VISUAL COGNITION, 2008, 16 (2/3), 262–278

Psychology Press
Taylor & Francis Group

Don't look back: Retroactive, dynamic costs and benefits of emotional capture

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When people search for targets within rapid streams of images, irrelevant emotional distractors—relative to neutral distractors—spontaneously demand attention and impair subsequent target detection, an effect that can be likened to an emotion-induced "attentional blink". But what happens when emotional distractors appear *after* a target has already come and gone? Here, we describe new findings of retroactive emotion-induced effects on target awareness. First, emotion-induced impairments of target awareness extended even to targets that appeared immediately before emotional distractors (Experiment 1). Second, when targets preceded distractors by two items—rather than by one item—negative distractors led to *enhanced* target processing relative to when distractors were neutral (Experiment 2). In contrast, when a target appeared *after* an emotional distractor, target awareness was impaired regardless of whether it was the first or second subsequent item. These results potentially implicate separable impacts of emotion on target processing, which can be distinguished by their facilitatory versus disruptive effects and by their temporal dynamics.

Some things are more important to attend to than others. Given the choice between attending to a mobile phone conversation with one's spouse and the fact that one is going the wrong way down a one-way street, it is evident that one of these must take precedence: Oncoming traffic is more dire for one's well-being (depending on one's spouse) and therefore must receive its due. Of course, this assumes that we can usually control what we attend to, an assumption that is not always true. The requirements of a functional

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We thank Marvin Chun, Kim Curby, Jim Hoffman, Helene Intraub, Anna Papafragou, Paul Quinn, Nick Turk-Browne, and members of the University of Delaware cognitive brown-bag series for helpful comments and discussion.

http://www.psypress.com/viscog DOI: 10.1080/13506280701490062

attention system can seem paradoxical. On one hand, we must be able to focus and maintain attention in the face of distraction; otherwise, it would be difficult to accomplish even the most basic tasks. On the other hand, attention must also be distractible in case something vital to self-preservation unexpectedly occurs. Failures to attend to a stimulus lead not only to delayed reactions but also to failures to register the stimulus consciously even when it is right in front of our eyes (Chun & Marois, 2002; Mack & Rock, 1998; Most, Scholl, Clifford, & Simons, 2005; Most et al., 2001; Neisser & Becklen, 1975; Simons & Chabris, 1999).

Research on *attentional capture* has yielded important insights about conditions under which attention can shift without an individual's volition. Some stimulus properties, such as sudden onsets (Yantis & Jonides, 1984), motion signals (Franconeri & Simons, 2003), and salient, distinctive colours (Theeuwes, 1992, 1994), seem capable of attracting attention relatively automatically, although the degree of such automaticity has been a topic of debate within the literature (e.g., Folk, Remington, & Johnston, 1992). The features and events deemed most likely to capture attention have sometimes been discussed in terms of their adaptive significance (Franconeri & Simons, 2003; Yantis & Hillstrom, 1994), and this makes logical sense: An attention system wired to prioritize self-relevant information would confer substantial survival advantages. Consistent with such notions, attention appears preferentially to engage with particularly emotional stimuli. For example, in the "emotional Stroop" task, people tend to be slower to name the colour of emotional words than of neutral words (Pratto & John, 1991; Williams, Mathews, & MacLeod, 1996). Emotional stimuli even appear to guide attention when rendered undetectable through interocular suppression (Jiang, Costello, Fang, Huang, & He, 2006).

Recently, work from our lab showed that emotional distractors can engage attention so effectively that they impair awareness of subsequently appearing targets even when the targets share the same location as the distractors and represent the sole target of an observer's search (Most, Chun, Johnson, & Kiehl, 2006; Most, Chun, Widders, & Zald, 2005). The task involved a rapid serial visual presentation (RSVP) of pictures (100 ms/item): Each stream of images contained mostly upright landscape and architectural photographs but also one rotated image. On each trial, participants searched for the rotated image and reported its orientation. Although participants generally did well at this task, their accuracy dropped substantially when targets appeared soon after an emotionally aversive picture, relative to after an emotionally neutral picture, even though participants knew that these pictures were task-irrelevant. We dubbed this effect "attentional rubbernecking" (or "emotion-induced blindness"; Most et al., 2005a). Follow-up experiments revealed that arousing, emotionally positive pictures could induce similar effects (Most, Smith, Cooter, Levy, &

Zald, 2007), as could otherwise neutral pictures that participants had been conditioned to associate with startling bursts of white noise (Smith, Most, Newsome, & Zald, 2006). Similar effects have also been found with emotional words, although to a somewhat smaller degree (Arnell, Killman, & Fijavz, 2007; Barnard, Ramponi, Battye, & Mackintosh, 2005). In all cases, the emotional stimuli appear to induce spontaneous *attentional blinks* (Raymond, Shapiro, & Arnell, 1992).

