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Neuroticism as Mental Noise: A Relation Between Neuroticism and Reaction Time Standard Deviations

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Those higher in neuroticism are often more variable in their behavior and experience. On the basis of this observation, the authors hypothesized that the trait of neuroticism might be correlated with the variability of performance pertaining to relatively basic cognitive operations. Three studies involving 242 college undergraduates supported this prediction in that neuroticism correlated positively with the variability of performance across trials of reaction time tasks. These results link neuroticism to cognitive noise that intervenes between stimulus and response. Such noise has been associated with executive dysfunctions (e.g., frontal lobe injury) in previous research. The present findings are potentially useful for understanding why neuroticism often correlates with variations in the functionality of cognition and behavior.

Keywords: neuroticism, cognition, variability, reaction time

When considering both poles of each of the Big Five dimensions, people can usually say something in favor of both poles, although one pole might generally be recommended. An introverted person may have a richer introspective life; a disagreeable person may be more effective in securing selfish desires; a person low in conscientiousness may experience a certain sense of freedom from responsibility; and, finally, a person low in intellect or openness may experience fewer unwelcome surprises in life. Concerning high neuroticism, however, it would seem that few things could be said in favor of it. Individuals high in neuroticism experience more misery than those low in neuroticism and, in many cases, they are also less effective in regulating their behavior (Costa, Somerfield, & McCrae, 1986; Eysenck, 1947; Westen, 1998). For example, neuroticism has been associated with diverse manifestations of psychopathology (Widiger, Verheul, & van den Brink, 1999), response conflict (Robinson & Wilkowski, in press), temporal inconsistencies in behavior (Moskowitz & Zuroff, 2004), somatic complaints (Watson & Pennebaker, 1989), excessive worry (Watson & Clark, 1984), and poor coping habits (Kokkonen & Pulkkinen, 2001). There is little to recommend this collection of outcomes of neuroticism.

Many personality researchers wish not only to describe the correlates of traits but to understand such correlates as well (e.g., Pervin, 1994; Westen, 1995). Typically, and for good reason, researchers have sought to understand traits in terms of the self-regulatory systems that likely underlie cognition, behavior, and experience (Carver, Sutton, & Scheier, 2000; Watson, Wiese, Vaidya, & Tellegen, 1999). That is, we seek to “peek under the hood” to see how a trait *functions*: What are people trying to do and what difficulties do they encounter? Concerning neuroticism, there is no question of a deficiency in motivation. In fact, higher neuroticism is often viewed in terms of higher levels of motivation or drive (e.g., Eysenck, 1947; Spence, 1964). Therefore, the difficulties encountered by individuals high in neuroticism are likely because of either the goals in question or the efficiency with which they are pursued. In the present research, we focus on possible associations between neuroticism and the efficiency of basic cognitive operations.

Neuroticism as Instability

A prevalent metaphor for neuroticism is instability. Indeed, the low end of the neuroticism dimension is typically termed *stability*. Moreover, there are a variety of sources of data that suggest that instability in basic cognitive operations may well underlie the tendency for individuals high in neuroticism to experience more distress and behave in a less effective manner. For example, investigations concerned with behavior (Eysenck & Eysenck, 1985; Moskowitz & Zuroff, 2004) and emotional experience (Eid & Diener, 1999; Murray, Allen, & Trinder, 2002) have concluded that neuroticism correlates significantly with instability in behavior and experience over time. Such conclusions are reinforced by data showing that highly neurotic individuals are more reactive to stressors (Bolger & Schilling, 1991; Gross, Sutton, & Ketelaar, 1998). Reactivity processes necessarily produce variability in motivational and emotional processes (Gray, 1982; Patterson & Newman, 1993).

Furthermore, several prominent theories of neuroticism seem consistent with this emphasis on instability. Gray (1982) linked neuroticism (or anxiety) to the operation of a behavioral inhibition system, which would likely produce a start–stop pattern of behavior that is considerably less stable over time. In a related sense, Eysenck and Eysenck (1985) linked neuroticism to the excitability of the limbic system (for a recent review, see Matthews & Gilliland, 1999). To the extent that this excitability modulates ongoing cognitive processes and behavior, we would expect more variability from time to time. Finally, recent data have convincingly linked the trait of neuroticism to the avoidance self-regulation system (Carver et al., 2000; Watson et al., 1999). Self-regulation by

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avoidance, in turn, has been linked to a greater deal of variability in cognition and behavior (Carver & Scheier, 1990; Watson et al., 1999). In spatial dynamic terms, for example, there is only one direction of movement associated with approach, but many movement directions that can support avoidance of an object (Lewin, 1935).

