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Negativity bias in false memory: moderation by neuroticism after a delay

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\textbf{ABSTRACT}

The negativity bias is the tendency for individuals to give greater weight, and often exhibit more rapid and extreme responses, to negative than positive information. Using the Deese-Roediger-McDermott illusory memory paradigm, the current study sought to examine how the negativity bias might affect both correct recognition for negative and positive words and false recognition for associated critical lures, as well as how trait neuroticism might moderate these effects. In two experiments, participants studied lists of words composed of semantic associates of an unpresented word (the critical lure). Half of the lists were comprised of positive words and half were comprised of negative words. As expected, individuals remembered negative list words better than positive list words, consistent with a negativity bias in correct recognition. When tested immediately (Experiment 1), individuals also exhibited greater false memory for negative versus positive critical lures. When tested after a 24-hr delay (Experiment 2), individuals higher in neuroticism maintained greater false memory for negative versus positive critical lures, but those lower in neuroticism showed no difference in false memory between negative and positive critical lures. Possible mechanisms and implications for mental health disorders are discussed.

Memory warps time, as it does the sights and sounds and smells of reality; for what shapes it is emotion, which can twist what seems clear, just as the surface of a pond seems to bend the stick thrust into the water.

– Sherwood Smith

In this quote, Sherwood Smith draws connections between memory, time, and emotion, and argues that each biases the others. Decades of research on memory have illustrated that memory is constructive and subject to scores of biases. Furthermore, we pay more attention to information that is consistent with our own attitudes and viewpoints, giving rise to better memory for congruent versus incongruent information (cf. Edwards, 1941; Levine & Murphy, 1943; but see Eagly, Chen, Chaiken, & Shaw-Barnes, 1999). We use heuristics to allow for the efficient (but not always accurate) processing of greater amounts of information, giving rise to memory distortions (cf. Roediger & McDermott, 2000). On some level, these memory biases are beneficial; we remember information consistent with our perspectives and generalise situations to better recall events. Memory biases, however, also can be maladaptive in that they distort our representations of the world to be consistent with our expectations, and these distortions may influence behaviour. Thus, memory biases may both be helpful and harmful, depending on the situation.

One strong bias that has been frequently studied in the emotion literature is the negativity bias, or the tendency for negative information to have a stronger impact on psychological processes than positive information that is equally arousing and extreme (for reviews see Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; Cacioppo & Berntson, 1994, 1997, 1999; Norris, Gollan, Berntson, & Cacioppo, 2010; Rozin & Royzman, 2001). Individuals have been shown to exhibit a negativity bias in self-reported emotional responses in a controlled laboratory environment (Norris, Larsen, Crawford, & Cacioppo, 2011), as well...
as in neural responses to emotional stimuli (Ito, Larsen, Smith, & Cacioppo, 1998; Smith, Cacioppo, Larsen, & Chartrand, 2003). In general, negative information garners more attention (Öhman, Flykt, & Esteves, 2001), mobilises resources more quickly (Taylor, 1991), and generates stronger physiological responses (Cacioppo, Berntson, Larsen, Poehlmann, & Ito, 2000; Larsen, Berntson, Poehlmann, Ito, & Cacioppo, 2008) than positive. Little research, however, has directly examined the effect of the negativity bias on memory. Although emotional information is generally remembered better than neutral (Kensinger & Schacter, 2008), fewer studies have examined the effect of valence (i.e. negative versus positive) on memory. Given that individuals pay more attention and dedicate more cognitive resources to negative information than positive, negative information may be better remembered than positive. The negativity bias, however, may also lead to greater false memory of negative information, if it leads to increased spreading activation of related semantic material.

**False memory in the laboratory**

Roediger and McDermott (1995) popularised a laboratory-based approach to examining false memory, first introduced by Deese (1959). In the Deese-Roediger-McDermott (DRM) paradigm, participants are presented with lists of words (e.g. bed, rest, awake, tired) that are semantically associated with a non-presented word (sleep), the critical lure. Participants often falsely remember the critical lure, even though it is not presented during study. Several theories have been used to explain true and false memory in the DRM paradigm, notably the Activation/Monitoring theory and Fuzzy Trace Theory. According to the Activation/Monitoring Theory (McDermott & Watson, 2001; Roediger & McDermott, 1995; Roediger, Watson, McDermott, & Gallo, 2001) processing at both encoding and retrieval may contribute to false memories. During encoding, spreading activation may automatically trigger related items, particularly the critical lure, giving rise to a false sense of experience and increased false memory. In addition, a monitoring process during either encoding or retrieval (or both) may reduce false memory, given sufficient motivation and resources. In contrast, Fuzzy Trace Theory (Brainerd & Reyna, 1998; Brainerd, Wright, Reyna, & Payne, 2002) argues that true and false memory in the DRM paradigm relies on both verbatim traces (specific memory for individual items) and gist traces (memory for general semantic meaning). These representations are stored in parallel, which allows for the dissociation of true (verbatim) and false (gist) memory.

Many studies have examined the methodological and individual difference factors that contribute to false memory formation. More recently, researchers have taken an interest in how emotion affects both true and false memory. In a thorough review of this literature, Bookbinder and Brainerd (2016) examine the effects of emotional content (i.e. the valence of the event or stimulus) and emotional context (i.e. mood) on false memory. Interestingly, of 36 studies reported from 28 published articles, only 10 (28%) directly compare the effects of positive versus negative emotion on memory; the remaining studies generally compare positive and/or negative conditions to neutral conditions (Bookbinder & Brainerd, 2016). Bookbinder and Brainerd conclude that the effects of emotion on false memory are dependent on whether emotional content or context is studied, with negative emotional content increasing and negative emotional context decreasing false memory.

**Negativity bias & memory: emotional content**

In an initial investigation of the effects of emotional content on memory, Ochsner (2000) found differences in recollection and familiarity based on emotional content. Specifically, negative information was more likely to be remembered (i.e. participants could recall specific details) and positive information was more likely to be known (i.e. participants could not recall specific details, a feeling of familiarity), suggesting that negative information is more richly remembered than positive.

