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A. Hunter Threadgill & Philip A. Gable

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Negative affect varying in motivational intensity influences scope of memory

A. Hunter Threadgill and Philip A. Gable

Department of Psychology, The University of Alabama, Tuscaloosa, AL, USA

ABSTRACT

Emotions influence cognitive processes involved in memory. While some research has suggested that cognitive scope is determined by affective valence, recent models of emotion–cognition interactions suggest that motivational intensity, rather than valence, influences these processes. The present research was designed to clarify how negative affects differing in motivational intensity impact memory for centrally or peripherally presented information. Experiments 1 & 2 found that, relative to a neutral condition, high intensity negative affect (anger) enhances memory for centrally presented information. Experiment 3 replicated this effect using another high intensity negative affect (threat). Experiment 4 extended this by finding that, relative to a neutral condition, low intensity negative affect (sadness) enhanced memory for peripherally presented information. Finally, in Experiment 5, the effects of sadness and threat on scope of memory were directly compared, finding that threat narrowed scope of memory, while sadness broadened scope of memory. Together, these results provide additional support for the motivational dimensional model of cognitive scope, in that high intensity emotions narrow cognitive scope, while low intensity emotions broaden cognitive scope.

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For the past 50 years, research has suggested that all positive affects broaden cognitive scope, while all negative affects narrow cognitive scope (Easterbrook, 1959; Fredrickson & Branigan, 2005). However, more recent research investigating motivational intensity suggests that motivational intensity, instead of affective valence, influences cognitive scope (Gable & Harmon-Jones, 2008, 2010a; Gable, Threadgill, & Adams, 2016). This work has shown that affects high in motivational intensity (such as desire, anger, and disgust) narrow cognitive scope, while affects low in motivational intensity (such as amusement and sadness) broaden cognitive scope (Gable & Harmon-Jones, 2008, 2011, 2016; Gable, Poole, & Harmon-Jones, 2015; Gable, Threadgill, et al., 2016; Kaplan, Van Damme, & Levine, 2012). While this work has shown that affects differing in motivational intensity impact a variety of cognitive domains, no research has examined whether negative affects diffing in motivational intensity influences scope of memory. The present research provides the first test of this idea.

Motivational intensity levels within negative affects

Negative affects vary in motivational intensity. Some negative affects are low in motivational intensity (sadness), whereas others are higher in motivational intensity (anger, fear, and disgust). Motivational intensity is the strength of an urge to move toward or away (Gable & Harmon-Jones, 2010a). Motivational intensity is related to subjective arousal, but, unlike arousal, motivational intensity has action implications, even if those intentions are vague (Gable & Harmon-Jones, 2013).

Research examining cognitive consequences of negative affects

Much research has shown that negative affects high in motivational intensity are associated with a narrowing

CONTACT A. Hunter Threadgill ahunterthreadgill@gmail.com, Philip A. Gable pagable@gmail.com
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of cognitive scope. Early work on emotion found that negative affect with high motivational intensity narrowed attentional focus. For example, Combs and Taylor (1952) found that threatening statements elicited significantly more errors and longer reaction times in a coding task. They reasoned that this occurred because the perception of threat to oneself narrowed the perceptual field of the individual. More recent studies have found that negative affects high in motivational intensity narrow attentional breadth (Gable et al., 2015; Gable & Harmon-Jones, 2010b), inhibit processing of non-target information (Finucane, 2011), and cause worse performance on creative tasks (Byron & Khazanchi, 2011).

Research examining negative affects low in motivational intensity is less abundant. Direct tests of motivation on breadth of attention demonstrate that sadness broadens attentional scope (Gable & Harmon-Jones, 2010b). Also, individuals are less susceptible to false memories of irrelevant information (Van Damme, Kaplan, Levine, & Loftus, 2016), suggesting that under sad states individuals have a broadened scope of memory. Other work suggests that negative affects low in motivational intensity, such as sadness, may broaden cognitive scope. For example, individuals with depression show more creativity (Andreasen, 1987) and a broadening of memory (von Hecker & Meiser, 2005). Together, this work indicates that negative affects low in motivational intensity broaden cognitive processing.

Negative affects high in motivational intensity may elicit narrowed cognitive scope to assist in goal perception and attainment. Presumably, these emotions narrow cognitive scope to information that is central to their goals, increasing the chance of successful goal accomplishment, such as seeking to remove an obstacle that provokes anger (Harmon-Jones, Gable, & Price, 2013). Additionally, a narrowed cognitive scope would be beneficial in threatening situations, as this would increase cognitive resources devoted to the threat (Kaplan et al., 2012). Conversely, negative affects low in motivational intensity may promote broadened cognitive scope because they assist with disengagement from futile goal pursuit (von Hecker & Meiser, 2005). This would allow the organism to become open to new and previously irrelevant possibilities, allowing the individual to seek other goal opportunities to be pursued (Carver, 2003). Additionally, one can reflect on why goal pursuit was unsuccessful, reassess or reintegrate goal pursuit, and increase the likelihood of successfully attaining future goals (Frijda, 1987; Kaplan et al., 2012).

The present experiments

While much research has been conducted examining how negative affects varying in motivational intensity influence attentional scope, no past work has examined how negative affects varying in motivational intensity alter scope of memory (i.e. central vs. peripheral). Based on past work examining the role of motivational intensity on attentional scope, motivational intensity is likely to influence breadth of memory. We predict that negative affects high in motivational intensity should cause better memory for centrally presented stimuli, compared to a neutral state. Meanwhile, negative affects low in motivational intensity should cause better memory for peripherally presented information, compared to a neutral state.

Experiment 1 focused on anger, a negative affect high in motivational intensity, in order to conceptually replicate past findings (Gable et al., 2015) using a novel memory task. Experiment 2 extended the findings of Experiment 1 by utilising a different engagement task in order to make sure that narrowing of memory was not a result of the engagement task. Experiment 3 extended the previous findings by examining a different negative affect high in motivational intensity (threat), to ensure that narrowing of memory found in Experiments 1 and 2 was caused by motivational intensity and was not due to the particular methods of manipulating affect or assessing scope of memory. Experiment 4 extended the previous experiments by focusing on sadness, a negative affect low in motivational intensity, in order to examine whether negative affect low in motivational intensity would elicit the predicted broadening effect. Finally, in Experiment 5, we directly compared threat and sadness to see if negative affects differing in motivational intensity have differential effects on breadth of memory. We predicted that negative affects high in motivational intensity, as compared to a neutral state, should cause better memory for centrally presented information. However, negative affects low in motivational intensity, as compared to a neutral state, should cause better memory for peripherally presented information.

