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The Moderating Role of Neuroticism on Evaluative Conditioning: Evidence from Ambiguous Learning Situations

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Abstract

Numerous studies have demonstrated a link between neuroticism and negative biases. While some studies suggest that people with high neuroticism give more weight to negative information, others suggest that they respond more strongly to both positive and negative information. We investigated whether neuroticism is related to the evaluation of conditioned stimuli (CSs) in evaluative conditioning (EC) procedures that involve ambiguous learning conditions. We created ambiguous situations where CSs were paired with unconditioned stimuli (USs) consisting of both positive and negative pictures (Experiment 1) or paired alternatingly with positive and negative USs (Experiment 2). In addition to CSs consistently paired with positive and negative USs, we introduced neutral USs as a control condition. Our findings revealed that neurotic individuals negatively evaluated the CSs from ambiguous conditions relative to neutral conditions. Additionally, participants with high neuroticism scores generally rated CSs more negatively. Theoretical and clinical implications of these results are discussed.

Keywords: neuroticism, evaluative conditioning, ambiguity, ambivalent USs

The Moderating Role of Neuroticism on Evaluative Conditioning: Evidence from Ambiguous Learning Situations

Neuroticism is one of the most investigated personality traits in the Five-Factor Model (FFM) due to its association with both physical and mental health (e.g., Lahey, 2009; Sauer-Zavala & Barlow, 2021). It is characterized by the tendency to experience more frequent and intense negative emotions, perceive the world as a generally dangerous place, and overreact to both external and internal sources of stress, even if they are minor (Barlow et al., 2014; Eysenck, 1947; Goldberg, 1993). Recent meta-analytic findings have confirmed the link between heightened neuroticism and an increased propensity to experience negative affect (Kalokerinos et al., 2020).

The study of neuroticism is particularly important because it has been found to foster the development and maintenance of psychopathology, particularly in the context of mood disorders such as anxiety and depression (e.g., Barlow et al., 2014; Ormel et al., 2013; Vittengl, 2017; see the meta-analysis of Kotov et al., 2010). It has been argued that the onset, maintenance, and recurrence of mood disorder symptoms are rooted in a negativity bias in information processing (Beck et al., 1979; Beck & Haigh, 2014). Substantial empirical evidence indeed documents the link between negativity bias and neuroticism, emphasizing that highly neurotic people tend to give more weight to and selectively process negative internal and external information. For instance, Chan et al. (2007) concluded that people who score high on neuroticism show an increased tendency to process negative information and a decreased tendency to process positive information. Studies on neuroticism and attentional bias have also demonstrated that people with higher neuroticism scores allocate more attentional resources to negative stimuli and have difficulty withdrawing attention from them (e.g., Chen & Zheng, 2005; Rijsdijk et al., 2009).

Additionally, research on neuroticism and memory revealed that high levels of neuroticism are associated with a tendency to recall negative events (e.g., Gomez et al., 2002; Norris et al., 2019).

In this paper, we focus on whether neuroticism is also associated with a negativity bias in emotional learning, more specifically, the effects of contingencies that involve negative events. According to Sauer-Zavala and Barlow (2021), a bias in emotional learning could lead to the acquisition of pathological behavior patterns. For instance, increased sensitivity to negative social consequences of public speaking could increase the likelihood of developing social anxiety. Our focus is on one emotional learning type, evaluative conditioning (EC). As a procedure, EC involves the pairing of conditioned stimuli (CSs) with positive or negative unconditioned stimuli (USs). As an effect, EC refers to changes in evaluative responses to conditioned stimuli (CSs) that result from CS-US pairings (De Houwer, 2007; see Moran et al., 2023, for a review). If highly neurotic individuals exhibit a bias in learning preferences that makes them more likely to acquire dislikes rather than likes, this could indicate potentially risky contexts for the development of internalized psychopathology, such as anxiety and depression. Over time, such people may perceive the world as darker, triggering negative responses. Another possibility is that high levels of neuroticism are related not only to a bigger impact of negative USs but also to a smaller impact of positive USs. In this case, CSs would be generally rated more negatively as neuroticism increases, regardless of US valence.

As far as we know, only one previous study has attempted to investigate the relationship between neuroticism and EC (Vogel et al., 2019). The researchers adopted a typical EC paradigm in which initially neutral stimuli (CSs) were repeatedly paired with either positive or negative USs. Their findings suggested that individuals with high neuroticism scores evaluated

CSs paired with negative USs as more negative, while surprisingly, they also evaluated CSs paired with positive USs as more positive. In other words, an increase in neuroticism was associated with both a stronger negative valence transfer (from negative USs to CSs) and a stronger positive valence transfer (from positive USs to CSs). Rather than supporting the idea of a negativity bias in emotional learning, the data suggest that increased neuroticism is linked to a general strengthening of emotional learning (see Larsen & Diener, 1987).

The study by Vogel et al. (2019) may not have revealed a negative bias in emotional learning due to the straightforward contingencies presented to participants. In situations where the contingencies are clear and predictable, a propensity for negativity bias is less likely to manifest (Lissek et al., 2006). Therefore, we re-examined the relation between neuroticism and negative bias in more ambiguous EC procedures, that is, in procedures that create ambiguity regarding the contingencies in which negative stimuli are involved. In a situation that can be interpreted in more than one way (Carleton, 2012), negative events might still receive more weight than positive events for people high in neuroticism (i.e., negative outweighs positive; Brock et al., 2022; Snyder & Ickes, 1985). The results of our study are also likely to have higher ecological validity as many real-life situations involve ambiguous stimulus-stimulus contingencies.

To increase generalizability, we induced ambiguity in two ways. In Experiment 1, we used ambivalent USs which were pictures blending two opposite valences. In Experiment 2, we conducted a conceptual replication of Experiment 1, but showing alternating pictures of opposite valence. Target CSs were paired with positive USs in 50% of trials and negative USs in the other 50%. Whereas the first manipulation creates ambiguity regarding the valence of the US, the second manipulation creates ambiguity regarding the presence of a positive or negative US. As real-world analogues, consider giving presentations at different conferences and receiving a mix of positive and negative feedback within the comments (ambiguous feedback similar to the ambivalent USs from Experiment 1) or sometimes receiving overall positive comments and sometimes overall negative comments (ambiguous feedback similar to alternating USs in Experiment 2). Given the ambiguity, people might evaluate the feedback in multiple ways (Carleton, 2012). We predicted that participants scoring high on neuroticism would transfer to a higher extent negative than positive valance in ambiguous situations, as they tend to interpret such situations more negatively than others (e.g., Salemink & van den Hout, 2010). This would be an instance of a negativity bias in emotional learning, that is, more negative ratings for CSs from ambiguous conditions.

Experiment 1

In Experiment 1, we conceptualized ambiguity by using ambivalent USs (Glaser et al., 2018). These USs were used in addition to typical, positive, and negative USs. We also used neutral USs as a control. This allowed us to investigate whether the relation between neuroticism and emotional learning is specific to situations with ambivalent USs.

Method

Design

The procedure involved a 4-levels (US valence: positive vs. negative vs. neutral vs. ambivalent) within-subjects unifactorial design.

Participants

Participants (N = 556; 364 female, 192 male, M_{age} = 24.42, SD = 7.38) were undergraduate and graduate Romanian students. They received course credit in exchange for their participation.

Materials

The 48-item Neuroticism scale from the NEO PI-R (Costa & McCrae, 1992) ($\alpha = .93$) was used to measure both neuroticism and its six facets. We opted for this scale to extend the conceptualization of neuroticism beyond the anxiety and depression facets that Vogel et al. (2019) used in their research. The self-report measure uses a 5-point Likert scale (1 = *not agree at all* to 5 = *agree at all*). The descriptive statistics of the scale are presented in Supplemental Materials Section 2.

For the conditioning task, we utilized eight computer-generated grayscale fractals as CSs, previously employed successfully in similar evaluative conditioning studies (i.e., Sava et al., 2020). As in Glaser et al. (2018), a US consisted of two embedded pictures that were either both positive (unambiguous positive US), both negative (unambiguous negative US), both neutral (neutral US) or of opposite valence (i.e., one positive and one negative; ambiguous USs). Each of these four USs was presented twice. The stimuli used in constructing the USs were selected from the International Affective Picture System (IAPS; Lang et al., 2008). More details regarding the pairing and the USs are presented in Supplemental Materials Section 1. An example of an ambivalent US is also presented in the supplemental materials.

Procedure

Participants completed the experiment in a laboratory setting. They were informed that the experiment consisted of a visual perception task. The materials were presented on a computer screen via Inquisit 5 software (2016). After providing demographic information and completing the neuroticism scale, participants took part in the EC task. Each CS was repeatedly presented simultaneously with the same US (i.e., one-to-one pairing strategy). The CSs were always shown on the left side of the screen, while the USs were presented on the right. The size of the CSs was 3.15 × 3.15 inches, and the size of the USs was 4.17 × 3.15 inches. The whole EC procedure consisted of eight presentations of each of the 8 CS-US pairs, resulting in 64 trials. The assignment of CSs to USs was counterbalanced across participants using a generalized version of the Latin Square design of order eight (also see Sava et al., 2020). Each pair was presented on the computer screen for 2500ms with an inter-stimulus interval of 1000ms. After the EC procedure ended, participants were asked to evaluate how much they liked or disliked each fractal (i.e., likeability measure for each CS). Each CS was evaluated on a scale ranging from -3 (*very unpleasant*) to +3 (*very pleasant*). Valence awareness was also measured (Stahl et al., 2009) by asking participants which type of valenced US was paired with each CS during the EC procedure. Participants also evaluated the perceived valence of each US on a categorical scale. This measure was used as a valence check for USs. See Supplemental Materials Section 1 for details.

Sample Size Determination

When deciding on the sample size, we ensured sufficient participants for stable and reliable effects (Schönbrodt & Perugini, 2013) in the event of relatively small effect sizes. We aimed at collecting a sample size of at least 500 participants, which provides sufficient power at .80 (with $\alpha = .05$ one-tailed) for detecting an effect of $r \geq |.11|$, which should be considered a relatively small effect (corresponding to Cohen's $d = 0.22$).

Results

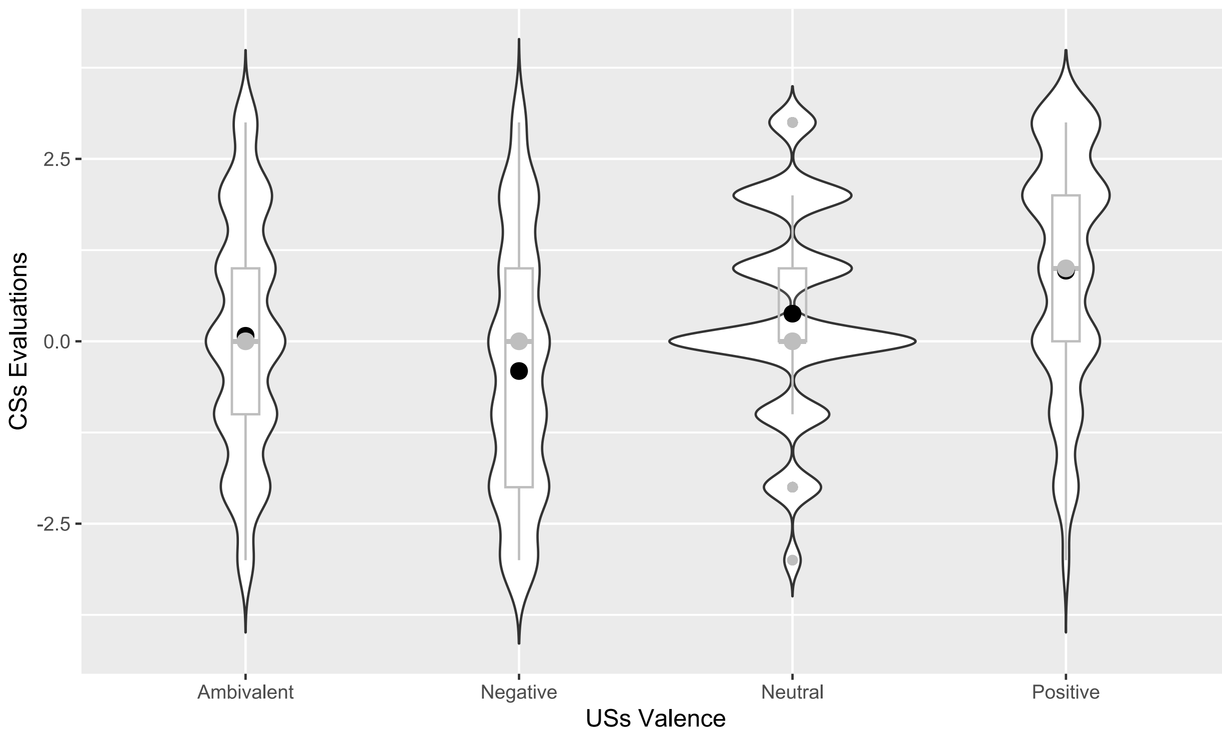
The analyses of Experiments 1 and 2 follow the same rationale. Both experiments' datasets and R codes (we used version 4.1.1) can be accessed on the OSF repository through the following link: https://osf.io/mcgvs/?view_only=eff937ac13de494f94235c961ef193ed.

Preliminary Analyses. To test our hypothesis on the interaction between neuroticism and the US valence on CSs, we used Linear Mixed Effects Regression (Brown, 2021), modeled with the *lmerTest* package (Kuznetsova et al., 2017). First, we were interested in detecting the EC effect. Thus, we verified a *Null Model* by including random intercepts for participants and stimuli (i.e., 8 CSs). The variance of the CSs in this Null Model was close to zero (i.e., 0.07; see Supplemental Materials Section 3). Therefore, we implemented the *General Model* by including only the by-participant random intercept: $\beta = 0.25$, $SE = 0.03$, 95% CI [0.19, 0.32], $t = 7.80$, $p < .001$ (see Supplemental Materials Section 4).

As we introduced the ambivalent USs in addition to the positive, negative, and neutral USs, we used a dummy-coding scheme by setting the ambivalent valence as the reference level, treating the US valence as a categorical factor. First, we verified whether the EC effect emerged as intended. The full model indicated that the evaluation of CSs paired with negative USs was estimated as being significantly more negative relative to the CSs paired with ambivalent USs: $\beta = -0.48$, $SE = 0.06$, 95% CI [-0.61, -0.36], $t = -7.62$, $p < .001$. As expected, the evaluation of CSs paired with positive USs was significantly more positive relative to the CSs from the ambivalent condition: $\beta = 0.89$, $SE = 0.06$, 95% CI [0.77, 1.02], $t = 14.09$, $p < .001$. The CSs paired with neutral USs were also significantly more positively evaluated relative to the reference level: $\beta = 0.30$, $SE = 0.06$, 95% CI [0.18, 0.43], $t = 4.78$, $p < .001$. See Supplemental Materials Section 5 for details. Figure 1 depicts the descriptive statistics and the density of CSs evaluations for each condition.

