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Executive Functioning and Negative Affect: an Examination of the Meditational Effects of Emotion Regulation

Kelsey S. Dickson[1,2] · Jeffrey A. Ciesla[3]

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Abstract

Recent data highlight maladaptive emotion regulation strategies as a transdiagnostic risk factor. Executive functioning (EF) is also conceptualized as a transdiagnostic mechanism. Drawing these two areas together, data supports the intervening role of rumination, a form of emotion regulation, in the EF clinical symptomatology link. However, research has yet to fully examine various emotion regulation strategies as transdiagnostic mechanisms in youth. The relationship between EF components, emotion regulation strategies, and transdiagnostic negative affect was examined. Set-shifting was associated with general emotion regulation difficulties as well as rumination, worry, and thought suppression. Inhibition was only related to general emotion regulation difficulties and the brooding subtype of rumination. Finally, various forms of emotion regulation were observed to mediate the relationship between set-shifting and negative affect.

Keywords Executive functioning · Emotion regulation · Negative affect · Adolescence

Executive functioning (EF) is comprised of a collection of higher-order processes that are thought to enable goal-directed behavior, thereby underscoring its critical role in daily activities and functioning (Banich 2009). Specifically, individual differences in EF have significant implications for one's ability to monitor and regulate behaviors, to plan and initiate actions, to inhibit automatic or stereotyped behaviors, and to switch between tasks or habits (Banich 2009). More recently, research has underscored the role of EF as a transdiagnostic risk factor (Snyder et al. 2015), with particular attention on the role of EF in affective disorders. In addition to its significant role during the development and acute

✉ Kelsey S. Dickson
ksdickson@ucsd.edu

[1] University of California, San Diego, CA, USA

[2] Child and Adolescent Services Research Center, San Diego, CA 92123, USA

[3] Kent State University, Kent, OH, USA

phases of affective disorders, EF deficits are known to persist following remission (see Snyder 2014) and contribute to increased symptoms over time (Letkiewicz et al. 2014), underscoring the critical role of these neurocognitive risk factors in the development of affective disorders.

Akin to EF, emotion regulation (ER) strategies have also been conceptualized as a transdiagnostic mechanism, namely for internalizing disorders such as anxiety and depression (Aldao et al. 2010). Further, there is a large literature highlighting the significant association between emotion regulation and negative affect and symptoms (e.g., Gross and John 2003). There has been a distinction between ER strategies that are thought to be adaptive given their association with decreases in symptomatology, and those that are categorized as maladaptive given their known contribution to greater symptomatology. For example, reappraisal and active problem solving are two widely supported adaptive forms of ER that have demonstrated efficacy in appropriately managing various forms of psychopathology, including anxiety and depression (Aldao and Nolen-Hoeksema 2010; Aldao et al. 2010). Rumination is conceptualized as a maladaptive form of ER and is one of the most widely examined and strongly implicated ER strategies in the development and maintenance of various forms of psychopathology across the lifespan (Aldao et al. 2010).

Similarly, worry is known to be associated with both anxious and depressive symptoms in adults (Fresco et al. 2002; Segerstrom et al. 2000) and youth (Muris et al. 2004). However, the precise impact of worry on broad clinical psychopathology is not well understood as worry has often been omitted in previous research examining the transdiagnostic impact of rumination and other ER strategies (e.g., Aldao et al. 2010). Yet, worry is theorized to have a strong avoidant function such that individuals' worry in order to avoid or suppress the experience of anxiety (see Borkovec 1994; Newman and Llera 2011), thereby highlighting its overlap with the specific maladaptive ER strategy of avoidance. Finally, suppression is a widely conceptualized maladaptive ER strategy and risk factor for clinical symptomatology. Suppression has a detrimental impact on affect and symptoms, including negative affect, among clinical and non-clinical populations such that it serves to paradoxically intensify intrusive thoughts or concerns that exacerbate negative affect (Magee et al. 2012). The present study will focus on these three specific maladaptive forms of ER (rumination, worry, and suppression) given their well-documented influence on clinical symptomatology. Further, the broader construct of difficulties in emotion regulation will also be examined to provide a point of comparison for the specific strategies examined.

