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Intrusive Thoughts Mediate the Association between Neuroticism and Cognitive Function

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Abstract

Although research has established a negative association between trait neuroticism and cognition, little is known about the mechanisms that underlie this relationship. We examined the tendency to experience intrusive thoughts and negative affect as potential mediators of the relationship between neuroticism and cognitive performance. We hypothesized that the tendency to experience intrusive thoughts reflects ineffective attentional control and would account for the relationship between neuroticism and cognitive performance over and above the mediating effect of negative affect. Three hundred seventeen adults ($M_{age} = 49.43$) completed a series of attention-demanding cognitive tasks as well as self-report measures of intrusive thoughts, negative affect, and neuroticism. Intrusive thoughts mediated the association between trait neuroticism and cognitive performance beyond negative affect. These findings are consistent with the hypothesis that the tendency to experience intrusive thoughts is a mechanism through which trait neuroticism influences cognitive performance.

Keywords

Neuroticism; cognition; intrusive thoughts; repetitive thinking; rumination; worry; negative affect

1. Introduction

Neuroticism is a dimension of personality characterized by emotional distress (Larsen & Ketelaar, 1991), lability (Eid & Diener, 1999), and reactivity (Bolger & Zuckerman, 1995). Those with high levels of neuroticism are at increased risk for poor physical and psychological health (Mroczek & Spiro, 2007; Lahey, 2009). High levels of neuroticism are also associated with facets of cognitive health, including inefficient cognitive performance (Robinson & Tamir, 2005), cognitive decline (Wilson et al., 2005), and increased risk of Alzheimer's disease (Duchek, Balota, Storandt & Larsen, 2007; Wilson, Arnold, Schneider, Li, & Bennett, 2007). However, the psychological mechanisms through which neuroticism influences cognitive function remain largely uninvestigated. One hypothesis is that high

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neuroticism individuals exhibit less efficient cognitive processing due to elevated “mental noise” caused by mental preoccupations with task-irrelevant intrusive thoughts (IT) and distress (Robinson & Tamir, 2005). The current study provides an explicit test of this hypothesis by examining the mediational effects of individual differences in IT and emotional distress on the neuroticism-cognition relationship.

1.1 Neuroticism and Cognitive Performance

Studies have generally found negative associations between neuroticism and a broad range of cognitive functions in both cross-sectional and prospective longitudinal designs. Cross-sectional studies show negative associations between neuroticism and attention-demanding cognitive tasks that comprise fluid intelligence, such as episodic memory, numeric and abstract reasoning, and tasks of perceptual speed (Jorm et al., 1993; Moutafi, Furnham, & Paltiel, 2005). In contrast, neuroticism and performance on crystallized tasks are not robustly associated (Costa, Fozard, McCrae, & Bosse, 1976). Prospective studies have shown longitudinal associations between neuroticism and different indices of cognitive decline and impairment. Individuals high in neuroticism are at increased risk for developing mild cognitive impairment as well as Alzheimer’s disease and other dementias (Wilson et al., 2003). Neuroticism is also a risk factor for cognitive decline in the absence of dementia—those who score high in neuroticism decline an average of thirty percent faster than those low in neuroticism (Wilson et al., 2005). Altogether, cross-sectional and longitudinal evidence indicates that effects are most pronounced for attention-demanding tasks, such as episodic and working memory. These findings raise the question of what specific processes drive the association between neuroticism and cognitive performance in attention-demanding tasks.

The tendency to experience recurrent and intrusive thoughts represents a possible psychological mechanism underlying the relationship between neuroticism and cognitive performance. Intrusive thoughts (IT) reflect a range of related concepts such as worry and rumination, and occur with greater frequency in high neuroticism individuals (Muris, Roelofs, Rassin, Franken, & Mayer, 2005; Nezlek, 2005; Suls & Martin, 2005). IT may contribute to the neuroticism-cognition relationship by depleting attentional resources that are required to effectively perform attention-demanding cognitive tasks. Preoccupations with task-irrelevant intrusive thoughts can cause “mental noise” in high neuroticism individuals, resulting in less efficient and more variable cognitive processing (Robinson & Tamir, 2005; Robinson, Wilkowski & Meier, 2006). Support for this hypothesis comes from analyses showing that high neuroticism individuals are more variable on response time tasks, possibly due to more frequent attentional lapses. Related work by Eysenck and colleagues (1992, 2007) suggests that performance-related IT interferes with online processing and results in impaired performance (Eysenck, Derakshan, Santos, & Calvo, 2007).