Figure 1

The Summary Statistics and the Density of the CSs Evaluations for Each Condition



Note. The violin plots present the summary statistics and the density of the evaluations for the CSs paired with ambivalent USs (the first plot), negative USs (the second plot), neutral USs (the third plot), and positive USs (the fourth plot). In each plot, there is a boxplot representation of the evaluative response distributions. The black point from each violin plot represents the mean of the evaluative responses for each condition, while the grey point represents the median of the evaluative responses for each condition.

Main Analyses. We introduced neuroticism as a supplementary predictor in the general model to investigate the interaction effect with the valences of USs paired with CSs. The results revealed a statistically significant interaction only between neuroticism and the evaluation of CSs paired with neutral USs relative to the CSs paired with ambivalent USs (the reference level): β = 0.005, *SE* = 0.002, 95% CI [0.001, 0.01], *t* = 2.33, *p* = .019. No interaction effects were found between neuroticism and CSs paired with positive USs or with negative USs relative to the ambivalent condition: β = 0.003, *SE* = 0.002, 95% CI [-0.001, 0.01], *t* = 1.54, *p* = .123, respectively β = 0.002, *SE* = 0.002, 95% CI [-0.001, 0.01], *t* = 1.15, *p* = .247. Decomposing the significant interaction effect, we found that highly neurotic people evaluated more negatively the

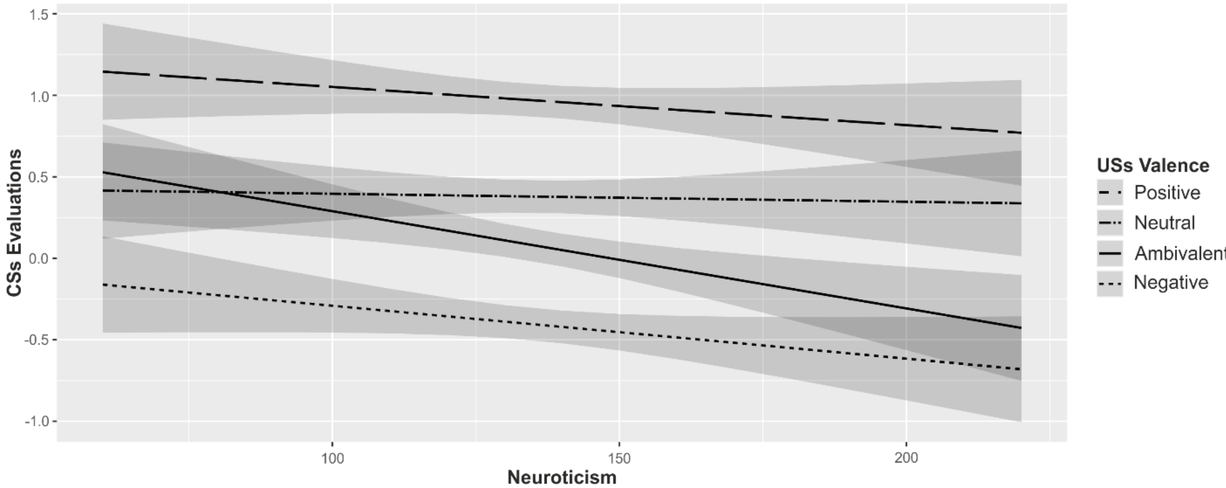
CSs paired with ambiguous relative to the CSs paired with neutral stimuli (see Figure 2). Thus, the selective bias in evaluation seems to be captured here only when the evaluations of CSs paired with ambivalent USs are compared to a neutral, non-valenced learning condition. That is, highly neurotic people evaluated the CSs paired with ambivalent USs as more negative compared to the CSs paired with neutral USs. The magnitude of these effects was small (see Supplemental Material Section 6).

When we introduced in the analysis the categorization of the USs valence as a dummy variable (i.e., 1 – stimulus categorized according to its normative valence vs. 0 – stimulus categorized as having different valence than intended), the result of the interaction remained similar to the one presented above (see Supplemental Materials Section 7). Thus, the perception of the USs' valence did not affect the robustness of the revealed interaction effect.

The analyses also revealed a significant main effect of neuroticism: β = -0.005, *SE* = 0.001, 95% CI [-0.01, -0.001], *t* = -3.18, *p* = .001. This effect showed that the ratings of CSs decreased across conditions as the neuroticism score increased in the sample. That is, highly neurotic participants gave lower ratings to the CSs, independent of the US valence paired with. Figure 2 shows these results, also highlighting the interaction effect previously discussed.

Figure 2

The Main Effect of Neuroticism on the CSs Evaluations



Note. Each slope becomes more abrupt as the level of neuroticism increases, reflecting the general negative ratings received by CSs, independent of the condition. The interaction effect between neuroticism and the evaluations of the CSs paired with ambivalent USs, relative to the neutral condition is also visible (see the second and third lines).

Experiment 2[1]

Experiment 2 represents a conceptual replication of Experiment 1, the main difference being that ambiguity was operationalized by mixed pairings. Specifically, in the ambiguous condition, CSs were alternatingly paired with positive USs in 50% of trials and negative USs in the other 50% of trials. This experiment was preregistered at https://aspredicted.org/QB4_YZG.

[1] We conducted an earlier study almost identical to Experiment 2, with the main difference that it did not include a condition with neutral USs. Results were similar to the ones obtained in the new experiment (see Supplemental Materials Section 15). We opted to report only the results of the new study because the earlier one did not include the condition with neutral USs, which is vital to examine whether the interaction effect observed in Experiment 1 can be replicated.

We expected to find the same key results as for Experiment 1: a main effect of neuroticism on the CSs ratings and an interaction effect of neuroticism and the ambiguous experimental condition (compared to the control one).

Method

Design

The conditioning procedure involved a 4-levels (USs' valence: 100% Negative vs. 100% Positive vs. 100% Neutral vs. 50% Negative – 50% Positive) within-subjects unifactorial design.

Participants

For this experiment, the participants were recruited via Prolific (https://www.prolific.co/). Four hundred participants (197 female, 203 male, M_{age} = 28.57, *SD* = 9.31), eligible based on the exclusion criteria mentioned in the pre-registration, took part in the study. Participants are part of the general population. In Supplemental Materials Section 8 is presented a table with the country of residence for the participants involved in this experimental replication.

Materials

Given the online data collection, we opted to use a copyright-free Neuroticism scale (Johnson, 2014) (α = .91) for this second experiment. The scale is part of the International Personality Item Pool and can be accessed at https://ipip.ori.org/30FacetNEO-PI-RItems.htm. This scale also presents the six facets of neuroticism. Considering that our main aim was focused on the whole trait of neuroticism, in the main analyses reported in the manuscript we did not take into account the individual facets. However, their descriptive statistics are reported in Supplemental Materials Section 8. This self-report measure also uses a 5-point Likert scale (1 = *Strongly disagree* to 5 = *Strongly agree*).

All eight fractals from Experiment 1 were employed as CSs. Ten pictures selected from IAPS (Lang et al., 2008) were used as USs: two for the positive condition, two for the negative condition, two for the neutral condition, and four for the ambiguous condition. All USs pictured a human or child’s face expressing positive or negative emotions (except for the neutral condition). For this experiment, the USs are singular images, most of them being used for the merged US pictures from Experiment 1. The USs were not evaluated (as in Experiment 1), given the lack of an effect in the previous study. The IAPS codes and the detailed EC procedure are described in Supplemental Materials Section 8.

Procedure

All materials were presented using Inquisit 6 software (2016). After providing informed consent, participants completed the neuroticism self-report measure. The EC task started immediately afterward. Two CSs were always paired (100%) with positive USs (each CS was paired with the same US), two CSs were always paired (100%) with negative USs (each CS was paired with the same US), two CSs were always paired (100%) with neutral USs (each CS was paired with the same US), and two CSs were paired equally often with a positive US and with a negative US (i.e., 50% of the trials included a positive US and 50% included a negative US). Throughout the EC procedure, each CS was presented eight times with its corresponding US, resulting in 64 trials (similar to Experiment 1). The Latin Square design of order 8 allowed us again to counterbalance the CS-US pairings. The CSs were always presented on the left side of the screen, while the USs were presented on the right. The size of the CSs was 3.15 × 3.15 inches, and the size of the USs was 4.17 × 3.15 inches. As in Experiment 1, each pair was displayed on the computer screen for 2500ms with an inter-stimulus interval of 1000ms. After the EC procedure ended, participants were asked to evaluate how much they liked or disliked the fractals (from -3 = *very unpleasant* to +3 *very pleasant*). The valence awareness was also measured (see Experiment 1). The data collection concluded with a debriefing section.

Sample Size Determination

We targeted a sample size of around 400, which provides sufficient power at .80 (with $\alpha = .05$ one-tailed) for detecting an $r \geq |.14|$, which is a relatively small effect (corresponding to Cohen's $d = 0.3$).

Results[2]

Similar to Experiment 1, we analyzed data using Linear Mixed Effects Regression.

Preliminary analyses. First, we tested whether there was an EC effect. We computed a *Null Model* by including random intercepts for participants and stimuli (i.e., 8 CSs). The variance of the CSs in the overall model was close to zero, similar to Experiment 1 (i.e., 0.07; see Supplemental Materials Section 9). Thus, we implemented the *General Model* by including only the by-participant random intercept: $\beta = 0.002$, $SE = 0.04$, 95% CI [-0.08, 0.09], $t = 0.067$, $p = .947$ (see Supplemental Materials Section 11).

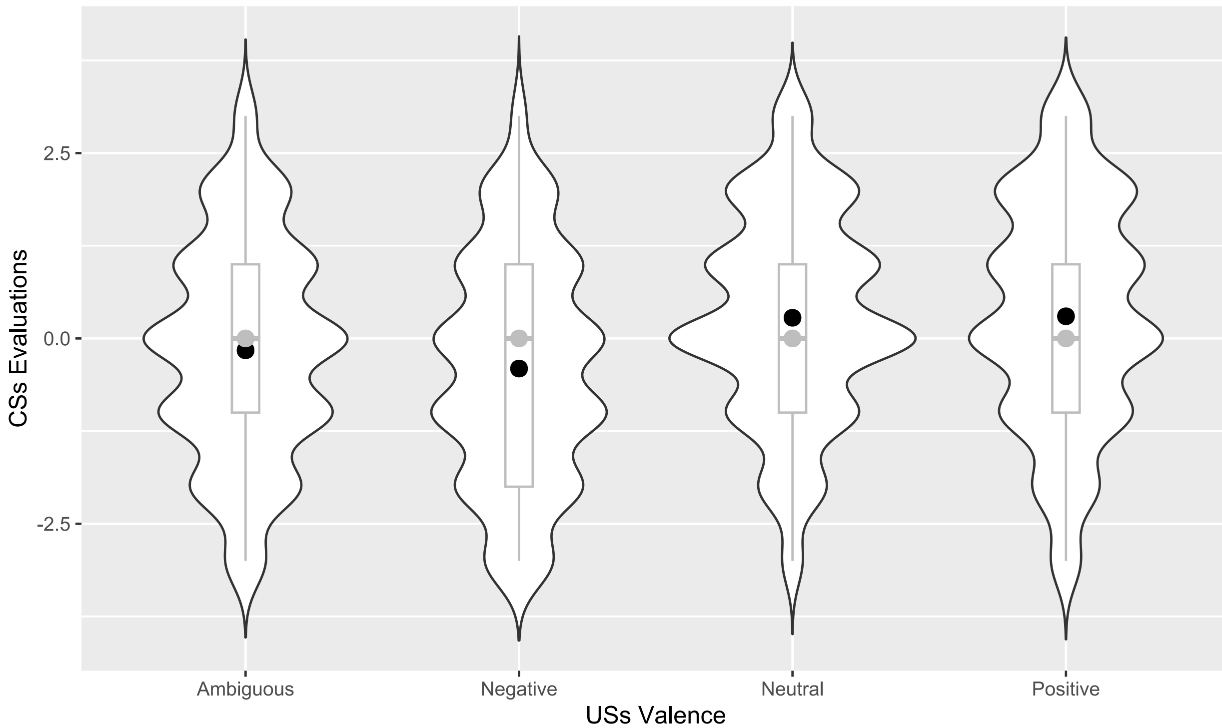
Analogous to the analyses we carried out for Experiment 1, we used the percentage of the valence pairing as a categorical factor and created dummy scores by setting the 50%-50% condition as the reference level (i.e., the ambiguous condition). The results showed that the CSs paired only with negative USs were evaluated significantly more negatively relative to the CSs from the ambiguous condition: $\beta = -0.24$, $SE = 0.06$, 95% CI [-0.37, -0.12], $t = -3.83$, $p < .001$. The CSs paired only with positive USs were evaluated significantly more positive relative to the CSs from the ambiguous condition: $\beta = 0.45$, $SE = 0.06$, 95% CI [0.33, 0.58], $t = 7.13$, $p < .001$) Finally, the CSs from the neutral condition were evaluated significantly more positive relative to the ambiguous condition: $\beta = 0.43$, $SE = 0.06$, 95% CI [0.31, 0.56], $t = 6.82$, $p < .001$ (see

[2] Supplementary Analyses of Experiments 1 and 2 regarding neuroticism's withdrawal and volatility components are presented in Supplemental Materials Section 14.

Supplemental Materials Section 12). Figure 3 presents the descriptive statistics and the density of CSs evaluations for each condition.

Figure 3

The Summary Statistics and the Density of the CSs Evaluations for Each Condition



Note. The violin plots present the summary statistics and the density of the evaluations for the CSs from the ambiguous condition (the first plot), negative condition (the second plot), neutral condition (the third plot), and positive condition (the fourth plot). In each plot, there is a boxplot representation of the evaluative response distributions. The black point from each violin plot represents the mean of the evaluative responses for each condition, while the grey point represents the median of the evaluative responses for each condition.

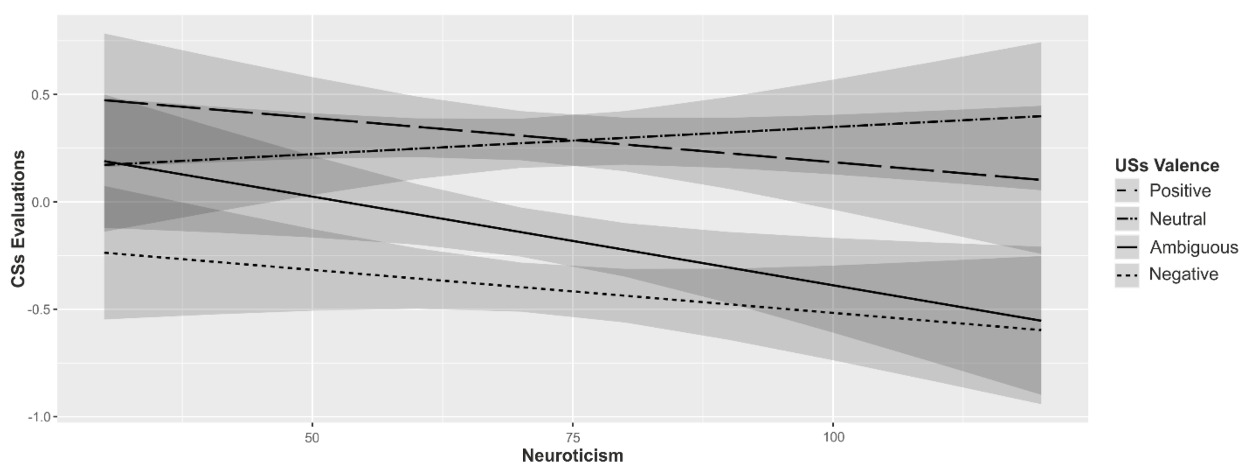
Main Analysis. Besides the categorical valence factors, we introduced the neuroticism score as a supplementary predictor in the general model to investigate the interaction effect between neuroticism and the conditions. Again, the reference level was represented by the ambiguous learning condition (50%-50%). When we looked at the interaction effect between neuroticism and the CSs from the neutral condition relative to the CSs from the ambiguous condition, we identified a significant interaction effect similar to that observed in Experiment 1: β = 0.01, *SE* = 0.003, 95% CI [0.00, 0.02], *t* = 2.77, *p* = .005 (see Figure 4).

