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Differential associations between rumination and intelligence subtypes

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Abstract

Although prior theory suggests that rumination contributes to cognitive impairments associated with depression, recent work suggests that rumination is associated with higher levels of intelligence. The present study examined the relations between two ruminative subtypes (brooding and reflective pondering) and multiple measures and types of intelligence (verbal and performance) after controlling for rumination's overlapping variance with depression. Participants were 751 individuals from the Colorado Longitudinal Twin Study who completed the Ruminative Response Scale; the Center for Epidemiological Studies–Depression Scale and a fully structured clinical interview as measures of depression; and verbal and performance intelligence tasks at age 16 and the Raven's Advanced Progressive Matrices at age 23. Reflective pondering was positively associated with all measures of intelligence, whereas brooding was not associated with intelligence. Our findings indicate that any negative associations between rumination and intelligence are attributable to shared variance with depression, and that examination of rumination as a multifaceted construct may provide new insights into the relations between rumination and cognition.

Keywords

cognition; brooding; reflection; repetitive thinking; depression

Theoretical models, like the Resource Allocation Theory, hypothesize that rumination, a pattern of self-focused, repetitive thinking, may contribute to cognitive impairments of depression by increasing cognitive load and draining resources (e.g., Levens, Muhtadie, & Gotlib, 2009). This hypothesis may explain the positive relation between depression and cognitive impairment across tasks (e.g., Marazziti, Consoli, Picchetti, Carlini, & Faravelli,

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2010). An alternative theory, the Analytical Rumination Hypothesis, suggests that rumination may be associated with *higher* levels of intelligence (Andrews & Thomson, 2009). This hypothesis suggests that rumination is an evolutionarily adaptive process that enhances problem solving, but these effects are masked by the fact that rumination is typically studied in the context of depression (e.g., Penney, Miedema, & Mazmanian, 2015). To examine these hypotheses, we estimated the relations of two subtypes of rumination with multiple measures of intelligence, and tested whether these relations are driven by rumination's overlapping variance with depression.

As rumination and depression strongly correlate, negative associations between rumination and intelligence may reflect depression-associated deficits in concentration, executive functions (EFs), and speed (e.g., Marazziti et al., 2010), rather than variance that is unique to rumination. For example, Penney et al. (2015) found that, after controlling for state negative affect and test anxiety, rumination was positively associated with verbal intelligence in a sample of nondepressed undergraduate students. Their results suggest that rumination in the absence of depressed or negative mood does not hinder cognitive performance. Their findings are consistent with the Analytical Rumination Hypothesis, which argues that, in the context of depression, rumination prioritizes the problem (i.e., depression) over all else, which leads to poor performance on laboratory tasks but is not indicative of the maladaptive nature of rumination broadly.

Prior studies examining rumination and cognitive functioning have largely focused on EFs (Yang, Cao, Shields, Teng, & Liu, 2016). For example, we examined relations of rumination to a latent variable EF model based on nine tasks, and found that rumination was associated with a Common EF factor predicting all nine EF tasks, but not variance specific to updating working memory or shifting mental sets (du Pont et al., 2019). Although EFs and intelligence are correlated, specific EF abilities are differentially associated with measures of intelligence. In the same sample examined by (du Pont et al., 2019), (Friedman et al., 2008) found that intelligence as measured by the Wechsler Intelligence Scale (WAIS; Wechsler, 1997) was equally associated with the Common EF factor and Updating-specific factors. As rumination and intelligence are associated with Common EF variance, but intelligence is also associated with Updating-specific variance, the direction and magnitude of the association between intelligence and rumination is unclear.

