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IN PRESS, *COGNITION*

Freeze or flee? Negative stimuli elicit selective responding

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## Abstract

Humans preferentially attend to negative stimuli. A consequence of this automatic vigilance for negative valence is that negative words elicit slower responses than neutral or positive words on a host of cognitive tasks. Some researchers have speculated that negative stimuli elicit a general suppression of motor activity, akin to the freezing response exhibited by animals under threat. Alternatively, we suggest that negative stimuli only elicit slowed responding on tasks for which stimulus valence is irrelevant for responding. To discriminate between these motor suppression and response-relevance hypotheses, we elicited both lexical decisions and valence judgments of negative words and positive words. Relative to positive words (e.g., *kitten*), negative words (e.g., *spider*) elicited slower lexical decisions but faster valence judgments. Results therefore indicate that negative stimuli do not cause a generalized motor suppression. Rather, negative stimuli elicit selective responding, with faster responses on tasks for which stimulus valence is response-relevant.

**KEYWORDS:** automatic vigilance; lexical decision; negative delay; stimulus valence; valence judgment.

Humans preferentially attend to negative stimuli, such as an image of a snake or the word “coffin”. This *automatic vigilance* for negative stimuli is presumed to facilitate the rapid detection—and ultimately, the avoidance—of hostile stimuli (Fazio, 2001; Lazarus, 1982; Neumann, Forster, & Strack, 2003; Zajonc, 1980). Indeed, many theorists have argued that aversion of threatening stimuli is more time-sensitive than attainment of appetitive stimuli (see Ito, Larsen, Smith, & Cacioppo, 1998; Smith, Cacioppo, Larsen, & Chartrand, 2003; Taylor, 1991). Pratto and John (1991) aptly characterized this position: “Averting danger to one’s well-being, such as preventing loss of life or limb, often requires an immediate response. In comparison, positively valenced activities, such as feeding and procreation, are less pressing; although they are of crucial importance in the long term, pleasure is simply less urgent than pain” (p. 380).

Automatic vigilance may operate via preferential engagement or delayed disengagement of attention. That is, negative stimuli may attract more attention (preferential engagement) or hold attention longer (delayed disengagement) than neutral or positive stimuli. To discriminate between these mechanisms, Fox, Russo, Bowles, and Dutton (2001) utilized a spatial cuing paradigm in which a cue stimulus (e.g., a negative, neutral, or positive word) appeared on either side of a central fixation, followed by a target stimulus that appeared at either the same location (valid trial) or the opposite location (invalid trial). Fox and colleagues found that valid cues facilitated target identification regardless of their valence, thus suggesting that negative stimuli do not engage attention any more than other stimuli. The valence of an invalid cue, however, did affect target identification. Specifically, targets at uncued locations were identified more slowly when the cue word was negative than when it was neutral or positive. Yiend and Mathews (2001; see also Tipples & Sharma, 2000) obtained the same result with image cues rather than word cues. Thus, attention is disengaged more slowly from negative stimuli than from other stimuli. Several other paradigms have

corroborated this finding. In the attentional blink paradigm, perception of a neutral image is less accurate when it is preceded by a negative image than when preceded by another neutral image (Most, Chun, Widders, & Zald, 2005). In the emotional Stroop paradigm, naming the color of a neutral word is slower when it is preceded by a negative word than when preceded by a neutral or positive word (McKenna & Sharma, 2004). These results provide convergent evidence that it is more difficult to disengage attention from negative stimuli than from other stimuli.

A consequence of this delayed disengagement is that negative stimuli tend to elicit relatively slow responding on a host of cognitive tasks. For instance, relative to neutral and positive words, negative words typically elicit slower color naming (McKenna & Sharma, 1995; Pratto & John, 1991; Williams, Mathews, & MacLeod, 1996), word naming (Algom, Chajut, & Lev, 2004; Estes & Adelman, in press), and lexical decisions (Estes & Adelman, in press; Wentura, Rothermund, & Bak, 2000). We will refer to this generally slowed responding to negative stimuli as a *negative delay*. Evidently, the sustained attention to negative valence disrupts the processing of other stimulus properties. In order to pronounce a word, to name its font color, or to judge its lexical status, one must disengage attention from its valence. And because attentional disengagement takes longer for negative stimuli than for other stimuli, responding tends to be slower to “snake” than to “bird”.

