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Research paper

Borderline personality disorder features are associated with inflexible social interpretations

Jessica M. Duda [a,*], Sarah K. Fineberg [b,c], Wisteria Deng [a], Yvette Ma [a], Jonas Everaert [d,e], Tyrone D. Cannon [a,b], Jutta Joormann [a]

[a] Department of Psychology, Yale University, New Haven, CT, USA
[b] Department of Psychiatry, Yale University, New Haven, CT, USA
[c] Connecticut Mental Health Center, New Haven, CT, USA
[d] Department of Medical and Clinical Psychology, Tilburg University, the Netherlands
[e] Research Group of Quantitative Psychology and Individual Differences, KU, Leuven, Belgium

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ABSTRACT

Background: Borderline personality disorder (BPD) is thought to involve aberrant social learning, including impaired revision of social interpretations with new evidence (social interpretation inflexibility). However, this topic has received little empirical attention outside of specific literatures, such as moral inference or behavioral economics. Further, the contribution of comorbid depression to BPD-related interpretation inflexibility has not yet been assessed.

Methods: In two independent samples (Study 1: $N = 213$; Study 2: $N = 210$, oversampled for BPD features), we assessed the associations between BPD symptoms, depressive symptoms, and task-based measures of social interpretation flexibility.

Results: We found that BPD symptoms, particularly volatility of identity and relationships, were associated with less revision of social interpretations with both positive *and* negative evidence. Meanwhile, depressive symptoms were associated with a pattern of less revision of social interpretations with positive versus negative information.

Limitations: The use of cross-sectional, crowdsourced samples limits causal interpretations. Translation to clinical populations should be assessed in future studies.

Conclusions: Results suggest that inflexible social interpretations across valences may be a feature of BPD-related pathology, and could be connected to symptoms involving volatility in social contexts. Future studies should investigate whether treatments geared toward increasing the flexibility of social interpretations are effective in treating BPD symptoms, especially those involving interpersonal difficulties.

Volatile interpersonal relationships are a central feature of borderline personality disorder (BPD; Johansen et al., 2004), and tend to persist after other symptoms remit (Gunderson et al., 2011). Aberrant social learning, including impression formation and updating, is thought to contribute to relational instability in BPD (Fineberg et al., 2018; King-Casas et al., 2008; Siegel et al., 2020), yet the mechanisms remain unclear. In this study, we examined whether BPD symptoms were associated with a form of aberrant social learning, interpretation inflexibility, involving reduced integration of new information into interpretations (Everaert et al., 2018).

Social interpretation flexibility has received little direct empirical attention in BPD, although evidence from diverse literatures implicates inflexible impressions and behavior in the disorder. First, neuropsychological studies indicate diminished set-shifting in BPD, a marker of reduced cognitive flexibility (Ruocco, 2005). Further, literature on moral inference indicates a tendency toward developing negative, inflexible moral impressions in BPD (Siegel et al., 2020). Individuals with BPD also may revise expectancies of social acceptance (Liebke et al., 2018) and evaluations of themselves (Korn et al., 2016) with negative, but not positive, social feedback. According to hypermentalizing literature, BPD involves difficulty adapting impressions to external cues due to overweighting internal sources of information (e.g., own thoughts and interpretations) over external sources (e.g., social cues; McLaren et al., 2022). BPD is also associated with difficulty

* Corresponding author at: Yale University, 100 College Street, New Haven, CT 06510, USA.
E-mail address: jessica.duda@yale.edu (J.M. Duda).

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reestablishing cooperation following relational rupture, a form of inflexible social behavior (King-Casas et al., 2008).

Biased interpretations of social information may contribute to the maintenance of inflexible interpretations in BPD. The term "interpretation bias" is the tendency to integrate evidence toward a characteristic conclusion. Interpretation biases are thought to contribute to inflexible interpretations via encouraging integration of bias-confirming evidence (Kube and Rozenkrantz, 2021). In BPD, a tendency toward negative interpretations of ambiguous social stimuli (Baer et al., 2012) could encourage attendance to and integration of bias-confirming information, thereby reducing revision with disconfirmatory evidence. However, no studies to our knowledge have yet examined whether BPD-related inflexibility can be explained by biased interpretations alone, or whether BPD symptoms are associated with reduced integration of disconfirmatory social evidence even after accounting for interpretation biases. Two tasks have been designed to disentangle social interpretation flexibility and bias, the emotional Bias Against Disconfirmatory Evidence task (BADE; Everaert et al., 2018) and interpretation inflexibility task (IIT; Deng et al., 2022a), which are well-suited for probing these processes in BPD.

Studies are also needed to investigate whether individuals with BPD show interpretation inflexibility beyond what can be explained by depressive symptoms. BPD and major depressive disorder (MDD) are highly comorbid, with rates of MDD as high as 83% among individuals with BPD (Shah and Zanarini, 2018). Depressive symptoms have been associated with a pattern of inflexible, negative social interpretations (Deng et al., 2023; Deng et al., 2022a; Everaert et al., 2018), resembling the pattern previously shown in BPD (e.g., in the context of moral inference; Siegel et al., 2020). Given the putatively similar pattern of social interpretation inflexibility between the two disorders and high comorbidity, it remains unclear whether BPD involves inflexible social interpretations beyond what can be explained by comorbid depression.

Given BPD's comorbidity with mood disorders, paired with the heterogeneity of its diagnostic criteria, calls have been growing to move beyond categorical diagnoses to examine BPD dimensionally and investigate symptom profiles (e.g., Hopwood et al., 2018; Siegel et al., 2020; Smits et al., 2017). Dimensional approaches facilitate the examination of symptoms across the spectrum of severity and allow for the examination of BPD-typical problems among those who do not meet full disorder criteria. Further, research into separable symptom clusters may map more closely onto underlying mechanisms (Cuthbert, 2022) and could facilitate the identification of specific BPD-related phenotypes. In the context of interpretation flexibility, these approaches would facilitate investigations into whether various BPD symptoms at varying severity levels are associated with inflexible social interpretations, a largely open question in the literature.