Questions about the potential adaptive and maladaptive consequences of rumination are further complicated by the fact that depressive rumination (e.g., as measured with the Ruminative Response Scale or RRS) is multifaceted, comprised of two separable factors: brooding and reflective pondering (Treynor, Gonzalez, & Nolen-Hoeksema, 2003). The brooding subscale is characterized by a tendency to dwell on negative affect, whereas the reflective pondering subscale is characterized by analysis of emotions and thoughts. Some studies suggest that brooding is strongly associated with depression, but that reflective pondering may be a neutral or adaptive process (e.g., Johnson et al., 2016; Kross, Ayduk, & Mischel, 2005). For example, Treynor and colleagues (2003) found that reflection was associated concurrently, but not longitudinally, with depressive symptoms. This result is consistent with the idea that reflective pondering may be distressing, but adaptive over time. Given the differences between brooding and reflective pondering, reflective pondering may

drive the positive association between rumination and intelligence reported by Penney et al. (2015).

The Present Study

The present study builds upon prior work by examining the relations between multiple ruminative subtypes (brooding and reflective pondering) and measures of intelligence (Raven's Advanced Progressive Matrices and WAIS Verbal and Performance Intelligence subscales). We also included depressive symptoms and lifetime diagnosis of major depressive disorder (MDD) as covariates to examine the independent association between rumination and intelligence.

We predicted that rumination, depressive symptoms, and lifetime MDD would be associated with poorer performance on measures of intelligence (e.g., Marazziti et al., 2010), but that rumination would be positively associated with intelligence after controlling for depressive symptoms/MDD (Penney et al., 2015). We also hypothesized that the positive association between rumination and intelligence would be driven by the RRS reflective pondering subscale rather than the brooding subscale, which is more closely associated with depressive symptoms. Thus, we predicted that the independent variance in reflective pondering after controlling for shared variance with brooding would be positively associated with intelligence.

Next, we examined whether the relation between rumination and intelligence differs across performance and verbal intelligence. As rumination is a highly verbal process, like worry (McEvoy, Watson, Watkins, & Nathan, 2013), we hypothesized that rumination would be associated with higher verbal intelligence and that the association between rumination and verbal intelligence would be stronger than the association between rumination and performance intelligence.

Method

Participants

Participants were 751 twins in the Colorado Longitudinal Twin Study (LTS), an ongoing study of behavioral, emotional, and cognitive development of twins, who completed a longitudinal study through the Center for Antisocial Drug Dependence (CADD) at the University of Colorado and a concurrent study of EFs and self-regulation. Participants completed measures of depression, intelligence, and rumination at age 23 ($M=22.80$, $SD=1.27$), as well as measures of performance and verbal intelligence at age 16 ($M=16.52$, $SD=0.75$). The overall sample was 92% white, 5% multiracial, 2% other, and 1% not reported (for additional sample details, see Rhea et al., 2013). Research protocols were approved by the Institutional Review Board at the University of Colorado Boulder.

Measures

Rumination.—Rumination was measured at age 23 using the 10-item version of the RRS that does not include items overlapping with depressive inventories (Treynor et al., 2003). The RRS measures how participants typically respond when they “feel down, sad, or

depressed” on a scale from 1 (*almost never*) to 4 (*almost always*). It has two subscales, brooding (RRS-B; “[I] think, why do I have problems that other people don’t have?”) and reflective pondering (RRS-R; “Analyze recent events to try to understand why you are depressed”).

Depression symptoms.—Depression symptoms were assessed using two measures at age 23: the Center for Epidemiological Studies–Depression scale (CESD; Radloff, 1977), and the Diagnostic Interview Schedule-IV Major Depressive Disorder Module (DIS-IV; Compton & Cottier, 2004). The CESD is a 20-item questionnaire that measures the frequency of depressive symptoms in the past week on a scale from 0 (*less than one day*) to 3 (*most or all of the time [5-7 days]*). The DIS-IV MDD Module is a structured clinical interview that assesses MDD lifetime symptoms and diagnoses ($n=651$ no diagnosis; $n=99$ diagnosis).

Intelligence.—Intelligence was measured at mean ages 23 and 16 years. At age 23, twins completed a short form of Raven’s Advanced Progressive Matrices (Raven; Raven, 1962), a measure of nonverbal fluid intelligence. The short-form Raven consisted of the 18 odd items of the 36 original items. Participants were given 20 minutes to complete as many as possible. Scores were proportion correct out of 18.

