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BRIEF REPORT

Neuroticism is associated with larger and more prolonged electrodermal responses to emotionally evocative pictures

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Abstract

Elevated neuroticism is associated with increased psychological reactivity to stressors. Research on individual differences and physiological reactivity (e.g., electrodermal activity), however, has focused on clinical samples and measures of basal activity (e.g., nonspecific skin conductance responses) or responses to nonaffective stimuli. Surprisingly, there is a dearth of work on physiological reactivity to emotional stimuli as a function of neuroticism. Thus, the authors sought to examine the relationship between neuroticism and skin conductance reactivity to emotionally evocative pictures in a nonclinical sample. Individuals higher in neuroticism exhibited both greater skin conductance reactivity to emotional (and particularly aversive) pictures as well as more extended reactivity than did emotionally stable individuals. Implications for health are discussed.

Descriptors: Individual differences, EDA, Neuroticism, Emotional stability

According to Eysenck's (1967) theory of personality, neuroticism is associated with increased reactivity of the limbic system and a low tolerance for stress or aversive stimuli. Indeed, neurotics show greater distress and depressive symptomology following stressful life events, such as unemployment (Creed, Muller, & Machin, 2001), spousal caregiving (Gallant & Connell, 2003), and breast cancer surgery (Millar, Purushotham, McLatchie, George, & Murrary, 2005). In laboratory settings, neurotics are more sensitive to negative mood inductions than are emotionally stable individuals (Larsen & Ketelaar, 1991).

Additional research has investigated the relationship between neuroticism and physiological reactivity. Schwebel and Suls (1999) found that neurotics exhibited larger increases in cardiovascular measures in response to an aggregate of psychological (e.g., anger imagery) and physical (e.g., hand grip) stressors. Closer examination, however, revealed that these effects were driven by responses to physical stressors. Thus, Schwebel and Suls found no evidence for differences in cardiovascular reactivity to psychological or emotional stressors as a function of neuroticism.

Complementary lines of research suggest that neurotics may exhibit greater skin conductance reactivity than emotionally stable individuals. As compared to control samples, patients with schizophrenia, who tend to be high in neuroticism (Horan, Subotnik, Reise, Ventura, & Nuechterlein, 2005), show greater skin conductance activity at rest. In addition, schizophrenics exhibit reduced habituation of skin conductance responses (SCRs) to repeated sensory stimulation (Akdag et al., 2003). Slow habituation of SCRs is also associated with anxiety neurosis (Lader & Wing, 1966), trait anxiety in normal populations (O'Gorman, 1975), state anxiety (Maltzman et al., 1971), and individual differences in "excitability" (Duffy, 1962). As schizophrenia and anxiety disorders have been associated with elevated neuroticism (Horan et al., 2005; Kopp & Gruzelier, 1989), we might also expect a relationship between neuroticism in nonclinical populations and rate of habituation. Consistent with this hypothesis, Eysenck (1967) demonstrated that neurotics required more time than emotionally stable individuals to return to baseline after sensory stimulation.

Furthermore, in that neurotics are more psychologically reactive to emotional events (Larsen & Ketelaar, 1991), they might also be more physiologically reactive to emotional events. Skin conductance is a particularly appropriate measure for testing this hypothesis, as pleasant and unpleasant stimuli (e.g., pictures, sounds, imagery) elicit greater skin conductance activity than

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neutral stimuli (i.e., an arousal effect; Bradley, 2000). Thus, individuals higher in neuroticism should show especially strong skin conductance reactivity to emotional (and especially aversive) stimuli. Though this hypothesis has not been tested, preliminary evidence comes from the finding that individuals high in harm avoidance, which is correlated with neuroticism, show longer half-recovery times to unpleasant than to neutral pictures (Mardaga, Laloyaux, & Hansenne, 2006). To more directly test the hypothesis that individuals higher in neuroticism exhibit stronger and more prolonged responses to emotional stimuli, we examined the relationship between neuroticism and skin conductance reactivity to emotionally evocative pictures.

Method[1]

During two sessions separated by 2 weeks, 61 right-handed undergraduate women viewed 66 pictures from the International Affective Picture System (IAPS). Pictures were selected based on normative valence ratings (Lang, Bradley, & Cuthbert, 1999) to span the valence dimension and vary widely in content.[2] Pictures were presented in different orders in Session 1 and Session 2. Participants were instructed to attend to each picture for its entire duration and think about how it made them feel. Trials consisted of a 3-s baseline, a 6-s picture presentation, and a 3-s recovery period.