In addition to the theoretical frameworks mentioned above, there is a rich clinical tradition that highlights the diversity of outcomes associated with high levels of neuroticism (Freud, 1926; Horney, 1945; Westen, 1998). For example, neuroticism has been associated with a great diversity of defensive coping mechanisms, including projection, reaction formation, transference, and so forth (Westen, 1998). Neuroticism has also been associated with a great diversity of disorders related with emotional experience (Clark, Watson, & Mineka, 1994), behavior (Widiger et al., 1999), and personality (Lynam & Widiger, 2001). In addition, high levels of neuroticism are implicated in the personality disorders characterized by erratic behavior (Lynam & Widiger, 2001). For example, the most robust Big Five predictor of borderline personality disorder is neuroticism (Trull, Widiger, Lynam, & Costa, 2003). Borderline personality disorder has, in turn, been linked to higher levels of emotional variability across time (Koenigsberg et al., 2002; Tolpin, Gunthert, Cohen, & O'Neill, 2004). This suggests that a focus on the intraindividual variability of emotion and behavior may offer a unique and productive perspective on borderline personality disorder (Tolpin et al., 2004). In summary, clinical observations and data link neuroticism to cognitive and behavioral processes that promote instability (Freud, 1926; Horney, 1945; Lynam & Widiger, 2001; Westen, 1998).

The preceding research suggests that the metaphor of neuroticism as instability may have considerable value. Given this prior theoretical and empirical background, we hypothesized that neuroticism would be associated with variability in stimulus–response behavior as measured by reaction time (RT). Although there appears to be no prior research examining such a relation, there are a number of recent investigations linking individual differences to RT standard deviations.

RT Variability as Mental Noise

Many behaviors in life involve the entrainment of responses to stimuli. For example, threats to the self should lead, somewhat automatically and reflexively, to defensive maneuvers (Fanselow, 1994; Robinson, 1998). Likewise, it would seem adaptive to notice and respond to behavioral opportunities in a somewhat reflexive manner (Tamir & Robinson, 2005). Indeed, people would generally be well-served by automating their behaviors to the greatest extent possible (Gollwitzer, 1999; James, 1890), provided that they do not lose capacities for behavioral override when current circumstances demand it (Baddeley, 1996; Muraven & Baumeister, 2000). In this connection, regularity (i.e., lack of variability) in behavioral response has been linked to automaticity (Logan, 1988), which is crucial to the effective self-regulation of many routine behaviors (Bargh & Chartrand, 1999; Muraven & Baumeister, 2000).

Within this context in which regularity in cognitive operations is beneficial, there is also evidence to suggest that the standard deviation of response time is a useful index of mental noise (Baumeister, 1998; Jensen, 1992; Rabbitt, Osman, Moore, & Stollery, 2001). For example, age (Hultsch, MacDonald, & Dixon, 2002), frontal lobe damage (Cismaru & Chertkow, 1999), attention-deficit/hyperactivity disorder (Leth-Steensen, Elbaz, & Douglas, 2000), and intelligence (Baumeister, 1998) have all been linked to a greater variability of response times across trials of an RT task. In addition, standard deviations of performance have been linked to less effective neural control (Jensen, 1992; Slifkin & Newell, 1998) and less effective neural transmission (Deary & Caryl, 1997; Hanes & Schall, 1996).

As pointed out by Baumeister (1998), standard deviations of RT are typically viewed as error, but such error (from trial to trial) is an individual difference (Baumeister, 1998; Jensen, 1992; Rabbitt et al., 2001). Indeed, studies have found that, although mean RTs are often correlated with standard deviations in a positive manner (i.e., slow = more variable), both are independent predictors of intelligence (Baumeister, 1998), with standard deviations being the generally stronger predictor (Dougherty & Haith, 1997). Rabbitt et al. (2001) have also found that standard deviations of RT are stable across tasks and over time, thus qualifying as an individual difference variable.

What do RT standard deviations assess? As shown by multiple authors, RT standard deviations likely assess noise within information-processing systems (e.g., Baumeister, 1998). To the extent that such deviations are higher, the individual is necessarily less effective in regulating his or her behavior over time, at least with reference to the specific processing task (Rabbitt et al., 2001). The variability of RT performance also appears to provide a useful window on the efficiency of basic cognitive operations, as indicated by its correlates, including old age, frontal lobe damage, and low intelligence. Given that neuroticism has been associated with both temporal variability (e.g., Eysenck & Eysenck, 1985) and less effective self-regulation (e.g., Costa et al., 1986), it seemed likely to us that the dimension of neuroticism, too, might be associated with the variability of cognitive performance across trials.