At age 16, intelligence was measured using the WAIS-III (Wechsler, 1997). The 11 subtests administered were vocabulary, similarities, arithmetic, digit span, information, comprehension, picture completion, digit–symbol substitution, block design, picture arrangement, and object assembly. Verbal and performance scores were based on relevant subtests (vocabulary, similarities, comprehension, and arithmetic, digit span, information, and comprehension for verbal; block design, picture completion, digit–symbol substitution, object assembly, and picture arrangement for performance).

Statistical analysis

Descriptive statistics for continuous variables are shown in Table 1. RRS subscale scores were calculated for participants who completed 80% or more of the items for each subscale. To improve normality of the CESD scale, we used a square root transformation. We ran all models in Mplus 8.1 (Muthén & Muthén, 1998-2017) using robust maximum likelihood estimation, which treats missing data as missing at random and uses all available data (full information maximum likelihood). We used Mplus’ TYPE=COMPLEX option to obtain model fit and standard errors corrected for twin family nonindependence. We used an alpha level of .05 for all analyses.

Results

Preliminary Analyses

Table 2 presents zero-order correlations by sex for all variables. As expected, both rumination subscales were associated with CESD scores and MDD diagnoses. CESD showed small associations with intelligence scores at both ages, some of which reached

significance. MDD diagnoses were not significantly associated with any intelligence measures, and were not considered further.

Brooding was not correlated with any of the measures of intelligence. In contrast, reflective pondering was positively associated with each measure of intelligence for women, and with verbal intelligence scores at age 16 for men. Due to the similarities between sexes in preliminary findings, we collapsed across sex and included sex and age as covariates in all subsequent analyses.

Rumination and Intelligence at Age 23

Table 3 presents results from multiple regression analyses of rumination and intelligence. For each intelligence measure, we estimated separate models with the ruminative subtypes as independent variables: in Model 1, RRS total; in Model 2, reflective pondering; in Model 3, brooding; and in Model 4, brooding and reflective pondering in the same model. We reran all analyses covarying depression symptoms to examine the independent associations of rumination and depressive symptoms on intelligence measures (Models 1B-4B).

Total RRS scores positively associated with Raven before and after controlling for depression symptoms, consistent with the hypothesis that rumination may be associated with higher levels of intelligence. When we examined the two ruminative subtypes in separate models, reflective pondering was positively associated with Raven, and this association remained significant after controlling for depressive symptoms. In contrast, brooding was not significantly associated with Raven, but became positively associated after controlling for depressive symptoms.

When we included both ruminative subtypes as predictors of Raven scores, reflective pondering remained significantly related to Raven, and brooding had a marginally significant negative association with Raven, which became nonsignificant after controlling for depressive symptoms. Equating the relations of brooding and reflective pondering with Raven significantly hurt model fit, $\chi^2(1)=9.86, p=.002$, suggesting that the relations between rumination and intelligence vary across ruminative subtype. These results suggest that positive relations between rumination and intelligence are driven by reflective pondering, and relations between brooding and Raven scores are attributable to overlapping variance with reflective pondering and depressive symptoms.

Rumination's Associations with Performance and Verbal Intelligence

Table 3 presents the same set of models applied to verbal and performance intelligence scores. As we did not have a concurrent measure of rumination and verbal/performance intelligence, we used intelligence measures from a prior wave (mean age 16).

Consistent with our findings for Raven, verbal and performance intelligence were positively associated with total RRS after controlling for depressive symptoms, and this association appeared to be driven by reflective pondering. Verbal and performance intelligence were positively associated with reflective pondering before and after controlling for depressive symptoms. In contrast, verbal intelligence was not associated with brooding before controlling for depressive symptoms but was positively associated after controlling for

depressive symptoms, and performance intelligence was not associated with brooding before or after controlling for depressive symptoms.

When brooding and reflective pondering were included in the same model, reflective pondering was associated with higher performance intelligence and brooding was associated with lower performance intelligence. After controlling for depressive symptoms, reflective pondering remained positively associated with verbal and performance intelligence. In contrast, brooding did not have an independent association with verbal or performance intelligence after accounting for shared variance with reflective pondering and depressive symptoms.