In this initial examination of the effects of different negative affective states on memory, the physical location of stimuli was varied to be either central or peripheral. Consistent with past research, centrally presented information may be better remembered than peripherally presented information (Gable & Harmon-Jones, 2010c). We are primarily focused on testing the differences between an affective and neutral state on centrally (or peripherally) presented information.

Experiment 1

In order to conceptually replicate previous findings examining negative affect varying in motivational intensity and cognitive scope, in Experiment 1, we examined anger, an approach-motivated negative affect high in motivational intensity. Anger is a negative affect high in motivational intensity that occurs when goal pursuit is blocked (Carver & Scheier, 2008). Presumably, anger should cause a narrowing of cognitive scope as individuals shut out irrelevant stimuli in order to move towards an anger-evoking object.

Anger was manipulated using affective pictures. Then, participants may have been exposed to a neutral word on a computer screen presented either centrally or peripherally. Finally, participants responded to a flankers task. After all trials, participants completed a surprise recognition memory test. We predicted that anger pictures would cause better memory for centrally presented stimuli than neutral pictures.

Method

Seventy introductory psychology students participated in exchange for partial course credit. Data collection ended at the end of the semester in which the experiment was run.

Participants sat approximately 24 inches away from the computer monitor. Each trial ($n = 96$) began with an anger ($n = 48$) or neutral ($n = 48$) picture displayed in the centre of a computer monitor (2 s), followed by an interstimulus interval (ISI) of 500–1100 ms. Pictures were presented on a 23.5-inch computer monitor, using the entire screen. All pictures were displayed in 1024 × 768. Neutral pictures were drawn from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005).[1] Anger pictures were taken from the internet.[2] These pictures were chosen from a larger collection of images because pilot testing showed they evoked the most anger and have also been used in much previous research to evoke anger (Gable & Poole, 2014).[3] Anger pictures depicted anti-American scenes, such as flag-burning and 9/11 events. Past research has found that these same pictures elicit more anger than sadness, pride, determination, and fear (Gable et al., 2015), suggesting that the anger pictures primarily elicit approach-motivated anger, and not some other high intensity negative affect. Each picture was shown three different times.

In 40 trials, participants then saw a neutral word for 250 ms presented either centrally or peripherally. Centrally presented words were presented in the centre of the screen (10 central words presented after anger pictures and 10 central words presented after neutral pictures); peripherally presented words were presented in the centre of one of four quadrants around the screen (10 peripheral words presented after anger pictures and 10 peripheral words presented after neutral pictures). The visual angle of the peripherally-presented stimuli was ±20.08° (height) × ±20.08° (width). Participants were told that these words would be displayed but were unrelated to the task at hand. All words came from the Affective Norms of English Words (ANEW; Bradley & Lang, 1999).

Next, subjects were presented with a flankers task (Eriksen & Eriksen, 1974). Participants were instructed to indicate the direction of the centre arrow in a row of five arrows by pressing buttons marked left or right as quickly as possible. The flankers task was included to engage participants in the trials and to keep them focusing on the monitor during and after each picture. The flankers task had a visual angle of 1.19° (height) by 3.58° (width). ITI varied between 3 and 5 s. Four practice trials occurred at the beginning of the experiment (see Figure 1).

Following the completion of all trials, memory of the words was measured using a surprise recognition task (Gable & Harmon-Jones, 2010c). Participants viewed all 40 words from the experimental trials, as well as 40 new neutral foil words, one at a time. Participants indicated whether they remembered seeing the word during the task.

After all trials were completed, participants rated all pictures. Each picture was displayed for 2 s. Participants indicated their valence (1 = *positive*, 9 = *negative*) and arousal (1 = *excited*, 9 = *calm*; lower scores indicate that the picture was more arousing). One participant's ratings data was lost due to computer malfunction.[4]

Results

Picture ratings

Means and standard deviations for all ratings data across all experiments are presented in Table 1. A dependent-sample *t*-test revealed that anger pictures

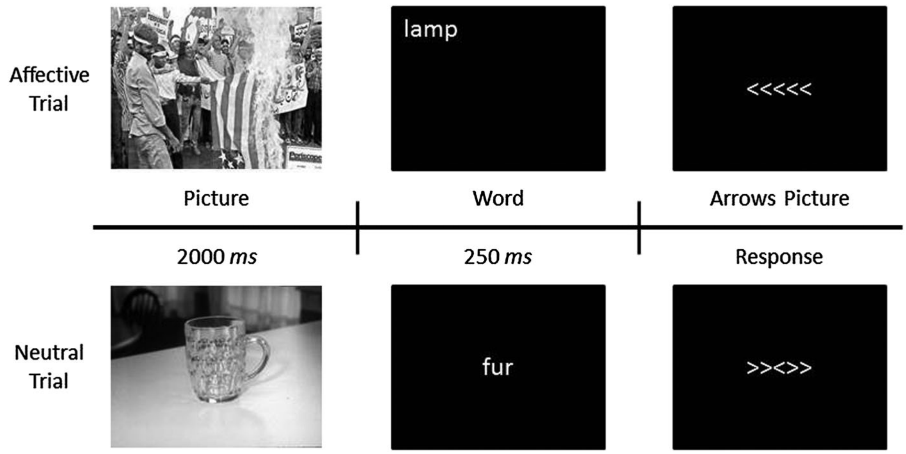

Figure 1. Experiment example trials.

Table 1. Means and standard deviations for picture ratings by picture type across all studies.