Individual differences in the tendency to experience IT are associated with lower working memory in college students (Klein & Boals, 2001) and older adults (Stawski, Sliwinski, & Smyth, 2006). A recent study also found that rumination was associated with impaired mental set shifting (Altamirano, Miyake, & Whitmer, 2010). Stawski and colleagues (2006) proposed that the experience of IT acts as a dual-task load that depletes attentional resources resulting in impaired performance in attention-demanding tasks. Consistent with this reasoning, studies have found that individuals who tend to experience more IT have lower working memory capacity (Kane et al., 2007) and are more likely to make more mistakes when they experience IT (McVay, Kane & Kwapil, 2009).

An explicit test of whether IT mediates the relationship between neuroticism and cognition has yet to be conducted. Testing the role of IT as a mediator requires a simultaneous

evaluation of negative affect (NA) against IT because elevated NA is both a core feature of neuroticism and related to greater frequency and intensity of IT (Moberly & Watkins, 2008; Muris et al, 2005; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008; Robinson, Wilkowski & Meier, 2006). Studies have also linked NA with slower information processing and with declines in performance on attention-demanding tasks (Backman, Hill, & Fursell, 1996; Dotson, Resnick, Zonderman, 2008). Thus, we examine if IT associated with neuroticism mediates the neuroticism-cognition relationship beyond the effects of NA.

1.2 Hypotheses

First, we hypothesized that individual differences in IT would mediate the association between neuroticism and cognitive function. Because of the robust empirical association between IT and NA, we examined this hypothesis in two steps. First, we tested for mediation by examining both IT and NA in separate models and second, by examining them simultaneously in the same model. Our second hypothesis was that individual differences in IT would mediate the effect of neuroticism on cognition beyond the effects of trait NA.

In addition to testing these hypotheses, we also examined age as a moderator of the neuroticism-intrusive thought-cognition relationship. Because previous research suggests that increasing age in adulthood is associated with diminished inhibitory control that could increase susceptibility to the effects of intrusive thoughts (Hasher, Zacks, & May, 1999), we expected stronger associations among these variables in older compared to younger adults. Specifically, we examined two predictions: a) that the association between neuroticism and IT would increase with age, and b) that the effect of IT on cognitive performance would be stronger with advancing age in adulthood.

2. Method

2.1 Participants

Three hundred seventeen adults were recruited using advertisements in local newspapers, flyers in community centers, and other public venues. Participants were given an introduction to the study and informed consent was obtained as approved by the Syracuse University Institutional Review Board. Participants were compensated \$75. Recruitment was stratified by age to obtain a uniform age distribution. Average age of the current sample was 49 ($SD=17.23$, range = 19–83), and 49.69% were female. The average years of education were 13 years ($SD=2.71$); 52.1% of participants were white, 37.6% black, 1.5% Hispanic, and 8.7% other.

2.2 Measures

Cognitive tasks were administered in a fixed order over two in-lab sessions that were approximately one week apart. The following tasks were administered in the first session: trail making test, logical memory I, existence choice reaction time (CRT) task, digit span, verbal set switching, reading span, verbal paired associates, number comparison, and the auditory verbal learning test (AVLT). The rest of the tasks were administered during the second session in the following order: category fluency, parity CRT, magnitude CRT, word span, number set switching, counting span, Raven's progressive matrices, letter fluency, orientation CRT, location CRT, spatial span, spatial set switching, operation span, and the Shipley vocabulary test. A number of health measures were also collected during these in-lab sessions and participants provided two cortisol samples across five consecutive days following the first session—these measures were not used in the current analysis. Between sessions, participants completed questionnaires assessing personality, intrusive thoughts, affect, and life experiences.