Although we found significant associations between reflective pondering and both verbal and performance intelligence, we further tested whether reflective pondering is more strongly associated with verbal intelligence than performance intelligence within a path analysis that included both intelligence measures as dependent variables. We were unable to constrain the verbal intelligence-reflective pondering association to be equal to the performance intelligence-reflective pondering association, $\chi^2(1)=19.65, p<.001$, which suggests that reflection is more strongly associated with verbal than performance intelligence.

Discussion

Consistent with Penney et al. (2015), we found that overall rumination scores were positively associated with verbal intelligence. However, further examination of brooding and reflective pondering subscales suggested that this association is driven by reflective pondering. Reflective pondering was positively associated with each measure of intelligence, and these relations remained significant after controlling for depressive symptoms. These results are consistent with the Analytic Rumination Hypothesis, which hypothesizes that rumination is an adaptive process that facilitates complex problem-solving (Andrews & Thomson, 2009). Our findings underscore the importance of examining rumination as a multifaceted construct and suggest that differentiating between brooding and reflective pondering may be important for understanding the link between rumination and cognitive ability.

Our results suggest that brooding's null to negative associations with intelligence (depending on whether reflective pondering was also included in the model) are a result of overlapping variance with reflective pondering and depression. This finding is consistent with prior work indicating that brooding is more closely associated with depression than reflection (e.g., Burwell & Shirk, 2007) and suggests that the independent variance in reflective pondering may be closely associated with self-insight or introspection (e.g., Harrington & Loffredo, 2010).

Understanding the differences between reflective pondering and brooding may provide useful information about the adaptive and maladaptive consequences of rumination. Work by Kross et al. (2005) has examined the potential characteristics of brooding (i.e., self-immersed focus on one's emotions and sensations) and reflection (i.e., self-distanced focus

on the reasons underlying one's emotions) that may explain why not all forms of self-focused introspection are harmful. Teasing apart when self-focused thought becomes unhelpful may also have implications for the treatment of depression or other disorders that are exacerbated by rumination. Most people think that rumination is a helpful process (Papageorgiou & Wells, 2001); thus, psychoeducation about the multidimensional nature of rumination and how to identify rumination versus reflective pondering may facilitate a nuanced understanding of rumination.

Additional examination of the pathways by which brooding and reflective pondering can contribute to negative and positive outcomes will be an important next step. Some studies have begun exploring how brooding and reflective pondering differentially relate to cognitive biases or coping strategies that contribute to depression (e.g., Joormann, Dkane, & Gotlib, 2006), or the extent to which brooding and reflective pondering activate different regions and networks of the brain (Satyshur, Layden, Gowins, Buchanan, & Gollan, 2018). For example, Joormann et al. (2006) found that brooding was associated with attentional biases toward sad faces, but reflective pondering was not. Others suggest that conceptualizing these subtypes differently may provide more insight; for example, Kross et al. (2005) suggest that the maladaptive and adaptive consequences of rumination can be better understood when examining self-immersed versus self-distancing thoughts.

The present study focused on intelligence, but rumination is associated with a range of cognitive abilities and processes, including memory retrieval (e.g., Connolly & Alloy, 2018), and shared variance across executive function tasks (e.g., du Pont et al., 2019; Yang et al., 2016). It may be that reflective pondering and brooding may have different relations with other cognitive impairments that are implicated in depression, in addition to intelligence (e.g., cognitive biases; Joormann et al., 2006). Additional studies examining brooding and reflective pondering may further inform current understanding of the relations between rumination and cognitive vulnerability to depression, as well as vulnerability to other forms of psychopathology (e.g., du Pont, Rhee, Corley, Hewitt, & Friedman, 2018).

Exploration of ruminative subtypes may be useful for understanding vulnerability to depression. However, brooding and reflection may become less differentiated among individuals with MDD. To test this hypothesis, Whitmer and Gotlib (2011) examined the factor structure of the RRS in participants who were currently, formerly, or never depressed. They found evidence of brooding and reflective pondering factors for the never or formerly depressed groups, but not the currently depressed group. Their findings suggest that brooding and reflection are harder to distinguish in currently depressed individuals, and raise questions about whether findings in population samples will generalize to clinical populations. These results highlight the importance of examining the relations between rumination and intelligence in clinically ascertained samples of varying levels of severity.