Overview of the Studies

Our investigation sought to examine the hypothesis that the metaphor of variability, underlying typical conceptions (Eysenck & Eysenck, 1985) and longitudinal treatments (Eid & Diener, 1999; Moskowitz & Zuroff, 2004) of neuroticism, also extends to basic cognitive operations. We expected neuroticism to correlate positively with trial-to-trial variations in performance (i.e., higher neuroticism = higher RT standard deviations). We expected this association to be independent of mean RT, which typically does not correlate with neuroticism (e.g., Robinson, 2004; Tamir & Robinson, 2004).

In demonstrating such an association, we conducted three studies. The first study involved multiple semantic distinctions, the diversity of which may be seen as adding to the generalizability of the present findings. However, each given categorization task has its own unique variance and predictive value (Robinson, 2004) and therefore the diversity of tasks examined in Study 1 likely leads to an underestimation of the neuroticism–standard deviation relationship. We therefore conducted a second study in which a Stroop task was used across all trials of the computer program. Given the constant task, we expected Study 2 to provide the best estimate, examined here, of the magnitude of the neuroticism–standard deviation relationship.

Studies 1 and 2 involved choice RT, which is only one type of fundamental RT task. In addition to choice RT, it is worth considering simple RT, which merely requires the detection of a stimulus, and go/no-go RT, which requires both detection and discrimination processes, but no response selection process (Donders, 1868/1969; Ulrich, Mattes, & Miller, 1999). To the extent that the mental noise theory examined here is quite general, one might expect no interaction across such basic cognitive tasks. Study 3 examines this prediction.

Study 1

Study 1 sought to establish the generality of the present hypothesized relation by examining performance within a wide variety of distinct choice RT tasks.

Method

Participants. Participants were 159 college undergraduates from the University of Illinois at Urbana–Champaign.

Procedures. Participants performed a choice RT task and then reported on their levels of neuroticism. This assessment order was used because there are some hints that completing personality self-report scales can alter performance within cognitive tasks (e.g., Spielman, Pratto, & Bargh, 1988). However, we are aware of no evidence showing that performance in cognitive tasks can affect scores on trait self-report measures.

Measures. Neuroticism levels were measured through the use of Goldberg's (1999) 10-item scale. Participants were asked the extent to which a series of statements (e.g., "have frequent mood swings") are descriptive of the self (1 = *very inaccurate*; 5 = *very accurate*). Goldberg reports extensive evidence for the reliability and validity of the scale. For example, the scale correlates ($r = .82$) with the longer neuroticism scale from the NEO (Costa & McCrae, 1992). In the present sample, alpha was .85.

Our cognitive measure pertained to a number of choice RT tasks that have been used and validated in previous research (for reviews, see Robinson, 2004; Robinson & Neighbors, in press; Robinson, Vargas, & Crawford, 2003). The specific blocks required distinctions contrasting *not animal* (e.g., chair) versus *animal* (e.g., mouse) words, *unpleasant* (e.g., cancer) versus *pleasant* (e.g., candy) words, *not blame* (e.g., baldness) versus *blame* (e.g., malpractice) words, *not threat* (e.g., mildew) versus *threat* (e.g., knife) words, *neutral* (e.g., string) versus *positive* (e.g., sunset) words, *not wealth* (e.g., friend) versus *wealth* (e.g., fortune) words, and *neutral* (e.g., street) versus *negative* (e.g., pimple) words. Words were generally chosen from extant word affect lists (e.g., Bradley & Lang, 1999) and, in previous research, accuracy rates were reasonably high with respect to all distinctions. In total, there were 16 blocks and 368 trials. In the case of all blocks, category endpoints (e.g., *not animal* vs. *animal*) remained on the screen during the course of the trials, and responses involved the 1 versus 9 keys at the top of the computer keyboard. Accurate responses were followed by a 150-ms interstimulus interval, whereas inaccurate responses were penalized with a 1,500-ms error message.