Given the parallels that exist, researchers have begun to examine the extent to which various forms of ER involve the same processes, content, and consequences. For example, there has been a good deal of work specifically examining whether worry and rumination are related processes, with data suggesting that they represent conceptually distinct factors in their temporal focus, with worry being future and rumination being past focused (Muris et al. 2004; Watkins et al. 2005). Further, these two ER strategies have unique outcomes; whereas rumination and worry are related to both symptoms of anxiety and depression, worry has been found to be more broadly predictive of affective symptoms among adults, more so than rumination (Hong 2007; Muris et al. 2004; Segerstrom et al. 2000; though see Fresco et al. 2002 for an exception). In contrast, some preliminary data suggest that rumination may be more strongly predictive of affective symptoms in non-clinical youth (Dickson et al. 2012). In terms of thought suppression, limited extant data similarly suggest suppression and rumination are inter-related but unique constructs that may have stem from

different underlying mechanisms (e.g., cognitive avoidance; Dickson et al. 2012; Watkins and Moulds 2009). However, the overlap and potentially differential influence between worry, rumination, and suppression has yet to be fully understood, especially in terms of possible mechanisms underlying these separate constructs in non-clinical youth.

Not surprisingly, researchers have begun to examine the neurocognitive correlates of ER (see Ahmed et al. 2015 for review). Highlighting the overlap with EF, ER has been conceptualized as a process by which individuals monitor their emotions, evaluate environmental demands or standards, and select and implement strategies to moderate their emotions in response to these demands (Gratz and Roemer 2004; Gross 1998; Thompson 1994). From this, it is not hard to see how impaired executive abilities may negatively impact one's ability to successfully regulate emotions. For example, individuals with difficulties monitoring or updating will likely experience difficulties evaluating their current emotional state and regulating their emotions. Further, difficulties with inhibition and set-shifting may contribute to ongoing selection or reliance on unsuccessful maladaptive regulation strategies such as rumination or worry. Indeed, data support the key role of EF in ER (Ahmed et al. 2015). In terms of specific ER strategies, the majority of the extant literature in this area has focused specifically on rumination, with data denoting a strong executive component in rumination (Demeyer et al. 2012; Whitmer and Banich 2007; Zetsche and Joormann 2011). Although EF impairments have also been associated with increased worry (Crowe et al. 2007; Snyder et al. 2014), thought suppression (Brewin and Smart 2005), and ER (Carlson and Wang 2007), the nature of these impairments in adolescents, especially in comparison to ER more broadly, have yet to be fully explored.

Drawing these two areas together, recent data highlight the mediating role of ER in the link between EF and clinical symptomatology and affect (Demeyer et al. 2012; Dickson et al. 2016; Hsu et al. 2015). Specifically, rumination has been observed to mediate the effect of impaired EF on depressive symptoms 1 year later in a sample of remitted depressed adults (Demeyer et al. 2012). Looking transdiagnostically, Hsu et al. (2015) found that rumination accounted for the relationship between EF and both anxiety and depressive symptoms among clinical adults. However, the reverse relationship with EF functioning serving a mediator was not supported, thereby suggesting a unique intermediary role of rumination. Although preliminary data supports these associations, the majority of this work has primarily focused on the impact of rumination within the context of depression. As such, there is a paucity of investigations examining the relationship between EF, ER, and transdiagnostic affect or symptoms more broadly, especially among non-clinical samples. However, preliminary data within this extant literature supports the mediating function of ER. Specifically, using a broad measure of emotion regulation, ER was found to mediate the effect of EF on depressive symptoms among non-clinical adolescents (Wante et al. 2017). While these data are promising, further research is warranted to better elucidate the exact nature of the relationship between EF and ER, including specific ER strategies, transdiagnostically. The broader focus of the current project mirrors the increased emphasis on transdiagnostic mechanisms currently within the field (Cuthbert and Insel 2013; Insel et al. 2010).

