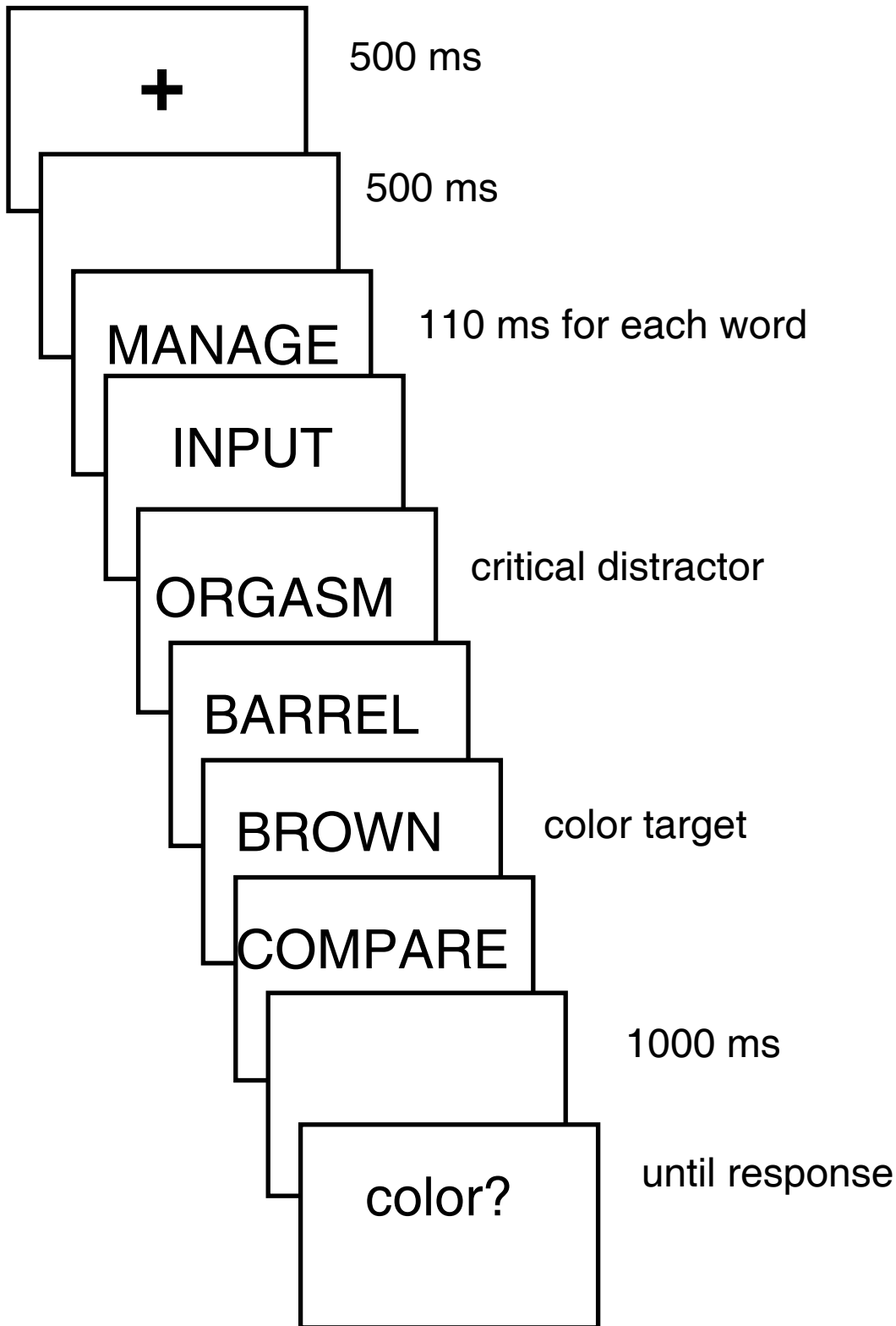
ORGASM — critical