The "attentional blink" typically occurs when participants look for two targets embedded within a RSVP stream; the term refers to the common finding that if the second target (T2) follows soon after the first target (T1), participants often can report T1 but not T2 (Chun & Potter, 1995; Nieuwenstein, 2006; Raymond et al., 1992). However, if the two targets are separated by enough time in the stream, participants can usually report both. According to an influential "two-stage" model, all items in the stream are processed in an initial target detection stage, during which transient representations are instantiated and briefly available for more elaborate processing (e.g., Potter, 1993). However, these representations fade rapidly if not immediately selected and structured meaningfully in a second *consolidation* stage, which is slow and capacity-limited; processing in this stage is thought to be necessary for conscious report (Chun & Potter, 1995). An attentional blink occurs if T2 appears while limited resources are busy consolidating T1, as without rapid entry into Stage 2 consolidation, representations of T2 decay or are overwritten by subsequent stimuli (Giesbrecht & Di Lollo, 1998; but see Giesbrecht, Bischof, & Kingstone, 2003).

Emotion-induced impairments of target detection within an RSVP stream ("attentional rubbernecking") are distinct from the most common versions of the attentional blink, where purposeful attention to T1 impairs perception of T2. Instead, in the emotion-induced version, participants search for only one target, and attentional engagement with an emotional distractor impairs target detection spontaneously. It is important to note that emotionally neutral but distinctive stimuli within a stream are also capable of inducing attentional blinks, especially when they contain properties that characterize targets (Folk, Leber, & Egeth, in press; Maki & Mebane, 2006; Spalek, Falcon, & Di Lollo, 2006). However, evidence suggests that emotional distractors induce target detection impairments over and beyond those caused by distinctive neutral distractors (Most et al., 2005a; Smith et al., 2006).

Although previous reports of attentional rubbernecking have tested a number of conditions, the temporal order of distractor and target has been constant, with the emotional distractor generally preceding the target. In part, this has been due to assumptions about the nature of the deficit: It makes intuitive sense to conceptualize the effect as forward feeding, with attentional prioritization of emotional stimuli leading to the temporary, *subsequent* unavailability of processing resources central to awareness. Such a mechanism would also be consistent with evidence that emotional stimuli cause attention to linger rather than draw attentional shifts in the first place (e.g., Fox, Russo, Bowles, & Dutton, 2001). However, this account potentially underestimates the impact of emotional stimuli; might emotional distractors gain such priority in the stream of visual processing that they impair perception of all temporally adjacent items regardless of whether they come before or after the emotional distractor? This intriguing possibility has some precedent. For example, when T2 immediately follows T1 in an attentional blink task, accuracy in reporting T1 decreases, suggesting some mutual competition between T1 and T2 (Chun & Potter, 1995). When presentation is extremely rapid (with SOAs ranging from 13 to 53 ms), detection of T2 is actually better than for T1; but as SOAs increase, the advantage shifts to T1, with this shift occurring when SOAs reach about 100 ms (Potter, Staub, & O'Connor, 2002). A two-stage model accommodating such findings suggests that when two items are detected in Stage 1, the first one to be identified gets selected for Stage 2. At extremely short SOAs, the appearance of T2 draws identification resources away from T1, leading to a benefit for T2; at longer SOAs, however, T1 has enough of a head start that it receives the advantage (Potter et al., 2002).

The literature contains even more direct hints suggesting that distractor emotionality might retroactively impair target detection: In a result reported tangentially, when participants actively sought two targets in a stream of words, they were somewhat worse at detecting T1 if T2 was both emotional and the very next item; in contrast, if T2 appeared two items later, detection of T1 was better when T2 was emotional (Anderson, 2005, Exp. 1). Interestingly, although the paper reporting this result contained several experiments, this particular pattern emerged only in the first experiment, and it may be that design changes to subsequent experiments (e.g., manipulating T2 emotionality, defining T1 and T2 by different properties, or increasing distractor heterogeneity) prevented robust replication of this possibly delicate effect. Thus, it will be noteworthy if such a pattern emerges in the current experiments, especially given that our participants were explicitly instructed to ignore emotional and neutral distractors.