Skin conductance was recorded with 8-mm Ag/Ag-Cl electrodes attached to the thenar and hypothenar eminences of the left palm. A solution of sodium chloride in a neutral base was used as an electrode paste, and a constant 0.5-V signal was applied across the two electrodes. A strain gauge was placed high around the thorax to measure respiration. Skin conductance was relayed to a Biopac electrodermal response amplifier, model GSR100C (Biopac Systems, Inc., Santa Barbara, CA); signals were digitized at 1000 Hz. Off-line, skin conductance was submitted to a 10-Hz low-pass filter, and visually inspected. When an irregular breath and an increase in skin conductance occurred together, the response was splined from trough to half-time recovery point. To correct for the positive skew inherent to skin conductance, data were square-root transformed (Dawson, Schell, & Filion, 2000). Skin conductance was averaged over the first 3 s of each picture presentation (early picture epoch), the last 3 s of each picture presentation (late picture epoch), and the 3 s immediately following picture offset (recovery epoch). Skin conductance reactivity was defined as the difference between each of these epochs and the 1 s immediately preceding picture onset.[3] To increase reliability of measurement, skin conductance reactivity was collapsed across stimuli based on normative valence ratings to create three categories: unpleasant (22 most negative pictures), neutral (22 most neutral pictures), and pleasant (22 most positive pictures).

Personality Dimensions

Participants completed the Emotional Stability (i.e., the inverse of neuroticism) and Surgency (i.e., Extraversion) subscales of the Big 5 Personality Dimensions scale (Goldberg, 1992). For each subscale, participants indicated how accurately 20 traits described them on a 9-point scale, ranging from 1 (*extremely inaccurate*) to 9 (*extremely accurate*); responses were averaged to obtain extraversion ($\alpha = .88$) and neuroticism ($\alpha = .73$) scores. Sample items for neuroticism and extraversion subscales, respectively, are "high-strung" and "sociable."[4]

Results

Extraversion and Neuroticism

Extraversion ($M = 6.00$, $SD = 0.94$) and neuroticism ($M = 3.85$, $SD = 0.84$) scores were normally distributed and negatively correlated, $r(59) = .32$, $p < .05$. Although we were primarily interested in the effect of neuroticism on skin conductance reactivity to emotional stimuli, we included extraversion as a separate factor to examine its independent effects.

Skin Conductance Reactivity

To examine the effects of neuroticism on skin conductance reactivity, we conducted a 2 (Session: 1, 2) $\times$ 3 (Valence: unpleasant, neutral, pleasant) $\times$ 3 (Epoch: early picture, late picture, recovery) repeated measures general linear model (GLM), with neuroticism and extraversion entered as continuous between-participants factors. A GLM is a multiple regression that allows tests of continuous between-participants factors, categorical within-participants factors, and their interactions. By treating neuroticism as a continuous variable, GLM offers greater statistical power than other analytic techniques (e.g., ANOVA) requiring median splits (e.g., Cohen, 1983). To assist in interpretation of results, we examined estimates at 1 *SD* above and below the mean of the continuous variable in the current sample (Aiken & West, 1991).

A main effect of valence, $F(2,57) = 4.93$, $p < .05$, indicated that skin conductance reactivity was greater in response to unpleasant ($M = 0.007$, $SE = 0.004$, all units in microsiemens) and pleasant ($M = 0.005$, $SE = 0.003$) than to neutral ($M = 0.001$, $SE = 0.002$) pictures, pairwise $ps < .01$. Skin conductance reactivity did not differ for unpleasant and pleasant pictures, $p = .66$. This effect replicates the arousal pattern typical of skin conductance (Bradley, 2000).

In addition, a main effect of neuroticism, $F(1,58) = 4.96$, $p < .05$, indicated that individuals higher in neuroticism exhibited greater skin conductance reactivity ($M = 0.010$, $SE = 0.004$) than individuals lower in neuroticism ($M = 0.003$, $SE = 0.004$). The main effect of neuroticism was qualified by two interactions. A Valence $\times$ Neuroticism interaction, $F(2,57) = 7.56$, $p < .001$,

[1]Due to space constraints, only methodological details critical for the current study are presented.

[2]IAPS stimuli: 1052, 1121, 1274, 1660, 1710, 1750, 1930, 2050, 2057, 2208, 2340, 2661, 2800, 3100, 3130, 3160, 3250, 3261, 3400, 4000, 4004, 4230, 4302, 4520, 4534, 4571, 4598, 4641, 4656, 4680, 4770, 4800, 5300, 5731, 5910, 5920, 5971, 5972, 6150, 6260, 6561, 6610, 6930, 7002, 7006, 7010, 7050, 7217, 7430, 7460, 7600, 8060, 8080, 8185, 8210, 8260, 8311, 8370, 8460, 8501, 9102, 9500, 9520, 9560, 9570, and 9810.