To examine effects of emotional content on both true and false memory, Brainerd, Stein, Silveira, Rohenkohl, and Reyna (2008) created DRM lists that were negatively-, positively-, and neutrally-valenced. The authors found that both true and false memory were higher for negative information, middling for neutral information, and lowest for positive information. Furthermore, the negativity bias for false memory was stronger than that for true memory, an effect that was not due to response bias to negative items. Brainerd et al. (2008) argue that their results are due to two separate processes: first, negative valence increases the perceived similarity of critical lures to list words; and second, negative valence decreased the use of verbatim memory to reject critical lures.
Related work (Bookbinder & Brainerd, 2017) using a picture-memory paradigm, showed similar findings based on emotional content. Importantly, this study found that false memory was higher for both positive and negative information (compared to neutral) on an immediate test but at a delayed test, false memory for negative information was higher than neutral but false memory for positive information was not, suggesting a sustained negativity bias in false memory.

**Negativity bias & memory: emotional context**

The remaining studies comparing the effects emotion on memory have primarily manipulated (or measured) mood. Storbeck and Clore (2005) induced negative and positive mood states and assessed recall of neutral DRM lists (McDermott & Watson, 2001). Compared to the positive-mood and no mood induction control groups, the negative-mood group showed decreased false memory for critical lures but there were no differences in true memory across groups. Furthermore, decreased false memory in the negative-mood group was not due to increased efficacy of monitoring during retrieval, suggesting that negative mood may impacted false memory at encoding. The authors argued that negative affective cues increase item-specific processing and decrease relational processing, resulting in a reduction in the accessibility of related lures in the DRM paradigm.

Induced mood has also been shown to increase false memory for mood-congruent critical lures (Ruci, Tomes, & Zelenski, 2009; see review by Eich, Geraerts, Schooler, & Forgas, 2008). This effect is thought to be due to spreading activation of mood-congruent non-presented information (Bower, 1981; Zhang, Gao, Jiang, Zhang, & Zhang, 2012). If mood increases spreading activation for mood-congruent information, then individuals experiencing chronic mood states should exhibit stronger false memory for mood-congruent information. Consistent with this, individuals with higher subjective well-being, who experience more positive affect and frequent positive moods, showed increased false memory for positive critical lures compared to individuals with lower subjective well-being, an effect not observed for neutral lures (Koo & Oishi, 2009). More relevant for the current paper, individuals with a diagnosis of major depressive disorder show stronger false memory for depression-related critical lures than healthy controls (Howe & Malone, 2011; Moritz, Gläscher, & Brassen, 2005). High levels of neuroticism, or the tendency to experience negative affect and anxiety, have also been associated with greater retrieval of negative personal memories, regardless of current mood (Ruiz-Caballero & Bermúdez, 1995). This suggests that a chronic tendency to experience a particular form of affect may influence memory beyond an acute manipulation of mood.

Thus, individual differences in chronic mood states have been shown to moderate the effects of emotion on memory. In the current paper, we investigate individual differences in susceptibility to a negativity bias in false memory and predict that individuals predisposed to experience negative states (e.g. those high in trait neuroticism) may exhibit a stronger tendency towards a negativity bias in false memory. That is, individuals who experience more negative affect and a tendency to negatively bias their interpretations of the world may show increased spreading activation for negative semantic information.

We focus on individual differences in neuroticism for a number of reasons. First, neuroticism is correlated with depression and anxiety (Muris, Roelofs, Rassin, Franken, & Mayer, 2005), but unlike these clinical diagnoses, varies widely in the general population. Furthermore, neuroticism is linked to worry and rumination (Davey & Tallis, 1994; Muris et al., 2005), which are defined as apprehensive expectation of negative outcomes and thinking about depressive symptoms, respectively. Both worry and rumination are conceived of as frequent, recurrent negative thoughts; thus, the effects of individual differences in neuroticism may be stronger following a delay in which initial exposure to negative information may result in increased spreading activation over time. Studies that have investigated true and false memory for negative and positive content both immediately and after a delay (e.g. Bookbinder & Brainerd, 2017) have studied the same individuals at both time points. Because an immediate memory test impacts performance on a subsequent delayed test, the current experiments sought to disentangle the effects of multiple tests by examining each separately (in two studies) using different participants.

We used the DRM paradigm to examine a series of related questions. First, we were interested in replicating prior work (Brainerd et al., 2008) showing that true and false memories were susceptible to a negativity bias. Second, given that trait neuroticism is characterized by chronic negative, depressed mood and anxiety and has been shown to bias retrieval of personal memories (Ruiz-Caballero & Bermúdez, 1995), we sought to investigate whether neuroticism may moderate the negativity bias in memory. Third, we were
interested in how a 24-hr delay between study and test would affect true and false memory for emotionally-valenced words. Although studies on neutral DRM lists have typically found that false memory for critical lures decays less rapidly than true memory (e.g. Brainerd, Payne, Wright, & Reyna, 2003; McDermott, 1996; Payne, Elie, Blackwell, & Neuschatz, 1996), it is possible that the negativity bias may result in maintained true memory for negative words and dissipation of false memory for critical lures. Finally, a delay may differentially affect individuals, based on personality. Individuals low in trait neuroticism may show reduced false memory for negative critical lures after a delay because the activation of negative items may dissipate. In contrast, individuals higher in neuroticism who show persistence of negativity, may exhibit a maintained negativity bias in false memory.

**Experiment 1**

In this study, we sought to examine the negativity bias in true and false memory for emotional words when tested shortly after encoding, and hypothesised that memory for negative words would be better than that for positive words. Brainerd et al. (2008) have provided support for a negativity bias in both false and true memory; however, we made a number of changes in order to be able to provide stronger evidence for this effect: (a) we used more word lists (10 per valence instead of 6) to provide stronger reliability; (b) we created word lists to be equal in arousal and extremity (i.e. distance from the midpoint of the rating scale – this is a crucial measure to match the intensity of positive and negative stimuli; Norris et al., 2011), and we provide full statistics demonstrating that our positive and negative list words and critical lures do not differ on either of these dimensions; and (c) participants answered the same question (Is this word old or new?) for all test items versus one of three questions (verbatim, gist, both), again to increase reliability.

Including more negative and positive word lists allows the inclusion of a greater number of both critical lures and list words during the test phase, which increases reliability of our measures of false and correct memory. Previous studies have been limited on the number of word lists included for each valence category due to the inclusion of neutral word lists; however, given that our theoretically-based predictions focus solely on negative and positive lists, we decided to exclude neutral lists in favour of increasing the number of negative and positive lists. Closer matching of positive and negative word lists eliminates additional confounds, including the possibility that any observed differences may be due to negative words being more extreme (i.e. further from the neutral midpoint) than positive words. Indeed, valence ratings provided by Study 1 participants in Ochsner (2000) demonstrate that negative pictures were rated more extremely (1.80) than were positive pictures (1.49), indicating a possible confound between valence and extremity. Matching extremity for negative and positive stimuli allows for a true test of the impact of valence on memory. Finally, using a single question for all items versus three questions randomly assigned to different subsets of items reduces measurement error and simplifies the memory task for participants.