Prior to scoring the variability measure, we removed inaccurate responses (*M* accuracy = 94.89%). We then performed a log transformation of raw millisecond values to normalize the distribution. Subsequent to this, we replaced (log) latencies that were 2.5 standard deviations below and above the grand latency mean with these cutoff values. Such replacement procedures lessen the impact of particularly fast and slow outliers (Ratcliff, 1993). As noted above, mean RT and RT standard deviations are often positively correlated (i.e., slower = higher RT standard deviations). This was true here as well ($r = .50$, $p < .01$). Given this correlation, we sought to establish that the present effects pertain to tendencies toward variability independent of tendencies to be slow. To accomplish this aim, we performed a regression that predicts RT standard deviations on the basis of RT means. We used the resulting regression equation to remove the common variance to these two measures. We calculated a residual standard deviation variable that was necessarily uncorrelated with mean RT, owing to the residualizing procedures.

Finally, we sought to characterize the internal consistency of residual standard deviation variability scores. To do so, we computed two independent residual standard deviation scores, one based on performance on odd trials and one based on performance on even trials. We then correlated these two independent estimates and found a reasonably high correlation ($r = .72$, $p < .01$). This indicates that individual differences that are related to lesser or greater RT variability were consistent across trials.

Results

To gain a broad appreciation of the relations among neuroticism, accuracy, mean RT, RT standard deviation, and the residual variability scores, we intercorrelated all measures. The resulting correlations are reported in Table 1. As shown in the table, neuroticism did not correlate with accuracy or mean RT within the choice tasks. However, neuroticism did correlate with RT standard deviations as well as the residual standard deviation measure. The correlations indicate that neuroticism was somewhat specifically related to RT standard deviations, as hypothesized. Figure 1A provides a graphic display of this relationship.

Discussion

Intraindividual variability in RT has typically been treated as statistical noise, yet recent developments suggest that such cognitive tendencies toward noise may be reliable and important indicators of the reproducibility of basic cognitive operations, for example in the context of cognitive aging (Hultsch et al., 2002). The present results, too, suggest that tendencies toward less or more variable cognitive performance are robust across odd versus even trials of diverse choice RT tasks. It is important to note that the present research provides initial support for the idea that neuroticism relates to the variability of basic cognitive processes,

Table 1
Correlations Between Neuroticism and Performance Measures for All Studies

	Categorization performance measure				
Study and measure	1	2	3	4	5
1					
1. Neuroticism	—	−.06	−.04	.22*	.27*
2. *M* Accuracy		—	.05	−.21*	−.27*
3. *M* RT			—	.50*	.00
4. RT *SD*				—	.86*
5. Residual *SD*					—
2					
1. Neuroticism	—	−.04	−.35*	.41*	.45*
2. *M* Accuracy		—	−.09	.14	.14
3. *M* RT			—	.09	.00
4. RT *SD*				—	.99*
5. Residual *SD*					—
3					
1. Neuroticism	—	.01	−.12	.28	.31*
2. *M* Accuracy		—	.16	−.37*	−.47*
3. *M* RT			—	−.73*	.00
4. RT *SD*				—	.71*
5. Residual *SD*					—

Note. RT = reaction time.
* $p < .05$.