[3]Many researchers have used a similar measure to examine skin conductance reactivity (e.g., Palomba, Sarlo, Angrilli, Mini, & Stegagno, 2000). Furthermore, although Dawson et al. (2000) define a specific, stimulus-induced SCR as a change in skin conductance occurring within 1–3 s of stimulus onset that exceeds a given amplitude, they also indicate that the traditional amplitude threshold of 0.05 μS has been antiquated by technological advances that now permit more sensitive recording of EDA. Thus, our index of skin conductance reactivity is essentially a measure of SCRs, as we are examining event-related changes in skin conductance without a minimum amplitude. To avoid confusion with the standard use of the term SCR, however, we refer to our measure as "skin conductance reactivity."

[4]Neuroticism and emotional stability represent opposite ends of the same Big 5 dimension. To be consistent with the existing literature's focus on neuroticism (Eysenck, 1967), we discuss results in terms of neuroticism.

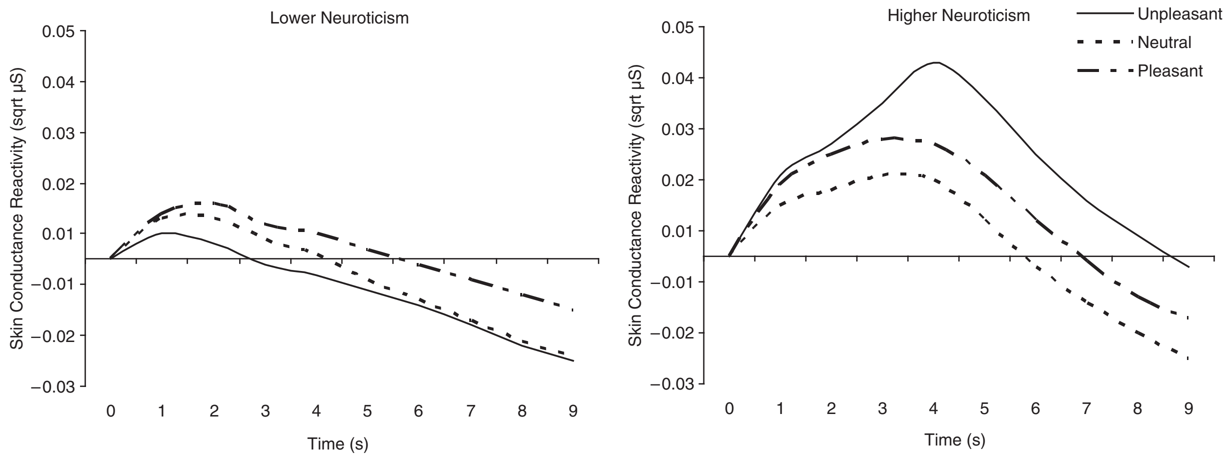

Figure 1. Skin conductance reactivity as a function of picture valence, time, and neuroticism. Pictures were presented from 1–6 s. Estimated means for participants lower (1 *SD* below the mean) and higher (1 *SD* above the mean) in neuroticism are plotted separately.

showed that although participants lower in neuroticism showed no significant differences in skin conductance reactivity as a function of valence, participants higher in neuroticism showed greater skin conductance reactivity to unpleasant ($M = 0.019$, $SE = 0.006$) and pleasant ($M = 0.009$, $SE = 0.005$) than to neutral ($M = 0.002$, $SE = 0.004$) pictures, $ps < .05$ (Figure 1). In addition, participants higher in neuroticism exhibited greater skin conductance reactivity to unpleasant than to pleasant pictures, $p < .05$.[5] Finally, an Epoch × Neuroticism interaction, $F(2,57) = 3.98$, $p < .05$, indicated that neuroticism was associated with different patterns of recovery. Individuals lower in neuroticism exhibited a linear pattern, such that skin conductance reactivity was highest during the early picture epoch ($M = 0.006$, $SE = 0.004$), middling during the late picture epoch ($M = -0.003$, $SE = 0.005$), and lowest during the recovery epoch ($M = -0.013$, $SE = 0.005$), pairwise $ps < .05$. Individuals higher in neuroticism, however, exhibited no differences between the early ($M = 0.018$, $SE = 0.004$) and late ($M = 0.017$, $SE = 0.005$) picture epochs, $p = .79$; although both picture epochs differed from the recovery epoch ($M = 0.006$, $SE = 0.005$), $ps < .001$. The GLM revealed no other significant effects.