	Affective pictures		Neutral pictures	
Ratings	*M*	*SD*	*M*	*SD*
Experiment 1 (Anger)				
Valence	7.24	1.65	4.42	0.96
Arousal	5.28	2.30	7.26	1.56
Experiment 3 (Threat)				
Valence	7.51	0.96	4.00	1.23
Arousal	5.35	2.13	7.50	1.49
Threat	6.06	1.86	1.50	0.96
Down	5.42	2.04		
Sad	5.66	1.99		
Experiment 4 (Sad)				
Valence	6.39	1.22	4.06	1.11
Arousal	6.67	1.58	7.09	1.63
Sad	5.91	1.31	1.52	0.61
Threat	3.13	1.53		
Experiment 5 (Sad & Threat)				
Sad Condition				
Valence	6.67	1.16	4.14	0.86
Arousal	6.45	1.53	6.92	1.61
Sad	5.87	1.28	1.53	0.61
Threat	3.00	1.30		
Anger	2.67	1.48		
Threat Condition				
Valence	7.62	1.45	3.80	1.37
Arousal	4.95	2.11	7.37	1.41
Threat	6.35	1.43	1.56	0.69
Sad	5.83	1.62		
Anger	5.75	1.78		

Notes: Within each experiment, comparisons were made between affective and neutral pictures for valence, arousal, and the target emotion. For affective ratings that were not the target emotion, ratings were between levels of the target emotion and other affective states for affective pictures only. Scales: valence (1 = *positive*, 9 = *negative*), arousal (1 = *excited*, 9 = *calm*), and affective state ratings for Threat, Down, Sad, and Anger (1 = *no emotion*, 9 = *strongest feeling*).

were rated as more negative ($t(68) = 13.75$, $p < .001$) and arousing ($t(68) = -6.40$, $p < .001$) than neutral pictures.

Signal detection analysis

Because we wanted to make sure that answers to the surprise recognition task were due to actual memory, and not bias, chance, or confidence, we conducted a signal detection analysis to measure discriminability sensitivity between words shown centrally and peripherally after anger pictures and words shown centrally and peripherally after neutral pictures. To measure discriminability sensitivity, we calculated d', following the methods used in Pixton (2011). d' reflects the sensitivity of "'pure' memory processes" (Miller & Lewis, 1977, p. 84). First, the proportion of successful hits (i.e. successfully remembered words that appeared after all pictures and were presented centrally or peripherally) and false alarms (i.e. indicating that one remembered seeing a foil word that had not been shown before) were computed for each participant. If the proportions of hits or false alarms equalled 0, the proportion was converted to the quotient of $1/(2N)$, where N is the total number of trials per condition (10 for each word presentation and picture type combination and 40 for the foil words; Macmillan & Creelman, 1991). If the proportion of hits or false alarms equalled 1, the proportion was converted to the quotient of $1 - 1/(2N)$. Proportion scores were then z-transformed. Sensitivity (d') was calculated as $d' = z(\text{hits}) - z(\text{false alarms})$; higher

Table 2. Means and standard deviations for signal detection analyses (d') across all studies.

	Centrally presented words		Peripherally presented words	
d'	*M*	SD	*M*	SD
Experiment 1 (Anger)				
Anger	0.97	0.81	0.57	0.64
Neutral	0.63	0.75	0.47	0.76
Experiment 2 (Anger)				
Anger	1.00	0.82	0.52	0.82
Neutral	0.74	0.83	0.54	0.78
Experiment 3 (Threat)				
Threat	0.57	0.97	0.06	0.93
Neutral	0.14	0.92	−0.09	1.17
Experiment 4 (Sad)				
Sadness	1.10	0.77	0.91	0.68
Neutral	1.05	0.79	0.72	0.76
Experiment 5 (Sad & Threat)				
Sadness Condition				
Sadness	0.72	0.63	0.64	0.69
Neutral	0.71	0.65	0.46	0.65
Threat Condition				
Threat	0.96	0.81	0.71	0.77
Neutral	0.90	0.92	0.85	0.83
Difference Scores				
Sadness minus Neutral	0.01	0.48	0.18	0.49
Threat minus Neutral	0.06	0.50	−0.14	0.53

Note: Difference scores for Experiment were calculated as d' (affective) – d' (neutral).

scores indicate greater discriminability sensitivity. Means and standard deviations for all signal detection analyses across all experiments are presented in Table 2.

One participant's sensitivity score for one condition was removed because it was more than three standard deviations away from the mean. A 2 (picture type: anger vs. neutral) × 2 (word presentation: central vs. peripheral) ANOVA examining d' scores revealed a main effect of picture type, $F(1, 68) = 22.70$, $p < .001$, $\eta_p^2 = .25$, and word presentation, $F(1, 68) = 32.69$, $p < .001$, $\eta_p^2 = .32$. Finally, there was a significant interaction, $F(1, 68) = 4.61$, $p = .035$, $\eta_p^2 = .06$.

Follow up analyses indicated that d' was higher for centrally presented words after anger pictures than centrally presented words after neutral pictures, $t(68) = 4.17$, $p < .001$. Conversely, there was no difference in d' for peripherally presented words after anger pictures and neutral pictures, $t(68) = 1.47$, $p = .145$. Finally, d' was higher for both centrally presented words after anger pictures than peripherally presented words after anger pictures, $t(68) = 5.01$, $p < .001$, and for centrally presented words after neutral pictures than peripherally presented words after neutral pictures, $t(68) = 2.23$, $p = .029$.

Flankers task RTs

Reaction times were logarithmically transformed. Trials with incorrect responses or RTs more than 3 standard deviations from the mean for each stimulus were removed (3.38% of all trials). Additionally, three participants answered every flankers response incorrectly for at least one trial type and were removed from analyses. A 2 (picture type: anger vs. neutral) × 2 (flanker: congruent vs. incongruent) ANOVA examining flankers task RTs did not reveal a significant interaction, $F(1, 66) = 2.00$, $p = .162$, $\eta_p^2 = .03$.[5]

Discussion

As compared to a neutral state, anger, a high intensity negative state, caused better memory for centrally presented stimuli. Conversely, results indicated that there was no difference for memory of peripherally presented stimuli between anger and neutral states. Together, these results suggest that anger enhances central memory, relative to a neutral state.

Experiment 2

In Experiment 2, we sought to further replicate the effects of the previous experiment using a different engagement task. Specifically, we replaced the flankers task of Experiment 1 with a single arrow, to which participants indicated which direction the arrow was pointing. This change allowed us to test whether the peripheral arrows of the flankers task may have contributed to the observed outcomes on cognitive breadth (e.g. the flankers task may have narrowed cognitive scope by forcing participants to respond to the centre arrow). Similar to Experiment 1, we predicted that anger pictures would cause better memory for centrally presented stimuli than neutral pictures.