EXPERIMENT 1

In order to assess whether emotional distractors impair perception of preceding targets, half the trials in Experiment 1 contained a target that appeared one item (100 ms) before the critical distractor. For comparison purposes, the remaining half of trials contained a target that appeared two items after the critical distractor; in previous experiments, robust disruption of target detection occurred at this lag.

Method

Participants. Participants were 26 students (ages 18–21; 18 females) from the University of Delaware. Each participated for course credit and gave informed written consent.

Materials and procedure. Stimuli were colour photographs: 56 emotionally aversive pictures, 56 emotionally neutral pictures, 56 scrambled versions of the aversive pictures, 210 upright landscape/architectural scenes, and 168 target images (84 landscape/architectural photos rotated 90 degrees to the left and right). Stimuli were 9.4 cm wide, 7.1 cm high, and were presented on a CRT monitor with a 99 Hz refresh rate via the Psychophysics Toolbox extensions for Matlab (Brainard, 1997; Pelli, 1997). Emotional and neutral pictures were drawn mostly from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2001) and were supplemented by similar pictures from publicly available sources (see Most et al., 2005a). Negative pictures were of people or animals and included graphic images of violence, distress, and medical trauma. The neutral pictures were balanced with the negative pictures for numbers of depictions of people and animals. Scrambled versions of the negative pictures served as controls, ensuring that behavioural differences elicited by negative and neutral conditions were due to emotionality of the pictures rather than low-level visual features such as colour. Scrambled-negative pictures were created by dividing each negative picture into an 8×6 grid of squares and randomly reordering the segments. Compensating for the fact that this scrambling introduced artificial junctions of features, all experimental stimuli—including target, nontarget, and distractor items—appeared with one-pixel lines at the sites where the segment junctions occurred in the scrambled pictures.

Experimental trials consisted of a rapid serial visual presentation (RSVP) of 12 images, each presented for 100 ms. Except for two images, all were upright landscape/architectural photographs; the remaining two images consisted of the critical distractor and the target stimulus. Depending on the trial, the fourth, sixth, or eighth stimulus was the critical distractor: an emotionally aversive, emotionally neutral, or scrambled version of one of the aversive pictures. The target stimulus was a landscape/architectural photo rotated 90 degrees to the left or right, which appeared either one item before or two items after the critical distractor (Lag-minus-1 and Lag 2, respectively; see Figure 1). At the end of each trial, participants pressed either the left-arrow key or the right-arrow key to indicate the rotation of the target.

Participants began with a short practice session that included no critical distractors or pictures from the actual experiment. Next, to ensure fully informed consent, they were shown samples of both negative and neutral distractors. Instructions emphasized that the rotated target would always be a landscape/architectural photo and that participants should ignore all pictures of people or animals. Forty-two trials were presented in each of four self-contained blocks, and within each block the computer randomized the order of trials as well as which pictures were paired with which lag.

Results and discussion

An overall 3 (distractor type: negative vs. neutral vs. scrambled) $\times$ 2 (lag: Lag-minus-1 vs. Lag 2) ANOVA revealed a main effect of distractor type, $F(2, 50) = 20.55$, $p < .001$, and of lag, $F(1, 25) = 5.89$, $p = .023$, as well as an interaction between them, $F(2, 50) = 5.86$, $p = .005$. Consistent with previous findings (e.g., Most et al., 2005a), participants' target-detection accuracy was significantly worse at Lag 2 when the critical distractor was emotionally negative rather than neutral or scrambled (negative: $M = 76.9$, $SD = 10.4$;