The reliable occurrence of a negative delay has led some researchers to speculate that negative stimuli may elicit a general suppression of motor activity, akin to the freezing response exhibited by animals under threat (Fox et al., 2001). That is, humans have “a general purpose defense mechanism that responds to threat by temporarily freezing all ongoing activity” (Algom et al., 2004, p. 325). Such a freezing response is assumed to be adaptive for minimizing the likelihood of detection by threatening stimuli. Essentially, upon encountering the proverbial tiger in the jungle, one’s most likely means of survival is to avoid being

detected by the tiger. According to this *motor suppression* hypothesis, all concurrent motor activities are suppressed upon presentation of a negative stimulus.

Research on animal behavior casts doubt on the motor suppression hypothesis. Although the sudden appearance of a threatening stimulus does sometimes cause immediate cessation of movement, other times it causes immediate defensive movement. For example, upon detection of a predator, marmoset monkeys move rapidly for cover before the motionless freeze (Ferrari & Lopes Ferrari, 1990; Searcy & Caine, 2003). In fact, many species exhibit distinct alarm calls to elicit either freezing or fleeing among group members. Bradbury and Vehrencamp (1998) distinguish alert signals, which cause receivers “to remain stationary and look around”, from flee alarms, which cause receivers “to rapidly disperse, run, or hide” (p. 603; see also Seyfarth & Cheney, 2003). Motor suppression may well facilitate the avoidance of detection, but it would also interfere with the equally critical reflex to flee from danger.

As an alternative to the motor suppression hypothesis, we suggest that responding to affective stimuli may depend on the type of task that the participant is undertaking. It may be that negative stimuli only elicit slowed responding on tasks for which stimulus valence is irrelevant for responding. As described above, in the color naming, word naming, and lexical decision tasks the participant must disengage attention from the valence of the stimulus in order to respond appropriately. So given the delayed disengagement from the negativity of a stimulus, responses to negative stimuli are slowed in these tasks (i.e., a negative delay occurs). Importantly, though, this *response-relevance* hypothesis predicts that the converse should also be observed: In tasks for which stimulus valence is response-relevant, attention need not be disengaged from valence, and hence the sustained attention to negative valence should actually speed responding to negative stimuli. For instance, if the task were to judge

the valence of the word (i.e., whether it is negative or positive), then negative words should elicit relatively fast responses since they maintain attention to their valence.

The experiment reported below was designed to discriminate between the motor suppression and response-relevance hypotheses. Following prior investigations of the negative delay (see above), the present study used words as stimuli. For the same set of negative words and positive words, we elicited both lexical decisions and valence judgments (between-participants).<sup>1</sup> If negative stimuli evoke a generalized motor suppression, then negative words should elicit slower responses than positive words in both tasks. Alternatively, the response-relevance account predicts that negative words should elicit slower lexical decisions but faster valence judgments than positive words, since attention must be disengaged from stimulus valence in the former task but not in the latter. Thus, the motor suppression account predicts a main effect of valence, whereas the response-relevance account predicts an interaction of valence and task.

### Method

*Participants.* Thirty-five undergraduates at the University of Georgia provided valence ratings, 28 provided arousal ratings, and 102 participated in the experiment proper. Each participant completed only one of these tasks. All participants were native English speakers, all had normal or corrected-to-normal vision, and all received partial course credit for participation.

*Stimuli.* Thirty-five participants rated the valence of randomly intermixed animal and artifact words. The scale ranged from 1 (“extremely negative”) to 5 (“extremely positive”). Twenty positive words and 20 negative words, matched for length in syllables ( $M_{\text{pos}} = 1.75$ ,  $SE = .14$ ;  $M_{\text{neg}} = 1.65$ ,  $SE = .17$ ;  $p = .65$ ) and Kucera-Francis frequency ( $M_{\text{pos}} = 5.55$ ,  $SE = 1.53$ ;  $M_{\text{neg}} = 4.90$ ,  $SE = 2.41$ ;  $p = .82$ ), were selected for use in the experiment proper. Valence ratings for positive ( $M = 3.58$ ,  $SE = .07$ ) and negative ( $M = 2.09$ ,  $SE = .07$ ) words

differed significantly [ $t(38) = 14.64, p < .001$ ]. Twenty-eight participants rated the arousal of each word on a scale from 1 (“not at all arousing”) to 5 (“very arousing”). Following the methodology of Bradley and Lang (1999), arousal was explained thus: “If a word is arousing, it reflects a state of feeling stimulated, excited, jittery, or wide-awake. If a word is not arousing, it reflects a state of feeling relaxed, calm, sluggish, or sleepy.” Arousal ratings were not correlated with valence ratings [ $r(40) = -.15, p = .37$ ], nor did the mean arousal rating differ significantly between the positive and negative valence conditions [ $M_{\text{pos}} = 2.41, SE = .14; M_{\text{neg}} = 2.82, SE = .15; t(38) = 1.99, p > .05$ ]. Thus, positive words and negative words differed in valence but not in length, frequency, or arousal. Stimuli are presented in Table 1.