Building on these preliminary findings, it is possible that there is a discernable pattern in how EF impacts ER such that particular EF components are more strongly implicated in certain ER strategies compared to others. For example, perhaps an individual's difficulty with inhibition contributes to an increased tendency to worry, whereas one's

set-shifting difficulties are uniquely associated with difficulties disengaging from the ruminative process. This notion is actually consistent with prior work demonstrating a discernable pattern in the EF-ER link (e.g., De Lissnyder et al. 2010; Whitmer and Banich 2007). Further, it is possible that magnitude of the indirect effect of ER varies as a function of the specific cognitive or emotion regulation strategy. For example, it could be that rumination serves to have a larger impact on the EF-affective symptomatology association than worry. However, we know of no study to date that has examined the neurocognitive correlates of such strategies simultaneously, thereby permitting further direct comparison of the overlaps between ER strategies such as rumination and worry.

The need for further understanding of these constructs is especially true in adolescence. Adolescence is a key developmental time point respect to the development of affective symptoms and disorders such as depression and certain anxiety disorders (e.g., generalized anxiety disorder, social anxiety; Kessler et al. 2005), suggesting it is a critical point of focus in understanding their etiology. Similarly, adolescence also signifies a crucial period with respect to the development of associated risk factors, including EF and ER (see Ahmed et al. 2015). In addition to the significant maturation of executive abilities (see Huizinga et al. 2006), there are significant increases in use of maladaptive ER strategies such as rumination during this time period (Rood et al. 2009). Data also suggest that in comparison to children, adolescents develop trait-like tendencies to rely on particular emotion regulation strategies or attributional styles, especially in response to stress, that persist into adulthood (Cole et al. 2008; Rood et al. 2009). Despite the noted importance of adolescence, there is a paucity of data examining the relationship between EF, ER, and transdiagnostic affect or symptoms during this key developmental period. Further work examining the links between these constructs is needed, including examining whether the relationship among these constructs parallel those observed later periods during the lifespan.

The current study seeks to expand upon previous work through examining the relationship between EF, ER, and transdiagnostic negative affect more broadly among non-clinical adolescents. For this, we chose to look at general negative affect versus specific affect-laden symptoms (e.g., sadness, fear) in order to obtain a truly transdiagnostic understanding of these relationships. We also aim to examine the mediating effects of ER on the EF-negative affect relationships. Given these aims, we hypothesize that greater levels of EF difficulties would be associated with higher levels of negative affect and that greater levels of EF difficulties would be associated with more difficulties with both ER broadly as well as higher levels of worry, rumination, and thought suppression. Given results regarding differential impact of worry and rumination (Dickson et al. 2012; Hong 2007; Muris et al. 2004; Segerstrom et al. 2000), we also compare whether rumination or worry has stronger relationship with negative affect. Finally, in terms of our mediation models, we hypothesize that ER strategies will mediate the relationship between EF and negative affect.

Method

Participants and Procedures

Participants included 84 adolescents ages 16–18 ($M = 17.75$, $SD = 0.45$) in either 11th or 12th grade. The sample is 63% female and includes 84.5% Caucasian, 7.1% Asian

American, 3.6% Biracial, 2.4% Hispanic, and 2.4% other. Written consent was obtained from participants over the age of 18; parental consent and adolescent assent for those under 18 years of age were obtained from participants under the age of 18. Participants were recruited through their local high school and were asked to self-report their mood, thoughts, and cognitions. Participants were entered into an opportunity drawing to receive one of two honorariums upon completion of the study. This study received ethics approval in advance by an Institutional Review Board.

Measures

Positive and Negative Affect Schedule-X: Negative Affect Subscale (PANAS-X NA; Watson and Clark 1999) The PANAS-X was used to measure affective symptomatology. Participants were asked to rate the extent to which they experienced various positive and negative emotions using a Likert scale ranging from 1 (*very slightly or not at all*) to 5 (*extremely*), with higher scores indicative of greater affective symptoms. A subset of 12 items from the PANAS-X were selected to create the overall negative affect subscale utilized in the present study; specifically, the negative affect subscale was chosen to obtain a truly transdiagnostic measure of symptomatology as items loading onto this subscale are negatively valenced without substantial loading on other affective scales (e.g., fear, sadness) that are strongly associated with specific disorders. Sample items utilized include "angry," "hostile," and "irritable." The PANAS-X has been psychometrically validated in youth (Lonigan et al. 1999). Cronbach's alpha was 0.90 for the negative affect subscale.

Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer 2004) The DERS is a 36-item self-report measure of emotion regulation. Participants were asked to rate the extent to which they experience difficulties with various dimensions of emotion regulation using a Likert scale ranging from 1 (*almost never*) to 5 (*almost always*), with higher scores indicative of greater difficulties with emotional regulation. The DERS has been shown to have good reliability and validity in adolescents (Neumann et al. 2010). Cronbach's alpha was 0.94 for the current study.

Penn State Worry Questionnaire (PSWQ; Meyer et al. 1990) The PSWQ is a 16-item self-report measure of trait worry. Participants are asked to rate the extent to which various items regarding worrying applies to them using a Likert scale ranging from 1 (*not at all typical of me*) to 5 (*typical of me*), with higher scores indicative of a greater tendency to worry. The PSWQ is a reliable and widely utilized measure of worry (Meyer et al. 1990) and has been used in previous research with adolescents (e.g., Ciesla et al. 2012; Dickson et al. 2012). Cronbach's alpha was 0.94 for the current study.

Ruminative Response Scale (RRS; Nolen-Hoeksema and Morrow 1991) The RRS is a 22-item self-report measure of trait rumination. Participants were asked to rate the extent to which they engage in the ruminative process when feeling down, sad, or depressed using a Likert scale ranging from 1 (*almost never*) to 4 (*almost always*). Recent research suggests that the RRS is comprised of two factors, brooding and reflective pondering, that are differentially related to depressive symptomatology (Treynor et al. 2003). As such, we examined both the unique association of both

brooding and pondering with other study variables. The RRS has been widely used with adolescents (Rood et al. 2009). Cronbach's alpha was 0.83, and 0.83 for the brooding and pondering scales, respectively.

White Bear Suppression Inventory (WBSI; Wegner and Zanakos 1994) The WBSI is a 15-item self-report measure of thought suppression. Participants were asked to rate the extent to which they suppress or try to suppress or control unwanted thoughts using a Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), with higher scores indicating more thought suppression. The WBSI has demonstrated high internal consistency and good reliability and validity in youth and adults (Muris et al. 1996; Vincken et al. 2012). Cronbach's alpha was 0.91 for the current study.

The Behavior Rating Inventory of Executive Function- Self Report (BRIEF-SR; Guy et al. 2004) The BRIEF-SR is an 86-item self-report measure of EF in the everyday environment for youth between the ages of 11 and 18. Participants were asked to rate the extent to which they had difficulties with various behaviors associated with EF by selecting either *Never a problem*, *Sometimes a Problem*, or *Often a* Problem; higher T-scores (M = 50, SD = 10) are indicative of greater impairment. For the purposes of this study, only the shifting, inhibition subscales were included. The BRIEF-SR has good internal consistency and test-retest reliability (Guy et al. 2004). The BRIEF has been shown to have modest convergence with and complementary to other measures of EF, including performance-based measures, and is considered an ecologically valid measure of EF for use with a range of children, from neurotypical to significantly neurologically impaired (Kenworthy et al. 2008; Toplak et al. 2009). In the current study, Cronbach's alpha was 0.76 and 0.43 for the Shifting and Inhibition subscales, respectively.

Analytic Strategy

In terms of our first hypothesis, bivariate correlations were utilized to examine the associations between EF and other study variables. Follow-up partial correlations as well as Fisher *r*-to-*z* transformations were utilized to examine the strength or robustness of the association between the various forms of ER and EF and negative affect. Fisher *r*-to-*z* transformations calculate a *z* value that can be used to quantify the difference between two correlation coefficients (Meng et al. 1992). For our second hypothesis examining the differential impact of worry and rumination, we utilized hierarchical regression models in which age and gender were entered as covariates at the first step, worry at step two, and the two forms of rumination entered at the final step. Age and gender were entered as covariates given the developmentally sensitive nature as well as well-documented relationships with the current constructs (e.g., rumination [Rood et al. 2009], worry [Lewinsohn et al. 1998]). Models were compared by examining changes in the variance explained in the model (R^2). It is important to note that we chose to restrict our focus to rumination and worry given that the primary aim of this set of analyses is to expand on the literature specifically examining both the overlap between rumination and worry and their differential impact on symptomatology. Additionally, we chose to omit further forms of ER due to concerns regarding adequate statistical

power given the number of predictors included in the model. Our mediation hypotheses were tested using the bootstrapping method of mediation (Mackinnon et al. 2004). Given the number of statistical tests conducted, the false discovery rate was used to control for alpha inflation such that we set the significance value equal to the false discovery rate, or the expected proportion of falsely rejected hypothesis, and to be no more than 0.03 (Benjamini and Hochberg 1995).

