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Interpersonal emotion regulation mitigates the link between trait neuroticism and a more negative valence bias☆

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ABSTRACT

Emerging research suggests that trait neuroticism is associated with enhanced attention to and perception of negative emotional stimuli, increasing the risk for multiple forms of psychopathology including depression and anxiety. However, modifiable factors such as certain forms of emotion regulation have the potential to weaken this association. In a large sample ($N = 1252$), we investigated the link between neuroticism and valence bias in response to stimuli that have the potential for both positive and negative interpretations and examined the moderating role of interpersonal emotion regulation. Primary tests of hypotheses demonstrated that increased neuroticism was associated with a more negative valence bias in response to ambiguity, but only for individuals who are less likely to rely on interpersonal resources to regulate negative affect. Supplemental analyses suggest that this moderation effect of interpersonal emotion regulation might depend on the nature of the stimuli, and that regulation of *positive* emotions—not just negative affect—can also contribute to a less negative valence bias. Taken together, results suggest that individuals who are high in neuroticism, but consistently rely on interpersonal relationships to regulate their emotions, are better able to override the bias toward negativity that can occur when appraising ambiguity.

1. Introduction

Personality explains individual differences in behavioral and neural responses to emotion (Canli et al., 2004; Rothbart, 2007). In particular, *neuroticism* predicts greater attention to negative information and more negative attributions (Norris, 2019), a bias typically measured using stimuli with a clear valence (e.g., angry expressions). However, researchers have also identified meaningful differences in the appraisal of *ambiguous* stimuli as more negative when an equally plausible neutral interpretation is available (Hirsch & Mathews, 1997). Given individuals high in neuroticism have an especially difficult time with uncertainty (Berenbaum et al., 2007; Hirsh & Inzlicht, 2008), measuring appraisals of ambiguity – one type of uncertainty – provides an informative context for understanding biases toward negativity that are associated with neuroticism.

Because individuals high in neuroticism tend to experience greater negative affect generally (Watson & Clark, 1984), processes that down-regulate negative affect have the potential to minimize negativity in the context of uncertainty. Emotion regulation refers to a wide range of processes shaping one's emotional experience to support adaptive behavior (Gross, 2002; Thompson, 1994). For individuals who have a propensity to experience negative affect, the ability to regulate emotions is essential for mitigating the risk for adverse outcomes associated with trait neuroticism (Gu & Hyun, 2019; Yang et al., 2020). However, some work has shown that individuals high in neuroticism struggle with implementing more commonly studied regulation strategies, such as cognitive reappraisal (Ng & Diener, 2013), which are otherwise linked to a less negative valence bias (Harp et al., 2022). Thus, we focus here on emotion regulation that relies on external resources (e.g., interpersonal emotion regulation; IER; Hofmann et al., 2016; Roberts et al., 2018). In particular, having a reliable social network to draw on for coping with stress and regulating difficult emotions could minimize bias when encountering ambiguity. Indeed, past research has demonstrated that social connection and supportive interpersonal relationships reduce negative affect resulting from neuroticism (McHugh & Lawlor, 2012; Oddone et al., 2011).

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Although individuals are unlikely to actively solicit support from others to regulate their emotional response during appraisals of ambiguity, individuals who believe they can count on interpersonal relationships to regulate emotions, more generally, might be less inclined to appraise obscure life events as threatening *because of relatively stable mental representations of safety and security* (Williams et al., 2018). Indeed, consistent with attachment theory (Mikulincer & Shaver, 2007), individuals who tend to use interpersonal relationships to regulate emotions have more secure internal working models (Altan-Atalay, 2019; Gökdağ, 2021) which are associated with less threat-related amygdala reactivity (Long et al., 2020), a pattern of brain activity that is consistent with a less negative valence bias (i.e., decreased amygdala and increased prefrontal activity in response to ambiguity; Kim et al., 2003; Petro et al., 2018; Petro et al., 2021). Individuals high in neuroticism tend to experience an exaggerated neural response to uncertainty (i.e., potential threat; Hirsh & Inzlicht, 2008), highlighting the importance of IER for putatively mitigating this process.