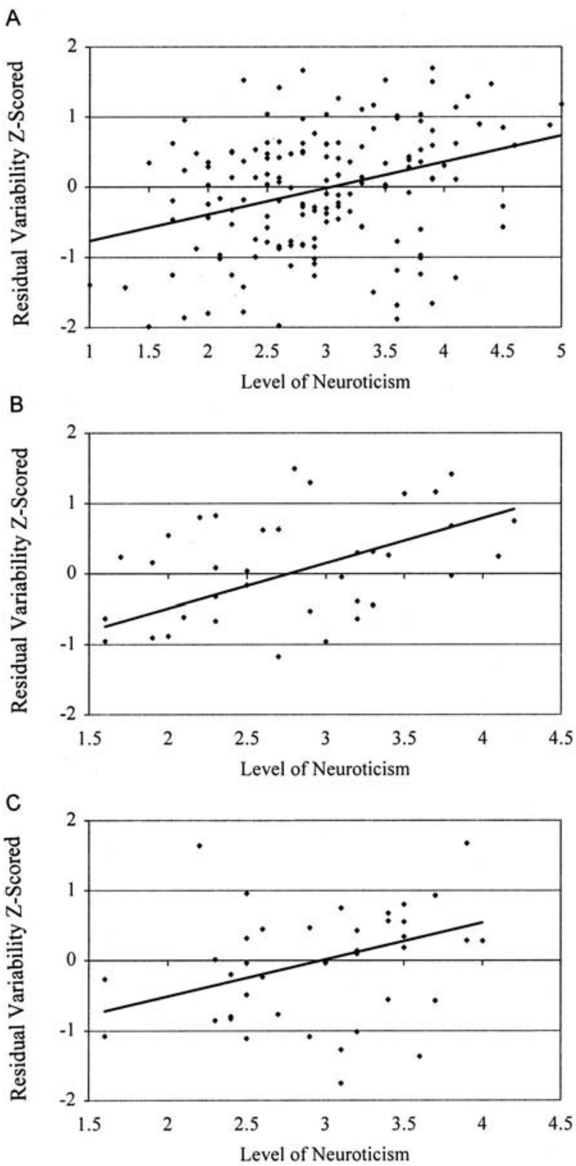

Figure 1. Neuroticism and residual standard deviation scores: Study 1 (A), Study 2 (B), and Study 3 (C).

such as those associated with choice RT. In this connection, neuroticism correlated with neither accuracy rates nor mean RT, but it did correlate with RT standard deviations, even when controlling for individual differences in mean RT.

In appreciating these results, it is worthwhile to note that neuroticism does not share much if any relationship with intelligence (Demetriou, Kyriakides, & Avraamidou, 2003; Eysenck, 1994). For example, Demetriou et al. (2003) have concluded that neuroticism is unique among the Big Five in being uncorrelated with both objective (i.e., performance-based) and subjective (i.e., self-rated) measures of intelligence (based on a sample size of 629). Despite such null relations, the present results nevertheless indicate that neuroticism, like intelligence, seems to be correlated with the cross-temporal stability of RT. We sought to replicate the latter correlation within a second study.

Study 2

The choice tasks used in Study 1 were largely affective in nature (e.g., *unpleasant* vs. *pleasant*), a factor that could have contributed to the results to some extent (see Tamir & Robinson, 2004). In Study 2, we sought to remove this factor from consideration by using a nonaffective Stroop task, which required categorizing letter strings as green or red. A second purpose of Study 2 was to investigate the size of the relation between neuroticism and RT standard deviations in a relatively constant task. To this end, Study 2 participants performed the Stroop task across 252 trials. Owing to the relatively constant nature of this task, our intuition was that the neuroticism–RT standard deviation relation might be even more substantial in Study 2 than in Study 1.

Method

Participants. Participants were 40 college undergraduates from the University of Illinois at Urbana–Champaign.

Procedures. Participants performed a Stroop task and then reported on their levels of neuroticism (Goldberg, 1999; $\alpha = .86$).

Measures. Within the version of the Stroop task, participants were asked to categorize the font color of letter strings as *green* (*1* key) or *red* (*9* key). The words *green* and *red* were presented on the computer screen during the trials to aid in the response mapping process. There were six stimuli created by crossing font color with one of three letter strings (*green*, *red*, or *xxx*). Each trial began with the random selection of a stimulus, which was presented within the center of the computer screen. If the response was accurate, then there was a 500-ms delay until the next stimulus. If the response was inaccurate, then there was a 2,000-ms error message. There were 252 trials.

Participants were quite accurate (*M* accuracy = 96.49%). Latencies were treated in three steps, specifically by removing inaccurate trials, log transforming the latencies, and replacing outliers (2.5 *SD*s) with these cutoff values. As in Study 1, we created a residual standard deviation measure by statistically removing the common variance to mean RT and RT standard deviations.

The procedures above were repeated for odd and even trials separately. Residual variability scores were quite reliable ($r = .83$, $p < .01$).

Results

Table 1 reports correlations between neuroticism, mean accuracy, mean RT, RT standard deviation, and residual variability scores. As in Study 1, neuroticism did not correlate with accuracy rates. Unlike Study 1, however, neuroticism correlated with mean RT, such that higher levels of neuroticism were associated with faster responses. Also unlike Study 1, there was no correlation between mean RT and RT standard deviations. Thus, Study 2 should be relatively useful in examining our central prediction within a task that produced a different pattern of correlations than within Study 1. As shown in Table 1 and graphically displayed in Figure 1B, neuroticism correlated with residual variability scores such that higher levels of neuroticism were associated with larger standard deviations across trials of the task.

Discussion

Study 2 sought to create conditions that might enhance the correlation between neuroticism and the residual standard deviation measure, relative to Study 1. Specifically, we used only one semantic distinction (i.e., green vs. red), pertaining to one block (i.e., font color categorizations), with a limited number of stimuli (i.e., six). The use of such constant conditions produced both a higher internal reliability coefficient ($r = .83$) and a higher neuroticism–residual standard deviation correlation ($r = .45$) than in Study 1. The results suggest that there is an intimate relation between neuroticism and mental noise, at least as indexed by residual standard deviation scores.