Results

All models were tested using Stata 11.0 (StataCorp 2009). Preliminary analyses were conducted to assess for normality, linearity, and outliers in the data with results indicating a normally distributed sample with no extreme outliers. Preliminary analyses indicated significant associations between age and the DERS as well as gender and PSWQ (p's < 0.05), thereby supporting their inclusion as covariates in further analyses.

Executive Functioning, Emotion Regulation, and Affect Full results for our bivariate correlations are presented in Table 1. BRIEF shifting was significantly associated with all study variables, suggesting that higher difficulties with set-shifting are related to higher levels of negative affect, rumination, worry, thought suppression, and ER difficulties more broadly. Our partial correlation results indicated that only difficulties with ER was significantly related to BRIEF shifting ($r = 0.26$, $p = 0.02$). Our Fisher r-to-z transformation analyses indicated a trend towards the difficulties with ER-BRIEF shifting correlation to be significantly larger than the pondering-BRIEF shifting correlation ($z = 1.61$, $p = 0.05$); all other significant correlations were not significantly different from one another ($z < 1.61$, p's > 0.1). BRIEF inhibition was only significantly associated with negative affect, brooding, and difficulties with ER more broadly, suggesting that inhibitory difficulties are related to more negative affect and ruminative brooding compared to other forms of ER. Examination of our partial correlation

Table 1 Descriptive statistics and bivariate correlations between study constructs

Construct	1	2	3	4	5	6	7.	Mean	SD	Range
1. PANAS-X NA	–							20.13	8.46	12–54
2. DERS	0.66**	–						85.90	24.47	44–139
3. PSWQ	0.50**	0.53**	–					51.89	15.47	23–77
4. RRS-brooding	0.67**	0.66**	0.58**	–				10.67	4.06	5–20
5. RRS-pondering	0.41**	0.48**	0.36**	0.71**	–			9.60	4.20	5–19
6. WBSI	0.49**	0.60**	0.48**	0.68**	0.59**	–		49.90	12.35	21–74
7. BRIEF-shifting	0.44**	0.47**	0.34**	0.39**	0.25*	0.31**	–	55.86	10.31	34–83
8. BRIEF-inhibition	0.35**	0.24*	0.15	0.29**	0.05	0.11	0.16	52.33	10.15	37–85

PANAS-X NA, Positive and Negative Affect Schedule-X: Negative Affect subscale; *DERS*, Difficulties in Emotion Regulation Scale; *PSWQ*, Penn State Worry Questionnaire; *RRS*, Ruminative Response Scale; *WBSI*, White Bear Suppression Inventory; *BRIEF*, Behavior Rating Inventory of Executive Function-Self Report

*$p < 0.05$, **$p < 0.01$; All p values were less than the False Discovery rate of 0.03

Table 2 Hierarchical linear regression analyses

Predictor	B	SEB	β	R^2	ΔR^2	*p* value
Step 1				0.01	–	0.62
Age	− 1.91	2.09	− 0.10			0.80
Gender	− 0.49	1.96	− 0.03			0.36
Step 2				0.30	0.29	< 0.001
Age	− 0.73	1.79	− 0.04			0.68
Gender	3.26	1.79	0.19			0.07
PSWQ worry	0.32	0.06	0.58			< 0.001+
Step 3				0.48	0.18	< 0.001
Age	−0.92	1.56	− 0.05			0.56
Gender	0.77	1.63	0.04			0.64
PSWQ worry	0.11	0.06	0.20			0.09
RRS-pondering	− 0.24	0.24	− 0.12			0.31
RRS-brooding	1.33	0.29	0.63			< 0.001+

+ Remains significant after FDR

results revealed that difficulties with ER ($r = 0.32$, $p < 0.01$) and brooding ($r = 0.31$ $p < 0.01$) were the only forms of ER significantly associated with BRIEF inhibition. The Fisher's r-to-z transformations suggested no significant differences between correlations with BRIEF inhibition (z's < 1.62, p's > 0.05).