2.2.1 Fluid Intelligence—Fluid intelligence was measured using Raven's progressive matrices (Raven, 1958). This task measured the extent to which individuals could think adaptively. Participants were presented with a series of incomplete abstract figures and they chose one of several abstract figures that best completed the figure. The dependent measure was the number of abstract figures completed correctly out of 30.

2.2.2 Episodic Memory—Episodic memory was measured by three tests that assessed participants' ability to recall previously learned information. In the logical memory I test, the experimenter read two stories to the participants and they were then asked to recall as much of the story as possible (Wechsler, 1997). In the verbal paired associates (Wechsler, 1997), the examiner read eight pairs of unrelated words to participants at a rate of one pair every three seconds. The researcher then gave the participants the first word in the pair and they were asked to produce the second. This was repeated four times, with the same pairs presented in a different fixed random order each time. In the AVLTL (Schmidt, 1996), participants were given one minute to study a list of 15 unrelated words. At the end of the minute, participants were given one minute to recall as many words as possible. Raw scores from each of the standard tasks were the dependent variables.

2.2.3 Primary Memory—Participants completed two tests of short term memory: digit span and word span (Conway, Cowan, Bunting, Theirrault, & Minkoff, 2002). Participants saw a series of digits or words one at a time for one second each. After being presented between 5 and 9 digits, the participant was asked to recall all of the digits they could remember in the order they saw them. The word span followed a similar procedure except that the total number of words in each series ranged from 4 to 8 words. Participants performed two trials at each list length for both tasks. The dependent measures were the total number of items recalled in the correct position.

2.2.4 Working Memory—Participants completed three tests of working memory. In the counting span, participants were presented with a series of displays that included dark blue circles (targets) and dark blue squares and light blue circles (distractors). After seeing 2 to 6 displays, three question marks “???” prompted the participant to recall their total count of dark blue circles from the series they had just seen. In the operation span, participants verified a series of equations aloud while trying to remember the words presented on the screen. They were then prompted to recall all the words from that series upon its completion (series length ranged from 2–5). In the reading span, participants verified sentences aloud while trying to remember simultaneously presented unrelated letters and were prompted to recall all the letters at the end of each series (series length ranged from 2–5). The dependent measure for these tasks was the total number of items recalled in the correct position (Conway, et al., 2002; Daneman & Carpenter, 1980).

2.2.5 Processing Speed—Participants completed six CRT tasks. In the *existence* task, participants classified a given word as either living or non-living (Goffaux, Phillips, Sinai, & Pushkar, 2006). In the *size* task, participants classified a given word as either bigger or smaller than a basketball (Mayr & Kliegl, 2000). In the *magnitude* task participants indicated whether a three-digit number was higher or lower than 500. In the *parity* task, participants indicated whether a three-digit number was odd or even. In the *orientation* task, participants indicated whether an arrow presented on the screen was pointing left or right. In the *location* task, participants indicated whether an arrow presented on the screen was above or below the midpoint of the screen. For these measures, the dependent variable was average reaction time (RT) for correct trials with greater RT scores indicating slower information processing.

2.2.7 Positive and Negative Affect—In the Positive and Negative Affect Schedule-Expanded Form (Watson & Clark, 1994), participants indicated the extent to which a series of adjectives described how they felt in general. Ratings were made from not at all (1) to extremely (5). Only negative affect items were used: *irritable, afraid, upset, guilty, nervous, hostile, jittery, ashamed, scared, and distressed*. One total score was obtained from these items with higher scores indicating greater negative affect.

2.2.8 Neuroticism—Participants rated whether 10 statements accurately described how they perceived themselves in general on a scale of 1 (very inaccurate) to 5 (very accurate). Items were taken from the International Personality Item Pool (Goldberg et al., 2006) and included statements such as "am not easily bothered by things". A composite score was calculated where higher scores indicated greater neuroticism.