distractor

BARREL

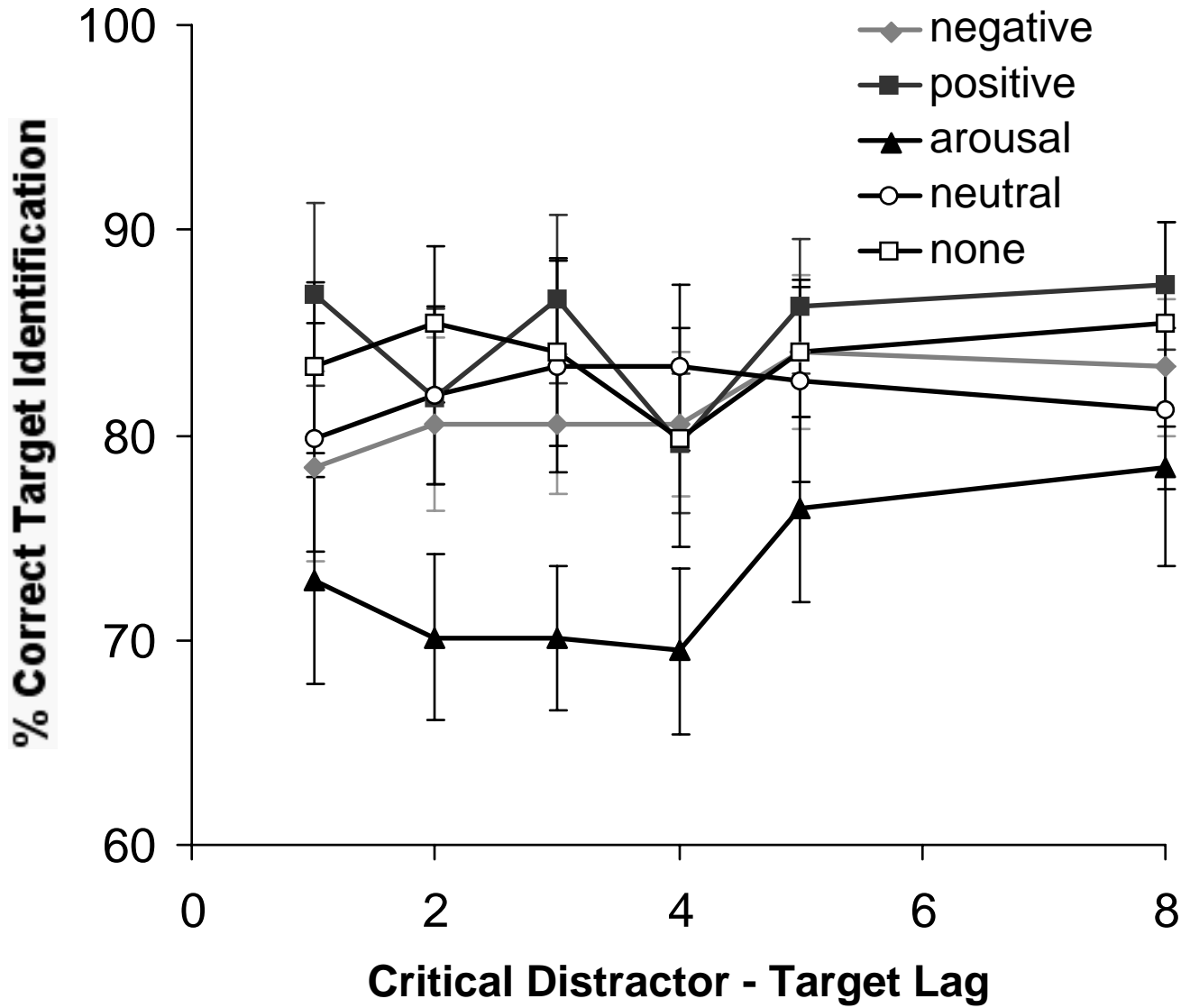