1. Overview of current work

As outlined above, studies probing the flexibility of social interpretations in BPD have typically been limited to very specific social contexts (e.g., morality), have not accounted for comorbid depression and interpretation biases, and have not been applied to dimensional measures. To address these gaps, we investigate whether dimensional BPD symptoms were associated with inflexible social interpretations, controlling for interpretation biases and comorbid depression, in two independent online samples (sample 2: enriched for BPD features). Participants completed self-report measures of BPD and depressive symptoms and task-based measures of social interpretation flexibility and bias. This two-study design allowed us to test the replicability of our findings with heterogeneous measures (i.e., constructive replication). Given evidence of specific impairments with updating negative impressions with positive evidence in BPD, we hypothesized that BPD symptoms would be associated with less revision of social interpretations with new positive, but not negative, evidence (i.e., less "positive flexibility"), including when accounting for depression and interpretation biases.

2. Study 1

2.1. Methods

2.1.1. Recruitment and procedure

Participants (N = 213) were recruited from Amazon Mechanical Turk's CloudResearch platform as part of a larger study of interpretation flexibility and memory (Deng et al., 2023; Deng et al., 2022b). An online platform was chosen for several reasons. First, research has demonstrated that crowdsourcing platforms are effective for recruiting large clinical samples (Shapiro et al., 2013), including with elevated BPD symptoms (Collison et al., 2018; Miller et al., 2017; Ooi et al., 2020). Second, crowdsourced and community samples (versus treatment-seeking clinical samples) allow for including individuals with sub-threshold symptoms or not currently seeking care. Finally, participants may be more comfortable disclosing sensitive experiences online (Chandler and Shapiro, 2016). CloudResearch samples have been shown to exhibit comparable or superior data quality to unselected MTurk samples, Qualtrics, and undergraduate student samples (Douglas et al., 2023).

All participants were at least 18 years old and residing in the United States. Study procedures were completed in a single session. Data quality approaches followed recommendations for crowdsourced samples (Chandler and Shapiro, 2016). Participants were required to have a 98% approval rate across past HITs, answer all attention checks correctly, and spend at least 60% of expected time completing study procedures. Participants provided informed consent in compliance with the Yale University Institutional Review Board and were compensated $6.

2.1.2. Questionnaires

Borderline Evaluation of Severity Over Time (BEST). The BEST (Pfohl et al., 2009) was used to measure BPD symptoms over the past month on a Likert-type scale (1–5). Subscale A (BEST-A: Thoughts/Feelings) comprised eight items assessing instability, identity issues, and paranoid thinking (possible range: 8–40). The suicidality item was not collected due to the anonymous nature of data collection; to increase comparability across studies, an average score was calculated across remaining items and added to participants' total score (Trockel et al., 2015). Subscale B (Behaviors-Negative) included four items assessing BPD-relevant behaviors (possible range: 4–20). Subscale C was not collected as it assesses treatment adherence. The BEST shows adequate internal consistency and test-retest reliability (Pfohl et al., 2009). Both subscales showed good internal consistency in this sample (BEST-A: ω = 0.89; BEST-B: ω = 0.88).

BDI-II. The BDI-II is a 21-item self-report measure of depression severity within the preceding two weeks rated on a 4-point scale (Beck et al., 1996). The suicidality item was not collected, and the total score was adjusted in line with the BEST. The BDI-II shows strong psychometric properties (Richter et al., 1998) and showed excellent internal consistency in this sample (ω = 0.96). The association between depression and interpretation flexibility with these data was reported by Deng et al. (2023).

2.1.3. Interpretation Inflexibility Task (IIT)

The IIT (Deng et al., 2022a) was utilized to measure social interpretation flexibility. The task comprises 24 scenarios in which a photo successively unblurred in three stages. In 12 scenarios, the unblurred photo depicted a positive scene (used to assess positive flexibility or revision with positive evidence), and in the other 12 scenarios, it depicted a negative scene (assessing negative flexibility). After viewing each photo, participants rated the plausibility of four explanations on a 7-point scale: an *Absurd* explanation, two *Lure* explanations (which appear plausible from the blurred photos, but were not ultimately

supported), and a *True* explanation. Interpretation bias and flexibility were calculated following Deng et al. (2022a).

2.1.4. Analyses

Outliers >3 standard deviations from the mean were removed prior to analyses and continuous predictors were mean-centered. To probe the association between interpretation flexibility and BPD symptoms, mixed-effects models predicting interpretation flexibility were run with the *lme4* RStudio package (Bates et al., 2015), with valence (a within-subject factor capturing the direction [positive vs. negative] of interpretation revision), BEST subscales (BEST-A or BEST-B), BDI-II, the interactions of valence with each clinical variable, interpretation biases, and a subject-specific random intercept.

2.2. Results

2.2.1. Sample Characteristics

The final sample ($N = 213$; $n_{male} = 111$; $n_{female} = 102$) included 179 individuals identifying as White or European American, 22 as Black or African American, 12 as Asian or Asian American, five as Native American or Alaska Native, three who preferred to self-describe, and 18 who identified as Hispanic or Latine (Table S1). Participants reported a range of depressive symptoms (BDI-II: $M = 11.0$, $SD = 12.5$; range: 0–52.5), BPD thoughts/feelings (BEST-A; $M = 12.0$, $SD = 5.7$; range: 8.0–30.9) and BPD behaviors (BEST-B; $M = 5.0$, $SD = 2.5$; range: 4.0–18.0). Raw BPD and depression scores showed a slight right skew; however, mixed-effects models have been shown to be robust to non-normal distributions (Schielzeth et al., 2020). Independent sample *t*-tests confirmed that BPD symptoms and depression did not differ by reported gender, $ps > .256$.

2.2.2. BPD symptom severity and interpretation flexibility

See Table S2 for zero-order correlations. A mixed-effects model accounting for depression and interpretation biases revealed a negative association between the BEST-A (BPD thoughts/feelings) and flexibility, $t(194) = -4.57$, $p < .001$, with a medium effect size, $\eta^2_p = 0.10$, 90% CI [0.04, 0.17] (Cohen, 2013). Contrasting with hypotheses, BEST-A did not significantly interact with valence, $t(194) = 1.70$, $p = .091$ (Fig. 1; Table 1). Given the trend toward an interaction, separate linear models were run by valence—BEST-A was associated with less negative flexibility, $R^2 = 0.13$, $F(4,196) = 8.58$, $\beta = -0.44$, $p < .001$, 95% CI [−0.63, −0.24] and positive flexibility, $R^2 = 0.07$, $F(4,194) = 4.70$, $\beta = -0.34$, $p < .001$, 95% CI [−0.54, −0.14]. A similar mixed-effects model with BEST-B (BPD behaviors) also revealed a negative association between BPD behaviors and flexibility, $t(192) = -3.40$, $p < .001$, with a small-to-medium effect size, $\eta^2_p = 0.06$, 90% CI [0.02, 0.12], and no significant