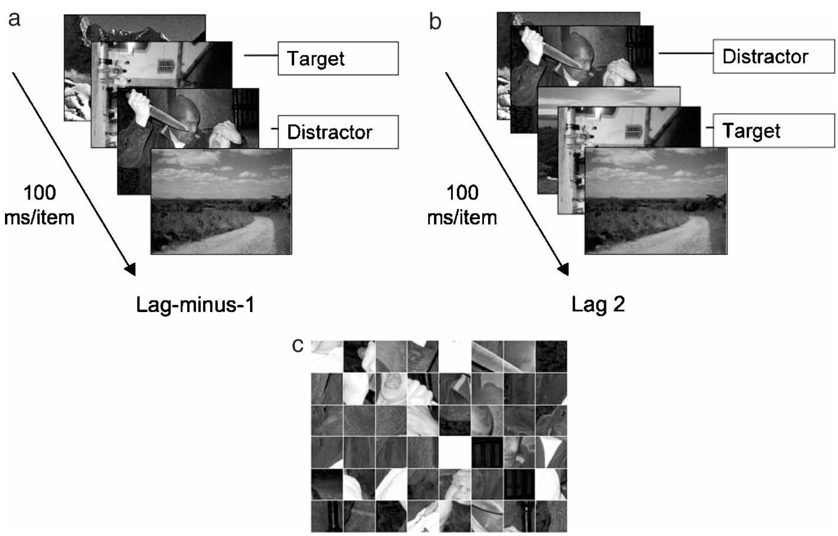

Figure 1. Sample segments of RSVP trials from (a) the Lag-minus-1 condition, in which targets preceded critical distractors by one item, and (b) the Lag 2 condition, in which targets followed critical distractors by two items. At bottom (c) is a scrambled version of a critical distractor with one-pixel background-coloured lines at the segment junctions. Note that all pictures were presented with lines at these locations regardless of whether they were targets, filler items in the stream, or scrambled or unscrambled critical distractors (these lines are not included in the first two parts of the figure for the sake of clarity).

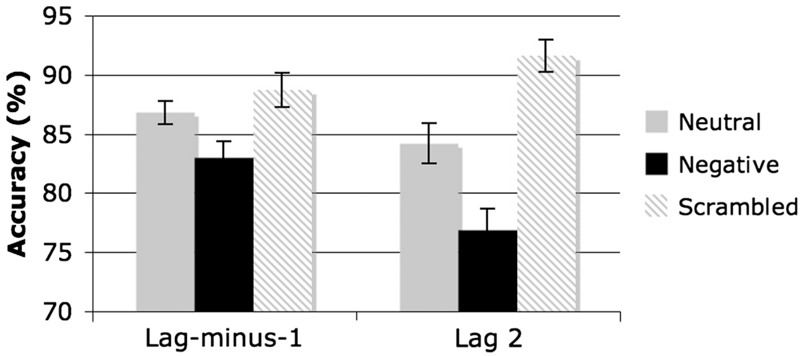

Figure 2. Mean accuracies with standard error bars from Experiment 1. At both Lag-minus-1 and Lag 2, accuracy in reporting the target substantially decreased when the critical distractor was a negative emotional picture versus a neutral or scrambled-negative picture.

neutral: $M = 84.2\%$, $SD = 9.2\%$; scrambled: $M = 91.6\%$, $SD = 5.5\%$). Importantly, this emotion-induced impairment was also present at Lag-minus-1 (negative: $M = 83.0\%$, $SD = 7.7\%$; neutral: $M = 86.8\%$, $SD = 6.5\%$; scrambled: $M = 88.7\%$, $SD = 7.5\%$; see Figure 2). Because accuracies were highest in the scrambled-negative condition, the relative deficit on emotional trials versus neutral trials cannot be explained by low-level differences such as colour or brightness.[1] Remaining analyses therefore focus on differences between negative and neutral conditions.

Accuracy in the presence of emotionally negative distractors was significantly worse than in the presence of neutral distractors at both Lag-minus-1, $t(25) = 2.60$, $p = .016$, and Lag 2, $t(25) = 2.79$, $p = .010$ (see Figure 2). In a 2 (distractor type: negative vs. neutral) $\times$ 2 (lag: Lag-minus-1 vs. Lag 2), the effect of valence did not interact with lag, $F(1, 25) = 2.08$, $p = .162$. Notably, the emotion-induced deficits (i.e., the accuracy difference between neutral and negative conditions) at Lag 2 and Lag-minus-1 were correlated with each other across individuals, $r = .43$, $p = .028$, suggesting potentially common processes underlying impairments at these lags (see Figure 4A).