It is worth noting that neuroticism is linked with emotional reactivity more broadly—not just negativity—including greater intensity of and variability in positive affect (Hisler et al., 2020). Consequently, under the right conditions—such as consistent access to reliable, supportive interpersonal relationships—neuroticism could also result in positive appraisals of ambiguity. In other words, IER could promote positive (rather than simply reduce negative) appraisals of ambiguity. To investigate this possibility, measures must capture appraisals along the entire valence spectrum—from negative to positive, rather than just from negative to neutral as in prior work. The current study leverages a measure of affective bias reflecting appraisals of dual-valence ambiguity, or the tendency to appraise stimuli as having a negative meaning when an equally plausible *positive* interpretation is available (Neta et al., 2009, 2013). For example, when surprised facial expressions are presented within a context that provides no information to disambiguate their valence, they are interpreted negatively by some people (e.g., the individual in the photo has just witnessed a car accident) and positively by others (e.g., the individual has just received an unexpected gift; Kim et al., 2003; Neta et al., 2009, 2013). This unique measure of bias, known as valence bias shows high test-retest reliability (Neta et al., 2009) and generalizes across a variety of dual-valence stimuli (Harp et al., 2020; Neta et al., 2013), including emotional facial expressions (i.e., surprised faces), scenes, and words.

1.1. *The present study*

There were two primary aims of the present study. Aim 1 was to build on emerging research linking neuroticism to valence bias (e.g., Norris, 2019) using a measure that captures both negativity and positivity on both ends of a spectrum in the context of ambiguity. We implemented two types of stimuli for measuring valence bias – surprised faces and ambiguous scenes – and, consistent previous research (e.g., Harp et al., 2020), we averaged across these conditions to obtain a robust and reliable assessment of valence bias. Aim 2 was to examine whether IER of negative affect moderated the neuroticism-valence bias link. We hypothesized that individuals higher in neuroticism would exhibit a less negative and/or more positive valence bias to the extent that they report a proclivity to use interpersonal relationships to negative affect. This aim holds promise for identifying a potential target for interventions tailored to the unique needs of individuals prone to experiencing a more negative bias. We also conducted supplemental analyses exploring whether (a) interpersonal regulation of *positive* emotion plays a role in valence bias and (b) the role of IER in valence bias depends on the nature of stimuli.

2. Method

2.1. *Participants*

As part of a large-scale investigation, we compiled data from eighteen different experiments, conducted on 1252 human subjects at University of Nebraska-Lincoln and through Amazon's Mechanical Turk (MTurk; see Supplemental Table S1 for demographics; see Supplementary Table S2 for individual study details/purpose). This sample provided sufficient power (0.80) for detecting small effects ($r > 0.08$) in a multiple regression with up to 7 predictors. Participants had normal or corrected-to-normal vision, were unaware of the experiment's purpose, and received monetary payment or course credit. Each participant provided informed consent. The only inclusion criteria in this report was that participants completed a baseline valence bias task and responded to the clearly positive and negative images with greater than 60% accuracy, a quality check used in previous work (Harp et al., 2020).

2.2. *Procedures*

Participants in all experiments first completed a valence bias task. In this task, images of faces (63 discrete identities) from the NimStim Set of Facial Expressions (14 identities, 7 females, ages 21–30 years) (Tottenham et al., 2009), Karolinska Directed Emotional Faces (20 identities, 10 females, age 20–30 years); (KDEF; Goeleven et al., 2008) and Umea University Database of Facial Expressions (29 identities, 14 female, age 17–39; Samuelsson et al., 2012) sets and scenes from the International Affective Picture System (IAPS; Lang et al., 2008) were presented. Faces were selected from multiple databases and included angry, happy, and surprised expressions, and the IAPS scenes reliably demonstrate differences in ratings of negativity, such that negative images are rated as most negative, positive images are rated as least negative, and ambiguous images are rated in a highly variable manner across individuals (e.g., Neta et al., 2009).