Moreover, we did not identify any interaction effect between neuroticism and the CSs paired only with negative USs relative to the CSs from the ambiguous learning condition: β = 0.004, *SE* = 0.003, *t* = 1.09, *p* = .273. We also did not find an interaction effect between neuroticism and the CSs paired only with positive USs relative to the ambiguous learning condition: β = 0.004, *SE* = 0.003, *t* = 1.06, *p* = .287. Therefore, these results also replicate the findings of Experiment 1 (see Supplemental Materials Section 13).

A simple effect of the Neuroticism factor revealed by the main analyses was also replicated: β = -0.008, *SE* = 0.003, 95% CI [-0.02, -0.001], *t* = -2.36, *p* = .018. Thus, the finding shows that the ratings of CSs generally decreased as the neuroticism score increased in the sample (see Figure 4).

Figure 4

The Simple Effect of Neuroticism Factor on the CSs Evaluations



Note. Figure 4 presents the slopes of CSs evaluations for each condition. Each slope becomes more abrupt as the level of neuroticism increases (except the neutral one – first line), reflecting the main effect as generally more negative ratings received by CSs, independent of condition. The interaction effect between neuroticism and the ambiguous condition (relative to the neutral one) over the evaluations of the CSs is also visible (see the second and third lines).

Discussion

The current studies investigated the relationship between neuroticism and EC under ambiguous learning conditions. Neuroticism is a personality trait frequently associated with a negativity bias, a factor with an essential role in the onset and maintenance of emotional disorders (e.g., Beck et al., 1979; Beck & Haigh, 2014). Such biases were mostly captured at the level of attention and memory (e.g., Chen & Zheng, 2005; Gomez et al., 2002; Norris et al., 2019; Brock et al., 2022).

In the current paper, we focused on capturing the negativity bias in emotional learning via EC procedures with ambiguous outcome stimuli. Vogel et al. (2019) previously identified, via a typical, unambiguous EC procedure, that people who score high on neuroticism respond more negatively to a negatively conditioned stimulus and more positively to a positively conditioned stimulus (as per the perspective of Larsen and Diener, 1987). In our research, we aimed to create conditions under which highly neurotic people may give more weight to negative events than to positive events. More specifically, in addition to pairing unambiguously positive, negative, and neutral USs with CSs, we introduced ambivalent USs (Experiment 1) or paired target CSs alternatingly with both positive and negative USs (Experiment 2). Considering that evidence supports that highly neurotic people respond negatively under conditions of ambiguity (e.g., Lommen et al., 2010; Salemink & van den Hout, 2010), we expected that participants who scored high on neuroticism would evaluate the CSs from the ambiguous conditions more negatively relative to the CSs from the neutral ones.

The results of both experiments robustly showed that participants who scored high on neuroticism evaluated the CSs from the ambiguous conditions more negatively as compared to CSs from the neutral conditions. In other words, we found and replicated a relation between neuroticism and a negativity bias in emotional learning when comparing ambiguous conditions with unambiguously neutral conditions.

It should be noted, however, that we did not find this relation when comparing ambiguous situations with unambiguously positive or negative situations. Interestingly and unexpectedly, the CSs from the positive and negative conditions received more negative ratings at higher neuroticism scores. Thus, our results are neither in accordance with the findings of Vogel and colleagues (2019) nor with the classical theoretical perspective on neuroticism that emphasizes the prominent focus on negative valence as being an essential feature for highly neurotic people (e.g., Eysenck, 1967; Gray, 1981). Our findings seem to align more with the idea of dispositional negativity. People high in dispositional negativity experience distress not only in contexts with clear sources of stress, but also when the potential stressors are diffuse or even absent (or positive, as in our positive learning conditions; see Shackman et al., 2016 for a theoretical and empirical review).

Having this said, a relation between neuroticism and the evaluation of CSs was absent for CSs paired with neutral USs. Rather than suggesting general dispositional negativity, this result indicates that neuroticism is related to general negativity toward emotional stimuli: it is not only the case that (CSs related to) negative stimuli are experienced as more negative but also that (CSs related to) positive stimuli are evaluated as less positive by people scoring high on neuroticism. This dispositional negativity in highly neurotic people could co-exist with a disposition to interpret emotionally ambiguous situations in a more negative manner. Such an interpretation is in line with our findings. Specifically, the relation between neuroticism and CSs paired with ambiguous stimuli was stronger than the relation between neuroticism and CSs paired with positive stimuli or with negative stimuli. However, this interpretation should be treated with caution because the significant effects were obtained for ambiguous conditions only in comparison with the neutral ones. Also, the effects were rather subtle in size. However, this is an important finding, informing that ambiguous situations might be the contexts under which neuroticism can predispose people to develop affective disorders such as (social) anxiety and depression (e.g., Sauer-Zavala & Barlow, 2021).

As limitations, we can note that we included only two CSs per condition in our experiments, while in Vogel et al.'s (2019) experiments, the procedures involved twelve. This complicates the comparison between our studies. Another difference concerns the selection of CSs. Vogel et al. (2019) implemented a pre-rating phase of CSs in some of their experiments and used only CSs that were rated neutrally. However, we used novel CSs but did not verify whether they were entirely neutral before the study. This again complicates the comparison between the studies. However, as noticed in a recent review (Moran et al., 2023), many experiments in the EC field have not used idiosyncratically determined neutral CSs (i.e., being pre-rated as neutral before including them in the EC procedure), an aspect which does not seem essential for EC. Another weakness of our studies, which might reduce the generalizability of the findings, concerns the stimuli selection and assignment in our EC paradigm. We used a limited number of specific USs for each of the four EC conditions. Future studies should consider employing a larger pool of USs with random assignment for each condition and each participant.

Future research should investigate the underlying mechanisms that lead to effects such as general negativity toward emotional stimuli and a negativity bias in ambiguous contexts. For instance, people scoring high on neuroticism may perceive USs as more negative than they are normatively perceived, as suggested by Ingendahl and Vogel (2023). Alternatively, they may transfer negative valence more easily from USs to CSs due to their heightened reactivity to emotional valence, as proposed by Casini et al. (in press). Another possibility is that highly neurotic individuals struggle more with negative emotions, leading them to rate such stimuli or emotions more negatively, as Trnka et al. (2012) noted.

These research questions, as well as the existing mixed findings on the relevance of neuroticism as a moderator for basic learning phenomena like EC, warrant further investigation to understand better the role of individual differences in conditioning and the significance of neuroticism as a basic personality trait in providing an account for the onset and/or maintenance of emotional disorders.

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Supplemental Materials for:

The Moderating Role of Neuroticism on Evaluative Conditioning: Evidence from Ambiguous Learning Situations

Table of Contents

<u>Supplemental Materials Section 1 – Experiment 1: The Method in Detail</u>

Experiment 1

Method

Materials (USs Stimuli)

Two USs for each valence (i.e., positive, negative, neutral, and ambivalent) were used. The ambivalent USs were the same as Glaser et al. (2018) illustrated in their original paper. For positive valence, negative valence, and neutral valence, one US was taken from Glaser et al. (2018), and one was constructed by capturing two pictures with the same valence (positive, negative, and neutral valence) in the same blurred image frame. All those pictures were selected from the International Affective Picture System (IAPS; Lang et al., 2008). The main selection criterion was to match their valence, arousal and dominance indices. These were closely related to the indices which characterize the pictures taken as examples from Glaser et al. (2018). The IAPS pictures used for ambivalent USs were: 1302 and 1595 for one US, and 2691 and 2151 for the other one US. For the positive USs, the picture combinations were: 1630 – 1610 and 2035 – 1920. For the negative USs, the picture combinations were: 9140 – 1271 and 2456 – 2457. For the neutral USs, the picture combinations were: 7045 – 7055 and 7020 – 7012.

Procedure

When the participants entered the lab, they were welcomed by a research assistant and seated in front of a computer. First, each participant read the consent form presented on the screen. By pressing the “Space” bar, the participants gave their agreement about study participation. Further, they filled in the demographic questions (e.g., age) and completed the Neuroticism scale. The EC experimental procedure started immediately after the practice stage. The EC task was provided as it was described in the paper. After measuring the CSs’ evaluations with regard to how much each CS was considered pleasant or unpleasant (the CSs were presented randomly on the screen from one participant to another during the likeability measure), participants had to identify what kind of US was paired with each CS (i.e., valence awareness measure; Stahl et al., 2009). Thus, each CS was randomly presented on the screen under the question, "*Which kind of photo was this image paired with during the first task?".* Participants had to assign one of the following evaluative options: *Pleasant photo*, *Unpleasant photo*, *Simultaneously with pleasant and unpleasant photos*, *Neutral photo,* or *I don't remember*. In the database, the first option was coded with 1, the second option with 2, the third option with 3, the fourth option with 4, and the fifth option with 5. In the next section, participants had to explain why a computer-generated image was always presented with a real-life picture. Finally, the valence of each US was also evaluated. For each of the eight USs (shown randomly on the screen from one participant to another), participants had to pick one of the options: *Positive*, *Negative*, *Neutral,* or *Ambivalent*. In the database, the *positive* response was coded with 1, the *negative* with 2, the *neutral* with 3, and the *ambivalent* with 4. This last measurement verified whether the participants perceived the USs as having the same valence as it was operationalizing in the current study. This measure was a valence check for the USs to examine whether the participants evaluated the valence of each US as we normatively used in the experiment (based on the IAPS standardization and on Glaser's et al. (2018) ambivalent stimuli). At the end of the experiment, participants were thanked, debriefed, and compensated.

Figure 1

An Example of an Ambivalent US (Glaser et al., 2018)

Supplemental Materials Section 2 – Experiment 1: Descriptive Statistics

Descriptive Statistics of the 48-Item Neuroticism Scale from NEO PI-R

Neuroticism and Facets	*α*	*M*	*SD*	*Skewness*	*Kurtosis*
Neuroticism (NEO PI-R)	.93	135.78	26.96	.001	-.191
Anxiety	.79	24.41	5.87	-.054	-.258
Angry-Hostility	.80	21.85	6.07	.17	-.507
Depression	.80	22.85	6.06	.233	-.24
Self-Consciousness	.73	23.24	5.53	.122	-.389
Impulsiveness	.67	23.47	4.97	.085	-.262
Vulnerability	.84	19.96	5.62	.261	-.182

Table S2.1 Descriptive statistics for the 48-Item Neuroticism scale from NEO PI-R and its six facets. The total sample of N = 556 participants.

Descriptive Statistics of the (mean of) CSs paired from each condition

CSs from each condition	*M*	*SD*	*Skewness*	*Kurtosis*
CSs paired with Positive USs	0.96	1.29	-.339	-.396
CSs paired with Negative USs	-0.40	1.37	.244	-.483
CSs paired with Ambivalent USs	0.07	1.23	.041	-.380
CSs paired with Neutral USs	0.37	1.13	-.033	-.130

Table S2.2 The total sample of N = 556 participants.

Supplemental Materials Section 3 – Experiment 1: The Null Model

Null Model for Experiment 1, including by-participant and by-item random intercepts

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant (Intercept)	0.28	0.53
CSs Stimuli (Intercept)	0.07	0.27
Residual	2.43	1.56

Number of obs: 4448, groups: participant, 556; CSs stimuli, 8

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.25	0.10	0.05 – 0.46	7.721	2.46	.040

Note. Marginal R^2 / Conditional R^2 0.000 / 0.128

Supplemental Materials Section 4 – Experiment 1: The General Model

General Model for Experiment 1, including only by-participant random intercept

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.27	0.52
Residual	2.51	1.58

Number of obs: 4448, groups: participant, 556

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.25	0.03	0.19 – 0.32	554.99	7.80	< .001

Note. Marginal R^2 / Conditional R^2 0.000 / 0.098

Supplemental Materials Section 5 – Experiment 1: The EC Effect

The Evaluations of CSs paired with Negative, Neutral, and Positive USs, Relative to the CSs paired with Ambivalent USs

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.30	0.55
Residual	2.22	1.49
Number of obs: 4448, groups: participant, 556		

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.07	0.05	-0.02 - 0.17	2529.867	1.49	.135
Negative USs	-0.48	0.06	-0.61 - 0.36	3889.00	-7.62	< .001
Neutral USs	0.30	0.06	0.18 - 0.43	3889.00	4.78	< .001
Positive USs	0.89	0.06	0.77 - 1.02	3889.00	14.09	< .001

Note. Marginal R^2 / Conditional R^2 0.089 / 0.200

Supplemental Materials Section 6 – Experiment 1: The Interaction Effect

The Interaction Effect between Neuroticism (and its facets – Table S6.2 to Table S6.7) and the CSs paired with specific US Valences

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.30	0.55
Residual	2.22	1.49
Number of obs: 4448, groups: participant, 556		

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.86	0.25	0.38 – 1.39	2542	3.41	**< .001**
Neuroticism (NEO PI-R)	-0.005	0.001	-0.01 – -0.00	2542	-3.18	**.001**
Negative Valence	-0.85	0.003	-1.49 – -0.21	3886	-2.61	**.009**
Positive Valence	0.4	0.003	-0.24 – 1.04	3886	1.23	.21
Neutral Valence	-0.44	0.003	-1.08 – 0.20	3886	-1.35	.17
Neuroticism*Negative Valence	0.002	0.002	-0.00 – 0.01	3886	1.15	.24
Neuroticism*Positive Valence	0.003	0.002	-0.00 – 0.01	3886	1.54	.12
Neuroticism*Neutral Valence	0.005	0.002	0.00 – 0.01	3886	2.33	**.02**