The degree to which emotional distractors impaired awareness of immediately preceding targets is striking. These findings are consistent with a two-stage model of visual processing in which fragile representations of detected targets reside in a first-stage buffer before being selected for second-stage consolidation (Chun & Potter, 1995; Potter et al., 2002). One possibility is that when the target and the emotional distractor coexist within

[1] The fact that accuracies were highest in this condition is likely due to the fact that scrambled pictures, being mere jumbles of colours and features, respresented less of a category shift within the stream than did either negative or neutral distractors.

this buffer, the emotional material captures Stage 2 processing resources regardless of whether it came before or after the target, even when target-processing has received a 100 ms head-start (cf. Potter et al., 2002). An important implication is that stimulus emotionality is therefore extracted and recognized prior to Stage 2 identification. A subtly different, additional possibility is that emotional stimuli do not always need to compete directly with a target for Stage 2 resources in order to induce their effect; in some cases, they may disrupt attentional selection so that targets are more difficult to isolate from the stream of competing stimuli in general (e.g., Di Lollo, Kawahara, Ghorashi, & Enns, 2005). These possibilities are not mutually exclusive; the relative roles of such potential mechanisms may change depending on whether targets precede or follow emotional distractors, although the correlation between the emotion-induced effects at Lag 2 and Lag-minus-1 suggest a common underlying source for the impairments (Figure 4A). Although the current experiments were not designed to support one of these accounts over the other, but we may gain insight into viable mechanisms by probing additional temporal lags.

EXPERIMENT 2

Two separate issues are addressed in Experiment 2. First, noting inconsistencies between the retroactive emotion-induced impairment in Experiment 1 and evidence that emotional distractors can sometimes *enhance* processing of preceding targets (e.g., Anderson, Wais, & Gabrieli, 2006), we test whether such discrepancies can be reconciled by taking into account the stage of target processing during which an emotional distractor appears. For example, in one earlier experiment, when participants searched for two targets in an RSVP stream, accuracy in reporting T1 was worse when T2 was emotional, but only when T2 was the very next item in the stream. When T2 was the second item after T1, accuracy in reporting T1 actually improved if T2 was emotional relative to when it was neutral (Anderson, 2005, Exp. 1). Although this finding was not replicated by other experiments in the same paper—perhaps due to alterations to experimental design—it hints at potentially important mechanisms determining the impact of emotion on conscious perception. In Experiment 2, we attempt to replicate this pattern, testing whether to-be-ignored emotional distractors might retroactively enhance target perception when targets have had more of a chance to access consolidation resources.

We also investigated accuracy when the target immediately followed the critical distractor to assess whether the emotion-induced deficit in this paradigm exhibits what is known as Lag-1-sparing (Potter, Chun, Banks, & Muckenhoupt, 1998). Lag-1-sparing refers to a common finding from traditional attentional blink tasks, where detection of T2 is not impaired if it is the item immediately following T1 (e.g., Chun & Potter, 1995; Raymond et al., 1992). According to one extensive review of the literature, Lag-1-sparing typically occurs only when attending to T2 does not entail altering one's selection criteria from those required for detecting T1 (Visser, Bischof, & Di Lollo, 1999). When the demands of attending to T2 after attending to T1 involve shifting one's selection criteria, performance at Lag 1 is at least as poor as at Lag 2 (see also Potter et al., 1998). In the context of the current task, where participants search for only one target, absence of Lag-1-sparing might suggest that spontaneous attentional engagement with an emotional distractor can disrupt attentional control, in essence requiring participants to reestablish their attentional set to perform their search for subsequent targets.

Method

Participants. Participants were 33 University of Delaware students (ages 18–21; 18 females). Each participated for course credit and gave informed written consent. Overall accuracy of one participant was three standard deviations below that of other participants and her data were dropped from all subsequent analyses.

Materials and procedure. Materials and procedure were identical to those in Experiment 1, with a couple of notable exceptions. In contrast to Experiment 1, the target could appear either two items before the critical distractor (Lag-minus-2) or one item afterwards (Lag 1). Depending on the trial, the critical distractor could appear as either the fifth, seventh, or ninth item in the stream of 12 pictures.

Results and discussion

An overall 3 (distractor type: negative vs. neutral vs. scrambled) $\times$ 2 (lag: Lag-minus-2 vs. Lag 1) ANOVA revealed a main effect of distractor type, $F(2, 62) = 31.73$, $p < .001$, and of lag, $F(1, 31) = 71.54$, $p < .001$, as well as an interaction between them, $F(2, 62) = 25.18$, $p < .001$. The two lag conditions addressed somewhat different questions and are reported separately in the analyses below (see Figure 3). As in Experiment 1, accuracy was highest in the presence of scrambled-negative distractors (Lag-minus-2: $M = 92.8\%$, $SD = 8.1\%$; Lag 1: $M = 90.3\%$, $SD = 8.3\%$), and consistent with Experiment 1 and other studies where scrambled-negative distractors had minimal impact (Most et al., 2005a), we focus mostly on the negative and neutral conditions for the remainder of the analyses.