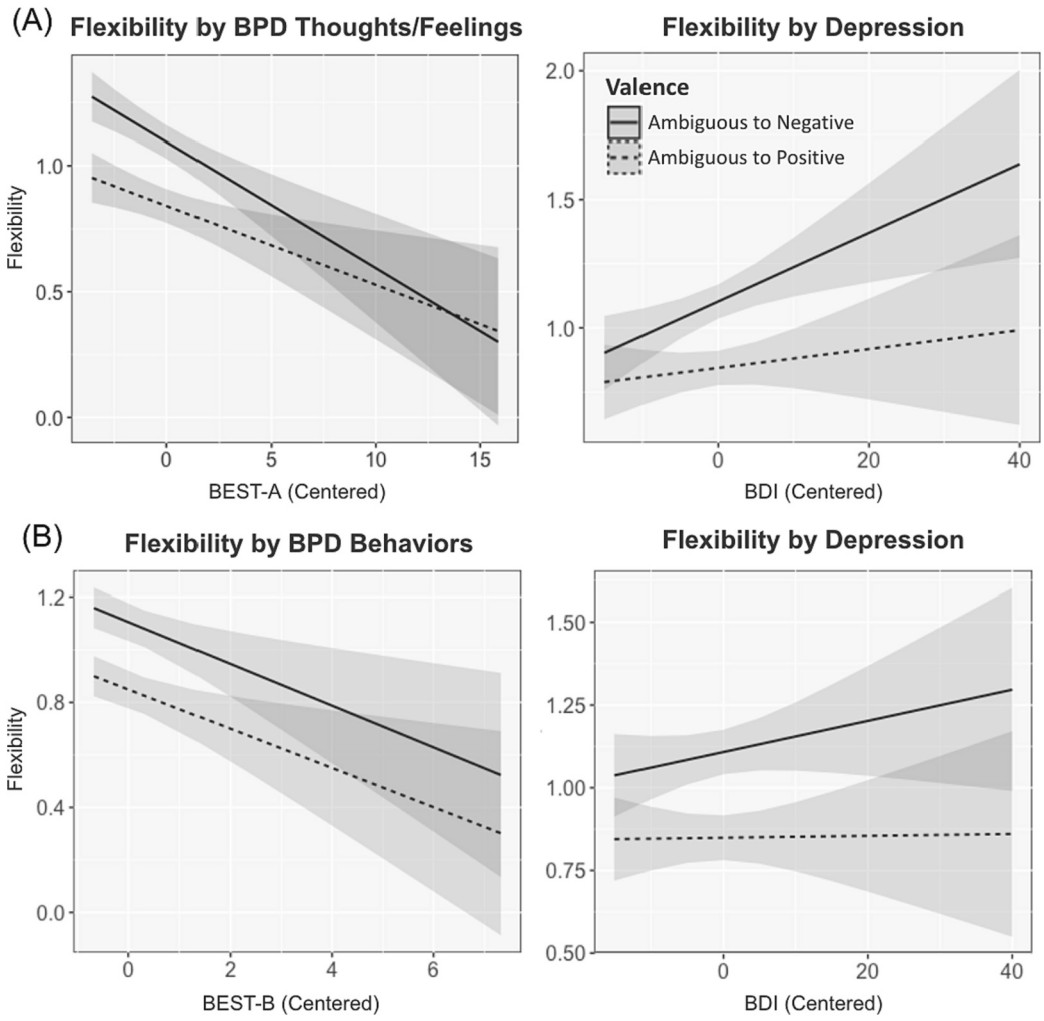

Fig. 1. Interpretation flexibility with depression and (A) BPD thoughts/feelings subscale or (B) BPD behaviors subscale in study 1.
Note. BEST: Borderline Evaluation of Severity over Time; BEST-A: thoughts/feelings subscale; BEST-B: behaviors subscale; BDI: Beck Depression Inventory; Valence: factor capturing direction of interpretation revision. Flexibility assessed with Interpretation Inflexibility Task, with outliers defined as outside 3 standard deviations from the mean. Graphs depict marginal effects from two mixed-effects models predicting interpretation flexibility with either BEST-A (A) or BEST-B (B), BDI, valence, interpretation bias, the interactions of valence with each clinical variable, and a subject-specific random intercept.

Table 1
Models with BPD symptoms, depression, and valence predicting (A) interpretation flexibility and (B) interpretation bias in study 1.

A) Interpretation Flexibility	Estimated coefficient (*b*)	*SE*	*df*	*t*	*p*
BEST-A (BPD Thoughts/ Feelings)					
Intercept	0.97	0.03	195	33.52	<0.001***
BEST-A	−0.04	0.01	194	−4.57	<0.001***
BDI-II	0.01	0.00	196	2.21	0.028*
Valence	−0.26	0.04	195	−7.20	<0.001***
Negative interpretation bias	−0.24	0.14	194	−1.78	0.076
Positive interpretation bias	−0.52	0.16	194	−3.26	0.001**
Valence*BEST-A	0.02	0.01	194	1.70	0.091
Valence*BDI-II	−0.01	0.00	197	−2.03	0.044*
BEST-B (BPD Behaviors)					
Intercept	0.98	0.03	193	33.39	<0.001***
BEST-B	−0.08	0.02	192	−3.40	<0.001***
BDI-II	0.00	0.00	195	0.77	0.440
Valence	−0.26	0.04	194	-7.10	<0.001***
Negative interpretation bias	−0.26	0.14	192	−1.90	0.058
Positive interpretation bias	−0.48	0.16	192	−2.99	0.003**
Valence*BEST-B	0.00	0.03	192	0.17	0.868
Valence*BDI-II	−0.00	0.00	195	−1.13	0.259
B) Interpretation Biases	Sum of Squares	Mean Square	*df*	*F*	*p*
BEST-A (BPD Thoughts/ Feelings)					
Between Subjects					
Intercept	405.02	405.02	1	13,895.94	<0.001***
BEST-A	0.01	0.01	1	0.28	0.600
BDI-II	0.01	0.01	1	0.27	0.607
Error	5.80	0.03	199		
Within Subjects					
Valence	3.39	3.39	1	56.32	<0.001***
Valence*BEST-A	0.56	0.56	1	0.94	0.334
Valence*BDI-II	0.23	0.23	1	3.79	0.053
Error (Valence)	11.96	0.06	199		
BEST-B (BPD Behaviors)					
Between Subjects					
Intercept	400.04	400.04	1	13,599.20	<0.001***
BEST-B	0.00	0.00	1	0.00	0.977
BDI-II	0.00	0.00	1	0.06	0.808
Error	5.80	0.03	197		
Within Subjects					
Valence	3.33	3.33	1	55.07	<0.001***
Valence*BEST-B	0.03	0.03	1	0.46	0.500
Valence*BDI-II	0.83	0.83	1	13.65	<0.001***
Error (Valence)	11.93	0.06	197		