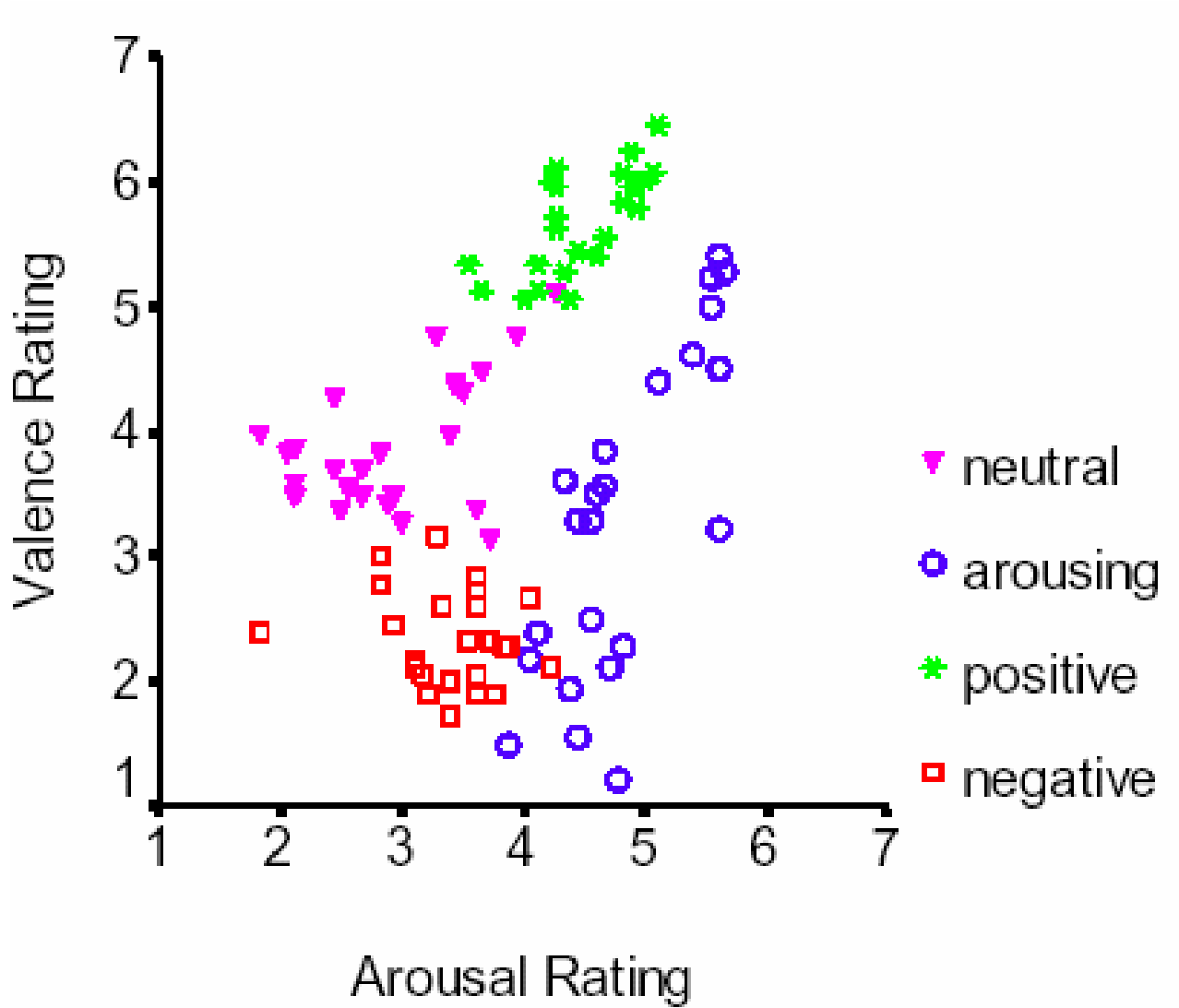BROWN — color target