Method

Eighty-four introductory psychology students participated in exchange for partial course credit. Data collection ended at the end of the semester in which the experiment was run.

Procedures were identical to Experiment 1, with one exception: the flankers task was replaced with a simple arrow task (see Figure 2). Participants were instructed to indicate whether an arrow, presented in the centre of the monitor, was pointing to either the left or the right by pressing buttons marked left or right as

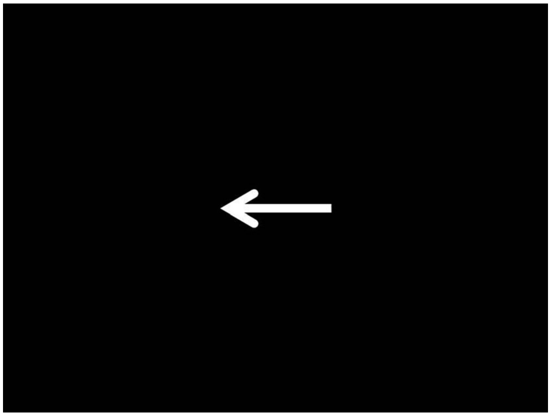

Figure 2. Experiment example arrow task.

quickly as possible. Participants indicated the direction the arrow was pointing based upon the edge of the arrows stimuli, as opposed to indicating the direction of the centre arrow in the flankers task. The size of the arrow stimuli was equivalent to the size of the flankers task stimuli; more specifically, the arrow had a visual angle of 1.19° (height) by 3.58° (width).

Results

Signal detection analysis

Procedures for calculating d' were identical to Experiment 1. One participant's sensitivity score for one condition was removed because it was more than three standard deviations away from the mean. A 2 (picture type: anger vs. neutral) × 2 (word presentation: central vs. peripheral) ANOVA examining d' scores revealed a main effect of picture type, $F(1, 82) = 8.07$, $p = .006$, $\eta_p^2 = .09$, and word presentation, $F(1, 82) = 43.74$, $p < .001$, $\eta_p^2 = .35$. Finally, there was a significant interaction, $F(1, 82) = 10.01$, $p = .002$, $\eta_p^2 = .11$.

Follow up analyses indicated that d' was higher for centrally presented words after anger pictures than centrally presented words after neutral pictures, $t(82) = 4.13$, $p < .001$. Conversely, there was no difference in d' for peripherally presented words after anger pictures and neutral pictures, $t(82) = -0.32$, $p = .747$. Finally, d' was higher for both centrally presented words after anger pictures than peripherally presented words after anger pictures, $t(82) = 6.96$, $p < .001$, and for centrally presented words after neutral pictures than peripherally presented words after neutral pictures, $t(82) = 2.97$, $p = .004$.

Arrows task RTs

Reaction times were logarithmically transformed. Trials with incorrect responses or RTs more than 3 standard deviations from the mean for each stimulus were removed (3.83% of all trials). Additionally, three participants answered every arrows response for at least one trial type incorrectly and were removed from analyses. A 2 (picture type: anger vs. neutral) × 2 (direction: left vs. right) ANOVA examining arrows task RTs did not reveal a significant interaction, $F(1, 80) = 0.73$, $p = .396$, $\eta_p^2 = .009$.[6]

Discussion

Results of Experiment 2 conceptually replicated the results of Experiment 1. As compared with a neutral state, anger, a high intensity negative affect, caused better memory for centrally presented stimuli. In contrast, results indicated that there was no difference for memory of peripherally presented stimuli between anger and neutral states. Across both studies, results indicate that the high intensity negative affect, anger, enhances central memory, compared to a neutral state.

Experiment 3

In order to conceptually replicate the previous findings, in Experiment 3, we examined threat, a withdrawal-motivated negative affect high in motivational intensity. Threat is a negative affect high in motivational intensity (Easterbrook, 1959). Presumably, threat should cause a narrowing of cognitive scope as individuals shut out irrelevant stimuli in order to withdraw from a threatening object. Accordingly, we predicted that threat pictures would cause better memory for centrally presented stimuli than neutral pictures.

Method

Fifty-nine introductory psychology students participated in exchange for partial course credit. Data collection ended at the end of the semester in which the experiment was run. Procedures were identical to Experiment 1, with one exception: all anger pictures were replaced with threat pictures. Threat pictures have been used in previous research to evoke the target emotion (Gable & Harmon-Jones, 2010b). Threat pictures depicted perilous situations, such as mutilated bodies, which could be a danger to individuals. These pictures were drawn from the IAPS.[7]

After all trials were completed, participants viewed all affective and neutral pictures and rated how each picture made them feel. Additionally, they also rated how disgusted, fearful, sad, and down each picture made them feel (1 = *no emotion*, 9 = *strongest feeling*). A threat index score was created by averaging fear and disgust ratings together for both threat pictures and neutral pictures. One participant's ratings data was lost due to computer malfunction.

Results

Picture ratings

A dependent-sample *t*-test revealed that threat pictures were rated as more negative ($t(56) = 16.37$, $p < .001$), arousing ($t(56) = -6.81$, $p < .001$), and threatening ($t(56) = 17.84$, $p < .001$) than neutral pictures. Threat pictures also elicited more threat than feelings of down ($t(56) = 5.68$, $p < .001$) and sadness ($t(56) = 3.87$, $p < .001$), suggesting that the threat pictures primarily evoked threat and not some other negative affect.

Signal detection analysis

Procedures for calculating d' were identical to the previous experiments. Three participants' sensitivity scores for at least one condition were removed because it was more than three standard deviations away from the mean. A 2 (picture type: threat vs. neutral) × 2 (word presentation: central vs. peripheral) ANOVA examining d' scores revealed a main effect of picture type, $F(1, 55) = 16.15$, $p < .001$, $\eta_p^2 = .23$, and word presentation, $F(1, 55) = 17.74$, $p < .001$, $\eta_p^2 = .24$. Finally, there was a significant interaction, $F(1, 55) = 3.24$, $p = .077$, $\eta_p^2 = .06$.