Note. BDI-II: Beck Depression Inventory, Second Edition; BEST-A: Borderline Evaluation of Severity over Time Subscale A (Thoughts/Feelings); BEST-B: Borderline Evaluation of Severity over Time Subscale B (Behaviors); BPD: borderline personality disorder; Valence: a factor capturing the direction of interpretation revision. All continuous predictors are mean-centered. Interpretation flexibility and bias are assessed with the Interpretation Inflexibility Task, with datapoints removed if outside 3 standard deviations from the mean. Part (A) of the table depicts results of two mixed effects models predicting interpretation flexibility with BEST (Subscale A or B), BDI-II, valence, interpretation biases, and the interactions of valence with each clinical variable, allowing a random intercept for subject. Part (B) depicts results of a repeated measures general linear model predicting interpretation bias with BEST (Subscale A or B), BDI-II, valence, and their interactions. A general linear model was utilized in lieu of mixed-effects models due to insufficient variation in subject-specific random intercepts. * $p < .05$. ** $p < .01$. *** $p < .001$.

interaction with valence, $p = .868$. Notably, BPD symptoms were not associated with interpretation biases, $ps > .334$, when accounting for depression (Table 1). Taken together, BPD symptoms were associated with less revision of social interpretations regardless of the valence of information, even when accounting for depression and interpretation biases.

2.3. Interim discussion

This study was the first to our knowledge to examine the relationship between BPD symptoms and the flexibility of interpretations across a range of social scenarios, accounting for interpretation biases and comorbid depressive symptoms. Results showed that BPD symptoms were associated with less revision of social interpretations with negative *and* positive disconfirmatory evidence, partially supporting hypotheses. This finding contrasts with the pattern of specifically inflexible *negative* impressions in depression (Everaert et al., 2018) and aligns with theoretical work and neuropsychological evidence implicating broad inflexibility in BPD-related pathology (Fonagy et al., 2015; Ruocco, 2005). Findings indicate a possible unique signature of BPD symptoms involving social interpretation inflexibility across valences, which is not explainable by a bias toward negative interpretations.

3. Study 2

A second sample was collected alongside Study 1 with separate validated measures of BPD symptoms and social interpretation flexibility to facilitate a constructive replication. A stratified sampling approach was used to oversample for BPD symptoms. Addressing calls to investigate BPD symptom clusters dimensionally (Siegel et al., 2020; Smits et al., 2017), we also performed an exploratory factor analysis to identify BPD- and MDD-related symptom clusters and probe their associations with interpretation flexibility.

3.1. Methods

3.1.1. Procedure

Data were again collected via CloudResearch (Litman et al., 2017) following similar procedures to Study 1 (with a minimum HIT approval of ≥95 %). To ensure adequate variability in BPD symptoms, a stratified sampling approach was implemented (Everaert et al., 2021) using established Borderline Symptom List-23 cut-offs (BSL-23; Bohus et al., 2009; Kleindienst et al., 2020). A sample of 600 participants completed a screening questionnaire, 271 participants were contacted for the main study (seeking an even number in the "low," "mild," and "moderate/above" BSL-23 categories), 223 completed all procedures, and 210 remained after quality checks. All participants provided informed consent in line with the Yale University Institutional Review Board. Participants were compensated up to $8.50.

3.1.2. Questionnaires

Borderline Symptom List (BSL-23). The BSL-23 is a 23-item self-report measure of BPD symptoms over the past week rated on a 5-point severity scale (0–4, Bohus et al., 2009). A mean BSL-23 score was calculated across items. The BSL-23 shows excellent internal consistency, test-retest reliability, and satisfactory sensitivity to change (Bohus et al., 2009; Wolf et al., 2009). In this sample, the scale's internal consistency was $\omega = 0.97$.

Structured Clinical Interview for DSM-IV Axis II Personality Disorder Questionnaire – BPD Scale (SCID-II-PQ). The SCID-II-PQ includes 15 yes/no questions corresponding to the BPD diagnostic criteria (First et al., 1997). The measure shows good internal consistency (Cronbach's $\alpha = 0.83–0.88$) and test-retest reliability (ICC = 0.87;

Fowler et al., 2018). The SCID-II-PQ has been shown to have comparable or superior predictive validity to other common self-report measures of BPD (van Alebeek et al., 2017). A score of 8 on the scale has been shown to have good sensitivity (78 %) and specificity (80 %) for a BPD diagnosis (Fowler et al., 2018). The scale showed adequate internal consistency in this sample: ω = 0.87. The SCID-II-PQ was utilized as our primary measure of BPD symptoms.

Beck Depression Inventory – Second Edition (BDI-II). The BDI-II (Beck et al., 1996) was analyzed utilizing the same process as Study 1. The scale's internal consistency in this sample was ω = 0.96.

3.1.3. Emotional bias against disconfirmatory evidence (BADE) task

The emotional BADE (Everaert et al., 2018) involves 24 written scenarios depicting interpersonal interactions, each comprising three consecutively presented statements. In *disconfirming-the-negative* scenarios, initial evidence suggested a negative interpretation, but subsequent evidence suggested a positive outcome, while disconfirming-the-positive scenarios showed the opposite pattern. After reading each statement, participants rated the plausibility of four possible explanations for the situation on a 21-point scale (*poor* to *excellent*). One explanation was *absurd*, two were *lures*, and one was *true*. Interpretation flexibility and bias were calculated in line with Everaert et al. (2018, 2021) with several modifications (see Supplement Section S2).