COMPARE

1000 ms

color? — until response

Figure 2

Figure 3

Figure 4
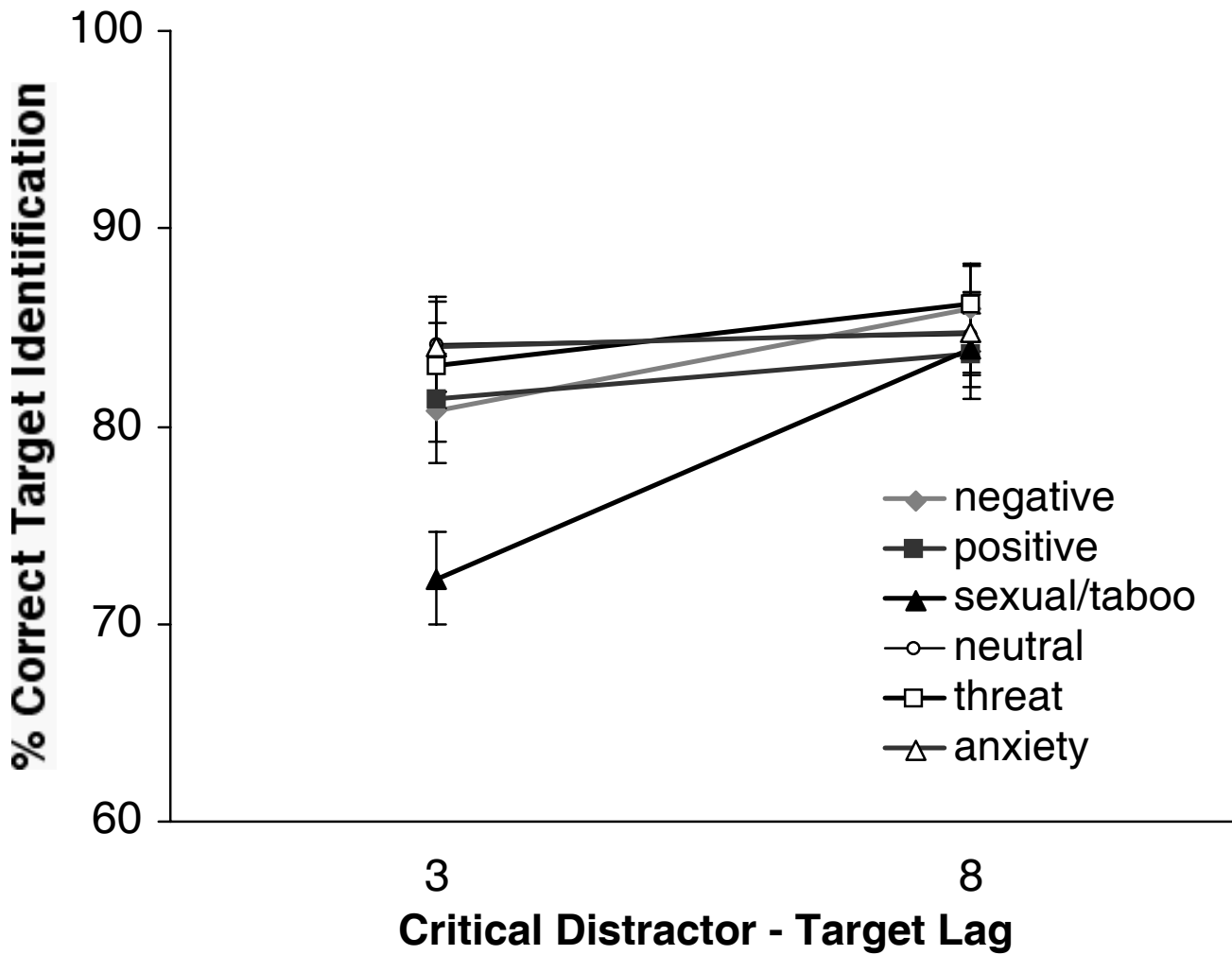
Figure 5
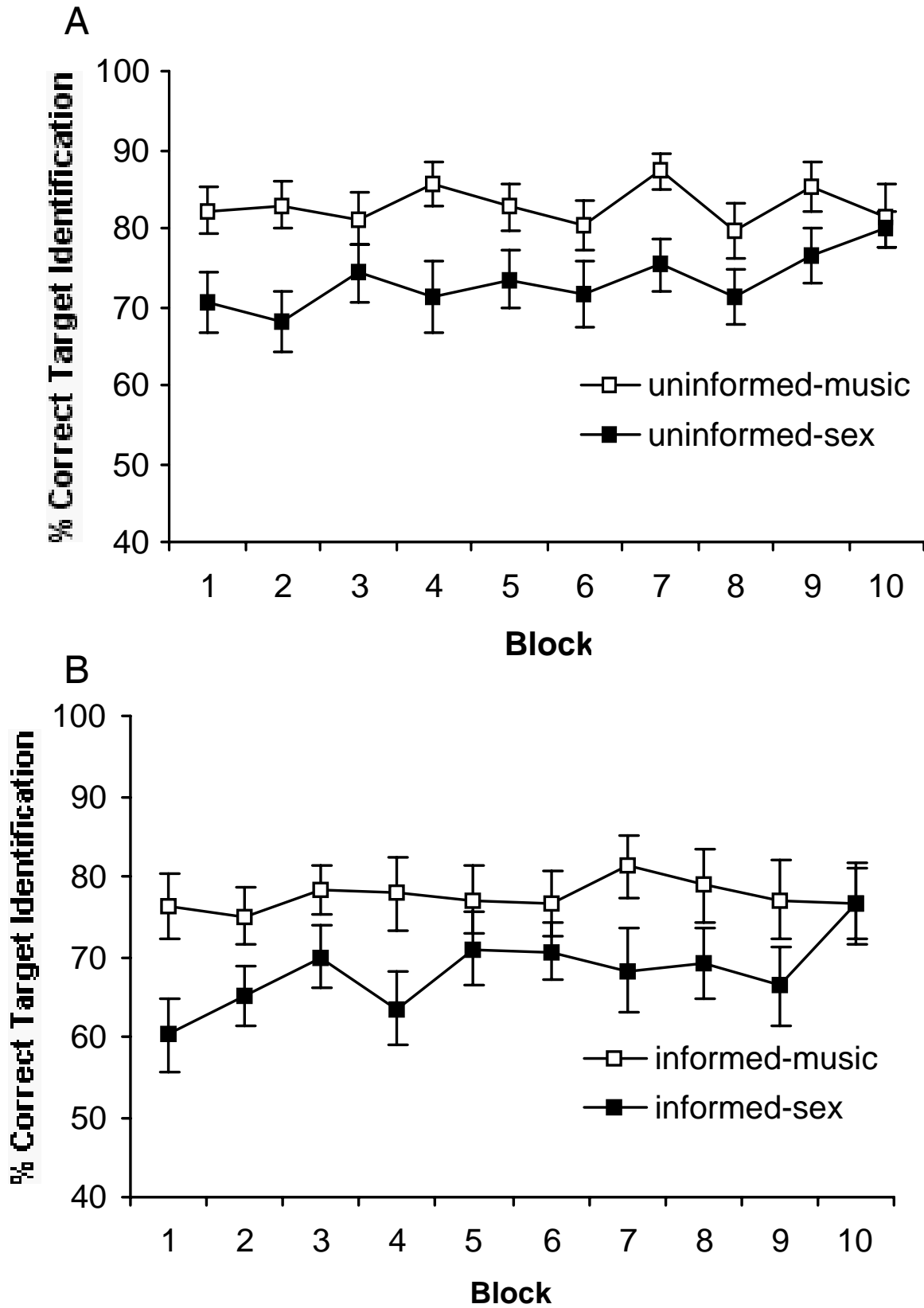
Appendix A