Participants performed the task to assess their baseline valence bias (prior to any study-specific experimental manipulations) in which they viewed positive, negative, and ambiguous images and rated (via keyboard press or mouse click) each as either positive or negative. Response sides were counterbalanced across participants for both the button press and mouse versions of the task. Across all experiments, participants viewed faces or scenes that appeared on the screen, one at a time, and were asked to categorize each image as positive or negative based on a gut reaction. Each block of stimuli included 24 images (either eight positive, negative, and ambiguous images or 12 ambiguous and 12 clear (6 positive, 6 negative) images) presented in a pseudorandom order, and blocks were counterbalanced between participants. *E*-prime, MouseTracker, and Qualtrics Computer Software were used to administer the task. Stimulus materials and other assessment tools are available upon request.

2.3. *Measures*

2.3.1. *Valence bias*

The dependent measure quantifying valence bias across experiments was the percent of trials on which a subject viewed an emotionally ambiguous stimulus (i.e., surprised face or ambiguous scene) and rated it as negative, out of the total number of ambiguous trials (excluding omissions). The valence bias measure was calculated as the average valence bias for both faces and scenes (r across the two response types was 0.20, $p < .001$). Although most of the participants completed valence bias tasks with both ambiguous (surprised) faces and scenes, a subset of participants completed the task with either faces ($n = 243$) or scenes ($n = 27$) alone. Given that measurements of valence bias across multiple stimulus categories provides a more robust and generalizable measure of the bias (Harp et al., 2020), valence bias was treated as missing for those participants who did not complete the task with both stimulus categories. Although primary analyses focused on scores of valence bias averaged across stimuli, we conducted supplemental analyses that examined whether the interactive effects of neuroticism and IER on valence bias varied across the two stimulus types. The more complex ambiguous scenes might offer greater opportunity for regulation of negativity resulting from neuroticism (i.e., greater malleability) than a static image of a surprised face.

2.3.2. Neuroticism

Scores were extracted from the NEO Five-Factor Inventory (NEO–FFI; Costa & McCrae, 1992) to assess neuroticism (NEON). The NEO-FFI is one of the most widely used instruments to assess personality. This 60-item questionnaire includes scales to measure the big five personality traits, with responses that range from 0 (strongly agree) to 4 (strongly disagree). The psychometric properties of the NEO-FFI have been well-established (e.g., Murray et al., 2003). The NEON scale consists of 12 summed items, with a possible range of 0–48. To account for missing data for any one question, replacement scores were calculated with mean imputation. In the present study, internal consistency for the NEON scale was excellent (Cronbach's alpha = 0.86).

2.3.3. Interpersonal emotion regulation

We administered the *Interpersonal Regulation Questionnaire* (IRQ; Williams et al., 2018) and focused on scales pertaining to the use of interpersonal relationships to regulate negative affect: (1) NT represents the *tendency* to use IER in regulating negative emotions (e.g., "When something bad happens, my first impulse is to seek out the company of others"), (2) NE represents appreciation for what relationships can do to help regulate emotion (i.e., perceived *efficacy*; e.g., "I appreciate having others' support through difficult times"). Given that the *tendency* subscale is a more direct measure of whether someone routinely manages their negative affect through relationships, this dimension held the most promise for understanding the link between neuroticism and valence bias, but we examined both scales as moderators. The IRQ also includes scales for regulation of positive emotions. Given the purpose of the present student was to understand bias arising from neuroticism which is most closely tied to a propensity to experience negative affect, especially in response to uncertainty, we focused on the regulation of negative emotion scales for tests of our primary hypotheses. Nonetheless, we also explored the role of interpersonal regulation of *positive* emotions in a set of supplemental analyses. In the present study, IRQ subscales had excellent internal consistency: IRQ-NT (Cronbach's alpha = 0.86), IRQ-NE (Cronbach's alpha = 0.85), IRQ-PT (Cronbach's alpha = 0.89), and IRQ-PE (Cronbach's alpha = 0.86). Replacement values for missing data on individual items were calculated using person mean imputation.