Follow up analyses indicated that d' was higher for centrally presented words after threat pictures than centrally presented words after neutral pictures, $t(55) = 4.44$, $p < .001$. Conversely, there was no difference in d' for peripherally presented words after threat pictures and neutral pictures, $t(55) = 1.33$, $p = .188$. Finally, d' was higher for centrally presented words after threat pictures than peripherally presented words after threat pictures, $t(55) = 4.71$, $p < .001$, and marginally higher for centrally presented words after neutral pictures than peripherally presented words after neutral pictures, $t(55) = 1.91$, $p = .061$.

Flankers task RTs

Reaction times were logarithmically transformed. Trials with incorrect responses or RTs more than 3 standard deviations from the mean for each stimulus were removed (2.59% of all trials). Additionally, two participants answered every flankers response for at least one trial type incorrectly and were removed from analyses. A 2 (picture type: threat vs. neutral) × 2 (flanker: congruent vs. incongruent) ANOVA examining flankers task RTs did not reveal a significant interaction, $F(1, 56) = 0.14$, $p = .706$, $\eta_p^2 = .003$.[8]

Discussion

In Experiment 3, high intensity withdrawal-motivated negative states narrowed scope of memory, as indicated by better memory for centrally presented stimuli following threat states than a neutral state. Conversely, results indicated that there was no difference for memory of peripherally presented stimuli between threat and neutral states. Together, these results suggest that threat enhances central memory, relative to a neutral state.

Experiment 4

The preceding experiments found that high motivational intensity negative affects narrow scope of memory. According to the motivational dimensional model of cognitive scope, low motivational intensity negative affects should have the opposite influence on scope of memory. Low motivational intensity negative affects should broaden scope of memory. No past research has directly examined how negative affects low in motivational intensity influence scope of memory. Experiment 4 was conducted to see if sadness, a low motivational intensity negative affect, broadens scope of memory. Such a result would support our conceptual model by showing that motivational intensity, not valence, causes changes in cognitive scope. We predicted that sadness pictures would cause better memory for peripherally presented stimuli than neutral pictures.

Method

One hundred thirty-nine introductory psychology students participated in exchange for partial course credit. We chose to sample more participants in Experiment 4 than Experiments 1–3 for three reasons: first, we predicted that sadness would elicit smaller effect sizes than anger or threat because sadness is low in motivational intensity (Gable & Harmon-Jones, 2010b). Second, emotion researchers have found difficulty in eliciting pure sadness in the lab (Rottenberg, Kovacs, & Yaroslavsky, 2017). Finally, sadness can have varying levels of motivational intensity and direction, thereby increasing variance in manipulations of sadness (Gray, Ishii, & Ambady, 2011). Consistent with other researchers, we hypothesised that only some of the participants would experience strong sadness in response to the picture stimuli (Martin, 1990; Westermann, Spies, Stahl, & Hesse, 1996).

We sought to strengthen our findings by focusing only on participants who experienced sadness from the sadness pictures. This is consistent with researchers proposing that we should only include participants who report an increase in the target affect, relevant to a neutral state (Rottenberg et al., 2017), and past work suggests that sadness emotion inductions elicit sadness in approximately 75% of participants (Martin, 1990; Westermann et al., 1996). Therefore, we created a sadness index difference score. This was done for both affective and neutral pictures by creating a difference score between sadness ratings to affective pictures and sadness ratings to neutral pictures. Individuals for whom ratings data were unavailable ($n = 8$) or whose sadness index scores were in the bottom quartile of the remaining participants ($n = 32$; $M < 1.93$) were excluded. Analyses were conducted for all participants who were in the top 75% of the sad index difference score ($n = 99$).[9]

Procedures were similar to Experiment 2. However, all affective pictures were sadness pictures drawn from IAPS.[10] These pictures have been used in previous research to evoke sadness (Gable, Neal, & Poole, 2016). All neutral pictures were the same as in Experiment 2. Additionally, 60 total words were presented (15 in each of the four conditions: 15 centrally presented words after sadness pictures, 15 peripherally presented words after sadness pictures, 15 centrally presented words after neutral pictures, 15 peripherally presented words after neutral pictures). One hundred-twenty total words (60 experimental trial words, 60 new neutral foil words) were shown during the word recognition task.

After all trials were completed, participants viewed all affective and neutral pictures and rated how each picture made them feel. Additionally, they also rated how sad, disgusted, and fearful each picture made them feel (1 = *no emotion*, 9 = *strongest feeling*). Seven participants' ratings data was lost due to computer malfunction, and one participants' data was removed for not following instructions.

Results

Picture ratings

A dependent-sample t-test revealed that sadness pictures were rated as more negative ($t(98) = 17.84$, $p < .001$), arousing ($t(98) = -3.21$, $p = .002$), and sad ($t(98) = 35.57$, $p < .001$) than neutral pictures. Finally, sadness pictures also evoked more sadness than threat ($M = 3.13$, $SD = 1.53$), $t(98) = 21.08$, $p < .001$, suggesting that sadness was the primary affect induced.

Signal detection analysis

Procedures for calculating d' were identical to the previous experiments. Three participants' sensitivity scores for at least one condition were removed because it was more than three standard deviations away from the mean. A 2 (picture type: sadness vs. neutral) × 2 (word presentation: central vs. peripheral) ANOVA examining d' scores revealed a main effect of picture type, $F(1, 96) = 10.04$, $p = .002$, $\eta_p^2 = .09$, and word presentation, $F(1, 96) = 48.01$, $p < .001$, $\eta_p^2 = .33$. Finally, there was a significant interaction, $F(1, 96) = 4.27$, $p = .042$, $\eta_p^2 = .04$.

Follow up analyses indicated that there was no difference in d' for centrally presented words after sadness pictures than centrally presented words after neutral pictures, $t(96) = 0.86$, $p = .391$. Conversely, d' was higher for peripherally presented words after sadness pictures than peripherally presented words after neutral pictures, $t(96) = 3.68$, $p < .001$. Finally, d' was higher for both centrally presented words after sadness pictures than peripherally presented words after sadness pictures, $t(96) = 3.58$, $p < .001$, and for centrally presented words after neutral pictures than peripherally presented words after neutral pictures, $t(96) = 6.42$, $p < .001$.