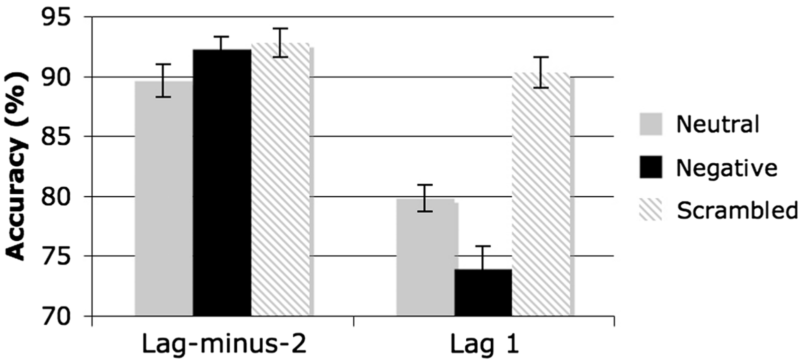

Figure 3. Mean accuracies with standard error bars from Experiment 2. At Lag-minus-2, accuracy in reporting the target was somewhat better when the critical distractor was emotionally negative rather than neutral. At Lag 1, there was a substantial emotion-induced impairment, with target report accuracy decreasing after an emotional distractor relative to after a neutral one.

In contrast to the retroactive emotion-induced deficit at Lag-minus-1 (in Experiment 1), at Lag-minus-2, accuracy in the negative emotional condition ($M = 92.3\%$, $SD = 7.2\%$) was somewhat better than accuracy in the neutral condition ($M = 89.6\%$, $SD = 7.8\%$), $t(31) = 2.36$, $p = .025$.[2] At Lag 1, accuracy was lowest of any lag across Experiments 1 and 2, and there was a robust difference between negative and neutral conditions (negative: $M = 73.9\%$, $SD = 9.9\%$; neutral: $M = 79.8\%$, $SD = 8.4\%$). This seems to suggest an absence of Lag-1-sparing, although we must note that the most convincing evidence for absent Lag-1-sparing would be a demonstration that, within individuals, performance at Lag 1 is no better than at Lag 2 or beyond. Importantly, though, target detection in both neutral and negative conditions was as bad or slightly worse at Lag 1 than it had been at Lag 2 in Experiment 1, between subjects $t(56) = 1.90$, $p = .06$, and $t(56) = 1.14$, $p = .26$, for neutral and negative conditions respectively. Furthermore, at Lag 1, there was a specific emotion-induced effect, with accuracy following a negative emotional distractor worse than accuracy following a neutral distractor, $t(31) = 3.24$, $p = .003$. Following from an extensive literature review (Visser et al., 1999), these Lag 1 results are consistent with the proposal that emotional distractors can briefly disrupt the maintenance or application of attentional set, which is necessary to single out a target from

[2] This emotion-induced enhancement at Lag-minus-2 did not cause performance to differ significantly from that in the scrambled-negative condition, $t(31) = 0.46$, $p = .645$, though this might be due to a ceiling effect. Future experiments may find that when performance is lowered from ceiling levels, emotion-induced enhancements at Lag-minus-2 boost accuracy above baseline; otherwise, one conclusion might be that such emotion-induced enhancements lie superimposed upon global impairments caused by the mere presence of a meaningful distractor.