Emotion Regulation and Affect Full results for our bivariate correlations and hierarchical linear regression models are presented in Tables 1 and 2, respectively. All forms of emotion regulation were significantly related to higher levels of negative affect (p's < 0.01), suggesting that higher levels of difficulties with various ER strategies are associated with increased negative affect. Results from our partial correlation analyses indicated that difficulties with ER ($r = 0.42$, $p < 0.01$) and brooding ($r = 0.32$, $p < 0.01$) were the only forms of ER significantly associated with negative affect. Further, Fisher r-to-z transformations indicated that the correlation between brooding and negative affect was significantly larger than all other correlations between various forms of ER and negative affect (z's > 1.65, p's < 0.05), with the exception of difficulties with ER-negative affect correlation, which was not significantly different ($z = 0.11$, $p = 0.45$). There was a trend for the difficulties with ER-negative affect correlation to be larger than the worry-negative affect ($z = 1.54$, $p = 0.06$) and thought suppression-negative affect correlations ($z = 1.62$, $p = 0.05$). The correlation between negative affect and difficulties with ER was significantly larger than the correlation with the pondering form of rumination ($z = 2.26$, $p < 0.02$).

Comparing worry and rumination in terms of the association with negative affect, examination of hierarchical linear regression models indicated that the addition of rumination (R^2 Change = 0.18, F[2,77] = 13.65, $p < 0.01$) was associated with a significant increase in explained variance. Whereas worry was independently associated with increased negative affect, this was no longer the case when rumination was included in the model, suggesting that

rumination was more strongly related to negative affect than worry.[1] Further examination of these models indicated that the brooding form of rumination was the main factor accounting for variance in negative affect, as indicated by the size of the standardized beta coefficients.[2]

In terms of our analyses examining the mediating role of emotion regulation, a significant indirect effect of difficulties with ER was observed on the relationship between both BRIEF shifting and negative affect (β = 0.22, 95% bootstrap CI 0.06–0.38), suggesting a mediating function of difficulties with ER. Looking at specific ER strategies, worry demonstrated a significant indirect effect on the relationship between BRIEF shifting and negative affect (β = 0.12, 95% bootstrap CI 0.03–0.22), supporting the mediating role of worry. Thought suppression demonstrated a significant indirect effect on BRIEF shifting and negative symptomatology (β = 0.07, 95% bootstrap CI 0.02–0.13). Finally, a significant indirect effect of brooding on the relationship between both BRIEF shifting (β = 0.18, 95% bootstrap CI 0.02–0.35) and BRIEF inhibition (β = 0.14, 95% bootstrap CI 0.004–0.29) and negative affect was observed, supporting the intermediary role of brooding on the EF-negative affect relationship. All other mediation models were non-significant. Full mediation results can be found in Table 3.

Discussion

Recently, there has been significant empirical attention exploring the role of executive functioning as a transdiagnostic factor impacting individual differences in emotion regulation and symptomatology. To date, the majority of this work has focused on rumination, a specific ER strategy, with data supporting a significant executive component in rumination. Further, extant literature investigating the relationship between EF and rumination transdiagnostically is limited. As such, the current study sought to examine the relationship between EF, ER, and negative affective symptomatology more broadly through examining various forms of ER—including rumination, worry, and thought suppression—and negative affect. The role of ER as a mediator of this EF-negative affect relationship was also explored.

Data support our first hypothesis, with a significant association between higher levels of EF difficulties and negative affective as well as difficulties with ER. Overall, these findings mirror prior work supporting the association between increased EF difficulties and increased levels of rumination (Altamirano et al. 2010; Whitmer and Banich 2007), worry (Crowe et al. 2007), thought suppression (Brewin and Smart

[1] A contrary model was also conducted in which rumination was entered at step 2 and step 1 to examine whether the addition of worry significantly increased the amount of variance accounted for in the model. Results from these analyses suggested that worry did not significantly increase the amount of variance explained (R^2 Change = 0.02; F[1,77] = 3.02, p = 0.09).