2.2.9 Intrusive Thoughts—We assessed the experience of intrusive thoughts using the White Bear Suppression Inventory (Wegner & Zanakos, 1994). This scale consisted of 15 items designed to assess the general experience of intrusive thoughts and what the individual does to control these thoughts (e.g., "I wish I could stop thinking about certain things" and "I often do things to distract myself from my thoughts"). Responses were made on a 5-point scale from strongly disagree to strongly agree and higher scores indicated a greater tendency to experience intrusive thoughts.

3. Results

3.1 Descriptive Statistics and Correlations

Descriptive statistics and correlations were conducted using SAS (SAS Institute, 2008). Apart from fluid intelligence, multiple indicators were used to assess all cognitive ability constructs. Based on exploratory and confirmatory factor analysis, we constructed z-score composites for processing speed, primary, episodic, and working memory. For all subsequent analyses, these z-score composite measures were used as the dependent measures. As shown in Table 1, all of the measures were within acceptable ranges for assumptions of normality for the regression analyses. Overall, the relationships among the variables were in the expected direction. Neuroticism was associated with lower cognitive performance in most tasks (r s range from $-.25$ to $-.11$, $p < .05$) but was not associated with processing speed ($r = .02$, ns). Neuroticism was also positively associated with IT ($r = .55$, $p < .05$) and IT was associated with lower performance on fluid intelligence, episodic, primary, and working memory (r s range from $-.29$ to $-.22$) as well as with slower response times on the processing speed task ($r = .17$, $p < .05$).

3.3 Mediation

Using Mplus software (Muthen & Muthen, 1998), we tested statistical mediation using bootstrap methodology to evaluate the significance of the indirect effect (Edwards & Lambert, 2007). Preliminary analyses showed that both NA and IT mediated the effect of neuroticism on the cognitive variables when examined separately. However, our primary interest was in the simultaneous mediation effects of IT and NA (see Figure 1). Results in Table 2 show that the total effect of neuroticism was significant for fluid intelligence, primary, and working memory ($p < .05$), marginally significant for episodic memory ($p = .05$) and not significant for processing speed. We tested for mediation effects between neuroticism and processing speed because mediation can still exist under this circumstance (MacKinnon & Fairchild, 2009). The direct effect of neuroticism was not significant for any of the cognitive measures after IT and NA were introduced to the model (B s range from $-.045$ to $-.001$, ns). The indirect effect of neuroticism through IT was statistically significant in all cases, (B s range from $-.054$ to $-.011$, $p < .05$ and $B = .010$, $p < .05$ for speed) providing

support for our hypothesis that IT mediates the neuroticism-cognition relationship. IT accounted for between 65% and 90% of the total effect of neuroticism on primary, episodic, and working memory and for 52% of the effect of neuroticism on fluid intelligence. Additionally, the indirect effect through NA was not significant for any of the cognitive measures (B s range from $-.005$ to $.003$, ns). Although NA covaried with both neuroticism and with all the cognitive tasks, it does not account for a significant amount of variance when IT is also included as an indirect path. This result indicates that the mediating effect of IT on the neuroticism-cognition relationship is independent of individual differences in NA.

3.4 Age Moderation

We tested for age moderation of the effect between neuroticism on IT and of the effect of IT and cognition (Edwards & Lambert, 2007). Results showed that the effect of neuroticism on IT did not vary across age ($B=.000$, ns) and that age did not significantly moderate the effect of IT on any of the composite cognitive variables ($Bs=.000$, ns). Contrary to our expectations, the effect of neuroticism on IT and the effect of IT on cognition was age invariant.

4. Discussion

Our results supported our two main hypotheses. First, we found that individual differences in intrusive thoughts (IT) accounted for the relationships between trait neuroticism and performance on attention-demanding cognitive tasks. Consistent with other empirical work (i.e., Eysenck et al., 1992; 2007), these results suggest that a cognitive tendency to experience IT indicates ineffective attentional control that results in lower cognitive performance. Second, the disposition to experience IT mediated the neuroticism-cognition relationship independent of trait negative affect (NA). These results demonstrate that individual differences in IT are more important than trait NA in accounting for the relationship between neuroticism and cognitive performance. Analysis of age moderation did not support our expectation that the effects of IT on cognition would increase with advancing age in adulthood.