3.1.4. Analyses

Procedures to test the main hypotheses matched Study 1. Given significant gender differences in the clinical variables, sensitivity analyses were run adding gender as a covariate (Section S3 of Supplement). In addition to these planned analyses, we ran an exploratory factor analysis (EFA) with the BPD and MDD questionnaires to identify symptom clusters. To assess the unique patterns of interpretation flexibility associated with these symptom clusters, we computed zero-order correlations and estimated mixed-effects models with each factor predicting interpretation flexibility controlling for interpretation biases.

3.2. Results

3.2.1. Sample characteristics

The final sample ($N = 210$; $n_{male} = 113$; $n_{female} = 92$; $n_{nonbinary} = 4$; $n_{agender} = 1$) included 171 participants identifying as White or European American, 15 as Asian or Asian American, 14 as Black or African American, eight as multiracial, one as Native American, one preferring not to report their race, and seven identifying as Hispanic or Latine (Table S3). The sample showed considerable variability in BPD symptoms, with 32.86% reporting low symptoms (BSL: 0–0.28), 32.38% reporting mild symptoms (BSL: 0.28–1.07), and 34.76% reporting moderate/high symptoms (BSL > 1.07; Kleindienst et al., 2020). Depressive symptoms ranging from minimal to severe were also reported (BDI-II: $M = 17.1$, $SD = 14.9$, range = 0–59).

3.2.2. BPD symptom severity and interpretation flexibility

See Table S4 for zero-order correlations. Mixed-effects model results again revealed a significant negative association between BPD symptoms and interpretation flexibility, $t(196) = -2.91$, $p = .004$, with a small effect size (Cohen, 2013), $\eta_p^2 = 0.04$, 90% CI [0.01, 0.10], and no interaction with valence, $p = .342$ (Fig. 2; Table 2). Thus, BPD symptoms were again associated with less flexibility *regardless* of the direction of revision, including after accounting for depression and interpretation biases. As expected, depression interacted with valence to predict flexibility, $t(198) = -3.76$, $p < .001$, with a medium effect size, $\eta_p^2 = 0.07$, 90% CI [0.02, 0.13], such that depression was associated with less revision with positive versus negative evidence. BPD symptoms were not associated with interpretation biases after accounting for comorbid depression, while depression was associated with greater negative versus positive biases (Table 2).

3.2.3. Exploratory factor analysis: BPD features and interpretation flexibility

See Supplement Section S5 for further EFA methods. A model using a Pearson correlation matrix yielded superior fit to a model with polychoric correlations (Supplement Section S6), and met established cutoffs for acceptability (RMSEA = 0.07; Tucker Lewis Index = 0.91;

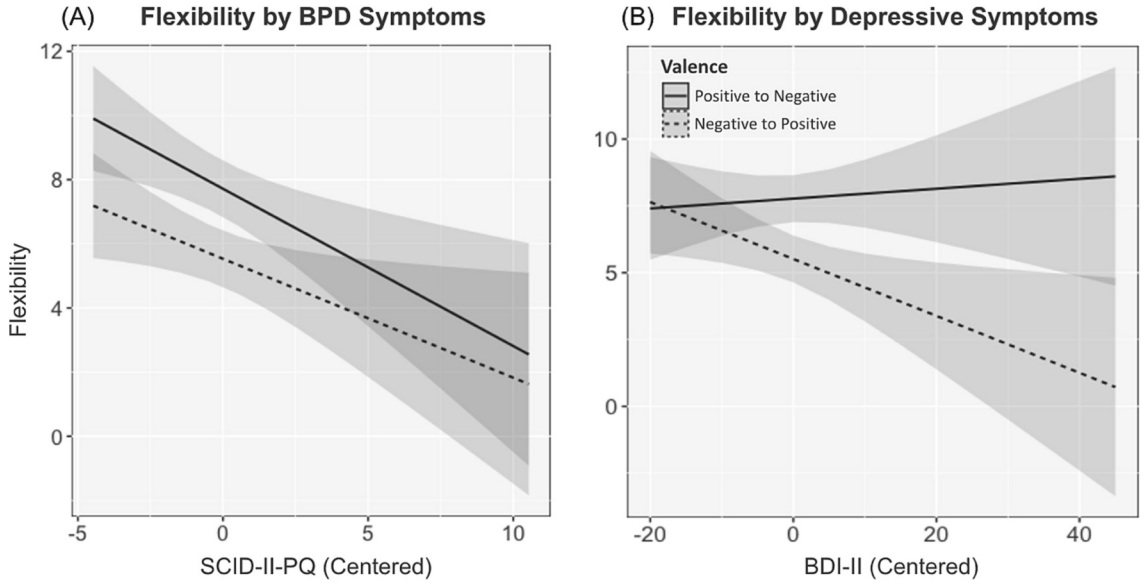

Fig. 2. Model-predicted interpretation flexibility with (A) BPD symptoms and (B) depressive symptoms in study 2.
Note. BDI-II: Beck Depression Inventory; BPD: Borderline Personality Disorder; SCID-II-PQ: Structured Clinical Interview for DSM-IV Axis II Personality Disorder Questionnaire, BPD Scale; Valence: variable capturing the direction of interpretation revision. Interpretation flexibility assessed with emotional Bias Against Disconfirmatory Evidence task, with outliers defined as outside 3 standard deviations from the mean. Graphs depict marginal effects from a mixed-effects model predicting interpretation flexibility with SCID-II-PQ, BDI-II, valence, interpretation bias, the interactions of valence with each clinical variable, and a subject-specific random intercept.

Table 2
Mixed-effects models with BPD symptoms, depression, and valence predicting A) interpretation flexibility and B) interpretation bias in study 2.