Correlation of Fixed Effects

	Intr	**Neur**	**Neg**	**Pos**	**Neutr**	**N x Neg**	**N x Pos**
Neuroticism	-0.98						
Negative Valence	-0.62	0.61					
Positive Valence	-0.62	0.61	0.50				
Neutral Valence	-0.62	0.61	0.50	0.50			
Neuroticism*Negative Valence	0.61	-0.62	-0.98	-0.49	-0.49		
Neuroticism*Positive Valence	0.61	-0.62	-0.49	-0.98	-0.49	0.50	
Neuroticism*Neutral Valence	0.61	-0.62	-0.49	-0.49	-0.98	0.50	0.50

Note. Marginal R^2 / Conditional R^2 0.093 / 0.201

Table 6.2

The Interaction Effect between Anxiety an the CSs paired with specific US Valences

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.30	0.55
Residual	2.23	1.49
Number of obs: 4448, groups: participant, 556		

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.71	0.21	0.30 – 1.14	2541.02	3.31	**< .001**
Anxiety	-0.02	0.008	-0.04 – -0.01	2541.02	-3.06	**.002**
Negative Valence	-0.74	0.27	-1.27 – -0.21	3886	-2.74	**.006**
Positive Valence	0.47	0.27	-0.06 – 1.00	3886	1.74	.081
Neutral Valence	-0.28	0.27	-0.81 – 0.25	3886	-1.04	.29
Anxiety*Negative Valence	0.01	0.01	-0.01 – 0.03	3886	0.98	.32
Anxiety*Positive Valence	0.01	0.01	-0.00 – 0.04	3886	1.59	.11
Anxiety*Neutral Valence	0.02	0.01	0.00 – 0.05	3886	2.22	**.026**

Correlation of Fixed Effects

	Intr	**Anx**	**Neg**	**Pos**	**Neutr**	**Anx x Neg**	**Anx x Pos**
Anxiety	-0.97						
Negative Valence	-0.62	0.61					
Positive Valence	-0.62	0.61	0.50				
Neutral Valence	-0.62	0.61	0.50	0.50			
Anxiety*Negative Valence	0.61	-0.62	-0.97	-0.48	-0.48		
Anxiety*Positive Valence	0.61	--0.62	-0.48	-0.97	-0.48	0.50	
Anxiety*Neutral Valence	0.61	-0.62	-0.48	-0.48	-0.97	0.50	0.50

Note. Marginal R^2 / Conditional R^2 0.092 / 0.201

Table 6.3

The Interaction Effect between Angry-Hostility and the CSs paired with specific US Valences

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.30	0.55
Residual	2.23	1.49
Number of obs: 4448, groups: participant, 556		

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.26	0.18	-0.11 – 0.63	2527	-1.39	.16
Anger	-0.008	0.008	-0.02 – 0.01	2527	-1.02	.30
Negative Valence	0.61	0.23	-1.08 – -0.15	3886	-2.60	**.009**
Positive Valence	0.87	0.23	0.41 – 1.34	3886	3.67	< **.001**
Neutral Valence	0.15	0.23	-0.31 – 0.62	3886	0.66	.50
Anger*Negative Valence	0.006	0.01	-0.01 – 0.03	3886	0.58	.55
Anger*Positive Valence	0.0009	0.01	-0.02 – 0.02	3886	0.09	.92
Anger*Neutral Valence	0.006	0.01	-0.01 – 0.03	3886	0.63	.52

Correlation of Fixed Effects

	Intr	**Angr**	**Neg**	**Pos**	**Neutr**	**Angr x Neg**	**Angr x Pos**
Anger	-0.96						
Negative Valence	-0.62	0.60					
Positive Valence	-0.62	0.60	0.50				
Neutral Valence	-0.62	0.60	0.50	0.50			
Anger*Negative Valence	0.60	-0.62	-0.96	-0.48	-0.48		
Anger*Positive Valence	0.60	-0.62	-0.48	-0.96	-0.48	0.50	
Anger*Neutral Valence	0.60	-0.62	-0.48	-0.48	-0.96	0.50	0.50

Note. Marginal R^2 / Conditional R^2 0.090 / 0.200

Table 6.4

The Interaction Effect between Depression and the CSs paired with specific US Valences

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.30	0.55
Residual	2.22	1.49
Number of obs: 4448, groups: participant, 556		

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.57	0.20	0.18 – 0.96	2538	2.88	**.0004**
Depression	-0.02	0.01	-0.04 – -0.01	2538	-2.59	**.01**
Negative Valence	-0.82	0.25	-1.31 – -0.34	3886	-3.33	**.001**
Positive Valence	0.73	0.25	0.25 – 1.21	3886	2.95	**.003**
Neutral Valence	-0.11	0.25	-0.60 – 0.37	3886	-0.45	.65
Depression*Negative Valence	0.01	0.01	-0.01 – 0.04	3886	1.42	.15
Depression*Positive Valence	0.01	0.01	-0.01 – 0.03	3886	0.68	.49
Depression*Neutral Valence	0.02	0.01	-0.00 – 0.04	3886	1.73	.08

Correlation of Fixed Effects

	Intr	**Dep**	**Neg**	**Pos**	**Neutr**	**Dep x Neg**	**Dep x Pos**
Depression	-0.96						
Negative Valence	-0.62	0.60					
Positive Valence	-0.62	0.60	0.50				
Neutral Valence	-0..62	0.60	0.50	0.50			
Depression*Negative Valence	0.60	-0.62	-0.96	-0.48	-0.48		
Depression*Positive Valence	0.60	-0.62	-0.48	-0.96	-0.48	0.50	
Depression*Neutral Valence	0.60	-0.62	-0.48	-0.48	-0.96	0.50	0.50

Note. Marginal R^2 / Conditional R^2 0.092/ 0.201

Table 6.5

The Interaction Effect between Self-Consciousness and the CSs paired with specific US Valences

Random Effects

Groups Name	Variance	Std. Dev
Participant		
(Intercept)	0.30	0.54
Residual	2.22	1.49

Number of obs: 4448, groups: participant, 556

Fixed Effects

	Estimate	Std. Error	95% CI	*df*	t value	*p*
(Intercept)	0.93	0.22	0.50 – 1.35	2547	4.25	**< .001**
Self-Consciousness	-0.04	0.01	-0.05 – -0.02	2547	-4.01	**< .001**
Negative Valence	-0.81	0.27	-1.34 – -0.27	3886	-2.94	**.003**
Positive Valence	0.21	0.27	-0.32 – 0.75	3886	0.77	.43
Neutral Valence	-0.50	0.27	-1.04 – 0.03	3886	-1.88	.06
Self-Cons*Negative Valence	0.01	0.01	-0.01 – 0.04	3886	1.21	.22
Self-Cons*Positive Valence	0.03	0.01	0.01 – 0.05	3886	2.55	**.011**
Self-Cons*Neutral Valence	0.03	0.01	0.01 – 0.06	3886	3.02	**.003**

Correlation of Fixed Effects

	Intr	Self-Cons	Neg	Pos	Neutr	Self-Cons x Neg	Self-Cons x Pos
Self-Consciousness	-0.97						
Negative Valence	-0.62	0.61					
Positive Valence	-0.62	0.61	0.50				
Neutral Valence	-0.62	0.61	0.50	0.50			
Self-Cons*Negative Valence	0.61	-0.62	-0.97	-0.48	--0.48		
Self-Cons*Positive Valence	0.61	-0.62	-0.48	-0.97	-0.48	0.50	
Self-Cons*Neutral Valence	0.61	-0.62	-0.48	-0.48	-0.97	0.50	0.50

Note. Marginal R^2 / Conditional R^2 0.094 / 0.202

Table 6.6

The Interaction Effect between Impulsiveness and the CSs paired with specific US Valences

Note. Marginal R^2 / Conditional R^2 0.090 / 0.200

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.30	0.55
Residual	2.22	1.49

Number of obs: 4448, groups: participant, 556

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.21	0.24	-0.27 – 0.69	2523	0.86	.38
Impulsiveness	-0.01	0.01	-0.03 – 0.01	2523	-0.57	.56
Negative Valence	-0.49	0.31	-1.09 – 0.11	3886	-1.61	.10
Positive Valence	0.57	0.31	-0.03 – 1.17	3886	1.85	.06
Neutral Valence	0.01	0.31	-0.59 – 0.61	3886	0.40	.96
Impulsiveness *Negative Valence	0.0005	0.01	-0.02 – 0.03	3886	0.40	.96
Impulsiveness *Positive Valence	0.01	0.01	-0.01 – 0.04	3886	1.08	.27
Impulsiveness *Neutral Valence	0.01	0.01	-0.01 – 0.04	3886	0.97	.33

Correlation of Fixed Effects

	Intr	**Impuls**	**Neg**	**Pos**	**Neutr**	**Impuls x Neg**	**Impuls x Pos**
Impulsiveness	-0.97						
Negative Valence	-0.62	0.61					
Positive Valence	-0.62	0.61	0.50				
Neutral Valence	-0.62	0.61	0.50	0.50			
Impulsiveness *Negative Valence	0.61	-0.62	-0.97	-0.48	-0.48		
Impulsiveness *Positive Valence	0.61	-0.62	-0.48	-0.97	-0.97	0.50	
Impulsiveness *Neutral Valence	0.61	-0.62	-0.48	-0.48	-0.97	0.50	0.50

Table 6.7

The Interaction Effect between Vulnerability and the CSs paired with specific US Valences

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.29	0.54
Residual	2.22	1.49
Number of obs: 4448, groups: participant, 556		

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.74	0.19	0.38 – 1.10	2558	3.98	**< .001**
Vulnerability	-0.03	0.01	-0.05 – -0.02	2558	-3.71	**< .001**
Negative Valence	-0.73	0.23	-1.19 – -0.28	3886	-314	**.002**
Positive Valence	0.57	0.23	0.11 – 1.03	3886	2.44	**.015**
Neutral Valence	-0.25	0.23	-0.71 – 0.20	3886	-1.08	.27
Vulnerability *Negative Valence	0.01	0.01	-0.01 – 0.03	3886	1.11	.26
Vulnerability *Positive Valence	0.02	0.01	-0.01 – 0.04	3886	1.42	.15
Vulnerability *Neutral Valence	0.03	0.01	0.01 – 0.05	3886	2.47	**.013**

Correlation of Fixed Effects

	Intr	**Vul**	**Neg**	**Pos**	**Neutr**	**Vul x Neg**	**Vul x Pos**
Vulnerability	-0.96						
Negative Valence	-0.62	0.60					
Positive Valence	-0.62	0.60	0.50				
Neutral Valence	-0.62	0.60	0.50	0.50			
Vulnerability *Negative Valence	0.60	-0.62	-0.96	-0.48	-0.48		
Vulnerability *Positive Valence	0.60	-0.62	-0.48	-0.96	-0.48	0.50	
Vulnerability *Neutral Valence	0.60	-0.62	-0.48	-0.48	-0.96	0.50	0.50

Note. Marginal R^2 / Conditional R^2 0.094 / 0.201

Supplemental Materials Section 7 – Experiment 1: The Interaction Effect (Controlling for US Valence)

The Interaction Effect between Neuroticism and the CSs paired with specific US Valences Controlling for the US Valence

Note. In Experiment 1, participants evaluated each US on a categorical scale by clicking on "1" whether they perceived the US as being positive, "2" for negative, "3" for neutral, and "4" for ambivalent. These responses were introduced in the analysis as dummy scores. In the database was created a specific variable ("US_dummy") that involves digit 1 – whether the response for a specific US was in accordance with the valence of the positive, negative, neutral or ambivalent condition of which the US normatively is part, and digit 0 - whether the response for a specific US was not in accordance with the valence of the positive, negative, neutral or ambivalent condition of which the US normatively is part.

Note. Marginal R^2 / Conditional R^2 0.093 / 0.200

Groups Name	**Variance**	**Std.Dev.**
Participant		
(Intercept)	0.29	0.54
Residual	2.22	1.49

Number of obs: 4448, groups: participant, 556

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.96	0.26	0.45 – 1.49	2634	3.669	< **.001**
US as Dummy Scores	-0.10	0.06	-0.22 – 0.022	4421	-1.646	.099
Neuroticism (NEO PI-R)	-0.005	0.001	-0.01 – -0.00	2550	-3.184	**.001**
Negative Valence	-0.85	0.325	-1.49 – -0.21	3883	-2.618	**.008**
Positive Valence	0.39	0.325	-0.24 – 1.03	3884	1.209	.226
Neutral Valence	-0.43	0.325	-1.07 – 0.21	3884	-1.323	.186
Neuroticism*Negative Valence	0.002	0.002	-0.00 – 0.01	3883	1.149	.250
Neuroticism*Positive Valence	0.003	0.002	-0.00 – 0.01	3884	1.571	.116
Neuroticism*Neutral Valence	0.005	0.002	0.00 – 0.01	3884	2.302	**.021**

Correlation of Fixed Effects

	Intercept	**US Dummy**	**N (Neuroticism)**	**Neg**	**Pos**	**Neutral**	**N x Neg**	**N x Pos**
US as Dummy Scores	-0.18							
Neuroticism	-0.96	-0.003						
Negative Valence	-0.61	-0.001	0.616					
Positive Valence	-0.62	0.013	0.616	0.50				
Neutral Valence	-0.61	-0.020	0.616	0.50	0.50			
Neuroticism*Negative Valence	0.60	0.004	-0.628	-0.98	-0.49	-0.49		
Neuroticism*Positive Valence	0.60	-0.018	-0.628	-0.49	-0.98	-0.49	0.50	
Neuroticism*Neutral Valence	0.60	0.018	-0.628	-0.49	-0.49	-0.98	0.50	0.50

Supplemental Materials Section 8 – Experiment 2: The Method in Detail

Experiment 2

Method

Materials (Instruments and USs Stimuli)

Pictures from IAPS (Lang et al., 2008) were used as USs. For the Positive Condition, two positive pictures were used as USs (picture 2035 and picture 2091). For the Negative Condition, two negative pictures were used as USs (picture 2345.1 and picture 2301). For the Neutral Condition, two neutral pictures were used as USs (picture 7045 and picture 7020). Regarding the Mixed Condition (i.e., the ambiguous condition), four pictures from IAPS were used to keep under control the content (the same face) and varying, alternatively, only the valence. Thus, one CS was alternatingly paired on 50% of trials with a positive picture (picture 2900.2) and on other 50% of trials with a negative picture (picture 2900). Whereas, another CS from the ambiguous condition was paired alternatingly on 50% of trials with a negative picture (picture 2375.2) and on other 50% of trials with a positive picture (picture 2375.1). For the 50%-50% condition, while a CS was firstly presented with a positive US (and then with a negative US), the other one CS was presented firstly with a negative US (and then with a positive US).

The first two USs (positive and negative) presented a white child in the center (smiling vs. crying). The following two USs (also one positive and one negative) had as the main representation a black female (smiling vs. being sad). These USs were used for the positive-negative alternations condition – the ambiguous one. The rationale was to keep control the symbolic content but to manipulate only the valence in the pairing presentations (alternate pairs of CS – positive US vs. CS – negative US).

All the four pairs (i.e., one CS paired only with a positive US, one CS paired only with a negative US, two CSs paired alternatively with a positive or negative USs) were randomly presented within a participant, and the pairs' formation was counterbalanced from a participant to another. The main selection criterion was to match for the valence, arousal and dominance indices for each valence (positive, respectively negative), their IAPS codes being presented above.