Limitations of the present study include the low prevalence of MDD diagnoses in our sample, which likely explains why we found an association between intelligence and CESD scores but not MDD diagnosis. Additionally, we did not have measures of rumination, verbal intelligence, and performance intelligence at both ages 16 and 23. However, the relations of reflective pondering (age 23) to Raven (age 23) and performance intelligence (age 16) were

remarkably similar, and both lower than its relation to verbal intelligence (age 16), suggesting little influence of the age gap between the WAIS and rumination assessments.

Furthermore, we were unable to examine questions about the reciprocal, longitudinal associations between reflection, brooding, and intelligence. It may be that reflective pondering can easily turn into brooding, or that reflective pondering is a problem-solving response to brooding (e.g., Andrews & Thomson, 2009; Joormann et al., 2006). Future longitudinal or experimental work may be able to disentangle temporal relations between brooding, reflection, and intelligence.

Conclusions

Our results suggest reflective pondering and brooding subtypes of rumination are differentially associated with measures of performance and verbal intelligence, and that any negative associations between rumination and intelligence are attributable to its overlap with depression. Examining rumination as a multifaceted construct may result in similar patterns when examining rumination and other, related cognitive processes (e.g., processing speed, working memory). Our findings suggest that not all components of rumination are maladaptive. These results, in conjunction with work indicating that brooding and reflection are less distinct in clinically depressed samples (Whitmer & Gotlib, 2011), support the rationale underlying treatment interventions focusing on providing psychoeducation about rumination and helping people identify when self-reflection becomes rumination (e.g., Rumination-Focused Cognitive-Behavioural Therapy; Watkins, 2018).

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Highlights

- Examined relations between ruminative subtypes and intelligence
- Reflective pondering was positively associated with all measures of intelligence
- Brooding was not associated with intelligence
- Negative rumination-intelligence relations are due to shared variance with depression

Table 1

Descriptive Statistics of Rumination, Depression, and Intelligence Measures by Sex

Measure	<i>n</i>	Mean	SD	Min	Max	Skewness ^a	Kurtosis ^a
Men							
RRS-B	350	1.89	0.57	1.00	4.00	0.53	0.12
RRS-R	350	1.95	0.67	1.00	4.00	0.29	−0.83
RRS	350	2.91	0.55	2.00	5.00	0.35	−0.23
CESD	347	2.94	1.38	0.00	6.78	0.09	0.07
Raven	346	0.63	0.20	0.11	1.00	−0.51	−0.33
Verbal IQ	324	104.30	13.04	73.00	140.00	0.14	−0.04
Performance IQ	324	101.45	11.32	72.00	136.00	0.15	−0.36
Women							
RRS-B	400	2.05	0.64	1.00	4.00	0.52	−0.24
RRS-R	401	2.13	0.70	1.00	4.00	0.33	−0.53
RRS	400	3.09	0.59	2.00	5.00	0.33	−0.32
CESD	369	3.08	1.39	0.00	6.63	0.10	−0.28
Raven	399	0.62	0.19	0.11	1.00	−0.27	−0.54
Verbal IQ	384	103.19	12.97	75.00	143.00	0.46	0.21
Performance IQ	384	101.96	10.85	74.00	136.00	0.22	0.08

Note. min=minimum; max=maximum; RRS-B=Ruminative Responses Scale–Brooding. RRS-R=Ruminative Responses Scale–Reflection. RRS=Ruminative Response Scale; CESD=Center for Epidemiologic Studies Depression scale. MDD=Major Depressive Disorder. Raven=Raven's Progressive Matrices at age 23. Verbal IQ =Verbal intelligence at age 16. Performance IQ= Performance intelligence at age 16.

^aSkewness and kurtosis reflect the distributions of the square root transformed scores for CESD.