4.1 Neuroticism, Intrusive Thoughts, and Cognitive Performance

We consider three possible explanations for our finding that IT mediated the relationship between neuroticism and cognitive performance. First, individuals with high levels of trait neuroticism may be more susceptible to experiencing IT under situations that tax their attentional control (e.g., Muris et al., 2005; Robinson & Tamir, 2005). Among these individuals, the experience of IT during a cognitive task may directly interfere with performance. This explanation is consistent with “mental noise” (Robinson & Tamir, 2005) and “processing efficiency” (Eysenck & Calvo, 1992; Eysenck et al., 2007) accounts which postulate that ITs disrupt online cognitive processing. A second possible explanation is that neuroticism-related IT correlates with cognitive performance because it is a marker of individual differences in attentional resources. Thus, individuals with high trait neuroticism perform worse on attention-demanding tasks not because they are more likely to experience disruptive IT while performing a task, but because they have less effective attentional resources required to successfully perform these tasks (e.g., Kane et al., 2007). That is, increased frequency of IT and poorer working memory do not bear a direct relationship with each other, but rather both result from a diminished capacity of attentional control.

However, neither of these two accounts can explain findings from longitudinal studies that show increased rates of decline and risk for cognitive impairment in high neuroticism individuals. A third explanation which could account for both cross-sectional and longitudinal associations between neuroticism and cognition is that trait IT could also be an

indicator of chronic stress (Wilson et al., 2003, 2005, 2007). The tendency to experience repetitive and intrusive thoughts has been proposed to be a mechanism through which stress leads to poor physical health outcomes (Brosschot, Gerin, & Thayer, 2006; Smyth, Zawadzki, & Gerin, 2013). This cognitive style is hypothesized to prolong the stress response because individuals who experience greater IT may relive stressful events in their mind even after those events have long passed. A prolonged physiological stress response due to IT may accumulate over time and lead to cognitive impairment (Sapolsky, Krey, & McEwen, 1986; Glynn, Christenfeld, & Gerin, 2002).

An important limitation of this study is that it involves only a cross-sectional analysis, precluding statements of the temporal precedence of elevated states of IT and cognitive performance. Additionally, we could not evaluate whether IT is a marker of cumulative stress that causes cognitive decline. A longitudinal examination of IT, stress, and cognition that examines the sequential and dynamic associations among these variables across multiple time scales is necessary to determine how IT may propagate and prolong the physiological stress response and negatively affect cognitive performance in both the short- and long-term.

4.2 Neuroticism, Intrusive Thoughts, and Age

We predicted that IT should impact performance on attention-demanding tasks to a greater extent among older as compared to younger adults (Hasher et al., 1999). Our hypothesis was not supported, as age did not moderate the indirect effect through IT. Our results are consistent with an alternative view that older adults may not have a specific deficit in inhibitory and attentional control (Verhaeghen, 2011). The negative association between age and IT may also indicate that older adults are better able to regulate negative intrusive thoughts compared to younger adults. Numerous studies indicate that older adults adopt more successful self-regulatory strategies, such as attention-shifting strategies that allow them to minimize negative emotional states and garner more positive emotional experiences (e.g., Carstensen, Isaacowitz, & Charles, 1999). This improvement in self-regulation strategies may also apply to thought control in which older adults may be better able to control intrusive thoughts compared to their younger counterparts.

We cannot rule out other extraneous factors that could have influenced these results. For instance, neuroticism is related to a broad range of physical health outcomes that can predispose individuals to develop more health problems as they age (e.g. Lahey, 2009) and increases in levels of neuroticism are associated with greater mortality risk (Mroczek & Spiro, 2007). Comparisons of younger and older adults on neuroticism may thus be biased by selective survivorship and underestimate differential effects of neuroticism across the adult lifespan.