Participants

Country of Residence for the Participants Involved in Experiment 2

Country Residence	Number of Participants
Australia	1
Belgium	1
Canada	1
Chile	5
Czech Republic	3
England	10
Estonia	4
France	1
Germany	1
Greece	26
Hungary	12
Iceland	1
Ireland	1
Israel	1
Italy	17
Japan	1
Latvia	3
Mexico	14
Netherlands	1
Poland	98
Portugal	86
Romania	1
Slovenia	3
South Africa	80
Spain	10
United Kingdom	12

Note. Only 394 participants (from the total sample of 400 participants) reported their residence.

Supplemental Materials Section 9 – Experiment 2: Descriptive Statistics

Descriptive Statistics of Neuroticism-Related Scales for Experiment 2

Neuroticism Measures	*α*	*M*	*SD*	*Skewness*	*Kurtosis*
Neuroticism	.91	72.33	16.56	.129	-.558
Anxiety	.85	13.94	3.87	-.432	-.588
Anger	.82	11.50	3.87	.249	-.631
Depression	.86	10.63	3.93	.282	-.806
Self-Consciousness	.77	13.28	3.84	-.179	-.877
Immoderation	.72	11.70	3.27	.257	-.124
Vulnerability	.84	11.26	4.10	.237	-.935

Table S9.1 The total sample of N = 400 participants.

Descriptive Statistics of the (mean of) CSs paired from each condition

CSs from each condition	*M*	*SD*	*Skewness*	*Kurtosis*
CSs paired with Positive USs	0.29	1.23	-.247	-.156
CSs paired with Negative USs	-0.40	1.23	-.027	-.578
CSs paired with Ambivalent USs	-0.16	1.18	.051	-.233
CSs paired with Neutral USs	0.27	1.20	-.058	-.067

Table S9.2 The total sample of N = 400 participants.

Supplemental Materials Section 10 – Experiment 2: The Null Model

Null Model for Experiment 2, including by-participant and by-item random intercepts

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant (Intercept)	0.50	0.71
CSs Stimuli (Intercept)	0.07	0.26
Residual	1.68	1.29

Number of obs: 3200, groups: participant, 400; CSs stimuli, 8

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.002	0.10	-0.20 – 0.21	8.967	0.027	.978

Note. Marginal R^2 / Conditional R^2 0.000 / 0.255

Supplemental Materials Section 11 – Experiment 2: The General Model

General Model for Experiment 2 including only by-participant random intercept

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.49	0.70
Residual	1.75	1.32
Number of obs: 3200, groups: participant, 400		

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.002	0.04	-0.08 – 0.09	399	0.067	.947

Note. Marginal R^2 / Conditional R^2 0.000 / 0.220

Supplemental Materials Section 12 – Experiment 2: The EC Effect

The Evaluations of CSs paired with Negative, Neutral, and Positive USs, Relative to the CSs paired Alternatingly with Positive and Negative USs (50% - 50% Condition as Ambiguous Condition)

Note. Marginal R^2 / Conditional R^2 0.040 / 0.265

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.50	0.71
Residual	1.65	1.28

Number of obs: 3200, groups: participant, 400

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	-0.16	0.05	-0.27 - -0.05	1257.21	-2.77	**.006**
100% Negative USs	-0.24	0.06	-0.37 - -0.12	2797.00	-3.83	**< .001**
100% Neutral USs	0.43	0.06	0.31 - 0.56	2797.00	6.82	**< .001**
100% Positive USs	0.45	0.06	0.33 - 0.58	2797.00	7.13	**< .001**

Supplemental Materials Section 13 – Experiment 2: The Interaction Effect

The Interaction Effect between Neuroticism (and its facets – Table S12.2 to Table S12.7) and Valenced Conditions in Experiment 2

Note. Marginal R^2 / Conditional R^2 0.043 / 0.268

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.50	0.71
Residual	1.65	1.28

Number of obs: 3200, groups: participant, 400

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.43	0.25	-0.07 – 0.94	1255	1.69	.091
Neuroticism	-0.008	0.003	-0.02 – -0.00	1255	-2.36	**.018**
100% Negative Valence	-0.55	0.288	-1.12 – 0.01	2794	-1.92	.054
100% Positive Valence	0.15	0.288	-0.40 – 0.72	2794	0.55	.579
100% Neutral Valence	-0.34	0.288	-0.91 – 0.22	2794	-1.18	.236
Neuroticism*100% Negative Valence	0.004	0.003	-0.00 – 0.01	2794	1.09	.273
Neuroticism*100% Positive Valence	0.004	0.003	-0.00 – 0.01	2794	1.06	.287
Neuroticism*100% Neutral Valence	0.010	0.003	0.00 – 0.02	2794	2.77	**.005**

Correlation of Fixed Effects

	Intr	**Neur**	**Neg**	**Pos**	**Neutr**	**N x Neg**	**N x Pos**
Neuroticism	-0.97						
100% Negative Valence	-0.55	0.54					
100% Positive Valence	-0.55	0.54	0.50				
100% Neutral Valence	-0.55	0.54	0.50	0.50			
Neuroticism*100% Negative Valence	0.54	-0.55	-0.97	-0.48	-0.48		
Neuroticism*100% Positive Valence	0.54	-0.55	-0.48	-0.97	-0.48	0.50	
Neuroticism*100% Neutral Valence	0.54	-0.55	-0.48	-0.48	-0.97	0.50	0.50

Table 13.2

The Interaction Effect between Anxiety and US Valence in Experiment 2

Note. Marginal R^2 / Conditional R^2 0.040 / 0.266

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.50	0.71
Residual	1.65	1.28
Number of obs: 3200, groups: participant, 400		

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.04	0.21	-0.38 – 0.47	1253	0.19	.846
Anxiety	-0.01	0.01	0.04 – 0.01	1253	-0.97	.332
100% Negative Valence	-0.39	0.02	-0.87 – 0.08	2794	-1.64	.101
100% Positive Valence	0.32	0.02	-0.15 – 0.79	2794	1.34	.180
100% Neutral Valence	0.17	0.02	-0.29 – 0.65	2794	0.74	.456
Anxiety*100% Negative Valence	0.01	0.01	-0.02 – 0.04	2794	0.63	.523
Anxiety*100% Positive Valence	0.009	0.01	-0.02 – 0.04	2794	0.58	.557
Anxiety*100% Neutral Valence	0.01	0.01	-0.01 – 0.05	2794	1.12	.263

Correlation of Fixed Effects

	Intr	**Anx**	**Neg**	**Pos**	**Neutr**	**Anx x Neg**	**Anx x Pos**
Anxiety	-0.96						
100% Negative Valence	-0.55	0.53					
100% Positive Valence	-0.55	0.53	0.50				
100% Neutral Valence	-0.55	0.53	0.50	0.50			
Anxiety*100% Negative Valence	0.53	-0.55	-0.96	-0.48	-0.48		
Anxiety*100% Positive Valence	0.53	-0.55	-0.48	-0.96	-0.48	0.50	
Anxiety*100% Neutral Valence	0.53	-0.55	-0.48	-0.48	-0.96	0.50	0.50

Table 13.3

The Interaction Effect between Anger and US Valence Reinforcement in Experiment 2

Note. Marginal R^2 / Conditional R^2 0.040 / 0.266

Random Effects

Groups Name	Variance	Std. Dev
Participant		
(Intercept)	0.50	0.71
Residual	1.65	1.28
Number of obs: 3200, groups: participant, 400		

Fixed Effects

	Estimate	Std. Error	95% CI	*df*	t value	*p*
(Intercept)	-0.14	0.18	-0.50 – 0.21	1253	-0.82	.409
Anger	-0.0009	0.01	-0.03 – 0.03	1253	-0.06	.950
100% Negative Valence	-0.30	0.20	-0.70 – 0.09	2794	-1.49	.135
100% Positive Valence	0.48	0.20	0.09 – 0.88	2794	2.40	**.016**
100% Neutral Valence	0.28	0.20	-0.11 – 0.68	2794	1.40	.159
Anger*100% Negative Valence	0.004	0.01	-0.03 – 0.04	2794	0.28	.775
Anger*100% Positive Valence	-0.002	0.01	-0.03 – 0.03	2794	-0.13	.895
Anger*100% Neutral Valence	0.01	0.01	-0.02 – 0.05	2794	0.81	.416

Correlation of Fixed Effects

	Intr	Angr	Neg	Pos	Neutr	Angr x Neg	Angr x Pos
Anger	-0.94						
100% Negative Valence	-0.55	0.52					
100% Positive Valence	-0.55	0.52	0.50				
100% Neutral Valence	-0.55	0.52	0.50	0.50			
Anger*100% Negative Valence	0.52	-0.55	-0.94	-0.47	-0.47		
Anger*100% Positive Valence	0.52	-0.55	-0.47	-0.94	-0.47	0.50	
Anger*100% Neutral Valence	0.52	-0.55	-0.47	-0.47	-0.94	0.50	0.50

<u>Table 13.4</u>

The Interaction Effect between Depression and US Valence Reinforcement in Experiment 2

Note. Marginal R^2 / Conditional R^2 0.044 / 0.268

Random Effects

Groups Name	Variance	Std. Dev
Participant		
(Intercept)	0.50	0.71
Residual	1.64	1.28
Number of obs: 3200, groups: participant, 400		

Fixed Effects

	Estimate	Std. Error	95% CI	*df*	t value	*p*
(Intercept)	0.25	0.16	-0.07 – 0.58	1255.20	1.53	.126
Depression	-0.03	0.01	-0.07 – -0.01	1255.20	-2.65	**.007**
100% Negative Valence	-0.31	0.18	-0.68 – 0.04	2794	-1.72	.084
100% Positive Valence	0.10	0.18	-0.26 – 0.46	2794	0.54	.583
100% Neutral Valence	-0.05	0.18	-0.42 – 0.30	2794	-0.31	.750
Depression*100% Negative Valence	0.006	0.01	-0.03 – 0.04	2794	1.41	.675
Depression*100% Positive Valence	0.033	0.01	0.00 – 0.07	2794	2.05	**.039**
Depression*100% Neutral Valence	0.046	0.01	0.01 – 0.08	2794	2.86	.004

Correlation of Fixed Effects

	Intr	Dep	Neg	Pos	Neutr	Dep x Neg	Dep x Pos
Depression	-0.93						
100% Negative Valence	-0.55	0.52					
100% Positive Valence	-0.55	0.52	0.50				
100% Neutral Valence	-0.55	0.52	0.50	0.50			
Depression*100% Negative Valence	0.52	-0.55	-0.93	-0.46	-0.46		
Depression*100% Positive Valence	0.52	-0.55	-0.46	-0.93	-0.46	0.50	
Depression*100% Neutral Valence	0.52	-0.55	-0.46	-0.46	-0.93	0.50	0.50

Table 13.5

The Interaction Effect between Self-Consciousness and US Valence Reinforcement in Experiment 2

Note. Marginal R^2 / Conditional R^2 0.043 / 0.267

Random Effects

Groups Name	Variance	Std. Dev
Participant		
(Intercept)	0.50	0.71
Residual	1.65	1.28
Number of obs: 3200, groups: participant, 400		

Fixed Effects

	Estimate	Std. Error	95% CI	*df*	t value	*p*
(Intercept)	0.36	0.20	-0.04 – 0.77	1254.59	1.76	.078
Self-Consciousness	-0.03	0.01	-0.07 – -0.01	1254.59	-2.63	**.008**
100% Negative Valence	-0.71	0.23	-1.17 – -0.26	2794	-3.07	**.002**
100% Positive Valence	0.14	0.23	-0.31 – 0.60	2794	0.62	.533
100% Neutral Valence	-0.11	0.23	-0.57 – 0.34	2794	-0.48	.627
Self-Cons*100% Negative Valence	0.03	0.01	0.00 – 0.07	2794	2.09	.**035**
Self-Cons*100% Positive Valence	0.02	0.01	-0.01 – 0.06	2794	1.41	**.**157
Self-Cons*100% Neutral Valence	0.04	0.01	0.01 – 0.07	2794	2.47	.013

Correlation of Fixed Effects

	Intr	Self-Cons	Neg	Pos	Neutr	Self-Cons x Neg	Self-Cons x Pos
Self-Consciousness	-0.96						
100% Negative Valence	-0.55	0.53					
100% Positive Valence	-0.55	0.53	0.50				
100% Neutral Valence	-0.55	0.53	0.50	0.50			
Self-Cons*100% Negative Valence	0.53	-0.55	-0.96	-0.48	-0.48		
Self-Cons*100% Positive Valence	0.53	-0.55	-0.48	-0.96	-0.48	0.50	
Self-Cons*100% Neutral Valence	0.53	-0.55	-0.48	-0.48	-0.96	0.50	0.50

<u>Table 13.6</u>

The Interaction Effect between Immoderation and US Valence Reinforcement in Experiment 2

Note. Marginal R^2 / Conditional R^2 0.043 / 0.267

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.50	0.71
Residual	1.64	1.28
Number of obs: 3200, groups: participant, 400		

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.21	0.21	-0.04 – 0.77	1254	0.99	.318
Immoderation	-0.03	0.01	-0.07 – -0.01	1254	-1.81	.070
100% Negative Valence	-0.30	0.23	-1.17 – -0.26	2794	-1.26	.205
100% Positive Valence	0.52	0.23	-0.31 – 0.60	2794	2.19	**.028**
100% Neutral Valence	-0.20	0.23	-0.57 – 0.34	2794	-0.86	.389
Immoderation *100% Negative Valence	0.004	0.01	0.00 – 0.07	2794	0.24	.807
Immoderation *100% Positive Valence	-0.005	0.01	-0.01 – 0.06	2794	-0.27	.780
Immoderation*100% Neutral Valence	0.05	0.01	0.01 – 0.07	2794	2.80	**.005**

Correlation of Fixed Effects

	Intr	**Immod**	**Neg**	**Pos**	**Neutr**	**Immod x Neg**	**Immod x Pos**
Immoderation	-0.96						
100% Negative Valence	-0.55	0.53					
100% Positive Valence	-0.55	0.53	0.50				
100% Neutral Valence	-0.55	0.53	0.50	0.50			
Immoderation *100% Negative Valence	0.53	-0.55	-0.96	-0.48	-0.48		
Immoderation *100% Positive Valence	0.53	-0.55	-0.48	-0.96	-0.97	0.50	
Immoderation*100% Neutral Valence	0.53	-0.55	-0.48	-0.48	-0.96	0.50	0.50

Table 13.7

The Interaction Effect between Vulnerability and US Valence Reinforcement in Experiment 2

Note. Marginal R^2 / Conditional R^2 0.042 / 0.267-0.15 – 0.51

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.50	0.71
Residual	1.65	1.28
Number of obs: 3200, groups: participant, 400		

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.17	0.16	-0.15 – 0.51	1256.22	1.04	.296
Vulnerability	-0.02	0.01	-0.06 – -0.00	1256.22	-2.12	**.034**
100% Negative Valence	-0.42	0.18	-0.79 – -0.05	2794	-2.23	**.025**
100% Positive Valence	0.31	0.18	-0.05 – 0.69	2794	1.70	.089
100% Neutral Valence	0.07	0.18	-0.30 – 0.44	2794	0.38	.700
Vulnerability *100% Negative Valence	0.01	0.01	-0.02 – 0.05	2794	0.98	.323
Vulnerability *100% Positive Valence	0.01	0.01	-0.02 – 0.04	2794	0.79	.429
Vulnerability *100% Neutral Valence	0.03	0.01	0.00 – 0.06	2794	2.07	**.038**

Correlation of Fixed Effects

	Intr	**Vul**	**Neg**	**Pos**	**Neutr**	**Vul x Neg**	**Vul x Pos**
Vulnerability	-0.94						
100% Negative Valence	-0.55	0.52					
100% Positive Valence	-0.55	0.52	0.50				
100% Neutral Valence	-0.55	0.52	0.50	0.50			
Vulnerability *100% Negative Valence	0.52	-0.55	-0.94	-0.47	-0.47		
Vulnerability *100% Positive Valence	0.52	-0.55	-0.47	-0.94	-0.47	0.50	
Vulnerability *100% Neutral Valence	0.52	-0.55	-0.47	-0.47	-0.94	0.50	0.50

Supplemental Materials Section 14 – Supplementary Analyses of Experiments 1 and 2

Withdrawal and Volatility Components. The pattern of results in both experiments seems to mimic another component of neuroticism, namely the "withdrawal facet" (Allen & DeYoung, 2017). This is the aspect of neuroticism that covers pessimistic views and the tendency toward negative interpretation of events (Davidson et al., 2001; DeYoung et al., 2007). The withdrawal facet differs from the volatility facet of neuroticism, which is mainly related to the outward expression of the negative affect, such as getting irritable and furious. Based on the neuroticism scales used, we defined the *withdrawal component* by summing the specific items from the anxiety, depression, and vulnerability facets. The items for anger, impulsivity (or immoderation), and self-consciousness defined the *volatility component*.