Discussion

We have provided evidence that individual differences in neuroticism, but not extraversion, predict different patterns of skin conductance reactivity to emotionally evocative stimuli. We first replicated the finding that skin conductance reactivity is greater for pleasant and unpleasant than for neutral pictures (i.e., an arousal pattern; Bradley, 2000). More importantly, we found that neuroticism interacted with both picture valence and recovery time. Neurotic individuals exhibit both greater reactivity and more sustained responses to emotional stimuli than do emotionally stable individuals. These effects were statistically significant but small and discernible in part because advances in instrumentation for electrodermal measurement over the past decade or so permit the reliable quantification of smaller changes in skin conductance than previously possible (Dawson et al., 2000).

Although in the aggregate people show greater skin conductance reactivity to high arousal than to low arousal stimuli (Bradley, 2000), Lang, Greenwald, Bradley, and Hamm (1993) have found substantial individual differences in this pattern. For instance, fully 29% of their female participants failed to exhibit a positive correlation between skin conductance reactivity to affective pictures and arousal ratings. Our results indicate that such individual differences are associated with neuroticism. Though individuals higher in neuroticism show greater skin conductance reactivity to arousing stimuli, individuals lower in neuroticism show comparable levels of reactivity to arousing and nonarousing stimuli.

Relative to comparably extreme and arousing positive stimuli, negative stimuli evoke stronger cognitive, emotional, and social responses (cf. Cacioppo & Gardner, 1999). Cacioppo, Berntson, Larsen, Poehlmann, and Ito (2000), for instance,

[5]In addition to the Neuroticism and Extraversion subscales of the Big 5 Personality Dimensions scale, we did administer other self-report instruments that are often strongly correlated with these factors. In the current sample, neuroticism was correlated with the Beck Depression Inventory (BDI; e.g., Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) at .60, the Spielberger Trait Anxiety Scale (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) at .71, and the Hostile Affect subscale of the Cook-Medley Hostility Scale (e.g., Barefoot, Dodge, Peterson, Dahlstrom, & Williams, 1989) at .55; these correlations met the Bonferroni corrected p value of .0004 (i.e., .05 divided by the number of tests conducted). To examine whether neuroticism predicts skin conductance reactivity even when controlling for these other individual difference factors, we conducted a series of hierarchical regressions. Each analysis involved two steps: in the first step, we conducted a 2 (Session: 1, 2) × 3 (Valence: negative, neutral, positive) × 3 (Epoch: early picture, late picture, recovery) repeated measures GLM, including one of the between-participants continuous factors as a separate factor (i.e., extraversion, BDI, hostile affect, anxiety); in the second step, we conducted the same analysis on the residuals from the first step, with neuroticism entered as a between-participants continuous factor. The critical Valence × Neuroticism interaction was significant in each of these four hierarchical regressions, indicating that even when controlling for highly correlated dimensions, neuroticism predicted skin conductance reactivity to emotional pictures. A second set of analyses tested the reverse hypothesis that, even when controlling for neuroticism, other personality dimensions predicted skin conductance reactivity. In the first step, neuroticism was entered as a between-participants continuous factor in the same three-factor repeated measures GLM as above; in the second step, each of four personality variables was included in the same analysis, predicting the residuals from the first step. Again, the critical Valence × Neuroticism interaction was significant in the first step; but valence did not interact with any of the other personality factors in the second step. In sum, neuroticism predicts skin conductance reactivity to emotional pictures above and beyond the effects of other highly correlated personality variables.

demonstrated that negative emotions elicit greater autonomic activity than positive emotions. In our study, individuals higher, but not lower, in neuroticism responded more strongly to unpleasant than to pleasant pictures, which is consistent with Eysenck's (1967) hypothesis that neuroticism involves hyperactivation of the limbic system and a consequently low tolerance for stressors or aversive stimuli. Although it is possible that the *negativity bias* in our study may be due to differences in arousal between unpleasant and pleasant pictures, our data suggest that neurotic individuals exhibit a stronger negativity bias in autonomic reactivity than do emotionally stable individuals.

Neuroticism has been associated with increased morbidity (e.g., Spiro, Aldwin, Ward, & Mroczek, 1995) and mortality (e.g., Wilson et al., 2005); what remains unclear is why. Following decades of evidence that individuals higher in neuroticism experience more intense emotional reactions to even minor stressors (e.g., Larsen & Ketelaar, 1991), our results indicate that these individuals also show greater autonomic reactivity to stressors. Whether such patterns of autonomic reactivity contribute to greater physiological wear and tear and adverse health outcomes in the long term is a question we leave to future prospective research.

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