[2] These analyses were also conducted including the total score of the RRS, thereby enabling us to evaluate whether similar results were observed with a broader measure of rumination. Results indicated a similar pattern to those observed with RRS brooding such that the addition of rumination was associated with significantly increased explained variance (R^2 Change = .16, F[1,78] = 23.40, p < 0.01). However, the size of the effect was observed to be smaller than that for the RRS brooding alone as indicated by the standardized beta of 0.46 for the total score versus .63 for brooding. However, given the evidence of a discernable impact of the two forms of rumination on negative affect, the model examining the separate forms of rumination was retained.

Table 3 Mediational analyses

IV	Mediator	Total effect	SE	Direct effect	SE	Indirect effect	SE	95% CI
BRIEF shifting								
	PSWQ worry	0.36	0.08	0.23	0.08	0.12	0.05	0.03–0.22
	RRS-brooding	0.35	0.08	0.17	0.07	0.18	0.06	0.02–0.34
	RRS-pondering	0.35	0.08	0.29	0.08	0.06	0.03	−0.02–0.14
	WBSI	0.33	0.07	0.26	0.07	0.07	0.03	0.02–0.13
	DERS	0.36	0.08	0.14	0.08	0.22	0.06	0.07–0.37
BRIEF inhibition								
	PSWQ worry	0.28	0.09	0.23	0.08	0.05	0.05	−0.04–0.15
	RRS-brooding	0.28	0.09	0.14	0.07	0.14	0.06	0.004–0.28
	RRS-pondering	0.28	0.08	0.28	0.08	0.002	0.04	−0.08–0.09
	WBSI	0.33	0.07	0.31	0.06	0.01	0.02	−0.03–0.08
	DERS	0.28	0.09	0.18	0.07	0.10	0.06	−0.03–0.24

2005), and maladaptive ER broadly (Ahmed et al. 2015), and support the emerging literature suggesting the importance of neurocognitive factors such as EF in understanding individual differences in emotion regulation. Interestingly, the strongest associations observed were with more broad difficulties with ER and the brooding subtype of rumination, suggesting that while other forms of ER may be involved, perhaps the specific strategy of brooding is a particularly potent mechanism impacting both negative affect as well as the EF-affective symptomatology link. In addition to supporting the role of ER as a transdiagnostic mechanism, these results are consistent with previous findings suggesting that brooding is the form of ER that is mostly strongly associated with various forms of psychopathology (Aldao and Nolen-Hoeksema 2010; Aldao et al. 2010; Watkins 2009) as well as various EF components, including inhibition and set-shifting (Whitmer and Banich 2007). In combination with the limited extant literature, the current results support the need for further research examining the impact of factors such as EF in the etiology of various emotion regulation strategies and negative affective conditions more broadly.

We also examined the differential impact of worry or rumination on negative affect. Counter to prior work (Hong 2007; Muris et al. 2004; Segerstrom et al. 2000), the results from our hierarchical regression models support the role of brooding as having the strongest relationship with negative affect. However, further examination of previous work may be helpful in understanding these divergent findings. In contrast to the current study, the majority of previous research has explored the relationship between worry and rumination more broadly versus examining the separate types of rumination. As our results imply, the brooding subtype may represent the more maladaptive component of rumination and focusing on rumination more generally may mask the discernable impact of the various subtypes. This is supported by work demonstrating that worry and brooding were equally strongly related to anxiety and depression among young adults (Fresco et al. 2002). This perspective is also consistent with theory suggesting that the construal of cognitive processes dictate the consequences, with abstract strategies such as worry or brooding rumination resulting in more unconstructive consequences

such as worry and depression (Watkins 2008). Finally, much of the extant literature support has examined these relations among adults. When looking specifically at adolescence, the current results are actually consistent with some of our prior work that found rumination to be more consistently related to both anxious and depressive affect compared to worry among adolescents (Dickson et al. 2012). It is possible that there is a distinct relationship between affective symptoms and specific ER strategies in adolescence compared to the rest of the lifespan.