Arrows task RTs

Reaction times were logarithmically transformed. Trials with incorrect responses or RTs more than 3 standard deviations from the mean for each stimulus were removed (2.08% of all trials). Additionally, six participants answered every arrows response incorrectly for at least one trial type and were removed from analyses. A 2 (picture type: sadness vs. neutral) × 2 (direction: left vs. right) ANOVA examining arrows task RTs did not reveal a significant interaction, $F(1, 92) = 0.14$, $p = .713$, $\eta_p^2 = .001$.[11]

Discussion

Consistent with predictions, these results indicated that sadness pictures caused better memory for peripherally presented words than neutral pictures. The results of Experiment 4 extend the previous experiments by showing that sadness, a low intensity negative affect, broadens scope of memory, relative to a neutral state. This important extension reveals that negative affects varying in motivational intensity alter the scope of memory.

Experiment 5

Experiment 5 was conducted to see if a high intensity negative affect (threat) causes a narrowing of memory as compared to a low motivational intensity negative affect (sadness). In line with the previous studies, we predicted that threat pictures would cause better memory for centrally presented stimuli than neutral pictures, while sadness pictures would cause better memory for peripherally presented stimuli than neutral pictures. However, we also hypothesised that sadness pictures would cause better memory for peripherally presented stimuli than threat pictures, while threat pictures would cause better memory for centrally presented stimuli than sadness pictures.

Method

Two hundred introductory psychology students participated in exchange for partial course credit. For the reasons mentioned in Experiment 4, we sought to collect a large sample of participants in the sad condition and an equivalent sized sample in the threat condition (approximately 100 participants in each group). We utilised a between-subjects design by having participants randomly-assigned to view either sadness pictures ($n = 106$) or threat pictures ($n = 94$). Similar to Experiment 4, we sought to focus only on participants who experienced sadness from the sadness pictures and threat from the threat pictures. This was done by creating a difference score between the target emotion (sadness or threat) ratings to affective pictures and the target emotion (sadness or threat) ratings to neutral pictures. Participants for whom sadness ratings data were unavailable ($n = 21$) or whose sad index scores were in the bottom quartile of the remaining participants ($n = 21$; $M < 2.54$) were excluded. Analyses were conducted for all participants who were in the top 75% of the sadness index difference score ($n = 64$). Participants for whom threat ratings were unavailable ($n = 10$) or whose threat index scores were in the bottom quartile of the remaining participants ($n = 21$; $M < 2.22$) were excluded. Analyses were conducted for participants who were in the top 75% of the threat index difference score ($n = 63$). This left us with a final sample of 127 participants (64 in the sadness condition and 63 in the threat condition).[12]

The sadness condition utilised the same methods and procedures as Experiment 4. The threat condition mirrored the sadness condition, except sadness pictures were replaced with the threat pictures used in Experiment 3.

After all trials were completed, participants viewed all the affective and neutral pictures and rated how each picture made them feel. Additionally, they also rated how disgust, fearful, angry, down, and sad each picture made them feel (1 = *no emotion*, 9 = *strongest feeling*). Twenty-one participants in the sadness condition and 10 participants in the threat condition ratings data was lost due to either computer malfunction or the experiment period ending before they were collected.

Results

Picture ratings

In the sadness condition, a dependent-sample *t*-test revealed that sadness pictures were rated as more negative ($t(63) = 19.56$, $p < .001$), arousing ($t(63) = -2.68$, $p = .009$), and sad ($t(63) = 31.44$, $p < .001$) than neutral pictures. Additionally, sadness pictures also evoked more sadness than threat ($t(63) = 19.86$, $p < .001$) and anger ($t(63) = 19.24$, $p < .001$).

In the threat condition, threat pictures were rated as more negative ($t(62) = 18.07$, $p < .001$), arousing ($t(62) = -7.70$, $p < .001$), and threatening ($t(62) = 28.48$, $p < .001$) than neutral pictures. Finally, threat pictures elicited more threat than sadness ($t(62) = 3.66$, $p < .001$) and anger ($t(62) = 3.75$, $p < .001$).

Signal detection analysis

Procedures for calculating d' were identical to the previous experiments. One participant's sensitivity score in both conditions was removed because it was more than three standard deviations away from the mean. We used a 2 (affect: sadness vs. threat) × 2 (picture type: affective vs. neutral) × 2 (word presentation: central vs. peripheral) mixed-methods ANOVA to examine differences in d' scores, where affect was the between-subjects variable and both picture type and word presentation were within-subjects variables. Results revealed a significant interaction, $F(1, 123) = 8.47$, $p = .004$, $\eta_p^2 = .06$. This three-way interaction was unpacked by examining the 2 (picture type) × 2 (word presentation) interaction for d' both within and between the sadness and threat conditions.

Within the sadness condition, there was a main effect of both picture type, $F(1, 62) = 6.47$, $p = .013$, $\eta_p^2 = .09$, and word presentation, $F(1, 62) = 15.12$, $p < .001$, $\eta_p^2 = .20$. Finally, there was a marginally significant interaction, $F(1, 62) = 3.13$, $p = .082$, $\eta_p^2 = .05$.

Follow up analyses indicated that there was no difference in d' for centrally presented words after sadness pictures than centrally presented words after neutral pictures $t(62) = 0.24$, $p = .815$. Conversely, d' was higher for peripherally presented words after sadness pictures than peripherally presented words after neutral pictures, $t(62) = 2.97$, $p = .004$. d' scores were not different between centrally presented words after sadness pictures and peripherally presented words after sadness pictures, $t(62) = 1.56$, $p = .123$, but were higher for centrally presented words after neutral pictures than peripherally presented words after neutral pictures, $t(62) = 3.43$, $p = .001$.

Within the threat condition, there was not a main effect of picture type, $F(1, 61) = 0.63$, $p = .431$, $\eta_p^2 = .01$; however, there was a main effect of word presentation, $F(1, 61) = 9.35$, $p = .003$, $\eta_p^2 = .13$. Finally, there was a significant interaction, $F(1, 61) = 5.71$, $p = .020$, $\eta_p^2 = .09$.