Effect	Estimated coefficient (*b*)	*SE*	*df*	*t*	*p*
A) Interpretation Flexibility					
Intercept	6.57	0.41	196	16.00	<0.001***
SCID-II-PQ	−0.43	0.15	196	−2.91	0.004**
BDI-II	−0.04	0.04	196	−1.06	0.291
Negative interpretation bias	0.22	0.06	196	3.43	<0.001***
Positive interpretation bias	−0.04	0.07	196	−0.57	0.569
Valence	−2.25	0.35	198	−6.43	<0.001***
Valence*SCID-II-PQ	0.12	0.13	198	0.95	0.342
Valence*BDI-II	−0.13	0.03	198	−3.76	<0.001***
B) Interpretation Bias					
Intercept	36.9	0.35	203	106.85	<0.001***
SCID-II-PQ	0.09	0.12	204	0.74	0.462
BDI-II	0.03	0.03	203	0.94	0.347
Valence	−3.08	0.56	203	−5.47	<0.001***
Valence*SCID-II-PQ	0.08	0.20	203	0.39	0.696
Valence*BDI-II	−0.24	0.05	203	−4.59	<0.001***

Note. BDI-II: Beck Depression Inventory, Second Edition; SCID-II-PQ: Structured Clinical Interview for DSM-IV Axis II Personality Disorder Questionnaire, BPD Scale; Valence: a factor capturing the direction of interpretation revision (with disconfirmatory negative vs. positive information). All continuous predictors are mean-centered. Interpretation flexibility and bias assessed with the emotional Bias Against Disconfirmatory Evidence Task, with datapoints removed if outside 3 standard deviations from the mean. The table depicts results of A) a mixed effects model predicting interpretation flexibility with SCID-II-PQ, BDI-II, valence, the interactions of valence with each clinical variable (SCID-II-PQ, BDI-II), and interpretation bias, allowing a random intercept for subject, and B) a mixed effects model predicting interpretation bias with SCID-II-PQ, BDI-II, valence, and the interactions of valence with each clinical variable, allowing a random intercept for subject, * $p < .05$. ** $p < .01$. *** $p < .001$.

Bentler and Bonett, 1980; Browne and Cudeck, 1992). The EFA produced four factors (Table 3) reflecting: depression-related symptoms (Factor 1: "Internalizing Symptoms"; Factor 2: "Physical Depression/Anhedonia"), symptoms of both depression and BPD (Factor 3: "Self-Harm/Punishment"), and BPD-specific symptoms (Factor 4: "Self/Other Volatility). Summed scores were calculated based on the raw items (ωs ≥ 0.79; Distefano et al., 2019).

Zero-order correlations revealed that both depression-related factors were associated with less positive flexibility: Factor 1, $r(202) = -0.21$, $p = .002$, 95% CI [−0.34, −0.08]; Factor 2: $r(202) = -0.32$, $p < .001$, 95% CI [−0.44, -0.19], but not negative flexibility, *ps* > .149 (Table S4). Meanwhile, a factor capturing BPD-typical relational and identity volatility (Factor 4) was associated with both less positive flexibility, $r(202) = -0.30$, $p < .001$, 95% CI [−0.42, −0.17], *and* negative flexibility, $r(203) = -0.21$, $p = .003$, 95% CI [−0.33, −0.07]. Factor 3 (Self-Harm/Punishment) was not associated with positive or negative flexibility, *ps* > .064.

Next, to control for interpretation biases, mixed-effects models were run predicting interpretation flexibility with each factor, valence, their interactions, and interpretation biases. Self/Other Volatility was again associated with less interpretation flexibility, $t(197) = -4.61$, $p < .001$, with a medium effect size, $\eta_p^2 = 0.10$, 90% CI [0.04, 0.17], but did not interact with valence, $p = .146$ (Fig. 3; Table S5). Meanwhile, both depression-related factors interacted with valence to predict flexibility (Internalizing Symptoms, $t(199) = -4.17$, $p < .001$, $\eta_p^2 = 0.08$, 90% CI [0.03, 0.15]; Physical Depression/Anhedonia: $t(199) = -3.91$, $p < .001$), $\eta_p^2 = 0.07$, 90% CI [0.02, 0.14], indicating an association with greater negative versus positive flexibility with a medium effect size. Factor 3 (self-harm) was associated with less interpretation flexibility, $t(194) = -2.36$, $p = .019$, with a small effect size $\eta_p^2 = 0.03$, 90% CI [0.00, 0.08], and did not interact with valence, $p = .398$, after controlling for interpretation bias (although the lack of significant zero-order correlations with negative or positive flexibility should be considered). In sum, a BPD-specific factor (volatility of identity and relationships) was associated with less interpretation flexibility *irrespective* of valence, both with and without controlling for interpretation biases. This pattern contrasted with results showing that depression-related factors were associated with reduced positive versus negative flexibility.

Table 3
Factor loadings for exploratory factor analysis on BSL-23, SCID-II-PQ, and BDI-II in study 2.

Item	Scale and item number	Factor loading			
		1	2	3	4
Internalizing symptoms					
Self-dislike	BDI 7	**0.91**	0.13	−0.13	0.01
Worthlessness	BSL 23	**0.90**	−0.09	0.15	−0.05
Worthlessness	BDI 14	**0.89**	0.08	0.01	−0.05
Past failure	BDI 3	**0.86**	0.10	−0.11	0.05
Hated self	BSL 11	**0.73**	−0.04	0.28	−0.01
Felt disgusted by self	BSL 21	**0.72**	−0.12	0.28	0.05
Self-criticalness	BDI 8	**0.71**	0.16	−0.05	0.12
Pessimism	BDI 2	**0.68**	0.25	0.04	−0.05
Suffered from shame	BSL 13	**0.68**	−0.07	0.19	0.15
Guilty feelings	BDI 5	**0.62**	0.12	0.01	0.17
Loneliness	BSL 8	**0.61**	0.04	0.11	0.10
Physical depression/ anhedonia					
Tiredness/fatigue	BDI 20	−0.05	**0.88**	0.06	−0.01
Loss of energy	BDI 15	0.04	**0.85**	0.03	−0.01
Loss of pleasure	BDI 4	0.20	**0.71**	0.04	0.08
Loss of interest	BDI 12	0.17	**0.68**	0.03	0.07
Concentration difficulty	BDI 19	0.02	**0.57**	0.21	0.15
Changes in sleep	BDI 16	0.11	**0.53**	−0.10	0.00
Self-harm/ punishment					
Thought of self-harm	BSL 5	0.01	0.22	**0.77**	−0.17
Wanted to punish self	BSL 12	0.18	0.05	**0.71**	0.08
Didn't believe in right to live	BSL 7	0.28	−0.05	**0.69**	0.05
Afraid of losing control	BSL 20	0.04	0.02	**0.66**	0.25
Fascination with death	BSL 18	0.10	0.07	**0.63**	0.00
Had images I was afraid of	BSL 10	0.00	0.23	**0.60**	0.12
Self/other volatility					
Dramatic changes in sense of self	SCID-II-PQ 4	−0.12	0.08	0.15	**0.67**
Sudden changes in identity/future	SCID-II-PQ 3	−0.04	0.02	−0.02	**0.63**
Sudden changes in goals/beliefs	SCID-II-PQ 6	0.15	0.02	−0.18	**0.62**
Extreme relational ups/ downs	SCID-II-PQ 2	−0.05	0.14	0.07	**0.55**
Different around different people	SCID-II-PQ 5	0.21	−0.01	−0.06	**0.54**
Franticly avoids abandonment	SCID-II-PQ 1	0.05	−0.02	0.11	**0.53**
Portion of variance explained		0.27	0.14	0.14	0.09
McDonald's Omega		0.97	0.92	0.92	0.79