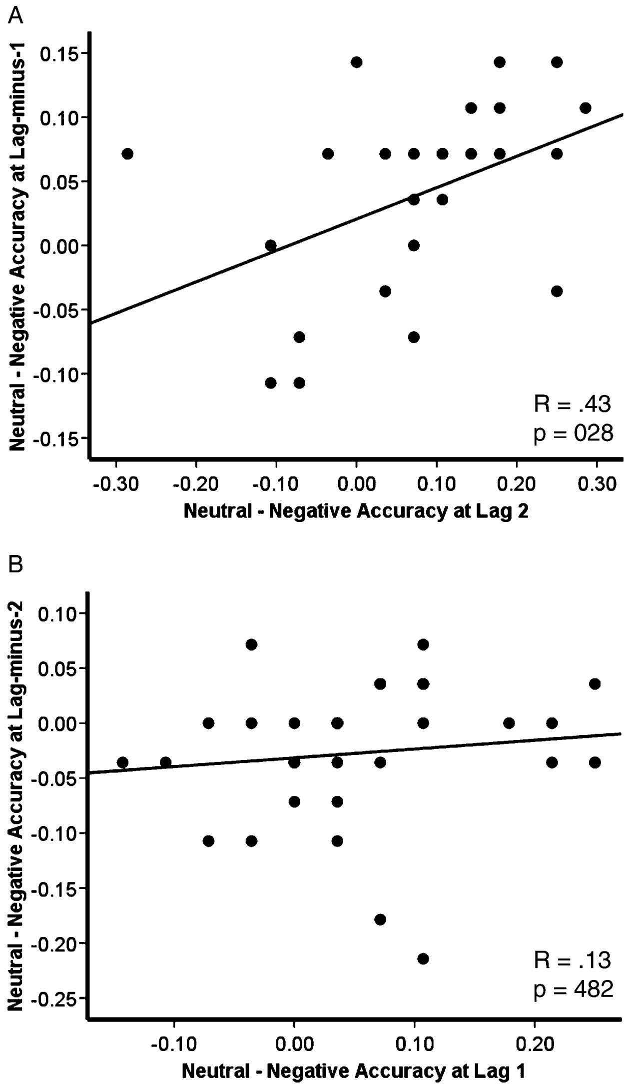

Figure 4. (A) In Experiment 1, the emotion-induced impairment at Lag 2 correlated significantly with the emotion-induced impairment at Lag-minus-1 across participants, suggestive of a potentially common underlying process. (B) In contrast, in Experiment 2, there appeared to be no relationship between the emotion-induced impairment at Lag 1 and the emotion-induced enhancement at Lag-minus-2.

temporally surrounding noise. Recovery from attentional rubbernecking, which typically occurs within 800 ms (Most et al., 2005a), might sometimes involve reestablishing attentional control. Such a mechanism might more likely underlie impairments for targets appearing after emotional distractors than for those appearing before emotional distractors, though it is conceivable that disruptions of attentional control could impair processing of preceding targets as well.

Notably, whereas the emotion-induced effects at Lag 2 and Lag-minus-1 (in Experiment 1) had been correlated with each other, no such relationship emerged between the two lags in the current experiment, $r = .13$, $p = .482$. The lack of such a correlation may suggest that the retroactive boost observed at Lag-minus-2 and the impairment seen at Lag 1 involve distinct mechanisms (see Figure 4B).

GENERAL DISCUSSION

Attentional allocation, as William James famously observed, often "implies withdrawal from some things in order to deal effectively with others" (1890/1983, p. 382). Research from recent decades has demonstrated that the consequences of attentional withdrawal include failures to notice stimuli even when they appear right in front of our eyes (Chun & Marois, 2002; Mack & Rock, 1998; Most et al., 2001; Most et al., 2005b; Neisser & Becklen, 1975; Simons & Chabris, 1999). Theoretically and practically, then, studies on attentional capture—the relatively involuntary allocation of attention to certain stimuli—can illuminate how the mind's prioritization and allocation of limited resources influences our awareness of the complex visual world.

It has frequently been observed that emotional stimuli are particularly robust in their ability to engage attention (Anderson & Phelps, 2001; Fox et al., 2001; Öhman, Flykt, & Esteves, 2001; Pratto & John, 1991). Consistent with such observations, studies using rapidly presented sequences of stimuli have found that explicitly task-irrelevant emotional items spontaneously impair subsequent awareness of even one's sole target, a phenomenon dubbed "attentional rubbernecking" (Most et al., 2005a). This effect has been interpreted as resulting from delayed disengagement from emotional distractors, as the induced impairment was observed after the emotional distractor had already come and gone (Most et al., 2005a; see also Fox et al., 2001). However, delayed disengagement from emotional distractors would not have predicted impairment for targets appearing immediately *before* an emotional distractor, an effect that emerged in Experiment 1. In contrast, in Experiment 2, when the target appeared two items—rather than one item—before the critical distractor, target detection was actually somewhat better if the distractor was emotional instead of neutral. This result is consistent with previously existing hints that emotional distractors confer dynamic costs and benefits to target detection, depending, in part, on the temporal lag between target and distractor (e.g., Anderson, 2005).