Follow up analyses indicated that there was no difference in d' scores between centrally presented words after threat pictures and centrally presented words after neutral pictures, $t(61) = 0.99$, $p = .324$. However, d' scores were lower for peripherally presented words after threat pictures than peripherally presented words after neutral pictures, $t(61) = -2.09$, $p = .041$. d' scores were higher for centrally presented words after threat pictures than peripherally presented words after threat pictures, $t(61) = 3.94$, $p < .001$. There was no difference in d' scores between centrally presented and peripherally presented words after neutral pictures, $t(61) = 0.71$, $p = .482$.

We then examined how affective states high and low in motivational intensity differ in sensitivity scores. First, to control for individual differences in memory, difference scores were created between d' scores for centrally presented words recognised after affective pictures and d' scores for centrally presented words recognised after neutral pictures, as well as between d' scores for peripherally presented words after affective pictures and d' scores for peripherally presented words after neutral pictures. Higher scores indicate better discriminability sensitivity for centrally or peripherally presented words following affective pictures. One participant's sensitivity score in both conditions was removed because it was more than three standard deviations away from the mean.

A 2 (affect) × 2 (word presentation) mixed-methods ANOVA revealed a main effect of affect, $F(1, 123) = 4.80$, $p = .030$, $\eta_p^2 = .04$; however, there was not a main effect of word presentation, $F(1, 123) = 0.08$, $p = .776$, $\eta_p^2 = .0006$. Finally, there was a significant interaction, $F(1, 123) = 8.47$, $p = .004$, $\eta_p^2 = .06$.

Follow up analyses indicated that there was no difference in d' scores for centrally presented words after sadness pictures and threat pictures, $t(123) = -0.55$, $p = .581$. However, peripherally presented words after sadness pictures had higher d' scores than peripherally presented words after threat pictures threat pictures, $t(123) = 3.54$, $p < .001$. d' scores were marginally lower for centrally presented words after sadness pictures than peripherally presented words after sadness pictures, $t(62) = -1.77$, $p = .082$. Conversely, centrally presented words after threat pictures had higher d' scores than peripherally presented words after threat pictures, $t(61) = 2.39$, $p = .020$.

Arrows task RTs

Reaction times were logarithmically transformed. Trials with incorrect responses or RTs more than 3 standard deviations from the mean for each stimulus were removed (2.5% of all trials). One participant in the threat condition answered every arrows response incorrectly for at least one trial type and was removed from analyses. A 2 (affect: sadness vs. threat) × 2 (picture type: affect vs. neutral) × 2 (direction: left vs. right) ANOVA did not reveal a significant interaction, $F(1, 124) = 2.17$, $p = .143$, $\eta_p^2 = .02$.[13]

Discussion

Consistent with the previous experiments, these results indicated that sadness pictures caused a broadening of memory, as indicated by better memory for peripherally presented words, compared to neutral pictures. However, threat pictures reduced broadening of memory, as indicated by reduced memory for peripherally presented words, compared to neutral pictures. Finally, when controlling for baseline memory, threat pictures reduced broadening of memory, as indicated by reduced memory for peripherally presented words, compared to sadness pictures. The results of Experiment 5 extend the previous experiments by showing that sadness, a low intensity negative affect, broadens scope of memory, relative to a neutral state, while threat, a high intensity negative affect narrows scope of memory, relative to a neutral state. This important extension reveals that high and low intensity negative affects have a differential effect on scope of memory.

General discussion

The present results indicate that high intensity negative affect enhances memory for centrally presented stimuli. In Experiment 1, anger, a negative affect high in motivational intensity, was found to improve memory for centrally presented stimuli. Experiment 2 replicated the results of Experiment 1 using a different engagement task. Experiment 3 demonstrated that threat, another high intensity negative affect, also improved memory for centrally presented stimuli. Experiment 4 extended this work, finding that the low intensity negative affect sadness enhanced memory for peripherally presented stimuli. In Experiment 4, sadness improved memory for peripherally presented stimuli. Finally, in Experiment 5, a direct comparison of negative affects high and low in motivational intensity (i.e. threat and sadness, respectively) found that threat and sadness differentially impacted scope of memory. Threat caused a narrowing of memory, while sadness caused a broadening of memory. These results provide the first evidence that negative affects varying in motivational intensity have diverse effects on breadth of memory.

Together, these results are consistent with the motivational dimensional model of cognitive scope, which posits that emotion–cognition interactions are not dependent on affective valence, but motivational intensity. The present studies build upon past research by examining the role of negative affect varying in motivational intensity on scope of memory. The current results conceptually replicate past studies which found that negative and positive affects high in motivational intensity narrow attention (Gable et al., 2015; Gable & Harmon-Jones, 2008, 2010b), whereas negative and positive affects low in motivational intensity broaden attention. Taken together with research examining the effect of motivational intensity of positive affects on memory (Gable & Harmon-Jones, 2010c), the current results support that affects high in motivational intensity narrow scope of memory, while affects low in motivational intensity broaden scope of memory, regardless of valence.

Emotions not only vary in motivational intensity, but also in motivational direction, ranging from approach (the impetus to move towards an object) to withdrawal (the impetus to move away from an object; Gable, Neal, et al., 2016). While motivational direction appears to have no direct influence on breadth of cognitive scope, the effect of motivational direction and intensity *together* on cognitive breadth presents unique implications for their adaptive functioning. Functionally, a narrowing of scope of memory (and cognitive scope in general) in high intensity, approach-motivated states, such as anger, may assist individuals in remembering what actions resulted in successful or unsuccessful goal pursuit in the past. Narrowing the scope of memory in high intensity, withdrawal-motivated states, such as disgust and fear, may prove beneficial in remembering what actions lead to a decreased likelihood of succumbing to some threat. Regardless of motivational direction, negative affective states high in motivational intensity presumably lead to more successful goal accomplishment, regardless of whether it is to move toward or away from some object.