In addition to investigating the negativity bias in memory, we sought to investigate the moderation of these effects by individual differences in neuroticism. We predicted that participants would on average show better true memory for negative versus positive list words and higher false memory for negative critical lures than positive. We further predicted that individuals higher in neuroticism would show a greater negativity bias in false memory than those lower in neuroticism, given their bias to experience and focus on negativity.

**Determination of sample sizes, data exclusions, manipulations, and measures**

Sample size was determined based on a thorough survey of the existing literature, and from our own prior research in which 100 participants per condition was found to be sufficient for adequate power (Fenn & Hambrick, 2012). Participants were run in groups of 6, and we estimated the number of no-shows and dropouts to manage recruitment with the goal of obtaining 100 participants. We stopped recruitment at the end of the week in which 100 (or more) participants completed the experiment. All manipulations and measures included in the study were determined a priori, based on our hypotheses.

**Method**

**Participants**

138 (91 female) undergraduates from Michigan State University participated for course credit. Participants...
were native English speakers who reported no history of speech, hearing, or memory disorders, and were between the ages of 18 and 25 ($M = 19.28$, $SD = 1.33$). All participants provided informed consent and procedures were approved by the MSU Institutional Review Board. Participants completed both a study phase and test phase, and were informed that they would be tested on their memory for the list words.

**Stimuli**

Forty emotionally valenced (20 positive, 20 negative) DRM lists were created using the Affective Norms for English Words\(^1\) (ANEW; Bradley & Lang, 1999), although participants only studied half of these – 20 lists (10 positive, 10 negative). Each list contained ten words that were semantically-related to an associated item that was not presented (i.e. the critical lure; see Appendix). For example, one positive list included the words: tranquil, serene, content, waterfall, calm, silent, pray, forceful, harmony, and hammock; the critical lure associated with the list words was peaceful. One negative list included the words: cocky, conceited, conceit, haughty, ego, proud, pushy, confident, obnoxious, and snotty; the critical lure was arrogant.

List words and critical lures were statistically matched for word length and frequency in the English language across positive and negative lists.\(^2\) Lists were also normed for backward associative strength (BAS; average likelihood that the critical lure would be generated during a free association test when given each of the study words), forward associative strength (FAS; average likelihood that a critical lure would be generated as an associate when given each of the list words) and connectivity (relatedness between list items) across positive and negative lists. Backward associative strength is a measure of the connectivity between list items and the associated critical lure. This measure has been found to significantly predict false memory in the DRM paradigm (Roediger et al., 2001). We obtained BAS for two lists (Health and Anger) from Roediger et al.’ (2001) analysis of factors that predict false memory in DRM lists. For lists that we created, we obtained BAS from the University of South Florida Free Association Norms (Nelson, McEvoy, & Schreiber, 1998) for each item in the list and averaged them.

More critically for the examination of the negativity bias (the central aim of this study), we needed to demonstrate that both arousal and extremity were equivalent across positive and negative lists. In this way, the only dimension on which words differ is whether they are negative or positive – they are equally arousing and equally extreme in terms of valence. Extremity is a slight modification of valence scores that allows for a direct comparison of positive and negative information. Given that valence ratings range from extremely negative (1) to extremely positive (9), they cannot be directly compared for negative and positive stimuli (i.e. there will always be a difference, as negative stimuli will always have lower scores than positive stimuli). Measuring extremity, which is the distance of valence scores from the midpoint of the norming scale (5), allows for a direct statistical comparison of negative and positive stimuli (Norris et al., 2011). Thus, we subjected arousal and extremity for the studied lists to separate one-way analyses of variance (ANOVA) to compare negative versus positive critical lures, studied and tested list words, and studied and untested list words. The ANOVAs for critical lures indicated no differences between negative ($M_{ARO} = 5.74$, $SD_{ARO} = 1.54$; $M_{EXT} = 2.21$, $SD_{EXT} = 0.56$) and positive ($M_{ARO} = 5.35$, $SD_{ARO} = 1.33$; $M_{EXT} = 2.51$, $SD_{EXT} = 0.54$) critical lures, $F(1,19) = 0.36$ and $1.51$, $ps = .56$ and .24, for arousal and extremity, respectively. Similarly, the ANOVAs for studied and tested list words indicated no differences between negative ($M_{ARO} = 5.67$, $SD_{ARO} = 1.17$; $M_{EXT} = 2.21$, $SD_{EXT} = 0.91$) and positive ($M_{ARO} = 5.45$, $SD_{ARO} = 0.81$; $M_{EXT} = 2.22$, $SD_{EXT} = 0.89$) list words, $F(1,29) = 0.42$ and 0.002, $ps = .52$ and .97, for arousal and extremity, respectively. Finally, the ANOVAs for studied and untested list words indicated no differences between negative ($M_{ARO} = 5.19$, $SD_{ARO} = 1.27$; $M_{EXT} = 1.76$, $SD_{EXT} = 0.84$) and positive ($M_{ARO} = 5.48$, $SD_{ARO} = 0.99$; $M_{EXT} = 2.05$, $SD_{EXT} = 1.16$) list words, $F(1,59) = 0.99$ and 1.20, $ps = .33$ and .28, for arousal and extremity, respectively. Thus, negative and positive critical lures, studied and tested list words, and studied and untested list words were matched in arousal and extremity.

**Procedure**

During the study phase, participants studied 20 (10 positive, 10 negative) DRM word lists containing 10 words each. The presentation of each list began with the word that was most highly associated with the critical item, and each word was presented in descending associativity from the critical item. Each word was presented visually for 1500 ms, with a
500 ms interstimulus interval. There was a 5-sec delay between lists. Participants were randomly assigned to one of two pre-determined orders of positive and negative lists; within each order, the lists were presented randomly. For example, in one order, the first list was positive. All participants assigned to this order viewed a positive list first, but the list was randomly chosen from the set of positive lists. In the other order, the first list was negative. At the conclusion of the study phase, participants watched an unrelated three-minute video (to minimise rehearsal) and then completed the test phase.