Critical Distractor Words for Experiment 1:

Neutral	Positive	Negative	Arousal
AISLE	BEAUTY	BROKEN	AIDS
BINDER	BIRTHDAY	DECAY	ASS
BLIMP	BOUQUET	DECLINE	BASTARD
BUTTER	CHAMP	DISMAY	BITCH
CARD	CHEER	DULL	CLITORIS
CHAT	FLOWER	FADED	COCK
CHEW	FRIENDLY	FAIL	DILDO
DAZZLE	FUN	FEEBLE	EROTIC
DESK	GLAD	GUILT	FIRE
FISH	GOLD*	NEGATIVE	FUCK
GEL	HAPPY	POORLY	GUN
GLOVE	HOLIDAY	PUNISH	INCEST
GUZZLE	JOYFUL	SAD	LESBIANS
HAGGLE	LEISURE	SLAVE	MURDER
JACKET	PRIZE	SLOB	NAKED
JUSTIFY	SKY	SUFFER	NAUGHTY
LOOP	SMART	TEDIOUS	NIPPLES
PLANET	SMILE	THIEF	ORGASM
RUFFLED	SUNNY	TIRED	ORGY
SPARE	SWEET	UNHAPPY	PENIS
STAPLE	TENDER	USELESS	PISS
VOTE	TREASURE	WEARY	RAPE
WIRE	VACATION	WEEP	SEXUAL
ZIPPER	WINNER	BROKEN	SHIT

- see footnote 1

Critical Distractors and Foils for Experiment 2:

Neutral	Positive	Sadness	Sexual/Taboo	Threat	Anxiety
AISLE	BEAUTY	BORING	ANUS	BEATEN	AFRAID
BINDER	BIRTHDAY	BROKEN	ASS	CANCER	ANXIETY
BUTTER	BOUQUET	CRY	BASTARD	CRASH	CONCERN
CABLE	CHAMP	DECAY	BITCH	CRISIS	CRITICISE
CARD	CHEER	DECLINE	BOOBS	DANGER	DISAPPOINT
CHAT	FLOWER	DEPRESSED	CLITORIS	DEATH	DISTRESS
CHEW	FRIENDLY	DISMAY	COCK	DISEASE	DREAD
COMPUTER	FUN	DREARY	DICK	FATAL	EMBARASSED
COTTON	GLAD	DULL	DILDO	GUN	EXAM
DESK	GOOD	FADED	EROTIC	HELL	FAIL
FISH	HAPPY	FEEBLE	FUCK	HORROR	FEAR
GEL	HOLIDAY	GLOOM	INCEST	HURT	FRET
GLOVE	HOME	GRIEF	LESBIANS	KILL	GUILT
GUZZLE	JOYFUL	LONELY	NAKED	MURDER	HUMILIATED
HAGGLE	LAUGH	MISERY	NAUGHTY	PAIN	LOSER
JACKET	LEISURE	PITY	NIPPLES	PANIC	MISTAKE
JUSTIFY	LOVE	SAD	ORGASM	POISON	NEGATIVE
LOOP	PRIZE	SORROW	ORGY	PUNISH	POORLY
PLANET	SMART	TEDIOUS	PENIS	RAPE	SLOB
RUFFLED	SMILE	TIRED	PISS	SCREAM	STUPID
SEND	SUNNY	TRAGIC	PUSSY	SICK	TEASED
STAPLE	SWEET	UNHAPPY	SEXUAL	SLAVE	TENSE
VOTE	TENDER	WEAK	SHIT	STABBED	TEST
WALK	TREASURE	WEARY	SLUT	SUFFER	UGLY
WIRE	VACATION	WEEP	TITS	TORTURE	USELESS
ZIPPER	WINNER		WHORE	WAR	WORRY

Foils					
STRAW	FATHER	ABANDON	CRAP	CHOKE	PATHETIC
TABLE	GIFT	SLOW	DAMN	CUT	REJECT
VIEW	MOTHER	SOB	RECTAL	KNIFE	UNPOPULAR