Note. Exploratory factor analysis with principal axis factoring and oblimin rotation, treating variables as continuous. Model was chosen over one with polychoric correlations due to superior model fit. For ease of interpretation, question wording in "Item" column is simplified. BDI-II: Beck Depression Inventory; BSL-23: Borderline Symptom List-23; SCID-II-PQ: Structured Clinical Interview for DSM-IV Axis II Personality Disorder Questionnaire, BPD Scale.

3.3. Interim discussion

In Study 2, we applied separate measures of BPD and interpretation flexibility, allowing for a constructive replication, along with stratified sampling for greater representation of BPD symptoms. The finding that

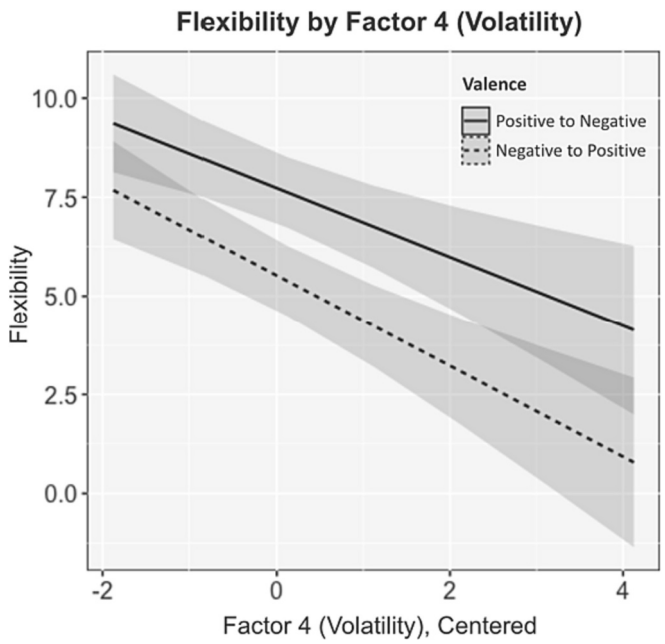

Fig. 3. Model-Predicted Effects of Interpretation Flexibility with Self/Other Volatility Factor in Study 2.
Note. Valence: a factor capturing the direction of interpretation revision. Interpretation flexibility assessed with emotional Bias Against Disconfirmatory Evidence task, with outliers defined as outside 3 standard deviations from the mean. Graph depicts marginal effects from a mixed-effects model predicting interpretation flexibility with an exploratory factor analysis-derived BPD-related factor (Self/Other Volatility), valence, interpretation bias, the interactions of valence with each factor, and a subject-specific random intercept.

BPD symptoms were associated with less revision of social interpretations with both negative *and* positive disconfirmatory evidence was replicated. This finding could not be explained by depressive symptoms, which were associated with greater negative versus positive flexibility, or by interpretation biases.

An EFA to determine whether specific BPD- and MDD-related symptoms were associated with inflexible social impressions yielded a largely BPD-specific factor (volatility of identity and relationships), a self-harm-related factor (a feature of both disorders), and two depression-related factors. Even after accounting for interpretation biases and gender, a factor capturing volatility of identity and relationships was associated with broad social interpretation inflexibility. In line with expectations, the associations between both depression-related factors and inflexibility were moderated by valence, indicating a greater association with inflexible negative versus positive interpretations. Results suggest that failure to dynamically revise social impressions with new evidence irrespective of valence may be a correlate of BPD-typical relational and identity instability.

4. General discussion

4.1. BPD symptoms and interpretation inflexibility

Across two studies, we demonstrated that BPD symptoms were associated with reduced revision of social interpretations with positive and negative information. Based on previous work demonstrating specific inflexibility of negative moral impressions (Siegel et al., 2020) and social expectations (Liebke et al., 2018) in BPD, we initially hypothesized that BPD symptoms would be associated with reduced revision of interpretations only with disconfirmatory *positive* evidence. Contrary to hypotheses, we found an association with inflexible social interpretations regardless of the direction of updating. In Study 2, we replicated these findings in an independent sample with a second set of measures. Our results suggest that BPD-related social interpretation inflexibility may not be specific to negative impressions, but rather span a broad range of interpersonal contexts. These findings align with neuropsychological evidence of blunted cognitive flexibility in BPD (Ruocco, 2005), as well as longstanding cognitive and personality theories that consider rigidity to be a central feature of personality pathology (Fonagy et al., 2015).

Our studies represent one of few task-based demonstrations of broad social interpretation inflexibility in participants with elevated BPD symptoms. Our findings address several important gaps in the literature. First, studies assessing the flexibility of social interpretations in BPD are limited, and existing studies have largely been siloed to specific literatures (e.g., moral inference, economic exchange games). Studies assessing the flexibility of social interpretations in other contexts are needed, especially given the centrality of interpersonal problems to BPD (Gunderson, 2007). Further, past studies have not directly examined whether BPD-related interpretation flexibility can be explained by interpretation biases (i.e., a tendency toward negative or positive interpretations overall). In our studies, the use of the IIT and emotional BADE allowed us to separately probe interpretation inflexibility and bias, revealing that BPD symptoms were associated with inflexibility even accounting for interpretation biases. Finally, we found that BPD and depressive symptoms were associated with distinct patterns of inflexibility, an important consideration given the high rates of comorbidity (Shah and Zanarini, 2018).