These retroactive effects fit well with a two-stage model of the attentional blink, which suggests that transient representations of stimuli co-exist within a high-capacity but fragile Stage 1 buffer and compete for low-capacity Stage 2 resources, through which they become consolidated, stabilized, and available for conscious report (Chun & Potter, 1995; Potter et al., 2002). Placed within this framework, target detection impairments can occur when emotional distractors themselves co-exist in Stage 1 with temporally adjacent targets, capturing Stage 2 resources even when processing of the target has received a 100 ms head-start. With Stage 2 resources allocated to the emotional stimuli, immediately adjacent target representations quickly deteriorate and escape awareness. In Experiment 2, where targets preceded emotional distractors by two items, the observed retroactive boost might also be consistent with a two-stage model: An intriguing possibility is that emotional distractors have a "dual-route" impact through which they impair aspects of target perception involving the maintenance or application of attentional selection while enhancing other aspects such as consolidation. When a target appears two items before an emotional distractor, the window critical for disrupting or usurping selection to Stage 2 may close before the distractor arrives, leaving only emotion-induced enhancement of consolidation processes to take effect. It is important that future studies further assess the possibility of such a dual-route impact. Notably, in the memory literature, substantial evidence suggests that postlearning arousal retroactively enhances memory consolidation (see Cahill & McGaugh, 1998). It may be that the effects of emotion are similar for consolidation into long-term memory and for the consolidation involved in perceptual awareness, although this link requires additional investigation.

Whereas the retroactive effects of emotional distractors on target awareness seem best explained by a two-stage account, impairments in detecting a target that appears *after* an emotional distractor are consistent with both a two-stage model and what is known as a "temporary loss of control" model (e.g., Di Lollo et al., 2005). The latter account would suggest that emotional distractors serve to disrupt the maintenance or application of attentional set, which otherwise would facilitate the selection of a target from nontargets in the stream. This account does fit well with our data suggesting absent Lag-1-sparing following an emotional distractor. For example, the profound emotion-induced impairments at Lag 1 are intriguingly consistent with findings that Lag-1-sparing disappears when the act of attending to one target after first attending to another item involves some shift of selection criteria (Visser et al., 1999), although conclusions stemming from our Lag 1 data must be confirmed through follow-up experiments in which performance at Lag 1 is compared to that at Lag 2 within individuals. Nevertheless, it may be telling that emotion-induced impairments appear to extend further forwards than backwards in time; although such an asymmetry does not necessarily implicate a different mechanism for forward feeding than for retroactive impairments—indeed, the Experiment 1 correlations between impairments at Lag 2 and Lag-minus-1 would suggest some degree of mechanistic overlap—it would be consistent with such a dissociation.

In what sense might the dynamic costs and benefits conferred by emotional distractors be attributed strictly to "attentional capture" by emotional stimuli? Consistent with the relatively involuntary nature of attentional capture, such emotion-induced effects seem to arise without participants' volition: In one study, attentional rubbernecking occurred despite a $90 incentive to detect targets (Most et al., 2007). However, because the emotional distractors in the current task were embedded within a stream already at the focus of attention, "capture" in this case would refer to manifestations other than the reflexive shifts of spatial attention typically implicated in traditional attentional capture research (e.g., Folk et al., 1992; Franconeri & Simons, 2003; Theeuwes, 1992, 1994; Yantis & Jonides, 1984). Instead, emotional distractors appear to break through attentional filters used to ignore neutral distractors at the spatial locus of attention. At least in some instances where emotional distractors impair target detection, emotional distractors might be said to have "captured" Stage 2 processing resources. Often, this is likely what underlies attentional rubbernecking, and some evidence indeed suggests that the emotional stimuli most likely to induce spontaneous attentional blinks are also those most likely to be remembered (Arnell et al., 2007). However, in cases where attentional rubbernecking might also be attributed to disruptions of attentional control (rather than competing with targets for consolidation resources), it is less clear whether the term "attentional capture" should apply; for example, one can imagine instances in which emotional distractors disrupt maintenance of attentional set in working memory despite receiving the same degree of attention that neutral distractors do. Future research should more clearly delineate the mechanisms implicated in attentional rubbernecking, as well as the phenomenon's relationship to more traditional forms of attentional capture. For example, given that distinctive neutral stimuli also appear capable of inducing spontaneous attentional blinks (Folk et al., in press; Maki & Mebane, 2006; Spalek et al., 2006), albeit perhaps less robustly than emotional stimuli (e.g., Most et al., 2005a; Smith et al., 2006), the retroactive effects of emotional distractors raise the question as to whether attentional capture by nonemotional items confers the same dynamic, retroactive costs and benefits to target processing. Investigation of such questions might determine the degree to which emotional stimuli affect conscious perception indirectly, through their impact on attention, and the degree to which they modulate visual awareness via a mechanism entirely their own.

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