In Experiment 1, *withdrawal* (α = .92) generated the same results as neuroticism. Specifically, when the ambiguous condition was set as the reference level, withdrawal interacted with the neutral condition relative to the reference level (β = 0.009, *SE* = 0.004, *t* = 2.38, *p* = .017). Hence, people with high withdrawal levels evaluated the CSs paired with ambivalent USs as more negative relative to the CSs paired only with neutral USs. Also, the CSs ratings were lower as the level of withdrawal increased (β = -0.01, *SE* = 0.003, *t* = -3.47, *p* < .001). *Volatility* (α = .85) also interacted significantly with the difference between the neutral and the ambiguous condition (β = 0.009, *SE* = 0.004, *t* = 1.95, *p* = .050). In addition, volatility significantly reduced the general CSs ratings (β = -0.009, *SE* = 0.003, *t* = -2.40, *p* = .016).

In Experiment 2, the *withdrawal* (α = .91) and *volatility* (α = .78) components also replicated the results from Experiment 1. Thus, withdrawal interacted with the ratings from the neutral condition relative to the ambiguous one (β = 0.01, *SE* = 0.006, *t* = 2.32, *p* = .020). A similar result was revealed for volatility (β = 0.02, *SE* = 0.008, *t* = 2.85, *p* = .004). Moreover, withdrawal

(β = -0.01, *SE* = 0.005, *t* = -2.21, *p* = .027) and volatility (β = -0.01, *SE* = 0.007, *t* = -2.12, *p* = .033) both produced a general decrease in CSs ratings. Detailed results are presented further in this section.

Table 14.1

The Interaction Effect between Withdrawal and the CSs paired with specific US Valences in Experiment 1

Random Effects

Groups Name	Variance	Std. Dev
Participant		
(Intercept)	0.30	0.54
Residual	2.22	1.49
Number of obs: 4448, groups: participant, 556		

Fixed Effects

	Estimate	Std. Error	95% CI	*df*	t value	*p*
(Intercept)	0.82	0.22	0.39 – 1.26	2550	3.72	**.0002**
Withdrawal	-0.01	0.003	-0.02 – -0.00	2550	-3.47	**.0005**
Negative Valence	-0.83	0.27	-1.38 – -0.29	3886	-3.02	**.002**
Positive Valence	0.52	0.27	-0.02 – 1.07	3886	1.87	.060
Neutral Valence	0.01	0.27	-0.89 – 0.20	3886	-1.22	.219
Withdrawal*Negative Valence	0.005	0.004	-0.00 – 0.01	3886	1.31	.187
Withdrawal*Positive Valence	0.005	0.004	-0.00 – 0.01	3886	1.36	.171
Withdrawal*Neutral Valence	0.009	0.004	0.00 – 0.02	3886	2.38	**.017**

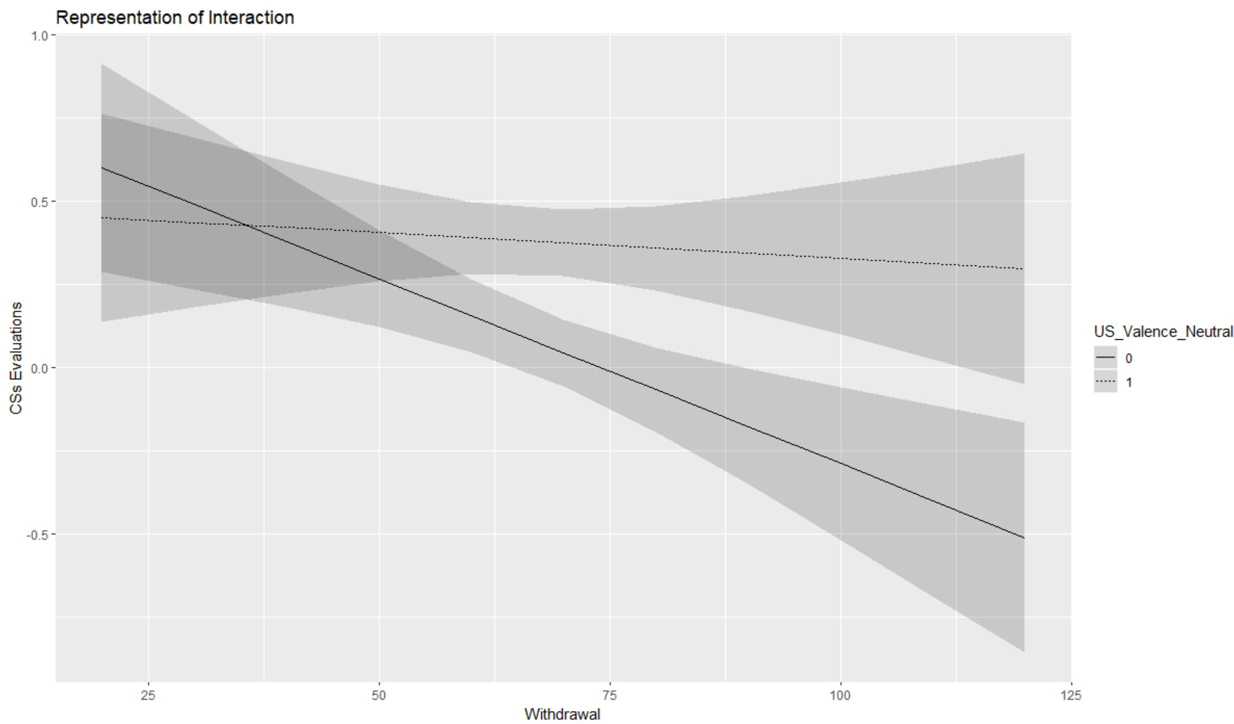
Correlation of Fixed Effects

	Intr	Withdr	Neg	Pos	Neutr	Withdr x Neg	Withdr x Pos
Withdrawal	-0.97						
Negative Valence	-0.62	0.61					
Positive Valence	-0.62	0.61	0.50				
Neutral Valence	-0.62	0.61	0.50	0.50			
Withdrawal*Negative Valence	0.61	-0.62	-0.97	-0.48	-0.48		
Withdrawal*Positive Valence	0.61	-0.62	-0.48	-0.97	-0.97	0.50	
Withdrawal*Neutral Valence	0.61	-0.62	-0.48	-0.48	-0.97	0.50	0.50

Note. Marginal R^2 / Conditional R^2 0.093 / 0.201

Figure 1

The Interaction Effect between Withdrawal and Neutral Condition Relative to Ambiguous Condition in Experiment 1



Note. Digit 1 represents the slope of the CSs evaluations paired with neutral USs. Digit 0 represents the slope of the CSs evaluations paired with non-neutral, respective the USs from the ambiguous condition. The slope of the CSs from ambiguous condition (0) is more abrupt, reflecting that the CSs received negative evaluations as withdrawal increased (on the OX axe).

Table 14.2

The Interaction Effect between Volatility and the CSs paired with specific US Valences in Experiment 1

Note. Marginal R^2 / Conditional R^2 0.091 / 0.201

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.30	0.55
Residual	2.22	1.49
Number of obs: 4448, groups: participant, 556		

Fixed Effects

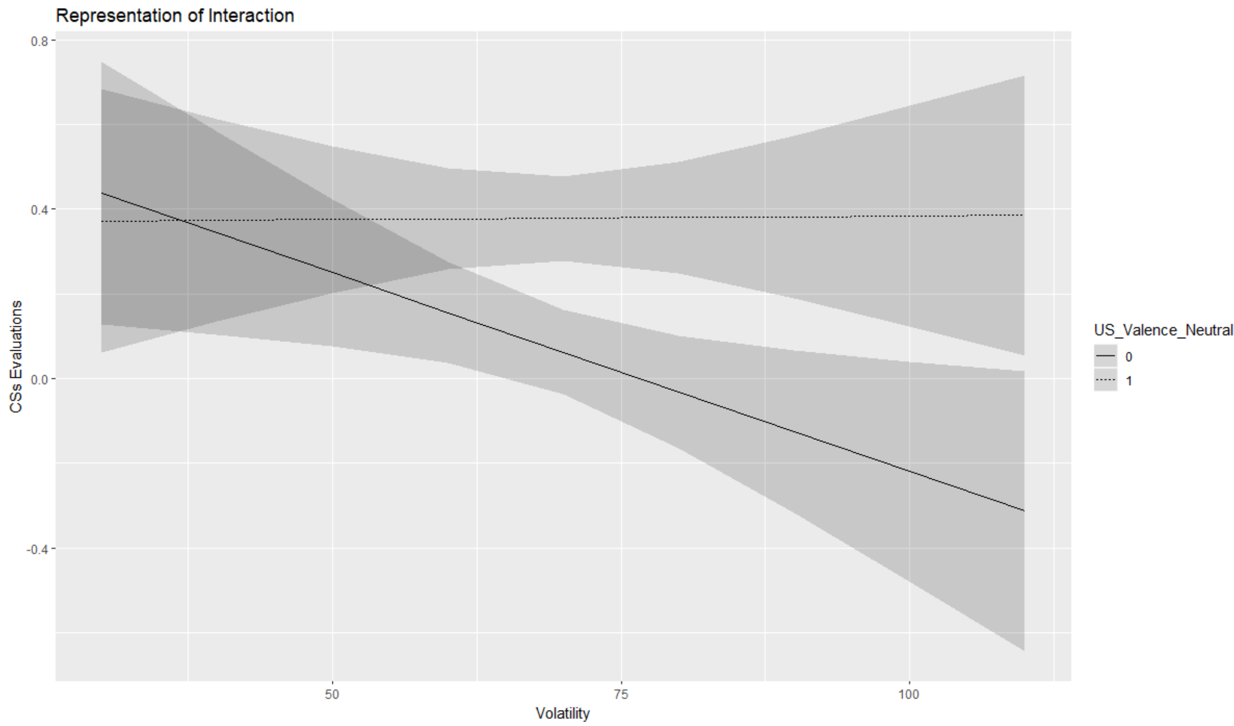
	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.71	0.27	0.19 – 1.25	2531	2.64	**.008**
Volatility	-0.009	0.003	-0.02 – -0.00	2531	-2.40	**.016**
Negative Valence	-0.75	0.34	-1.42 – -0.09	3886	-2.21	**.027**
Positive Valence	0.37	0.34	-0.29 – 1.04	3886	1.10	.271
Neutral Valence	-0.35	0.34	-1.02 – 0.32	3886	-1.03	.301
Volatility*Negative Valence	0.003	0.004	-0.01 – 0.01	3886	0.80	.419
Volatility*Positive Valence	0.007	0.004	-0.00 – 0.02	3886	1.54	.122
Volatility*Neutral Valence	0.009	0.004	-0.00 – 0.02	3886	1.95	**.050**

Correlation of Fixed Effects

	Intr	**Volat**	**Neg**	**Pos**	**Neutr**	**Volat x Neg**	**Volat x Pos**
Volatility	-0.98						
Negative Valence	-0.62	0.61					
Positive Valence	-0.62	0.61	0.50				
Neutral Valence	-0.62	0.61	0.50	0.50			
Volatility*Negative Valence	0.61	-0.62	-0.98	-0.49	-0.49		
Volatility*Positive Valence	0.61	-0.62	-0.49	-0.98	-0.49	0.50	
Volatility*Neutral Valence	0.61	-0.62	-0.49	-0.49	-0.98	0.50	0.50

Figure 2

The Interaction Effect between Volatility and Neutral Condition Relative to Ambiguous Condition in Experiment 1



Note. Digit 1 represents the slope of the CSs evaluations paired with neutral USs. Digit 0 represents the slope of the CSs evaluations paired with non-neutral, respective the USs from the ambiguous condition. The slope of the CSs from ambiguous condition (0) is more abrupt, reflecting that the CSs received negative evaluations as volatility increased (on the OX axe).