While our results provide evidence of inflexible social interpretations among individuals with BPD symptoms, the mechanisms are not yet clear. Several explanations are plausible based on existing literature. First, although evidence is mixed, some studies have shown reduced sensitivity to socioemotional cues in BPD (Anupama et al., 2018), which could hinder the integration of new social information into interpretations. Interestingly, BPD-related social cognitive impairments may be particularly pronounced for *ambiguous* and emotionally charged social stimuli (McLaren et al., 2022); future studies should vary the ambiguity and emotional intensity of the stimuli to clarify its effects on inflexibility in BPD. In addition, individuals with BPD symptoms might engage in cognitive reappraisal of disconfirmatory evidence to preserve existing beliefs ("cognitive immunization"; Kube et al., 2019), contributing to inflexible interpretations. Further, purported deficits in epistemic trust in BPD (Fonagy et al., 2015, 2017; Masland et al., 2020) may contribute to interpretation inflexibility, as reduced trust in social information may diminish learning from social (i.e., external) evidence. This mechanism aligns with the literature on hypermentalizing, in which difficulty flexibly integrating internal and external sources of information (McLaren et al., 2022) may interact with affective reactivity to produce inflexible behavior. In line with Belsky and Pluess's (2009) theory of differential susceptibility to the environment, innate susceptibility factors (e.g., heightened affective reactivity) may alter sensitivity to both negative *and* positive contextual conditions, which could explain the finding of inflexibility across valences. Additional research is needed to directly examine the role of social sensitivity, epistemic mistrust, and cognitive immunization in BPD-related social interpretation inflexibility.

4.2. BPD-related volatility and interpretation inflexibility

In Study 2, we also performed an exploratory analysis to identify BPD- and MDD-related symptom clusters and explore their specific associations with inflexibility. Factors included MDD-related internalizing symptoms and anhedonia, self-harm/punishment, and BPD-specific volatility symptoms. Zero-order correlations and mixed-effects model results demonstrated that BPD-related volatility symptoms (surrounding identity and relationships) were associated with inflexible social interpretations across valences. Further research is needed to better understand this association; however, one possible explanation is that social interpretation inflexibility involves reduced adaptation to

dynamic social cues, which could contribute to the development and maintenance of more rigid and extreme interpretations of others (e.g., splitting). Indeed, splitting is a common feature of BPD that is associated with relational conflicts (Fertuck et al., 2018). Interpretation inflexibility may also destabilize individuals' sense of identity, which is highly influenced by the social environment (Luyten et al., 2020).

This investigation of symptom profiles adds to the literature for several reasons. First, the EFA allowed us to parse BPD and MDD symptoms, which show considerable overlap and comorbidity. Second, dimensional examinations of symptom profiles address the heterogeneity of the BPD diagnostic criteria and may map more closely onto underlying mechanisms (Cuthbert, 2022; Hopwood et al., 2018). Finally, the diagnostic label of BPD is associated with significant stigma (Knaak et al., 2015), and has been disproportionately diagnosed in minoritized groups, especially the LGBTQ+ community (Rodriguez-Seijas et al., 2021). Analyses into specific dimensions of distress facilitate moving away from these diagnostic labels and their associated biases.

4.3. Limitations

Despite these strengths, our work faces several limitations. First, our samples were disproportionately White and non-Hispanic; future studies should be conducted in samples with greater racial and ethnic diversity. Second, effect sizes were modest, such that factors not analyzed here likely also predict individual differences in inflexibility. Third, relying on self-report measures can lead to biased responses, including overreporting when using an oversampling approach. To reduce incentives to overreport: 1) instructions in Study 2 did not allude to the inclusion criteria; 2) attention checks encouraged overreporting to flag participants exaggerating experiences; and 3) the SCID-II-PQ was used as our BPD measure, as it was collected during the main study in which there was less incentive to overreport. Fourth, the use of self-report measures precluded determination of formal psychiatric diagnoses. Research applying diagnostic interviewing is needed to examine the generalizability of our results to individuals with a formal BPD diagnosis. Nevertheless, we believe this online, dimensional approach is valuable for assessing a range of BPD-typical symptoms in the general population (in which rates of BPD may approach 6 %; Hasin and Grant, 2015). Finally, it bears mentioning that the clinical presentation of depression among those with borderline personality disorder likely diverges from major depression occurring alone, especially in the timescale of affective fluctuations and associations with interpersonal rejection (Beatson and Rao, 2013; Gunderson and Phillips, 1991; Koenigsberg et al., 1999). Thus, depression-related findings, especially in the sample enriched for BPD features, should be interpreted cautiously. Still, we are encouraged that the pattern of depression-related inflexible negative social interpretations in both samples matches past studies (Deng et al., 2023; Deng et al., 2022a; Everaert et al., 2018).

5. Conclusion and future directions

The present studies represent two of the first task-based demonstrations of BPD-related interpretation inflexibility across a range of social contexts. Results reveal a unique pattern of valence-agnostic inflexibility among those with BPD symptoms that cannot be explained by interpretation biases or depressive symptoms. Findings have implications for understanding BPD-typical social behavior. Failing to dynamically update social impressions may contribute to the maintenance of rigid or extreme beliefs about others, which aligns with the BPD-typical pattern of idealization and devaluation in relationships. Our findings could help explain why frontline treatments for BPD that promote flexible cognition (e.g., cognitive behavioral therapy, mentalization-based therapy, dialectical behavior therapy) are often effective.

Future research could build on this work in several ways. First, studies are needed to uncover the precise mechanisms through which BPD-related rigid interpretations are formed and maintained. For example, Bayesian approaches could be applied to assess whether social interpretation inflexibility relates to an imbalance between the precision afforded to existing beliefs (priors) versus new evidence (Kube and Rozenkrantz, 2021). Second, studies should include both familiar and unfamiliar social stimuli, given evidence that relational functioning is particularly disrupted with *close others* in BPD (Fitzpatrick et al., 2019). Finally, interpretation inflexibility could represent a promising treatment target for people with BPD symptoms, especially those experiencing stormy interpersonal relationships. Future studies should apply measures of interpretation flexibility before and after treatment to examine whether flexibility changes with treatment or predicts treatment response. Such analyses would further clarify the role of interpretation inflexibility in psychiatric distress and inform interventions.

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The funders of the study were not involved in study design, data collection, analyses, interpretation, writing, or decision to submit the article.

CRediT authorship contribution statement

Jessica M. Duda: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft. **Sarah K. Fineberg:** Conceptualization, Methodology, Writing – review & editing. **Wisteria Deng:** Data curation, Investigation, Project administration. **Yvette Ma:** Data curation, Visualization. **Jonas Everaert:** Writing – review & editing. **Tyrone D. Cannon:** Methodology, Supervision, Writing – review & editing. **Jutta Joormann:** Conceptualization, Funding acquisition, Methodology, Resources, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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