Returning to our results with EF, a discernable pattern of relationships between various EF components and forms of emotion regulation was observed, with set-shifting but not inhibition observed to be more robustly related across forms of ER, including worry, brooding, and thought suppression. Consistent with the current results, inhibition is known to be more specifically associated with the depressive or brooding form of rumination while set-shifting is thought to be more generally associated with more general ER strategies, including various forms of rumination (e.g., depressive, angry, intellectual) or difficulties with ER (De Lissnyder et al. 2010; Whitmer and Banich 2007). Although the majority of previous research with thought suppression has been primarily focused on the specific EF component of working memory, our results parallel the identified link between working memory and thought suppression (Brewin and Smart 2005). The evidence of a discernable relationship may help account for why individuals develop a tendency to engage in certain maladaptive ER strategies but not others. That is, perhaps specific patterns of EF impairments may help explain why some individuals develop a stronger tendency to rely on the strategy of rumination compared to others such as worry or thought suppression. This distinction between subtypes of rumination provides more context for our current results; however, further research investigating the particular pattern of relationships among these specific factors, especially the developmental progression between them, is needed.

Finally, in terms of our meditational results, there was evidence for the mediating role of set-shifting in the association between various forms of ER and negative affect. There was also evidence of a significant impact of inhibition on the ER-negative affect relationship. Although these results are to be interpreted with caution given the cross-sectional methodology utilized in the current study and the fact that we were unable provide a true test of mediation (see Maric et al. 2012), they may provide some insights into the clinical possibilities. In particular, our results provide additional support to findings suggesting that ER may serve as a intervening variable key to understanding the impact of cognitive and affective conditions such as depression and anxiety (Demeyer et al. 2012; Dickson et al. 2016; Hsu et al. 2015; Wante et al. 2017). Further, they add to recent theory regarding the key role of inhibition by suggesting that impairments in inhibition as well as set-shifting may lead to difficulties inhibiting or disengaging from the tendency to engage in negative cognitive processes such as rumination, thereby resulting in increased negative affect (De Raedt and Koster 2010; Joormann 2010).

Our meditational analyses may also have significant implications for the prevention and treatment of affective disorders. Specifically, the significant relationship between EF and negative affect through ER strategies suggests that interventions targeting specific neurocognitive and cognitive mechanisms underlying clinical symptomatology may be fruitful. As the current results imply, a targeted focus on those more robust mechanisms such as difficulties with set-shifting or the brooding form of rumination may be especially clinically valuable. In fact, recent efforts to develop interventions

specifically targeting cognitive processes like rumination have proven promising (Watkins 2015). Mindfulness-based interventions may also be extremely beneficial given data suggesting the beneficial effect of mindfulness on ER strategies such as worry and rumination (Ciesla et al. 2012) as well as executive abilities (Chiesa et al. 2011). The utility of these interventions is further supported by data suggesting that these interventions may be efficacious for depression due to their beneficial impact on rumination (Ramel et al. 2004). Finally, neurobehavioral interventions targeting increased attentional or cognitive control are also considered promising treatments for depression (Papageorgiou and Wells 2000; Siegle et al. 2007). Overall, there is a need to both further understand the role of underlying mechanisms like EF in affective conditions and corresponding cognitive processes and continued incorporation into intervention efforts in order to improve their efficacy.

The current study adds to the burgeoning literature supporting the transdiagnostic role of EF and is one of the first to examine its impact on ER strategies and affective symptomatology more broadly. However, limitations of the current study should be noted. First, our cross-sectional methodology precludes us from examining the directional nature of these relationships. Second, we relied on self-report measures of the constructs of interest. Further works examining the developmental progression between the study variables using multi-method measures (e.g., behavioral, interview-based) are warranted. Finally, we included a normative sample of adolescents. Given the paucity of data examining the relationships between EF, ER, and clinical symptomatology among adolescents, the data obtained from the current sample provides an apt foundation from which to build. Yet, future research should examine whether the same pattern of relationships can be observed in a more acute, clinical samples.

Compliance with Ethical Standards This study received ethics approval in advance by an Institutional Review Board.

Conflict of Interest The authors declare that they have no conflicts of interest.

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