During the recognition test, individual words were displayed on the screen and participants judged whether or not the word was old (i.e. had been presented in any of the lists) or new (had not been presented in any of the lists). Prior to the start of the test, participants were given the following directions:

This is the test phase of the experiment. You will now be given a recognition memory test for the 20 lists that you studied. A list of words will be visually presented one at a time on the computer screen. Some of these words were presented in the lists you saw, the OLD words, and some were not, the NEW words. Your job is to figure out for each word whether it’s OLD or NEW. If you think that word was presented during the earlier portion of the experiment, click on the button that says OLD. If you do not think that the word was presented, please click on the button that says NEW.

Test words were presented randomly and included studied list words from list positions 1, 6, and 8 ($n = 60$, half from positive lists and half from negative), critical lures associated with the studied lists ($n = 20$, half positive and half negative), unstudied list words ($n = 60$), and critical lures associated with the unstudied lists ($n = 20$). The unstudied list words and critical lures were taken from 20 (10 positive, 10 negative) unpresented DRM lists (see Appendix). Similar to the studied lists, unstudied list words were taken from list positions 1, 6, and 8.

**Big 5 personality factors**

Following the test phase, participants completed a 20-item measure of The Big Five factors of personality (i.e. the Mini-PIP; Donnellan, Oswald, Baird, & Lucas, 2006), which includes 4 items for each of the five personality subscales: neuroticism (our primary measure of interest), extraversion, agreeableness, intelligence, and conscientiousness. Participants rated personality descriptors (e.g. "I get upset easily") on a 5-point Likert scale ranging from very inaccurate (1) to very accurate (5). The Mini-PIP was chosen as it has been shown to have consistent and acceptable internal consistencies; similar test-retest reliability as other Big 5 scales; and comparable convergent, divergent, and criterion-related validity (Donnellan et al., 2006), while using fewer items. The use of the Mini-PIP reduced the time participants spent completing the survey, which allowed us to include more word lists and thus increase the reliability of our primary data (i.e. measures of memory). Items were reverse coded as necessary and an average of responses was calculated separately for each of the five personality factors.

**Results**

**Analysis approach**

To investigate the effects of both valence and neuroticism, as well as their interaction, we conducted a series of 2(valence: negative, positive) × (neuroticism) general linear models (GLMs). Neuroticism scores were z-transformed, then entered as a continuous between-participants factor (Aiken, West, & Reno, 1991; Norris, Dumville, & Lacy, 2011; Norris, Larsen, & Cacioppo, 2007; Rutherford, 2011). This approach allows us to examine (a) the main effect of valence, controlling for neuroticism; (b) the main effect of neuroticism, controlling for valence; and (c) the interaction between valence and neuroticism in a single analysis. Significant effects involving neuroticism were investigated using estimates at 1 standard deviation (SD) above (higher neuroticism) and below (lower neuroticism) the mean; thus, we utilise the entire range of neuroticism scores in each analysis rather than using a median split approach.

**Studied lists: correct recognition of list words**

Proportions of words correctly recognised were subjected to a 2(valence: negative, positive) × (z-scored neuroticism) general linear model (GLM), in which the first factor was manipulated within participants and neuroticism was entered as a continuous between participants covariate of interest. The valence main effect, $F(1, 136) = 24.03$, $p < .001$, $\eta^2_p = .15$, showed that participants exhibited higher correct recognition of negative list words ($M = 0.73$, $SE = 0.02$) than positive ($M = 0.67$, $SE = 0.01$), consistent with a negativity bias in accurate memory for studied items (Figure 1a). No effect involving neuroticism was significant.
A parallel GLM conducted on response times for words that participants correctly indicated they had seen before revealed no significant effects (Figure 2a).

**Studied lists: false recognition of critical lures**

Proportions of critical lures falsely recognised were subjected to a 2(valence: negative, positive) × (z-scored neuroticism) GLM, in which the first factor was manipulated within participants and neuroticism was entered as a continuous between participants covariate of interest. The valence main effect, $F(1, 136) = 18.52, p < .001, \eta^2_p = .12$, indicated that participants showed higher false recognition for negative critical lures ($M = 0.67, SE = 0.02$) than positive ($M = 0.59, SE = 0.02$; Figure 1b), consistent with a negativity

![Figure 1. Results from four 2(valence: negative, positive) × (z-scored neuroticism) general linear models (GLM).](image)

Experiment 1: (a) proportion of list words correctly recognised on an immediate test; and (b) proportion of critical lures falsely recognised on an immediate test. Experiment 2: (c) proportion of list words correctly recognised on a delayed test and (d) proportion of critical lures falsely recognised on a delayed test.
bias in false memory as well as accurate memory. No effect involving neuroticism was significant.

Again, a parallel analysis was conducted on response times and revealed a main effect of valence, $F(1, 133) = 5.01, p = .03, \eta_p^2 = .04$. Participants were faster to respond (inaccurately) to negative critical lures ($M = 1511.16$ ms, $SE = 37.67$) than positive critical lures ($M = 1614.40$ ms, $SE = 58.16$; Figure 2b).

**Unstudied lists**

In addition to investigating the negativity bias for studied information, we were interested in the extent to which the negativity bias would extend to unstudied information. A final pair of analyses was conducted on false recognition of words from unstudied lists and their corresponding response times. Because none of

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**Figure 2.** Results from four 2(valence: negative, positive) × (z-scored neuroticism) general linear models (GLM) conducted on response times (RTs). Experiment 1: (a) RTs for correctly recognised list words on an immediate test; and (b) RTs for falsely recognised list words on an immediate test. Experiment 2: (c) RTs for correctly recognised list words on a delayed test and (d) RTs for falsely recognised list words on a delayed test.
these words were actually studied, we conducted one analysis which included both list words and critical lures, making the design a 2(valence: negative, positive) × 2(item: list words, critical lures) × (z-scored neuroticism) GLM, in which the first two factors were manipulated within participants and neuroticism was entered as a continuous between participants covariate. The item main effect, $F(1, 136) = 27.18$, $p < .001$, $\eta^2_g = .17$, indicated higher false recognition for critical lures ($M = 0.27, SE = 0.02$) than for list words from unstudied lists ($M = 0.22, SE = 0.01$). This effect is not surprising because critical lures tend to have higher familiarity and frequency in the English language. The valence main effect, $F(1,136) = 66.31$, $p < .001$, $\eta^2_g = .33$, showed higher false recognition for negative unstudied words ($M = 0.30, SE = 0.02$) than for positive unstudied words ($M = 0.20, SE = 0.02$). Thus, a negativity bias is apparent even for words from unstudied lists. No other effects were significant. Importantly, neuroticism did not moderate the negativity bias in false memory for unstudied information.