Table 14.3

The Interaction Effect between Withdrawal and the CSs paired with specific US Valences in Experiment2

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.50	0.71
Residual	1.65	1.28
Number of obs: 3200, groups: participant, 400		

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.28	0.20	-0.13 – 0.69	1255	1.35	.176
Withdrawal	-0.01	0.005	-0.02 – -0.00	1255	-2.21	**.027**
100% Negative Valence	-0.42	0.23	-0.87 – 0.03	2794	-1.82	.068
100% Positive Valence	0.16	0.23	-0.29 – 0.62	2794	0.72	.470
100% Neutral Valence	-0.7	0.23	-0.53 – 0.38	2794	-0.33	.735
Withdrawal*100% Negative Valence	0.004	0.006	-0.01 – 0.02	2794	0.78	.430
Withdrawal*100% Positive Valence	0.008	0.006	-0.00 – 0.02	2794	1.31	.189
Withdrawal*100% Neutral Valence	0.01	0.006	0.00 – 0.03	2794	2.32	**.020**

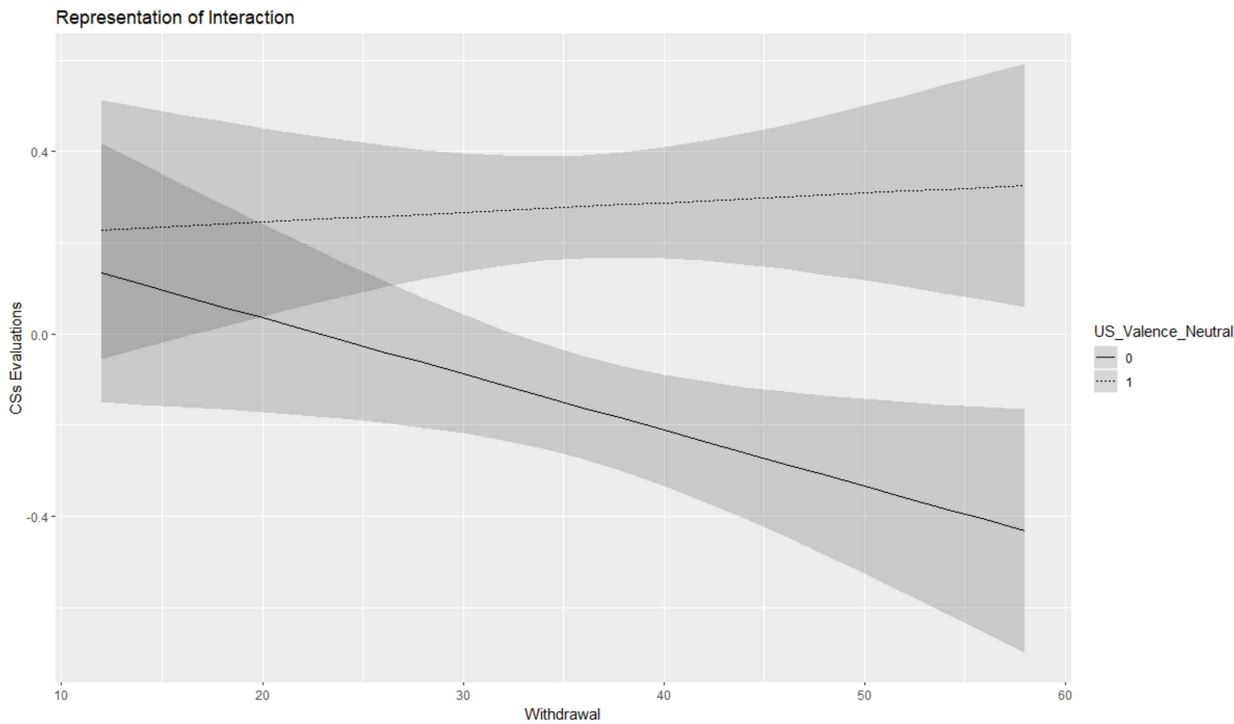
Correlation of Fixed Effects

	Intr	**Withdr**	**Neg**	**Pos**	**Neutr**	**Withdr x Neg**	**Withdr x Pos**
Withdrawal	-0.96						
100% Negative Valence	-0.55	0.53					
100% Positive Valence	-0.55	0.53	0.50				
100% Neutral Valence	-0.55	0.53	0.50	0.50			
Withdrawal*100% Negative Valence	0.53	-0.55	-0.96	-0.48	-0.48		
Withdrawal*100% Positive Valence	0.53	-0.55	-0.48	-0.96	-0.48	0.50	
Withdrawal*100% Neutral Valence	0.53	-0.55	-0.48	-0.48	-0.96	0.50	0.50

Note. Marginal R^2 / Conditional R^2 0.042 / 0.267

Figure 3

The Interaction Effect between Withdrawal and Neutral Condition Relative to Ambiguous Condition in Experiment 2



Note. Digit 1 represents the slope of the CSs evaluations paired with neutral USs. Digit 0 represents the slope of the CSs evaluations paired with non-neutral, respective the USs from the ambiguous condition. The slope of the CSs from ambiguous condition (0) is more abrupt, reflecting that the CSs received negative evaluations as withdrawal increased (on the OX axe).

Table 14.4

The Interaction Effect between Volatility and the CSs paired with specific US Valences in Experiment 2

Note. Marginal R^2 / Conditional R^2 0.043 / 0.268

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.50	0.71
Residual	1.64	1.28
Number of obs: 3200, groups: participant, 400		

Fixed Effects

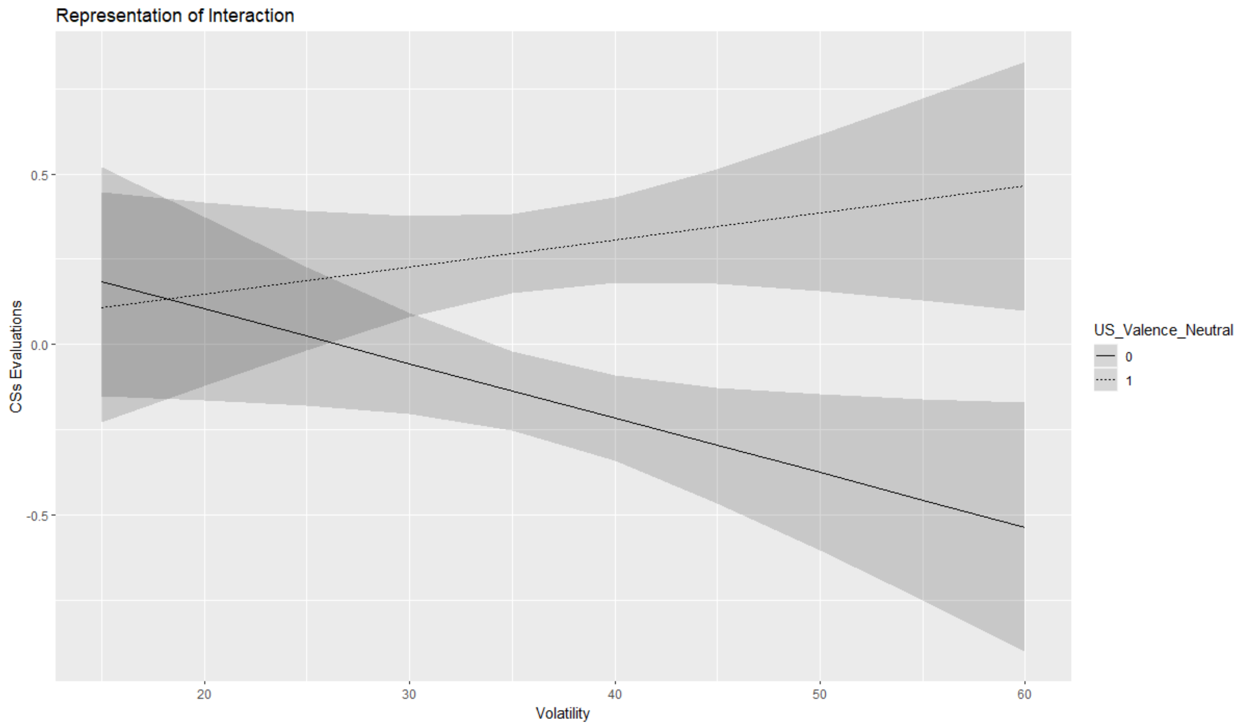
	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	0.42	0.28	-0.13 – 0.97	1253	1.50	.131
Volatility	-0.01	0.007	-0.03 – -0.00	1253	-2.12	**.033**
100% Negative Valence	-0.64	0.31	-1.26 – -0.03	2794	-2.05	**.039**
100% Positive Valence	0.29	0.31	-0.31 – 0.91	2794	0.95	.339
100% Neutral Valence	-0.43	0.31	-1.05 – 0.18	2794	-1.38	.165
Volatility *100% Negative Valence	0.01	0.008	-0.01 – 0.03	2794	1.30	.193
Volatility *100% Positive Valence	0.004	0.008	-0.01 – 0.02	2794	0.52	.601
Volatility *100% Neutral Valence	0.02	0.008	0.01 – 0.04	2794	2.85	**.004**

Correlation of Fixed Effects

	Intr	**Volat**	**Neg**	**Pos**	**Neutr**	**Volat x Neg**	**Volat x Pos**
Volatility	-0.97						
100% Negative Valence	-0.55	0.54					
100% Positive Valence	-0.55	0.54	0.50				
100% Neutral Valence	-0.55	0.54	0.50	0.50			
Volatility*100% Negative Valence	0.54	-0.55	-0.97	-0.48	-0.48		
Volatility*100% Positive Valence	0.54	-0.55	-0.48	-0.97	-0.97	0.50	
Volatility*100% Neutral Valence	0.54	-0.55	-0.48	-0.48	-0.97	0.50	0.50

Figure 4

The Interaction Effect between Volatility and Neutral Condition Relative to Ambiguous Condition in Experiment 2



Note. Digit 1 represents the slope of the CSs evaluations paired with neutral USs. Digit 0 represents the slope of the CSs evaluations paired with non-neutral, respective the USs from the ambiguous condition. The slope of the CSs from ambiguous condition (0) is more abrupt, reflecting that the CSs received negative evaluations as volatility increased (on the OX axe).

Supplemental Materials Section 15 – Method and Results of a Previously Exploratory Experiment

This experiment has not been preregistered, being carried out immediately after Experiment 1 as a conceptual replication of the ambiguous learning condition. Thus, the ambiguous condition was built up based on partial reinforcement manipulation by alternatingly pairing two CSs with positive USs in 50% of trials and with negative USs in the other 50% of trials (as in the actual Experiment 2). In addition to Experiment 2, this study involved more measures of neuroticism and related constructs but not implied a neutral experimental condition. The aim of introducing many other related scales is to broaden the conceptualization of the neuroticism theoretical construct by generating a broadband neuroticism factor.

Method

Design

The conditioning procedure involved a 3 (US valence reinforcement: 100% Negative vs. 100% Positive vs. 50% Negative – 50% Positive) within-subjects unifactorial design.

Participants

Participants (N = 306; 234 female, 72 male, M_{age} = 24.08, SD = 7.66) were also undergraduate and graduate students. They received course credit in exchange for their participation.

Materials

Besides the Neuroticisms Scale from NEO PI-R, we introduced the following scales to broaden the conceptualization of neuroticism. The 12-item Negative Emotionality scale from Big Five Inventory-2 (BFI-2; Soto & John, 2017) was included as an alternative Big Five neuroticism measurement. The Negative Emotionality was measured on a 5-point Likert scale (1 = *strongly disagree* to 2 = *strongly agree*). Scores for the 3-related facets were also computed

(Anxiety, Depression, and Emotional Volatility). Behavioral Inhibition System (BIS) was measured by using a 7-item scale from BIS/BAS instrument (Carver & White, 1994; Sava & Sperneac, 2006). The responses were recorded in a Likert format from 1 (*strong disagreement*) to 4 (*strong agreement*). The 19-item Neuroticism-Anxiety scale from the Zuckerman-Kuhlman Personality Questionnaire (ZKPQ; Zuckerman, 2002) was used to assess the neuroticism dimension from a psychobiological perspective. The response scale was dichotomous (True/False). The Emotionality factor from the 100-item HEXACO (Lee & Ashton, 2018) was used as an alternative measurement of Neuroticism on a 5-Likert scale (1 = *strongly disagree* to 5 = *strongly agree*). In addition, 10 Emotionality Adjectives from HEXACO model were used to assess the Emotionality State as a construct related to the low neuroticism state (Ashton et al., 2004). The responses were recorded on a Likert scale ranging from 1 (*not describe me at all*) to 5 (*totally describes me*). The 10-item Negative Affect Scale from PANAS (Watson et al., 1988) was used to self-report negative mood on a 5-point Likert scale (1 = *very slightly* to 5 = *extremely*). All these scales share a strong association with neuroticism while tapping on specific facets. Besides those neuroticism-related operationalizations, two-state measures were included to explore the relevance of the neuroticism state in the EC procedure. All these newly added measures aimed at exploring more nuancedly which facets of the neuroticism-related constructs are the strongest correlates of the tendency to evaluate CSs more negatively, as only some facets of neuroticism contributed to this bias effect in the first study.

The materials used in this experiment were partly similar to the materials used further in Experiment 2. Pictures from IAPS (Lang et al., 2008) were used as USs. For 100% Positive Reinforcement, two positive pictures were used as USs (picture 2035 and picture 2091). For 100% Negative Reinforcement, two negative pictures were used as USs (picture 2345.1 and picture 2301). Regarding the condition of 50% Positive Reinforcement – 50% Negative Reinforcement, four pictures from IAPS were used to keep under control the content (the same face) and vary, alternatively, the valence. Thus, one CS was alternatively paired on 50% of trials with a positive picture (picture 2900.2) and on 50% of trials with a negative picture (picture 2900). Whereas another CS from this condition was paired alternatively on 50% of trials with a negative picture (picture 2375.2) and on 50% of trials with a positive picture (picture 2375.1). For the 50%-50% condition, while a CS was firstly presented with a positive US (and then with a negative US), the other one CS was presented firstly with a negative US (and then with a positive US).

The first two USs (positive and negative) presented a white child in the center (smiling vs. crying). The following two USs (also one positive and one negative) represented a black female (smiling vs. being sad) as the main representation. These USs were used for the positive-negative alternations condition. The rationale was to keep control of the symbolic content but to manipulate only the valence in pairing presentations (alternative pairs of CS – positive US vs. CS – negative US).

All four pairs (i.e., one CS paired only with a positive US, one CS paired only with a negative US, and two CSs paired alternatively with a positive or negative USs) were randomly presented within a participant, and the pairs' formation was counterbalanced from a participant to another. The main selection criterion was to match for the valence, arousal and dominance indices for each valence (positive, respectively negative), their IAPS codes being presented above.

Procedure

Given the Pandemic context, this experiment was conducted during online meetings using the Google Meet tool from the Google Suite and not in a lab setting. An online meeting involved almost 15 participants. The link for the meeting was provided after participants completed a participation form which required the date and time when they would be available for the study participation. At the start of the meeting, participants were informed to keep their web camera on until they submitted their responses and to access the Inquisit link provided in chat for starting the study. Once they clicked the link, all the materials were presented on their computer screen via Inquisit 5 Lab program. Before being immersed in the study, the participants were informed and trained on how to install Inquisit 5.

First, the participants read the consent form presented on the screen. By pressing the "Space" bar, they gave their agreement with regard to study participation. Further, they filled in the demographics research part (e.g., age). Next, self-report instruments were provided. Firstly, participants had to complete the Emotionality Adjectives from HEXACO, reporting their responses at the last hour. Then, PANAS Negative Affect required responses regarding the state of negative affect at the time of completion. Trait measurements were provided afterward in the following order: Neuroticism scale from NEO PI-R, Negative Emotionality scale from BFI-2, BIS items, Emotionality scale from HEXACO, and Neuroticism-Anxiety from ZKPQ.