It is interesting to note that in Study 2, high neuroticism participants were both faster and more variable in their performance. This is atypical of RT performance, but it does dramatically highlight the distinct correlates of RT means and standard deviations (Baumeister, 1998; Rabbitt et al., 2001). Still, the relation between neuroticism and mean RT was unpredicted based on prior data (e.g., Tamir & Robinson, 2004) and was not replicated within the other studies. We therefore conclude that the neuroticism–mean RT correlation found in Study 2 was an anomaly that neither adds to, nor subtracts from, the substantive findings of the article.

Study 3

Study 3 sought to both replicate and extend the results of Studies 1 and 2. In terms of replication, we again expected a positive correlation between neuroticism and residual standard deviation scores. In terms of extending the results from prior studies, our major interest related to the cognitive operations involved in the present relationship. Specifically, on the basis of Donders's (1868/1969) distinctions among RT tasks (more recently reviewed in Ulrich et al., 1999), we can distinguish the cognitive operations involved in simple versus go/no-go versus choice RT. In a simple RT task, a person needs only to detect the presence of a stimulus to make a response. In a go/no-go task, both stimulus detection and stimulus discrimination are required. However, responses, as in the simple RT task, are always identical. Finally, in a choice RT task, there are at least three stages involved (Donders, 1868/1969): stimulus perception, stimulus discrimination, and response selection.

Study 3 systematically varied the nature of the RT task. To the extent that the neuroticism–residual standard deviation relation pertains to relatively low-level perceptual and response factors, there should be no Neuroticism × Task interaction. On the other hand, to the extent that the relation pertains to more complex cognitive operations, but not to simple ones, there should be a Neuroticism × Task interaction.

Method

Participants. Participants were 43 college undergraduates from North Dakota State University.

Procedures. Participants performed the RT task described under *Measures* and then reported on their levels of neuroticism (Goldberg, 1999; $\alpha = .82$).

Measures. Stimuli within the task were exceedingly simple. Specifically, either the digit 1 or the digit 9 was presented on every trial, selected on a random basis. Stimulus–response procedures, however, varied from simple RT to choice RT, following Donders's (1868/1969) taxonomy. In the simple RT task, participants were instructed to press a given response key (i.e., the *1* key in two blocks and the *9* key in two blocks), regardless of the stimulus under consideration. The task requires only the detection of an event. In the go/no-go RT task, participants were similarly asked to press only one response key during the entire block (i.e., the *1* key in two blocks and *9* key in two blocks). However, they were asked to press this key only in response to a matching stimulus (i.e., *1* key in the 1 blocks and *9* key in the 9 blocks), but to refrain from pressing this key when a nonmatching stimuli was presented (i.e., *9* key in the 1 blocks and *1* key in the 9 blocks). The task requires both event detection and event categorization. In the choice RT blocks, participants were asked to press the key that matched the stimulus (i.e., *1* key in the case of a 1 stimulus and *9* key in the case of a 9 stimulus). The task requires event detection, event discrimination, and response selection processes. Thus, the blocks differed with respect to the mental operations performed, from simple detection to response selection.

Participants performed 12 blocks. Blocks 1, 4, 7, and 10 involved simple RT; Blocks 2, 5, 8, and 11 involved go/no-go RT; and Blocks 3, 6, 9, and 12 involved choice RT. Each block had 30 trials, which resulted in 360 trials total. To accommodate the fact that no-go stimuli in the go/no-go blocks involved a nonresponse, stimuli were removed from the screen in 1,500 ms if there was no response on the given trial; this was true within all blocks. In the case of an accurate response, there was a 150-ms interstimulus delay. In the case of an inaccurate response, there was a visual error message presented for 2,500 ms. Accuracy rates were high regardless of the task under consideration (*M*s = 99.70%, 98.35%, & 98.6% for simple, go/no-go, and choice tasks, respectively).

To score RTs within the various tasks, we first deleted inaccurate responses. We then performed a log transformation of millisecond response times. Because of the 1,500-ms timeout value, there were few outliers within any task. Therefore, we did not replace outliers within Study 4. We then computed mean RT and RT standard deviations for each participant within each task. Reaction time and the standard deviation of RT were inversely correlated within the simple RT task ($r = -.87$, $p < .01$) but not within the go/no-go task ($r = .17$, $p = .28$) or the choice RT task ($r = .17$, $p = .28$). Within each task considered separately, we computed residual standard deviation scores that were correlated with raw standard deviations, but uncorrelated with mean RT.