2.3.4. Potential controls

Demographic characteristics (e.g., age, education, sex, household income, race, ethnicity, history of mental or physical illness, medication use) were examined for potential inclusion as control variables in the models. Only age and gender were significantly correlated with valence bias and at least one of the predictors and, as such, were included as controls. We also controlled for methodological differences in all analyses including (a) whether the study was completed on Mturk versus in the laboratory and (b) the response method used to complete the valence bias task (mouse versus keyboard).

2.3.5. Data analytic plan

The moderation models for the two forms of IER (i.e., tendency and perceived efficacy) were tested using Mplus 8 (Muthén & Muthén, 1998–2017) with a planned missingness design (Rhemtulla & Hancock, 2016). Specifically, our approach is an adaptation of a *multiform design* in which participants complete different sets of surveys rather than administering a full battery of questionnaires to everyone. This approach minimizes participant burden while still providing rigorous assessments of study constructs by using otherwise lengthy questionnaires with strong psychometric properties. Although different sets of surveys were administered, all participants completed the baseline valence bias task. Given the multiform design, missingness was randomly assigned. Missing data rates ranged from 0 to 46% (e.g., 54% of participants completed the IRQ) which is customary in planned missingness designs. To address missing data, we used Full Information Maximum Likelihood (FIML) estimation. Simulation studies demonstrate FIML's utility when rates of missingness are substantial (e.g., >50%), and its superiority to more traditional treatments (e.g., pairwise deletion; Enders, 2010). Robust maximum likelihood (MLR) estimation was implemented to account for violations of univariate and multivariate normality.

Valence bias was regressed on (a) the predictor, neuroticism, (b) the moderator, IER, (c) the interaction between neuroticism and IER, and (d) several covariates (age, sex, study, response method). This model was tested twice with each of the subscales of the IRQ representing (1) *tendency* to use interpersonal strategies to regulate negative emotions, and (2) *efficacy* in using interpersonal strategies to regulate negative emotions. Predictors (neuroticism and IRQ scores) were standardized (z-scored) in the models. A region of significance analysis was conducted for significant interactions to determine under what levels of IER were neuroticism scores significantly associated with valence bias, and whether the effect was fully buffered (i.e., no longer significant) at any levels of IER. Code and individual-level data are available upon request from the corresponding author.

3. Results

Correlations and descriptive statistics are reported in Supplemental Table S3 and were computed using MLR. Consistent with the hypothesis for Aim 1, higher scores of neuroticism were significantly associated with a more negative valence bias in the context of ambiguity ($r = 0.12$, $N = 1252$, $p = .00002$). Regarding Aim 2, model results are in Supplemental Table S4. Controlling for age, sex, and method differences, there was a significant negative interaction between neuroticism and IRQ-NT ($b = -1.82$, $p = .01$). The magnitude of the positive association between neuroticism and a more negative valence bias was stronger to the extent that IRQ scores were lower. A region of significance analysis revealed that neuroticism had a significant positive association with negative valence bias at scores of IRQ-NT that were 0.09 SD below the mean and lower. In contrast, once IRQ-NT scores surpassed that level (−0.09 z-score), neuroticism was no longer significantly associated with valence bias. See Fig. 1 for a graphical depiction. The IRQ-NE scale did not significantly interact with neuroticism, nor was it directly associated with valence bias when controlling for neuroticism. Results also suggest that a more negative valence bias is observed for females versus males, for younger than older adults, and when completing the valence bias task via Mturk versus the lab.