5. Conclusion

This study demonstrated that the tendency to experience intrusive thoughts mediates the relationship between neuroticism and cognitive performance. We found that the effect of intrusive thoughts remains after accounting for negative affect suggesting that this cognitive characteristic of neuroticism is more predictive of cognitive performance. The current results extend previous findings by demonstrating that individuals who score high in trait neuroticism may have poorer cognitive performance because of their tendency to experience intrusive thoughts.

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Highlights

We tested the effect of intrusive thought on the neuroticism-cognition association.

Intrusive thoughts mediated the association between neuroticism and cognition.

Intrusive thoughts mediated the association beyond the effects of negative affect.

Results stress the importance of future interventions targeting intrusive thought.

Figure 1.

Illustration of a multiple mediation design in which neuroticism (N) has an effect on cognition (C) through intrusive thought (IT) or negative affect (NA) as indicated by the products of a_{IT} by b_{IT} or a_{NA} by b_{NA} .

Table 1

Pearson correlation coefficients and descriptive statistics.

Measure	1	2	3	4	5	6	7	8	9	10	M	SD	Skew	Kurtosis
1. Neuroticism	-										25.83	17.23	0.32	-0.11
2. Intrusive thoughts	.55*	-									46.44	12.95	-0.28	-0.48
3. Episodic memory	-.11*	-.22*	-								0.03	0.81	0.06	0.27
4. Primary memory	-.16*	-.28*	.46*	-							0.01	0.85	0.06	0.27
5. Working memory	-.17*	-.29*	.57*	.66*	-						0.01	0.89	0.14	-0.39
6. Processing speed	.02	.17*	-.44*	-.54*	-.51*	-					-0.02	0.86	1.66	4.37
7. Fluid IQ	-.18*	-.24*	.49*	.48*	.56*	-.49*	-				20.53	5.99	-0.85	0.22
8. Negative affect	.61*	.46*	-.10 [†]	-.15*	-.17*	.04	-.14*	-			17.28	6.87	1.18	1.30
9. Education	-.20*	-.31*	.41*	.37*	.41*	-.23*	.47*	-.18*	-		13.34	2.71	0.22	0.38
10. Gender (female=1; male=0) ^a	-.00	.08	.11*	-.09	-.04	.08	-.04	-.08	.03	-	0.50	0.50		
11. Age	-.22*	-.20*	-.22*	-.25*	-.22*	.29*	-.20*	-.21*	.12*	.03	49.43	17.23	0.46	-1.02

Note.

^aCorrelations with gender reflect Spearman correlations.* $p < .05$.[†] $p < .10$.

Table 2
Individual Path Estimates and Multiple Mediation Estimates for Cognitive Variables

Dependent Variable	a_{IT}	b_{IT}	a_{NA}	b_{NA}	Total	Direct (c')	Indirect through:	
							IT	NA
Primary memory	.818 (.074)*	-.013 (.004)*	.514 (.044)*	-.007 (.008)	-.017 (.005)*	-.002 (.007)	-.011 (.003)*	-.004 (.004)
Working memory	.818 (.074)*	-.013 (.004)*	.514 (.044)*	-.009 (.008)	-.017 (.006)*	-.002 (.007)	-.011 (.004)*	-.005 (.004)
Episodic memory	.818 (.074)*	-.011 (.004)*	.514 (.044)*	-.001 (.008)	-.010 (.005) [†]	-.001 (.007)	-.009 (.003)*	.000 (.004)
Fluid intelligence	.818 (.074)*	-.067 (.028)*	.514 (.044)*	-.007 (.056)	-.103 (.043)*	-.045 (.057)	-.054 (.024)*	-.004 (.029)
Processing Speed	.818 (.074)*	.012 (.004)*	.514 (.044)*	.005 (.009)	.004 (.006)	-.008 (.008)	.010 (.004)*	.003 (.004)

Note. The small values necessitate reporting results to three decimal points. Results covaried for age, years of education, and gender. Bootstrap sample size=5,000.

IT= intrusive thoughts, NA= negative affect.

* $p < .05$.

[†] $p < .10$.