*Procedure.* Participants initiated each trial by pressing the spacebar. After 500 msec, the stimulus appeared in red 16-point font centered on a black background. Item order was randomized, with a 1-second interval between trials. Participants in the valence condition indicated by keypress whether each word was positive or negative. The assignment of valence to key was counterbalanced across two experimental lists. Participants in the lexical condition indicated by keypress whether each letter string was a word or a nonword. This condition included 40 pronounceable nonwords (e.g., *revicle*). All participants were instructed to respond as quickly and accurately as possible.

## Results

Relative to positive words (e.g., *kitten*), negative words (e.g., *spider*) elicited slower lexical decisions but faster valence judgments. Response times and error rates are illustrated in Figure 1 (panels A and B respectively). Incorrect trials were removed from response time analyses, as were responses more than 2.5 standard deviations from the condition mean. Five participants who apparently reversed the response keys were excluded from analyses. Data were analyzed separately across participants ( $F_1$ ) and items ( $F_2$ ). A  $2 \times 2$  mixed ANOVA revealed a significant main effect of Task, with faster responses [ $F_1(1, 95) = 48.65, F_2(1, 38)$



= 250.78,  $p < .001$ ] and fewer errors [ $F_1(1, 95) = 19.16$ ,  $F_2(1, 38) = 46.36$ ,  $p < .001$ ] in the lexical decision task than in the valence judgment task. The main effect of Valence was nonsignificant in both analyses ( $p > .10$ ). Most importantly, response latencies exhibited a significant interaction [ $F_1(1, 95) = 47.49$ ,  $F_2(1, 38) = 28.54$ ,  $p < .001$ ]. Paired comparisons confirmed that relative to positive words, negative words elicited slower lexical decisions [ $F_1(1, 42) = 40.29$ ,  $F_2(1, 38) = 10.38$ ,  $p < .01$ ] but faster valence judgments [ $F_1(1, 53) = 22.74$ ,  $F_2(1, 38) = 6.84$ ,  $p < .05$ ]. The error rates exhibited the same interaction [ $F_1(1, 95) = 3.71$ ,  $p = .057$ ;  $F_2(1, 38) = 5.07$ ,  $p < .05$ ], though negative words and positive words did not differ reliably within either the lexical condition [ $F_1(1, 42) = 7.17$ ,  $p < .05$ ;  $F_2(1, 38) = 2.26$ ,  $p = .14$ ] or the valence condition (both  $p > .20$ ).<sup>2</sup>

### Discussion

The delayed responding to negative stimuli observed in many prior studies has been likened to a freezing response that minimizes detection by threatening stimuli (Algom et al., 2004; Fox et al., 2001). However, aversion of a threatening stimulus often requires quick action, such as fleeing or fighting, rather than freezing. Consistent with this observation, the present results suggest that negative stimuli do not cause a generalized motor suppression. Rather, negative stimuli elicit selective responding. On tasks for which valence is response-irrelevant, such as lexical decisions, attention must be disengaged from the valence of the stimulus. Because attention is disengaged more slowly from negative stimuli than from other stimuli (Fox et al., 2001; Yiend & Mathews, 2001), negative words evoke slow responding on such tasks (Algom et al., 2004; Estes & Adelman, in press; McKenna & Sharma, 1995; Pratto & John, 1991; Wentura et al., 2000). Tasks for which valence is response-relevant, in contrast, do not require attentional disengagement from the valence of the stimulus. Indeed, when overtly responding to stimulus valence, the motor system may be prepared for

immediate action, and hence negative words induce faster responding. Results therefore support the response-relevance account of automatic vigilance.