Some research has found that sadness, relative to a neutral state, may actually narrow cognitive scope (Storbeck & Clore, 2005). However, we propose that this may be because the effect of sadness on cognitive scope depends on whether the induced sadness is lower or higher in motivational intensity. For example, sadness caused by social loss led to an increased desire to engage in social situations (high motivational intensity), while sadness due to failure led to inaction (low motivational intensity; Gray et al., 2011). Also, work from our own lab (Gable, Neal, et al., 2016) has found that individual can experience approach or withdrawal-motivated sadness. This variation in motivational intensity and direction within sadness may serve adaptive functions. When goal attainment is irrevocably lost, organisms can withdraw from the situation and assess why goal pursuit may or may not have been successful, reflecting on what actions and outside influences that were previously unnoticed led to failure to attain the goal. However, when motivation is adaptive to goal attainment, such as seeking social support, individuals can reflect on who may be the best source of comfort in that particular situation, leading to an organism to pursue support from that individual (Gray et al., 2011).

Some past work has suggested that emotional arousal enhances both the perception and encoding of central stimuli (Levine & Edelstein, 2009; Mather & Sutherland, 2011). However, it is unlikely that arousal in negative affect states is causing narrowing or broadening of memory as observed in the current studies. Consistent with prominent theories of emotion, we view motivational intensity as being closely related to the arousal level of affective states (Bradley & Lang, 2007), but these components have a distinct effect on cognitive breadth. For example, arousal created through physical exercise does not cause a narrowing of cognitive scope (Gable & Harmon-Jones, 2013). Such results suggest that motivational intensity, rather than arousal, is driving broadening and narrowing effects of cognitive scope. Furthermore, in Experiment 4, participants indicated that sadness pictures elicited greater levels of arousal than neutral pictures. However, in spite of sadness pictures eliciting more arousal than neutral pictures, participants exhibited greater memory for words presented peripherally after sadness pictures than after neutral pictures.

While previous models of emotion–cognition interactions have suggested that all negative affects narrow cognitive scope and positive affects broaden cognitive scope, the current results demonstrate for the first time that negative affects varying in motivational intensity differentially affect scope of memory. In our studies, high intensity negative affects caused better memory for centrally presented stimuli, while low intensity negative affects caused better memory for peripherally presented stimuli. Together with past findings, these results support the motivational dimensional model of cognitive scope, in that motivational intensity, rather than affective valence, influences scope of cognition. Future research should incorporate measures of motivational intensity when examining emotion–cognition relationships.

Notes

1. Neutral IAPS picture numbers: 2190, 2215, 2393, 2506, 2513, 2516, 2620, 2850, 5535, 5731, 5740, 7090, 7140, 7187, 7233, and 7493.
2. All pictorial stimuli and memory words used across all studies are provided in an online supplementary file.
3. On a scale of 1 (*no feeling*) to 9 (*strongest feeling*), pilot testing in a sample of 28 participants revealed that anger pictures ($M = 4.84$, $SD = 2.27$) elicited more anger than neutral pictures ($M = 1.24$, $SD = 0.30$), $t(27) = 9.12$, $p < .001$. In a separate sample of 65 participants, further testing also revealed that anger pictures elicited more anger ($M = 6.31$, SD = 2.21) than feelings of threat ($M = 6.07$, SD = 2.15; $t(64) = 2.54$, $p = .013$) and down ($M = 5.86$, $SD = 2.11$; $t(64) = 4.36$, $p < .001$).
4. The spreadsheets containing the data used for statistical analyses for all studies are available online at https://osf.io/q6uke/ (doi:10.17605/OSF.IO/Q6UKE).
5. We wanted to see if the same pattern of results as the flankers task reaction times analyses occurred when examining error rates for the flankers task. Error rates were calculated for each trial type by dividing the number of trials correctly answered by the total number of trials for that trial type (congruent and incongruent flankers following anger pictures and congruent and incongruent flankers following neutral pictures). A 2 (picture type: anger vs. neutral) × 2 (flanker: congruent vs. incongruent) ANOVA examining flankers task error rates did not reveal a significant interaction, $F(1, 66) = 0.52$, $p = .473$, $\eta_p^2 = .008$.
6. A 2 (picture type: anger vs. neutral) × 2 (direction: left vs. right) ANOVA examining arrows task error rates did not reveal a significant interaction, $F(1, 80) = 0.54$, $p = .465$, $\eta_p^2 = .007$.
7. IAPS picture numbers: threat pictures (1300, 2811, 3005, 3051, 3150, 3250, 3400, 3550, 6260, 6360, 6510, 6560, 9300, 9400, 9430, 9902); neutral pictures (2397, 2880, 5390, 5534, 7035, 7039, 7150, 7161, 7179, 7192; additionally, six pictures were used from the internet and were chosen from a larger collection of images because pilot testing showed they evoked no emotion).
8. A 2 (picture type: threat vs. neutral) × 2 (flanker: congruent vs. incongruent) ANOVA examining flankers task error rates did not reveal a significant interaction, $F(1, 56) = 0.97$, $p = .329$, $\eta_p^2 = .02$.
9. Analyses including all participants revealed that the interaction was still significant, $F(1, 133) = 4.35$, $p = .039$, $\eta_p^2 = .03$.
10. Sadness IAPS picture numbers: 2205, 2455, 2490, 2590, 2700, 2795, 3300, 9000, 9001, 9190, 9220, 9331, 9341, 9390, 9471, and 9912.
11. A 2 (picture type: sadness vs. neutral) × 2 (direction: left vs. right) ANOVA examining arrows task error rates did not reveal a significant interaction, $F(1, 92) = 0.11$, $p = .746$, $\eta_p^2 = .001$.
12. Analyses including all participants revealed that the 2 (picture type: target emotion vs. neutral) × 2 (word presentation: central vs. peripheral) ANOVA interaction was significant in the threat condition, $F(1, 93) = 6.73$, $p = .011$, $\eta_p^2 = .07$. However, the interaction in the sadness condition was not significant, $F(1, 103) = 1.53$, $p = .219$, $\eta_p^2 = .01$. This likely occurred because not all of the participants were experiencing the target emotion.
13. A 2 (affect: sadness vs. threat) × 2 (picture type: affect vs. neutral) × 2 (direction: left vs. right) ANOVA examining

arrow task error rates revealed a marginally significant interaction, $F(1, 124) = 2.96$, $p = .088$, $\eta_p^2 = .02$.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

A. Hunter Threadgill http://orcid.org/0000-0003-3620-5959

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