A parallel GLM conducted on response times for the unstudied lists revealed no significant effects.

**Other big 5 dimensions**

Although neuroticism had no effect on true or false memory for positive or negative words in Experiment 1, we conducted separate GLMs using each of the additional four dimensions of the Big 5 (i.e. openness, conscientiousness, extraversion, agreeableness) as a continuous between-participants factor to explore whether a different dimension did have an effect. To limit false positives, we corrected for multiple comparisons in these analyses. Given that there are 4 other factors, we only report results reaching an alpha level of .0125 (i.e. .05/4). No main effects of the other 4 factors, nor interactions with valence, were significant in analyses of proportions of correctly remembered list words, falsely remembered critical lures, or the response times for either.

**Experiment 1 discussion**

Participants exhibited higher correct recognition for negative list words than positive, providing support for our primary hypothesis regarding a negativity bias in veridical memory. Furthermore, this negativity bias extended to false recognition for both critical lures from studied lists and for words from unstudied lists, indicating that individuals were more likely to misremember having seen negative versus positive words during the study phase. The negativity bias was also apparent in response times; participants were faster to (incorrectly) respond to negative critical lures than positive, suggesting that the perception of familiarity for negative words was stronger than that for positive.

Contrary to our initial hypotheses, neuroticism did not moderate any of these effects; the negativity bias was observed regardless of individual differences in neuroticism. Although we argue that this bias may be adaptive for memory – it is advantageous to remember negative information that one has encountered before – it may be harmful for false memory, if individuals maintain that bias toward unfamiliar negative information over time. Thus, one important question remains: how durable over time is the negativity bias in both true and false memory? In the DRM paradigm, veridical memory for list words decays more quickly than false memory for critical lures. When considering the negativity bias, however, we argue that maintaining a bias in true memory may be advantageous, whereas extinguishing a bias in false memory may be advantageous. In other words, continuing over time to remember previously encountered negative information while “forgetting” falsely remembered negative information might prove to be the most adaptive functioning of the negativity bias.

Furthermore, although neuroticism did not moderate the negativity bias in either true or false memory at an immediate test, one key facet of neuroticism is focus (and potentially rumination) on negative information (Conway, Csank, Holm, & Blake, 2000). Indeed, studies have shown that the links between neuroticism and both anxiety and depression are mediated by rumination and worry (Muris et al., 2005; Roelofs, Huibers, Peeters, & Arntz, 2008). If individuals higher in neuroticism continue to focus on negative list words or even just negative information, in general, during a delay between study and test phases, they may show a maintained (or even exaggerated) negativity bias in either true or false memory. Thus, in Experiment 2 we sought to replicate and extend our findings by introducing a 24-hr delay between study and test.

**Experiment 2**

The design of Experiment 2 was identical to Experiment 1; the only difference was that the test was given 24 h after the study phase. We predicted that
participants would show a negativity bias in true memory for studied negative versus positive list words, even after a 24-hr delay and that neuroticism would moderate false memory for negative versus positive critical lures. Specifically, we predicted that individuals lower in neuroticism would show no negativity bias, as their gist memory for negative information would dissipate over the delay period; whereas individuals higher in neuroticism would show a negativity bias even after a 24-hr delay, given their focus on negative information.

Method

Participants

100 (50 female; 1 unreported) undergraduates from Michigan State University participated for course credit and completed both experimental sessions. An additional 13 participants completed Session 1 but failed to return for Session 2. Sample size was determined as in Experiment 1. Participants were native English speakers who reported no history of speech, hearing, or memory disorders, and were between the ages of 18 and 26 ($M = 19.74, SD = 1.75$). All participants provided informed consent and procedures were approved by the MSU Institutional Review Board. Participants completed a study and a test phase and were informed that they would be tested on their memory for the list words.

Stimuli

The stimuli were identical to Experiment 1.

Procedure

Procedure was identical to Experiment 1 with one major difference. After completing the study phase, including the distractor task, all participants were sent home. They returned to the laboratory 24 h later to complete the test phase. The test phase was identical to Experiment 1, and all participants completed the 20-item measure of The Big Five factors of personality (Donnellan et al., 2006) at the end of the session.

Results

Studied lists: correct recognition of list words

Proportions of words correctly recognised were subjected to a $2$ (valence: negative, positive) $\times$ ($z$-scored neuroticism) GLM, in which the first factor was manipulated within participants and neuroticism was entered as a continuous between participants covariate of interest. The valence main effect, $F(1, 97) = 9.72, p = .002, \eta^2_p = .09$, showed that participants exhibited higher correct recognition of negative list words ($M = 0.67$, $SE = 0.02$) than positive ($M = 0.63$, $SE = 0.02$), consistent with a negativity bias in accurate memory for studied items even 24 h after the study phase (Figure 1c). No effect involving neuroticism was significant.

A parallel analysis conducted on response times for words that participants correctly indicated they had seen before revealed no significant effects (Figure 2c).

Studied lists: false recognition of critical lures

Proportions of critical lures falsely recognised were subjected to a $2$ (valence: negative, positive) $\times$ ($z$-scored neuroticism) GLM. First, the valence main effect, $F(1,97) = 3.87, p = .052, \eta^2_p = .04$, indicated that false recognition was marginally higher for negative ($M = 0.66$, $SE = 0.02$) than positive ($M = 0.62$, $SE = 0.02$) critical lures. The valence $\times$ neuroticism interaction, $F(1,97) = 5.03, p = .027, \eta^2_p = .05$, however, indicated that this main effect was moderated by individual differences in neuroticism. Pairwise comparisons indicated that participants lower in neuroticism showed no difference in false recognition of negative ($M = 0.60$, $SE = 0.03$) and positive ($M = 0.61$, $SE = 0.03$) critical lures, $p = .82$; whereas those higher in neuroticism showed significantly higher false memory for negative ($M = 0.72$, $SE = 0.03$) than positive ($M = 0.63$, $SE = 0.03$) critical lures, $p = .005$ (Figure 1d). In other words, the negativity bias in false memory for negative critical lures emerged even after a 24 h delay following the learning period – but only for individuals higher in neuroticism.

A parallel analysis conducted on response times revealed a main effect of valence, $F(1,95) = 5.02, p = .027, \eta^2_p = .05$. Participants were faster to respond that they had seen negative critical lures ($M = 1445.12 \text{ ms}, SE = 45.39$) than positive ($M = 1559.53 \text{ ms}, SE = 46.86$; Figure 2d).