Results

We analyzed mean (log) RTs within a general linear modeling analysis, including the within-subject factor of Block (simple vs. go/no-go vs. choice) and the between-subjects factor of Neuroticism, which was *z* scored prior to this analysis. The analysis indicated a large main effect for Block, $F(2, 82) = 70.00$, $p < .01$, such that response times were faster in the simple RT task ($M = 291$ ms) than in the go/no-go RT task ($M = 426$ ms), which was in turn faster than the choice RT task ($M = 445$ ms), with all pairwise comparisons being significant (ps $< .05$). By contrast, there was no main effect for Neuroticism ($F < 1$) and no Neuroticism × Block interaction, $F(2, 82) = 1.76$, $p = .18$. Such results indicate that neuroticism has few implications for mean RT, at least within the present paradigm.

We next performed a parallel analysis on residual standard deviation scores. Within this analysis, there was no main effect for Block ($F < 1$) and no Neuroticism × Block interaction ($F < 1$). However, as in prior studies, there was a main effect for Neuroticism, $F(1, 41) = 4.28$, $p = .04$. Given that Neuroticism did not interact with Block in this analysis, we averaged residual standard deviation scores across the three blocks (i.e., simple, go/no-go, and choice). To examine the reliability of these residual scores, we also computed separate residualized standard deviation scores for odd and even trials within the tasks. Residual standard deviation scores were quite reliable ($r = .90$, $p < .01$), indicating a general tendency, regardless of the task, to be less or more variable in performance from trial to trial.

To estimate the strength of the neuroticism–residual standard deviation correlation, we correlated the two measures. As in prior studies, there was a significant correlation ($r = .31$, $p = .04$; see

Table 1 for the full matrix). Figure 1C displays this correlation in a graphic manner.

Discussion

Study 3 contributes a number of important findings to the article as a whole. First, we found that the relation between neuroticism and residual standard deviation scores was remarkably robust across RT tasks. Such results suggest that the present relation pertains to variability in the stimulus-to-response sequence rather than to variability in any specific cognitive operation associated with RT performance. Second, we found that residual standard deviation scores were highly reliable when computed across diverse RT tasks ($r = .90$). This suggests a general factor related to instability in RT that is independent of the specific cognitive operations performed. Third, neuroticism predicted deviations within all tasks equally, in that there was no hint of a Neuroticism × Block interaction ($F < 1$).

Given the subtractive logic of Donders (1868/1969), which has fared reasonably well over time (Ulrich et al., 1999), the following conclusions appear to be legitimate. First, the locus of the neuroticism–residual standard deviation relation does not appear to be response selection processes, which would produce the greatest variability in the choice RT condition. Second, the locus of the relation does not appear to involve stimulus discrimination processes, which would produce greater variability in choice and go/no-go conditions relative to the simple RT condition. Instead, we may conclude that the neuroticism–residual standard deviation relation involves relatively simple cognitive processes related to the mere perception and reaction to events. Given the ubiquity of such cognitive operations, which can be found in all RT paradigms (Sanders, 1998), the neuroticism–residual standard deviation relation would appear to have quite general relevance to information processing.

General Discussion

One prevailing metaphor for neuroticism is instability. We pursued the premise that this instability might characterize not only behavior and emotional states over time, but also some basic cognitive processes involved in linking stimulus to response. This prediction was confirmed within Study 1, involving heterogeneous categorization tasks; Study 2, using an affect-neutral Stroop task; and Study 3, which sought to establish the generality of the phenomenon across simple, go/no-go, and choice tasks. Within the three studies, higher levels of neuroticism were associated with greater tendencies toward RT variability. Aside from the generality of the neuroticism–residual standard deviation relation, two other points add to the value of our findings. First, the relations shown here cannot be due to intelligence, as neuroticism and intelligence are almost completely, if not completely, unrelated (Demetriou et al., 2003; Eysenck, 1994). Second, the present dependent variable—standard deviations of RT performance—shares no semantic overlap with neuroticism and therefore the findings may be particularly impressive for this reason. The findings significantly extend our understanding of the individual difference correlates of Neuroticism and RT variability, as indicated below.