Results of supplemental analyses are reported in table S5. IER of positive affect (perceived efficacy but not tendency) emerged as a moderator of neuroticism when valence bias scores were averaged across stimuli and in the context of ambiguous scenes. When exploring effects for the two stimulus types separately, IER of negative affect only moderated the effect of neuroticism on valence bias in the context of ambiguous *scenes*, not faces, and this was the case for both tendency to use IER and perceived efficacy. Further, IER of positive affect was associated with a less negative and/or more positive valence bias in response to surprised faces regardless of neuroticism (i.e., direct effects). Although there was no evidence of moderation, greater IER of positive affect was associated with a less negative and/or more positive valence bias in the context of surprised faces, regardless of neuroticism. Finally, neuroticism was actually associated with a *more positive* valence bias in the context of scenes when interpersonal regulation of negative emotions was *very high*, but for a very small portion of the sample – 1.55 SDs above the mean or higher for IER-NT (7.11% of sample) and 1.93 SDs

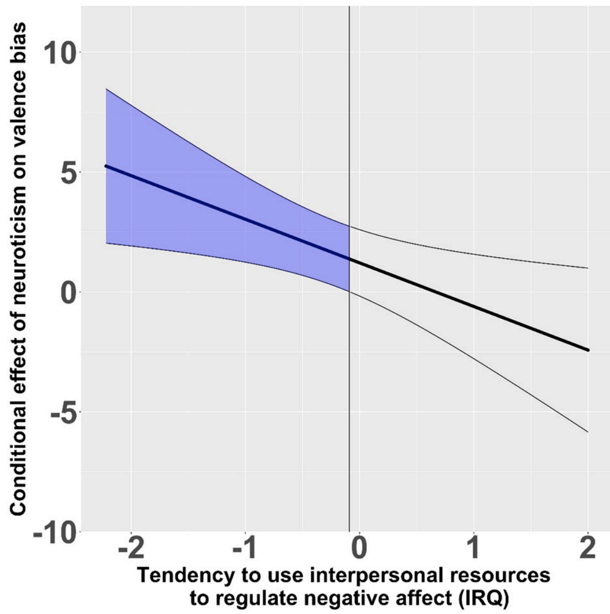

Fig. 1. Conditional effects of neuroticism on negative valence bias with 95% CI at varying levels of interpersonal emotion regulation. The shaded region represents significant conditional effects. As interpersonal emotion regulation increased, the positive association between neuroticism and a more negative valence bias decreased in magnitude and was not significant at scores of interpersonal emotion regulation that were −0.09 SDs below the mean and higher.

above the mean and higher for IER-NE (0% of sample).

4. Discussion

The current study represents an advancement in research linking neuroticism to negativity by incorporating a measure of bias in appraisals of dual-valence ambiguity. Consistent with our hypothesis, results of Aim 1 suggest trait neuroticism is associated with a more negative valence bias. This converges with research suggesting that neurotic individuals are more likely to attend to negative stimuli when there is a clear valence (e.g., remembering negative words), but builds on this by demonstrating a similar negativity bias when an equally valid positive interpretation is available. Results of Aim 2 suggest that this link varies as a function of IER. Specifically, the tendency to use relationships to regulate negative affect buffered this effect. In fact, beginning at near average levels of IER, the association between neuroticism and valence bias was no longer significant. However, at no point was a reverse effect observed – neuroticism was not associated with a more positive bias under very high levels of IER, although a trend emerged for regulation of positive affect. For individuals high in neuroticism, drawing on internal representations of relationships as dependable and secure when facing uncertainty might lessen negative appraisals, especially in the context of social cues which coincides with literature showing that attachment is associated with less amygdala response to threat (Long et al., 2020) and that decreased amygdala response to potential threat is associated with a more positive valence bias (Kim et al., 2003; Petro et al., 2018).