Unstudied lists

Again, we examined false recognition of words from unstudied lists and their corresponding response times to investigate the extent of the negativity bias after a 24-hr delay. A $2$ (valence: negative, positive) $\times$
2(item: list words, critical lures) × (z-scored neuroticism) GLM revealed an item main effect, $F(1, 97) = 43.49, p < .001, \eta^2_g = .31$, which indicated higher false recognition for critical lures ($M = 0.36, SE = 0.02$) than list words from unstudied lists ($M = 0.28, SE = 0.02$). The valence main effect, $F(1, 97) = 82.86, p < .001, \eta^2_p = .46$, showed higher false recognition for negative unstudied words ($M = 0.37, SE = 0.02$) than positive unstudied words ($M = 0.26, SE = 0.02$), even after a 24-hr delay following the study phase. No effect involving neuroticism was significant.

A parallel GLM conducted on response times for unstudied lists revealed a main effect of valence, $F(1, 78) = 4.72, p = .033, \eta^2_p = .06$, such that participants were faster to respond (inaccurately) to negative ($M = 1652.19$ ms, $SE = 54.72$) than positive ($M = 1780.57$ ms, $SE = 79.00$) unstudied list words.

**Other big 5 dimensions**

To examine whether effects were solely due to individual differences in neuroticism, we conducted separate GLMs using each of the Big 5 personality dimensions as a continuous between-participants factor and corrected for multiple comparisons in these analyses, as we did in Experiment 1. No main effects of the other 4 factors, nor interactions with valence, were significant in analyses of correctly remembered list words, falsely remembered critical lures, or the response times for either. Thus, our predicted results regarding neuroticism hold independent of the other Big 5 dimensions.

**Experiment 2 discussion**

Even with a 24-hr delay between study and test, individuals showed a negativity bias in memory. Correct recognition of negative words was higher than positive words, indicating that the negativity bias in true memory is robust and durable over time. A negativity bias also emerged in false memory; negative critical lures were misremembered at a higher rate than positive critical lures; however, this effect was only found in individuals higher in neuroticism. This suggests that neuroticism moderates the effects of false memory for negative and positive information after a 24-hr retention interval. Individuals lower in neuroticism show equivalent false recognition for negative and positive critical lures, suggesting that a delay may allow for negative information to dissipate. We argue that this is an adaptive pattern: a durable negativity bias in true memory promotes recollection of potentially harmful stimuli, whereas the dissipation of a negativity bias in false memory over time results in a healthier, more accurate perception of experience. Individuals higher in neuroticism, however, show higher false recognition for negative critical lures, suggesting that the accessibility of negative information is increased for such individuals. It is worth noting that, due to the lack of a neutral word list condition and that immediate and delayed conditions were examined in separate studies, we cannot conclusively state that individuals lower in neuroticism exhibit a decrease in negative false memories or an increase in positive false memories after a delay, or some combination of the two. An examination of Figure 1 suggests that perhaps both processes are at work. The fact remains that the relative difference between false recognition of negative and positive critical lures (i.e. the negativity bias) is eliminated after a delay for individuals lower in neuroticism. Importantly, our effects are specific to the dimension of neuroticism, as none of the other Big 5 personality factors moderated any effects. The maintained negativity bias in false memory for individuals higher in neuroticism may predispose them to continue to bias their perception of their past experiences toward negative information, potentially leading to increased depression and anxiety.

The remaining results from Experiment 2 replicate those from Experiment 1: there is a negativity bias in false memory for unstudied words, and a negativity bias in responses times for all falsely remembered information. As predicted, neuroticism did not moderate either false memory for unstudied words or response times. We believe this is the case primarily because neuroticism only moderates the negativity bias in false memory for negative information that is related to an individual’s experience. Critical lures are directly related to studied information and may therefore constitute the most ecologically valid test of false memory and its moderation by neuroticism.

**General discussion**

In the current studies we replicated and extended past research (Bookbinder & Brainerd, 2017; Brainerd et al., 2008) by examining the influence of the negativity bias on accurate and false memory, and the moderation of these effects by individual differences in neuroticism. First, individuals exhibited a negativity bias in correct recognition of studied items, regardless of
whether they were tested immediately or after a 24-hr delay. All participants showed better memory for negative list words than positive, even though the words were equally arousing, extreme, and frequent in the English language. Given that negative stimuli carry more information and weight than positive stimuli (Baumeister et al., 2001; Norris et al., 2010; Norris et al., 2011; Rozin & Royzman, 2001), this negativity bias in memory suggests that individuals encode negative information more deeply than positive. Indeed, the 24-hr delay had no effect on the negativity bias for studied words, which may suggest that the bias occurs at encoding and not at retrieval. Although the current study was not designed to test these alternatives, future research should explore the effects of the negativity bias at different stages in memory.

Perhaps most interesting, we found that individual differences in neuroticism moderated false recognition of negative information – but only after a 24-hr delay. Neuroticism did not moderate the negativity bias for studied words, which indicates that this memory bias for negative information may be similar for all individuals, regardless of personality traits. Similarly, neuroticism did not moderate the negativity bias in false memory when memory was tested immediately. In contrast, when memory was tested after a 24-hr delay, the negativity bias in false memory persisted for individuals higher in neuroticism, but was not observed for individuals lower in neuroticism. Importantly, neuroticism had no effect on false memory for unstudied words, indicating that personality impacts false memory only for information similar to what was experienced.

There are several potential reasons why individuals higher in neuroticism might show stronger false memory for negative items after a delay. It is possible that these individuals have higher spreading activation of negative information at encoding. If this were the case, however, then we might expect to see a greater negativity bias in false memory at immediate test. Instead, we speculate that individuals higher in neuroticism show stronger gist memory for negative versus positive information. According to fuzzy trace theory, gist representations are more resistant to forgetting than veridical representations (e.g. Brainerd et al., 2002; Brainerd et al., 2008; Brainerd & Reyna, 1998). Given that individuals higher in neuroticism are prone to negative thoughts and worry, they might rely on gist more for negative information than for positive information. Importantly, stronger gist memory for negative information may be harmful to individuals higher in neuroticism because it may increase false memory for negativity in their own lives at a higher rate than individuals lower in neuroticism.