The EC experimental procedure started immediately after the practice stage. After the EC procedure ended, participants were asked to evaluate how much they liked or disliked the fractals (CSs). Each CS was evaluated on a scale that ranged from -3 (*very unpleasant*) to +3 (*very pleasant*). Two other dependent variables were included as exploratory outcomes: *Expectancy* and *Thinking of*. For the Expectancy measurement, two questions were provided: (1) *To what* *extent do you expect the image generated by the computer [the fractal] will be presented simultaneously, in the following seconds, with a PLEASANT aspect?* and (2) *To what extent do you expect the image generated by the computer [the fractal] will be presented simultaneously, in the following seconds, with an UNPLEASANT aspect?* Both questions were rated on a scale from 0% to 100%. Each question was presented on the screen above each CS, but followed one after another for the same CS (in random order from one participant to another). The Thinking of outcome was measured using the same procedure, but the two questions were different: (1) *To what extent does the image generated by the computer [the fractal] make you think of a pleasant aspect?* and (2) *To what extent does the image generated by the computer [the fractal] make you think of an unpleasant aspect?* Firstly, the participants gave responses for *Expectancy* and afterwards for *Thinking of.*

Immediately after, participants had to identify what kind of US was paired with each CS (i.e., valence awareness). Similarly, each CS was presented on the screen to be assigned with one of the following options: *Pleasant pictures* (coded with 1), *Unpleasant pictures* (coded with 2), *Both with pleasant and unpleasant photos* (coded with 3), or *I don't remember* (coded with 4). Finally, participants had to explain briefly why they considered that a computer-generated image was always presented with a real-life picture. At the end of the experiment, participants were thanked, debriefed, and compensated.

Sample Size Determination

We targeted a sample size of around 300, which provides sufficient power at .80 (with $\alpha = .05$ one-tailed) for detecting an $r \geq -.14$, which is a relatively small effect (corresponding to Cohen's $d = .28$).

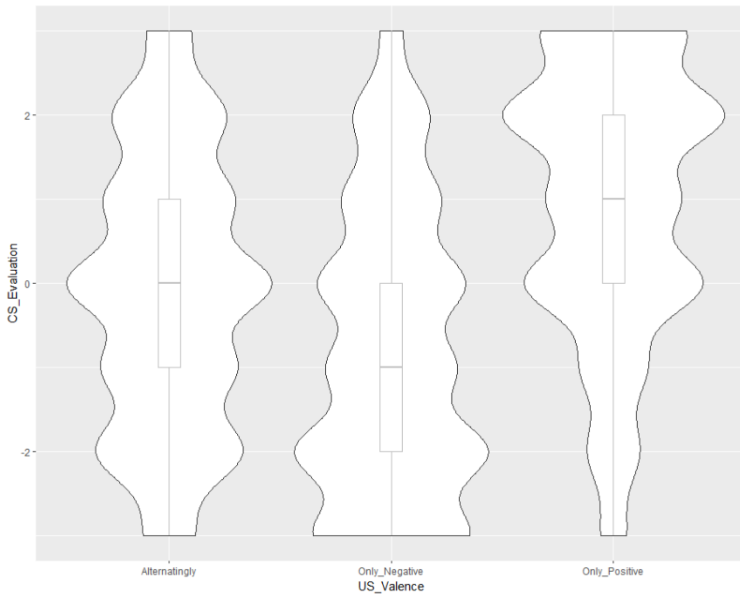
Results

We analyzed data using Linear Mixed Effects Regression.

Preliminary analyses. First, we tested whether there was an EC effect. We computed a *Null Model* by including random intercepts for participants and stimuli (i.e., 6 CSs). The variance of the CSs in the overall model was close to zero, similar to Experiment 1 (i.e., 0.08). Thus, we implemented the *General Model* by including only the by-participant random intercept (β = 0.001, *SE* = 0.04, 95% CI [-0.09, 0.10], t = 0.02, p = .98. When we introduced the valence of USs or the percent of valence reinforcement, we identified significant differences in evaluations between the CSs from the 50%-50% condition and CSs from 100% negative valence reinforcement (β = -0.70, *SE* = 0.08, 95% CI [-0.88, -0.53], t = -8.03, p < .001), respective 100% positive valence reinforcement (β = 1.04, *SE* = 0.08, 95% CI [0.87, 1.21], t = 11.87, p < .001). Like Experiment 2, we used the US valence reinforcement as a categorical factor and created dummy scores by setting the 50%-50% reinforcement condition as the reference level (i.e., the ambiguous condition). As the results show, the CSs paired only with negative USs were significantly negatively evaluated relative to the CSs alternatingly paired with positive and negative USs. The CSs paired only with positive USs were significantly positively evaluated relative to the CSs from the ambiguous condition.

Figure 5

The Distribution of the CSs Evaluation in Each Reinforcement Condition



Main Analyses. Given the numerous neuroticism-related scales used in this experiment, we extracted a single general neuroticism factor using only the scales for the trait (i.e., the neuroticism-related state scales were not included). We performed an Exploratory Factor Analysis with the total scores for Neuroticism (NEO PI-R), Negative Emotionality (BFI-2), Neuroticism-Anxiety (ZKPQ), BIS, and Emotionality (HEXACO), and all scales loaded highly on the general factor (see Table 1). The results of Bartlett's test of sphericity indicated that the correlation matrix was not random ($\chi 2(10) = 1243{,}619$, $p < .001$) (Bartlett, 1954), and the sampling adequacy was good (KMO = .86), being above the minimum standard for conducting EFA (Kaiser, 1974).

Table 1

Loadings of Neuroticism-Related Scales in the One-Factor Solution

Neuroticism-Related Scale	Factor
Neuroticism (NEO PI-R)	**.94**
Negative Emotionality (BFI-2)	**.89**
BIS	**.78**
Neuroticism-Anxiety (ZKPQ)	**.87**
Emotionality (HEXACO)	**.69**

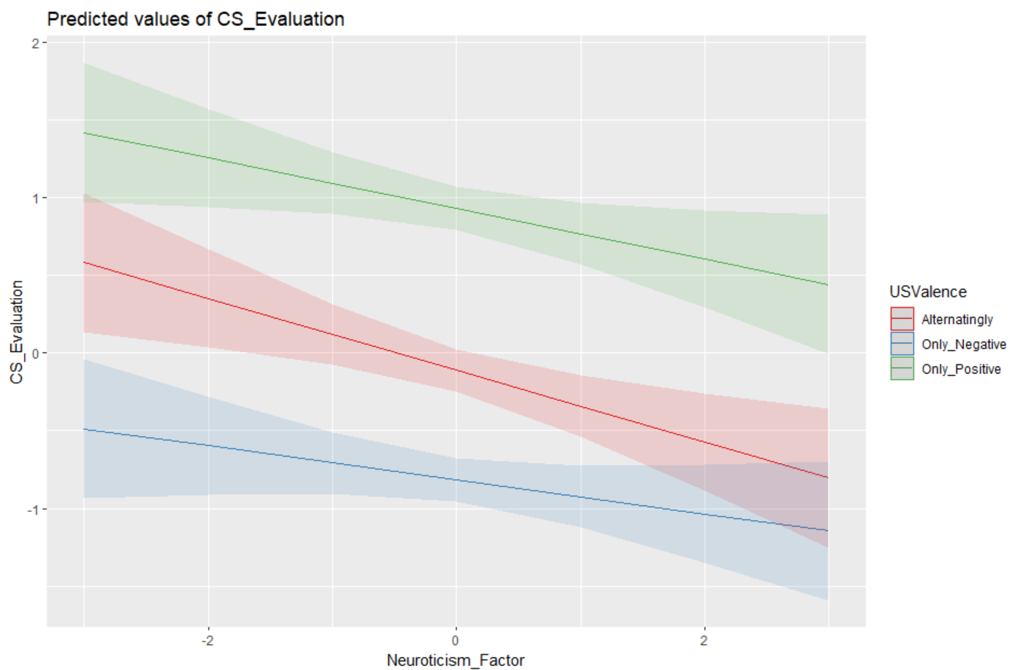
We introduced the new neuroticism factor score as a supplementary predictor in the general model besides the categorical valence factor to investigate the interaction effect between neuroticism and US valence reinforcement. Again, the reference level was represented by the ambiguous learning condition (50%-50%). Similar to Experiment 1 and Experiment 2, we did not identify an interaction effect between the Neuroticism Factor and the CSs paired only with negative USs relative to the CSs from the ambiguous learning condition (β = 0.12, *SE* = 0.09, *t* = 1.34, *p* = .17). We also did not find an interaction effect between the Neuroticism Factor and the CSs paired only with positive USs relative to ambiguous learning condition (β = 0.06, *SE* = 0.09, *t* = 0.75, *p* = .44). So, the results of this experiment replicated the findings of Experiment 1 and Experiment 2 regarding the lack of interaction when we reported positive and negative valenced learning conditions to an ambiguous one.

However, a simple effect of the Neuroticism Factor revealed by the main analyses was also replicated (β = -0.23, *SE* = 0.07, *t* = -3.20, *p* = .001). Thus, the finding shows that the ratings of CSs generally decreased as the neuroticism factor score increased in the sample. As in

Experiment 1 and Experiment 2, highly neurotic participants gave lower ratings to the CSs, independent of the US valence reinforcement condition (see Figure 8 for a visual representation).

Figure 6

The Simple Effect of Neuroticism Factor on the CSs Evaluations



Note. Figure 6 presents the slopes of CSs evaluations for each pairing condition. Each slope becomes more abrupt as the level of neuroticism increases, reflecting the simple effect of generally negative ratings received by CSs, independent of the condition.

Descriptive Statistics of Neuroticism-Related Scales

Neuroticism Measures	*α*	*M*	*SD*	*Skewness*	*Kurtosis*
Neuroticism (NEO PI-R)	.93	141.27	26.44	.001	-.09
Anxiety	.80	25.65	5.77	-.21	-.32
Angry-Hostility	.79	22.56	5.86	.14	-.44
Depression	.82	23.81	6.11	.08	-.31
Self-Consciousness	.74	24.55	5.53	.03	-.53
Impulsiveness	.65	23.87	4.69	.16	.08
Vulnerability	.82	20.80	5.35	.22	-.35
Negative-Emotionality (BFI-2)	.87	35.47	8.47	.03	-.56
Anxiety	.69	12.98	3.13	-.07	-.33
Depression	.73	11.06	3.38	.18	-.47
Emotional Volatility	.75	11.42	3.16	.02	-.74
Emotionality (HEXACO)	.81	3.25	0.56	-.24	-.09
Fearfulness	.62	12.18	3.04	-.13	-.23
Anxiety	.62	13.72	3.05	-.004	-.78
Dependence	.73	12.56	3.20	-.34	-.10
Sentimentality	.67	13.57	3.07	-.45	.15
Neuroticism-Anxiety (ZKPQ)	.89	8.43	5.35	.13	-1.15
Behavioral Inhibition Scale (BIS)	.79	19.67	3.72	-.31	.13
Emotionality State (HEXACO Adjectives)	.86	37.07	10.66	.45	-.28
Negative Affect (PANAS)	.91	19.61	8.13	.92	.21

Note. **The total sample of N = 306 participants.**

Null Model for including by-participant and by-item random intercepts

Random Effects

Groups Name	Variance	Std. Dev
Participant (Intercept)	0.25	0.50
CSs Stimuli (Intercept)	0.08	0.29
Residual	2.87	1.69

Number of obs: 1836, groups: participant, 306; CSs stimuli, 6

Fixed Effects

	Estimate	Std. Error	95% CI	*df*	t value	*p*
(Intercept)	0.001	0.13	-0.25 – 0.26	5.524	0.008	.99

Note. Marginal R^2 / Conditional R^2 0.000 / 0.106

General Model for Experiment 2 including only by-participant random intercept

Random Effects

Groups Name	Variance	Std. Dev
Participant (Intercept)	0.23	0.48
Residual	2.96	1.72

Number of obs: 1836, groups: participant, 306

Fixed Effects

	Estimate	Std. Error	95% CI	*df*	t value	*p*
(Intercept)	0.003	0.04	-0.09 – 0.10	305	0.02	.98

Note. Marginal R^2 / Conditional R^2 0.000 / 0.075

The Evaluations of CSs paired with Negative USs (100% Reinforcement) and Positive USs (100% Reinforcement) Relative to the CSs paired Alternatingly with Positive and Negative USs (50% - 50% Reinforcement)

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.31	0.56
Residual	2.35	1.53

Number of obs: 1836, groups: participant, 306

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	-0.11	0.07	-0.25 – 0.03	1063.35	-1.58	.115
100% Negative USs	-0.70	0.08	-0.88 – -0.53	1528.00	-8.03	**< .001**
100% Positive USs	1.04	0.08	0.87 – 1.21	1528.00	11.87	**< .001**

Note. Marginal R^2 / Conditional R^2 0.169 / 0.268

The Interaction Effect between Neuroticism Factor and US Valence Reinforcement

Random Effects

Groups Name	**Variance**	**Std. Dev**
Participant		
(Intercept)	0.31	0.56
Residual	2.34	1.53

Fixed Effects

	Estimate	**Std. Error**	**95% CI**	***df***	**t value**	***p***
(Intercept)	-0.11	0.07	-0.25 – 0.03	1084.05	-1.59	.11
Neuroticism Factor	-0.23	0.07	-0.37 – -0.09	1084.05	-3.20	**.001**
100% Negative USs	-0.70	0.08	-0.88 – -0.53	1526	-8.03	**< .001**
100% Positive USs	1.04	0.08	0.87 – 1.21	1526	11.87	**< .001**
Neuroticism Factor x 100% Negative USs	0.12	0.09	-0.06 – 0.30	1526	1.34	.17
Neuroticism Factor x 100% Positive USs	0.06	0.09	-0.11 – 0.25	1526	0.75	.44

Correlation of Fixed Effects

	Intr	**Neur Factor**	**100% Neg**	**100% Pos**	**Neur Factor x 100% Neg**
Neuroticism Factor	0.00				
100% Negative USs	-0.62	0.00			
100% Positive USs	-0.62	0.00	0.50		
Neuroticism Factor x 100% Negative USs	0.00	-0.62	0.00	0.00	
Neuroticism Factor x 100% Positive USs	0.00	-0.62	0.00	0.00	0.50

Note. Marginal R^2 / Conditional R^2 0.169 / 0.268

Correlations of *Expectancy* and *Thinking of* variables and Neuroticism measures for CSs paired alternatively with positive and negative USs (50% - 50%)

Neuroticism Measures	CSs paired with 50% of Positive USs and with 50% of Negative USs	
	Expectancy	Thinking of
Neuroticism (NEO PI-R)	-.12*	-.19***
Negative-Emotionality (BFI-2)	-.14**	-.21***
Emotionality (HEXACO)	-.20***	-.22***
Behavioral Inhibition (BIS)	-.18**	-.26***
Neuroticism-Anxiety (ZKPQ)	-.09	-.16**
Emotionality State (HEXACO)	-.08	-.13*
Negative Affect (PANAS)	-.03	-.11

Table S26. Correlations of Expectancy and Thinking of variables and Neuroticism measures for CSs paired alternatively with positive and negative USs (50% - 50%) in Experiment 2 for the total sample of N = 306 participants.

***p < .05, **p < .01, ***p < .001**

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