Table 2

Zero-order Rumination, Depression, and Intelligence Correlations by Sex

Men	1	2	3	4	5	6	7
1. RRS-B							
2. RRS-R	.57 *						
3. RRS	.87 *	.91 *					
4. CESD	.50 *	.37 *	.48 *				
5. MDD	.33 *	.33 *	.38 *	.35 *			
6. Raven (age 23)	-.01	.07	.04	-.16 *	.01		
7. Verbal IQ (age 16)	-.00	.18 *	.11	-.11	.12	.50 *	
8. Performance IQ (age 16)	-.01	.06	.03	-.04	.07	.48 *	.44 *
Women	1	2	3	4	5	6	8
1. RRS-B							
2. RRS-R	.56 *						
3. RRS	.87 *	.89 *					
4. CESD	.52 *	.32 *	.47 *				
5. MDD	.41 *	.39 *	.46 *	.44 *			
6. Raven (age 23)	.03	.16 *	.11 *	-.11	-.06		
7. Verbal IQ (age 16)	.07	.25 *	.19 *	-.07	-.01	.51 *	
8. Performance IQ (age 16)	-.05	.13 *	.05	-.14 *	-.14	.53 *	.55 *

Note. RRS-B=Ruminative Responses Scale–Brooding. RRS-R=Ruminative Responses Scale–Reflection. RRS=Ruminative Response Scale; CESD=Center for Epidemiologic Studies Depression scale. MDD=Major Depressive Disorder. Raven=Raven's Progressive Matrices age 23. Verbal IQ=Verbal intelligence age 16. Performance IQ=Performance intelligence age 16.

* $p < .05$.

Table 3**Multiple Regressions Predicting IQ with Ruminative Subtypes**

Models	Total RRS	Reflection	Brooding	CESD
Raven (age 23)				
Model 1: Total RRS	0.08 [.04] *			
Model 1B	0.18 [.04] *			−0.21 [.04] *
Model 2: RRS-R		0.12 [.04] *		
Model 2B		0.19 [.04] *		−0.19 [.04] *
Model 3: RRS-B			0.01 [.04]	
Model 3B			0.11 [.04] *	−0.18 [.04] *
Model 4: RRS-R & -B		0.17 [.04] *	−0.08 [.05] ⁺	
Model 4B		0.18 [.04] *	0.01 [.05]	−0.18 [.04] *
Verbal IQ (age 16)				
Model 1: Total RRS	0.16 [.04] *			
Model 1B	0.26 [.05] *			−0.21 [.04] *
Model 2: RRS-R		0.22 [.04] *		
Model 2B		0.29 [.04] *		−0.18 [.04] *
Model 3: RRS-B			0.04 [.04]	
Model 3B			0.12 [.05] *	−0.14 [.04] *
Model 4: RRS-R & -B		0.29 [.05] *	−0.13 [.05] *	
Model 4B		0.31 [.05] *	−0.04 [.05]	−0.17 [.04] *
Performance IQ (age 16)				
Model 1: Total RRS	0.04 [.04]			
Model 1B	0.11 [.04] *			−0.15 [.04] *
Model 2: RRS-R		0.10 [.04] *		
Model 2B		0.14 [.04] *		−0.14 [.04] *
Model 3: RRS-B			−0.04 [.04]	
Model 3B			0.02 [.04]	−0.10 [.04] *
Model 4: RRS-R & -B		0.18 [.05] *	−0.14 [.05] *	
Model 4B		0.18 [.05] *	−0.08 [.05]	−0.12 [.04] *

Note. Each model number is followed by the independent variables, and the corresponding model B includes the same independent variables and CESD scores. All models included age and sex as covariates. RRS=Ruminative Response Scale; RRS-B=RRS–Brooding. RRS-R=RRS–Reflection. CESD=Center for Epidemiologic Studies Depression scale. MDD=Major Depressive Disorder. Raven=Raven’s Progressive Matrices age 23. Verbal IQ=Verbal intelligence age 16. Performance IQ= Performance intelligence age 16. Standardized model results and standard error in brackets.

⁺ $p < .10$.

* $p < .05$.