It is worth considering the mechanisms by which neuroticism might moderate false memory for negative words following a delay, especially given that the personality trait of neuroticism contains myriad facets. One possibility is that individuals higher in neuroticism are prone to ruminate on negative information; such rumination over time may strengthen gist memory for negative critical lures. This possibility is unlikely, however, for a number of reasons. It is unlikely that a DRM paradigm using negative word lists constitutes a “stressful event” for our participants, even those higher in neuroticism and rumination in neuroticism is often focused on one’s own depressed thoughts or feelings, and our lists did not include words specific to depression. Even so, inclusion of a measure of rumination in future research would allow for a direct examination of the role of rumination in increased false memory for negative information after a delay. A second possible explanation concerns a potential difference between the positive and negative words. Although we controlled for extremity and arousal, the lists appear to include more self-referential negative critical lures (e.g. arrogant, tired, alone, angry, greed) than positive (e.g. care). Given that individuals higher in neuroticism are prone to ruminate on self-relevant information, it is possible that a bias toward self-referential negative words enhanced rumination for related critical lures. In addition, although we controlled for arousal using normative ratings, it is possible that individuals higher in neuroticism experienced greater arousal to negative words than individuals lower in neuroticism. Future studies could better control for or manipulate the number of self-referential words on negative and positive lists, and could measure arousal ratings to explore differences in experience as a function of neuroticism. A third possibility is that negative information may simply be more salient for individuals higher in neuroticism (Sutherland & Mather, 2012, 2015), leading to enhancement during consolidation. It is difficult, however, to explain why saliency at encoding might lead to biased false memory in high neurotic individuals after a delay but not on an immediate test. Fourth, given the literature showing that depressed individuals falsely remember more words related to depression due to their rich, more easily accessible,
and more detailed semantic networks for materials relevant to their condition (Howe & Malone, 2011), it is possible that individuals higher in neuroticism also have a richer semantic network for general negative information. Finally, given the research on mood-congruency effects in false memory and the prevalence of depressed, negative mood in neuroticism, it is possible that individuals higher in neuroticism show enhanced false memory for negative critical lures due to their generally negative mood state. Past studies have shown that depressed individuals exhibited more negative false memories than normal controls but did not exhibit more negative than positive false memories on an immediate test (Yeh & Hua, 2009), consistent with our results in a non-clinical sample. It is difficult to explain why negative mood-congruency would bias neurotic individuals toward more false memory for negative information only following a delay and not on an immediate test. Future research would do well to attempt to test each of these possible mechanisms underlying the moderating effects of neuroticism on (delayed) false memory for negative information.

In addition to these novel findings, we also explored false memory for list words and their associated critical lures from unstudied lists and found a negativity bias in words from unstudied lists. Negative words were misremembered at a higher rate than positive. Thus, the negativity bias in false memory extends to words that were completely unrelated to studied information.

Finally, in both studies, we found a negativity bias in response times, such that participants were faster to respond (inaccurately) to negative than positive critical lures and unstudied words both at an immediate and delayed test. No differences in response times emerged on correct recognition, suggesting similar retrieval efficacy for negative and positive list words. The negativity bias for false memory, however, indicated that not only were individuals more likely to falsely remember negative versus positive items, they also were faster to do so, indicating a misleading sense of confidence in their inaccurate judgments.

**Implications for mental health**

Importantly, the maintained negativity bias in individuals higher in neuroticism may have implications for both the stability of negative personality traits and their impact on the development and course of mental health disorders, such as major depressive disorder. It is widely known that neuroticism is a predisposing factor for clinical depression (Bagby, Parker, & Joffe, 1993) and is correlated with symptom severity (Larsen, 1992; Saklofske, Kelly, & Janzen, 1995). Neuroticism is also associated with increased emotional responsivity to stressful life events (Creed, Muller, & Machin, 2001; Gallant & Connell, 2003; Millar, Purushotham, McLatchie, George, & Murray, 2005) and physiological reactivity to emotional stimuli in the laboratory (Norris et al., 2007). The current study extends these findings by showing that individuals higher in neuroticism may construe stressful events in such a way as to bias memory toward negative information related to, but not directly experienced, in such events. Furthermore, for individuals higher in neuroticism, this memory bias emerged both during an immediate test and after a 24-hour delay, suggesting that it is stable over time. Thus, neuroticism may predispose individuals to misremember negative information, which may give rise to increased depressive symptomology and increased emotional responsivity. In this way, even in the absence of strong negative events, individuals high in neuroticism may be prone to self-perpetuate negative affect and even depressive symptoms via their tendency to focus on and misremember negative information at a higher rate. Future research should explore the adaptive role of the negativity bias in accurate memory and the potential detrimental role of the negativity bias in false memory, as well as its connection to neuroticism and mental health disorders.

**Notes**

1. We supplemented the ANEW words with additional words that were normed as part of a pilot study in our laboratory. Ratings were collected using the same scales as the ANEW.
2. Data are available from the authors.

**Acknowledgements**

C. J. Norris and K. M. Fenn developed the study idea. All authors contributed to study design. P. T. Leaf performed data collection and initial data reduction. C. J. Norris completed data analysis, and all authors contributed to interpretation of the data. C. J. Norris drafted the manuscript; both P. T. Leaf and K. M. Fenn provided critical feedback for revisions. All authors approved the final manuscript for submission.

**Disclosure statement**

No potential conflict of interest was reported by the authors.
References


Brainerd, C. J., & Reyna, V. F. (1998). When things that were never experienced are easier to “remember” than things that were. Psychological Science, 9, 484–489.


Appendix

All DRM lists from the current study are presented below. Critical lures (i.e. unpresented, highly associated words) are in bold, presented test items (from the 1st, 6th, and 8th positions in each list) are in italics.