As described above, the differential results in the lexical decision and valence judgment tasks may be explained by a delayed disengagement mechanism (Fox et al., 2001; Yiend & Mathews, 2001). However, alternative explanations also remain viable. Indeed, any experiment that compares performance on different experimental tasks is inherently susceptible to post hoc explanations related to differences between those tasks. In the present experiment, one difference is task difficulty. The valence judgment task was notably more difficult, with slower and less accurate responding than the lexical decision task. It could be that the negative delay is reversed in any relatively difficult task, not just those for which valence is response-relevant. Another way to characterize the difference between tasks is in terms of whether they induce implicit or explicit processing of valence. According to this conception, valence is processed implicitly in the lexical decision task, but is processed explicitly in the valence judgment task. It may be that the negative delay is reversed in any task for which valence is processed explicitly.<sup>3</sup> Thus, although the present results do unequivocally reject the motor suppression hypothesis, they do not uniquely support the delayed disengagement explanation.

Automatic vigilance and the negative delay often have been demonstrated with verbal stimuli (e.g., Algom et al., 2004; Estes & Adelman, in press; McKenna & Sharma, 1995; Pratto & John, 1991; Wentura et al., 2000; Williams et al., 1996). An advantage of this approach is that the critical factors of word recognition are relatively well documented (see Balota, Cortese, Sergent-Marshall, Spieler, & Yap, 2004), and hence the stimuli can be controlled precisely. A disadvantage of this approach, however, is the limited face validity of verbal stimuli: Given that automatic vigilance often is explained in evolutionary terms, and given that object recognition evolved before word recognition, pictorial stimuli may provide a

more direct test of automatic vigilance. Of course, this observation raises the question of whether current models of automatic vigilance (and indeed the present results) will generalize to pictorial stimuli. In support of generalization, words and images typically do evoke similar patterns of results in studies of affective processing (e.g., Constantine, McNally, & Hornig, 2001; Fox et al., 2001; Huijding & de Jong, 2005; Kindt & Brosschot, 1997). Nevertheless, testing the response-relevance hypothesis with pictorial stimuli remains an important goal for further investigation.

Although the motor suppression hypothesis was not supported, its analogy between automatic vigilance in humans and anti-predator behavior in other species may yet prove fruitful. A number of ecological factors are known to influence anti-predator behavior in other species, such as the urgency of the threat (Leavesley & McGrath, 2005; Manser, Seyfarth, & Cheney, 2002) and the proximity of conspecifics (Di Blanco & Hirsch, 2006; Zuberbuhler, Noe, & Seyfarth, 1997). Moreover, predator avoidance may be manifest in various behaviors, such as alarm calling, freezing, perceptual vigilance, and rapid fleeing. Thus, research on animal behavior provides a rich array of potential factors and measures that ultimately may guide the development of an ecological model of how humans respond to negative stimuli.

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## Footnotes

1. Our choice of stimuli was motivated by a concern about arousal. Because neutral stimuli tend to be less arousing than negative stimuli, many studies that compare negative stimuli to neutral stimuli inadvertently confound valence with arousal. This potential confound is problematic because arousal significantly predicts response times (Estes & Adelman, in press). Thus, it is important to control arousal, but this is practically impossible with a large set of neutral and negative words. Positive words, in contrast, also tend to be arousing and therefore can be matched closely with negative words.
2. Because arousal ratings were correlated with response times in the valence judgment task [ $r(40) = -.46, p < .01$ ], response times were also submitted to a 2 (Valence)  $\times$  2 (Task) ANCOVA in which arousal was treated as a covariate. The main effect of arousal was nonsignificant [ $F(1, 37) = 2.97, p = .09$ ], and the critical Valence  $\times$  Task interaction remained significant [ $F(1, 37) = 22.00, p < .001$ ]. Arousal did not correlate with response times in the lexical decision task [ $r(40) = +.16, p = .34$ ], nor with error rates in either the lexical decision task [ $r(40) = -.20, p = .22$ ] or the valence judgment task [ $r(40) = +.05, p = .76$ ]. Thus, arousal cannot explain the present results.
3. We thank an anonymous reviewer for these alternative explanations.



**Table 1.** Stimuli.

Valence			
Positive		Negative	
buffalo	kitten	buzzard	rat
butterfly	owl	cigarette	roach
cow	puppet	crutches	shark
duck	puppy	garbage	skunk
eagle	squirrel	grenade	snake
elk	toothbrush	handcuffs	spider
floss	trapeze	harpoon	termite
goat	trophy	leech	tombstone
hammock	trout	litter	wasp
helmet	turkey	mosquito	weasel

**Fig. 1.** Response times and error rates ( $M \pm 95\% CI$ ) as a function of valence and task. A significant interaction occurred in both response times (Panel A) and error rates (Panel B).