Supplemental analyses suggest that IER of positive emotion might also play an important role in valence bias, by either buffering the effect of neuroticism in the context of ambiguous scenes or directly impacting valence bias, regardless of neuroticism, in the context of surprised faces. Increasingly, investigators recognize that neuroticism is not necessarily specific to negative affectivity, and is likely associated with emotional reactivity more broadly, including greater intensity of positive affect (Hisler et al., 2020). Our results suggest that using interpersonal relationships to regulate not only negative but also positive emotions might reduce the negative perception of ambiguity. Further, the role of IER in valence bias might depend on the context, and more complex ambiguous scenes could offer greater opportunity for regulation of negativity from neuroticism than a static image of a surprised face. Finally, results suggest that both a *tendency* to use relationships to regulate emotion and the perceived *efficacy* of IER influence valence bias; however, future research should investigate the potential for these two dimensions of IER to influence valence bias through distinct mechanisms (e.g., neural activity).

4.1. Implications for research and practice and future directions

It is important to acknowledge limitations of the research design. First, missing data rates were relatively high for some variables due to the adapted multiform design; however, we employed FIML for addressing missing data (Enders, 2010; Enders & Bandalos, 2001), and missingness was assigned at random. Second, the sample was not racially or ethnically diverse, limiting the generalizability of the results. Future research should aim to include a more representative sample given discrimination and stigmatization related to one's race or ethnicity likely has consequences for interpretations of ambiguity in social contexts. Third, this was a cross-sectional study; longitudinal research would allow us to track if and how experiences with IER impact brain responses over time, resulting in downstream consequences for valence bias.

Despite these limitations, there are important implications. First, because individuals high in neuroticism are more likely to experience negative affect and emotional reactivity (Costa & McCrae, 1980; Watson & Clark, 1984), especially when facing uncertainty (Berenbaum et al., 2007; Hirsh & Inzlicht, 2008), processes that down-regulate negative emotion hold particular promise for minimizing negativity. Results demonstrate that IER might reduce attention to negativity during uncertain (here, ambiguous) situations. Future research is required to better understand how exactly IER minimizes negativity in these contexts, and to disentangle the relative effects of attachment security, IER, and related constructs (e.g., optimism). For example, perhaps internal representations of safety and security in relationships ultimately play a key role, especially in response to ambiguous social situations. Further, social relationships might emerge as particularly important for understanding how to best override a pre-potent negativity that is evident in response to ambiguity (Petro et al., 2018) given that individuals high in neuroticism tend to struggle with implementing *intrapersonal* strategies such as cognitive reappraisal (Ng & Diener, 2013). Although speculative, results point toward the potential efficacy of interventions promoting secure representations of relationships for regulating emotion (e.g., *emotionally focused couples therapy*; EFT; Wiebe & Johnson, 2016).

Finally, results bolster the utility of assessing biases toward negativity in experimental contexts that present relatively ambiguous stimuli that can be perceived as negative or positive to not only capture negativity, but also a propensity toward positivity on the same dimension. Results suggest higher neuroticism could be associated with a *more positive* valence bias at high levels of IER; however, this was only observed for a small portion of the sample. Nonetheless, neuroticism has been identified as an indicator of environmental sensitivity "for better or worse" (Ellis et al., 2011). Highly sensitive individuals with consistent exposure to threatening environments are at increased risk for psychopathology; however, when they are exposed to enriching and secure environments—and relationships—they have better outcomes than their less sensitive peers. Perhaps other features of the social environment, especially those present during key periods of neural development (e.g., responsive caregiving during early childhood), might reveal conditions under which neuroticism actually promotes a positivity bias. This represents an intriguing direction for future research.

CRediT authorship contribution statement

Rebecca L. Brock: Conceptualization, Software, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Nicholas R. Harp:** Conceptualization, Software, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Maital Neta:** Conceptualization, Methodology, Software, Validation, Resources, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.paid.2022.111726.

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