<table>
<thead>
<tr>
<th>Peaceful</th>
<th>Health</th>
<th>Heaven</th>
<th>Brother</th>
<th>Island</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tranquil</td>
<td>Well-being</td>
<td>Angel</td>
<td>Sister</td>
<td>Adventure</td>
</tr>
<tr>
<td>Serene</td>
<td>Mental</td>
<td>Starway</td>
<td>Sibling</td>
<td>Hawaii</td>
</tr>
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<td>Content</td>
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<td>Paradise</td>
<td>Twin</td>
<td>Harbor</td>
</tr>
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<td>Waterfall</td>
<td>Fiber</td>
<td>God</td>
<td>Kin</td>
<td>Tropical</td>
</tr>
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<td>Calm</td>
<td>Condition</td>
<td>Godliness</td>
<td>Brat</td>
<td>Treasure</td>
</tr>
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<td>Soul</td>
<td>Fraternity</td>
<td>Fantasy</td>
</tr>
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<td>Pray</td>
<td>Heal</td>
<td>Ascend</td>
<td>Son</td>
<td>Inlet</td>
</tr>
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<td>Forceful</td>
<td>Wealth</td>
<td>Saint</td>
<td>Cousin</td>
<td>Oasis</td>
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<td>Haven</td>
<td>Relative</td>
<td>Maroon</td>
</tr>
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<td>Hammock</td>
<td>Doctor</td>
<td>Eternal</td>
<td>Family</td>
<td>Hut</td>
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<table>
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<th>Sing</th>
<th>Laugh</th>
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<th>Respect</th>
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<td>Hum</td>
<td>Giggle</td>
<td>Concern</td>
<td>Admire</td>
<td>Victor</td>
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<td>Chorus</td>
<td>Joke</td>
<td>Handle</td>
<td>Dignity</td>
<td>Champion</td>
</tr>
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<td>Choir</td>
<td>Tickle</td>
<td>Tend</td>
<td>Salute</td>
<td>Contest</td>
</tr>
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<td>Song</td>
<td>Funny</td>
<td>Caution</td>
<td>Elders</td>
<td>Trophy</td>
</tr>
<tr>
<td>Opera</td>
<td>Amuse</td>
<td>Consider</td>
<td>Decency</td>
<td>Prize</td>
</tr>
<tr>
<td>Voice</td>
<td>Humor</td>
<td>Affection</td>
<td>Pride</td>
<td>Medal</td>
</tr>
<tr>
<td>Hymn</td>
<td>Comedy</td>
<td>Treatment</td>
<td>Integrity</td>
<td>Victory</td>
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<td>Rejoice</td>
<td>Clown</td>
<td>Child</td>
<td>Prestige</td>
<td>Instant</td>
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<td>Dance</td>
<td>Comedian</td>
<td>Hospital</td>
<td>Trust</td>
<td>Ribbon</td>
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<tr>
<td>Talent</td>
<td>Smile</td>
<td>Love</td>
<td>Trust</td>
<td>Earn</td>
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<table>
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<tr>
<th>Arrogant</th>
<th>Killer</th>
<th>Guilty</th>
<th>Argue</th>
<th>Alone</th>
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</thead>
<tbody>
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<td>Cocky</td>
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<td>Plead</td>
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<td>Serial</td>
<td>Verdict</td>
<td>Disagree</td>
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<td>Haughty</td>
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<td>Treason</td>
<td>Fuss</td>
<td>Lone</td>
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<tr>
<td>Ego</td>
<td>Shark</td>
<td>Accuse</td>
<td>Complain</td>
<td>Stag</td>
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<td>Proud</td>
<td>Weed</td>
<td>Evidence</td>
<td>Discuss</td>
<td>Single</td>
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<td>Ashamed</td>
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<td>Convince</td>
<td>Private</td>
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<td>Fault</td>
<td>Criticize</td>
<td>Widow</td>
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<td>Prisoner</td>
<td>Confess</td>
<td>Differ</td>
<td>Individual</td>
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</table>

<table>
<thead>
<tr>
<th>Lie</th>
<th>Tired</th>
<th>Odor</th>
<th>Greed</th>
<th>Anger</th>
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</thead>
<tbody>
<tr>
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<td>Smell</td>
<td>Selfish</td>
<td>Mad</td>
</tr>
<tr>
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<td>Fatigue</td>
<td>Misty</td>
<td>More</td>
<td>Fear</td>
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<td>Sleepy</td>
<td>Stench</td>
<td>Envy</td>
<td>Hate</td>
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<td>Deodorant</td>
<td>Generous</td>
<td>Rage</td>
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<td>Yawn</td>
<td>Scent</td>
<td>Ambition</td>
<td>Temper</td>
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<td>Bored</td>
<td>Musk</td>
<td>Blackmail</td>
<td>Fury</td>
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<td>Drowsy</td>
<td>Unpleasant</td>
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<td>Foul</td>
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<td>Fragrance</td>
<td>Fifth</td>
<td>Hatred</td>
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<tr>
<td>Deny</td>
<td>Sleep</td>
<td>Skunk</td>
<td>Possession</td>
<td>Mean</td>
</tr>
</tbody>
</table>

Notes: Unpresented critical lures and list words from the current study are presented below. Test words were taken from list positions 1, 6, and 8 so that they would have similar associativity to the unpresented critical lures. Critical lures are in bold, unpresented test items are in italics.
<table>
<thead>
<tr>
<th>Word</th>
<th>BAS</th>
<th>FAS</th>
<th>Connectivity</th>
<th>Letters</th>
<th>Syllables</th>
<th>Valence</th>
<th>Arousal</th>
<th>Frequency</th>
<th>Extremity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alone</td>
<td>0.2210</td>
<td>0.9302</td>
<td>1.30</td>
<td>5</td>
<td>2</td>
<td>2.41</td>
<td>4.83</td>
<td>195</td>
<td>−2.59</td>
</tr>
<tr>
<td>Anger</td>
<td>0.1940</td>
<td>0.0620</td>
<td>1.73</td>
<td>5</td>
<td>2</td>
<td>2.36</td>
<td>7.63</td>
<td>48</td>
<td>−2.64</td>
</tr>
<tr>
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<td>0.1390</td>
<td>0.0595</td>
<td>0.67</td>
<td>5</td>
<td>2</td>
<td>2.83</td>
<td>6.07</td>
<td>29</td>
<td>2.17</td>
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<tr>
<td>Greed</td>
<td>0.0388</td>
<td>0.0285</td>
<td>2.00</td>
<td>8</td>
<td>3</td>
<td>3.69</td>
<td>5.65</td>
<td>2</td>
<td>−1.31</td>
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<tr>
<td>Guilty</td>
<td>0.0960</td>
<td>0.0040</td>
<td>0.11</td>
<td>6</td>
<td>2</td>
<td>2.63</td>
<td>6.04</td>
<td>29</td>
<td>−2.37</td>
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<tr>
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<td>0.0200</td>
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<tr>
<td>Lie</td>
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<td>0.20</td>
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<td>2</td>
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<td>5.13</td>
<td>14</td>
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<tr>
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<td>0.4400</td>
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<td>2</td>
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<th>Syllables</th>
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<th>Arousal</th>
<th>Frequency</th>
<th>Extremity</th>
</tr>
</thead>
<tbody>
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<td>Brother</td>
<td>0.1280</td>
<td>0.0794</td>
<td>2.50</td>
<td>7</td>
<td>2</td>
<td>7.11</td>
<td>4.71</td>
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Notes: BAS = backward associative strength. FAS = forward associative strength.