Neuroticism and Mental Noise

Although individuals high in neuroticism “try hard,” they tend to be particularly unsuccessful at daily living, at least relative to more stable individuals (McCrae & Costa, 1994). For example, they are less effective in their coping skills (Kokkonen & Pulkkinen, 2001), less effective in their behavior (Elliot, Herrick, MacNair, & Harkins, 1994), and prone to experiences of worry (Watson & Clark, 1984), somatic distress (Watson & Pennebaker, 1989), and psychopathology (Widiger et al., 1999). The diversity of negative outcomes linked to neuroticism suggests a possible common basis. In the present investigation, we provided support for the idea that there is at least one basic information-processing factor that differentiates individuals high versus low in neuroticism.

Specifically, although individuals high in neuroticism tended to be neither faster nor slower in their RTs, they were more variable in their performance from trial to trial. Variability in performance, in turn, has been taken as a sign of less reliable cognitive processes, and thus its correlations with frontal lobe damage (Cismaru & Chertkow, 1999), attention-deficit/hyperactivity disorder (Leth-Steensen et al., 2000), age (Hultsch et al., 2002), and intelligence (Baumeister, 1998). Variability in RT, indeed, suggests some fundamental deficiencies related to the development of behavioral routines linking stimulus and response (Baumeister, 1998; Logan, 1988).

Furthermore, we suggest that variability in the stimulus-to-response sequence could well underlie the distinct types of variability that have been linked to neuroticism. Individuals high in neuroticism, relative to more stable individuals, are more variable in their behavior (Eysenck & Eysenck, 1985; Moskowitz & Zuroff, 2004), emotional experiences (Eid & Diener, 1999; Murray et al., 2002), and in their attempts at self-control (Costa et al., 1986; Freud, 1926; Westen, 1998). All of these findings suggest a sequence in which the same stimulus events give rise to divergent outcomes from one time to the next. In other words, the most reliable facet of neuroticism may be its unreliability. We note that some parallel suggestions have recently been offered with respect to borderline personality disorder (Koenigsberg et al., 2002; Tolpin et al., 2004), a diagnosis that is particularly likely given high levels of neuroticism (Trull et al., 2003).

Moreover, it is possible that the relationship between neuroticism and “mental noise” might have other consequences that fit the current framework. First, given the greater unreliability of mental processes, from one time to the next, individuals high in neuroticism may be more prone to worry about their ability to cope with future events. Such a speculation is consistent with the idea that worry performs a control function (Borkovec, Ray, & Stöber, 1998; Mathews, 1990). Second, individuals high in neuroticism may invoke executive control to deal with events that might be better handled by more automatic components of mind (Borkovec et al., 1998; Mathews, 1990). That is, individuals high in neuroticism may attempt to overcome information-processing deficits by effort. However, such a strategy can backfire, in that most mental and behavioral functions are best controlled by more automatic components of mind (Baddeley, 1996; Bargh & Chartrand, 1999).

Personality Functioning and Standard Deviations

The vast majority of investigations related to personality and RT consider only tendencies related to mean RT. The present findings encourage future research related to standard deviations of performance, which may reflect the efficiency or reproducibility of information-processing operations (Baumeister, 1998; Logan, 1988; Rabbitt et al., 2001). It is true that RT and standard deviations tend to be positively associated with each other (Baumeister, 1998; Rabbitt et al., 2001); however, the two types of measures are dissociable in their predictive utility with respect to individual difference outcomes (e.g., Hultsch et al., 2002; Kirkeby & Robinson, 2005).

Given prior results, suggesting that RT variability is predictive of intelligence (Dougherty & Haith, 1997), frontal lobe dysfunction (Cismaru & Chertkow, 1999), and attention-deficit/hyperactivity disorder (Leth-Steensen et al., 2000), it would seem that RT standard deviation taps the efficiency of the person's executive functions (Cismaru & Chertkow, 1999; Rabbitt et al., 2001). Specifically, larger deviations suggest that the mind is less consistent in its operations (Hanes & Schall, 1996; Slifkin & Newell, 1998). Such an assessment tool may also be useful with respect to other personality variables (e.g., conscientiousness, emotional intelligence, impulsivity, and need for cognition) that are also somewhat centrally linked to cognitive-processing tendencies and their reliability.

Conclusions

Three studies reinforce the idea that neuroticism and instability are intimately related to each other. We were able to show that such a relation characterizes relatively basic cognitive processes involved in linking stimulus and response over time. Specifically, neuroticism correlated positively with RT standard deviations, despite the fact that neuroticism did not correlate positively with mean RT within any of the studies. On the basis of such results, we offer a mental noise perspective on neuroticism that may help to explain why individuals high in neuroticism are more variable in their behavior and experience.

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