Received: 9 March 2016 | Revised: 8 June 2016 | Accepted: 13 June 2016

DOI: 10.1002/da.22539

REVIEW

WILEY AD/AA

The relationships between rumination and core executive functions: A meta-analysis

Yingkai Yang, B.S.[1] | Songfeng Cao, M.A.[2] | Grant S. Shields, M.A.[3] | Zhaojun Teng, M.A.[1] | Yanling Liu, Ph.D.[1,4]

[1]The Lab of Mental Health and Social Adaptation, Faculty of Psychology, Research Center of Mental Health Education, Southwest University, Chongqing, China

[2]Zhou Enlai School of Government, Nankai University, Tianjin, China

[3]Department of Psychology, University of California, Davis, CA, USA

[4]School of Life Science and Technology, University of Electronic Science and Technology of China, Chengdu, China

Correspondence
Yanling Liu, Faculty of Psychology, Southwest University, No. 2 Tiansheng Street, Beibei District, 400715 Chongqing, China.
Email: ssq@swu.edu.cn

Grant sponsor: National Social Science Foundation of China; Grant number: BBA140049.

Background: Rumination has been thought to relate to deficits in core executive functions (EFs), but the empirical findings for this idea are mixed. The aim of the present study is to synthesize existing literature to clarify these relations.

Methods: A comprehensive literature search revealed 34 published as well as unpublished studies on the associations between rumination and core EF. These studies report on 3,066 participants. The effect size in the meta-analyses was obtained by the *z* transformation of correlation coefficients.

Results: Analysis revealed significant negative associations between rumination and both inhibition ($r = -.23$) and set-shifting ($r = -.19$). There was no significant association between rumination and working memory. These associations were not moderated by age, sex, type of sample (depressed or healthy), type of outcome measure (accuracy vs. reaction time), or affective content of the task, although statistical power for these tests was limited.

Conclusions: We found significant negative associations between rumination and inhibition or set-shifting. There was no significant association between rumination and working memory. Future research should adopt multiple measures of EF to provide clear evidence on the associations between EF and rumination. A better understanding of this relationship may have important implications for intervention of rumination, such as training programs to improve EF or teach compensatory strategies to mitigate the effects of EF impairments.

KEYWORDS
core executive functions, inhibition, meta-analysis, rumination, set-shifting, working memory

1 | INTRODUCTION

Rumination is often defined as repetitive thinking about negative personal concerns and/or about the implications, causes, and meanings of a negative mood state (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Individuals are engaged in depressive rumination because they believe that ruminating about their mood and symptoms will help to understand themselves better (Koster, De Lissnyder, Derakshan, & De Raedt, 2011). However, rather than leading to increased self-understanding, rumination can intensify negative thoughts and affect by highlighting one's current negative mood (Lyubomirsky & Nolen-Hoeksema, 1995). Moreover, accumulating evidence points toward rumination being an important vulnerability factor in the development of depression (Joormann & Quinn, 2014). Recently, rumination has been acknowledged as a transdiagnostic process (Nolen-Hoeksema & Watkins, 2011) that contributes to a variety of psychopathological conditions or behaviors, including anxiety (Mellings & Alden, 2000), substance abuse (Nolen-Hoeksema, Stice, Wade, & Bohon, 2007), and self-injurious behavior (Hilt, Cha, & Nolen-Hoeksema, 2008).

1.1 | Rumination and executive function

Because of its pervasive maladaptive consequences, both theoretical and empirical research has explored the underlying mechanisms that promote and maintain rumination. Rumination is different from negative automatic thoughts because rumination is a style of thought, rather than just negative content in thoughts (Joormann & Vanderlind, 2014). As an unproductive style of thinking, rumination is difficult to control or stop (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). This perseverative nature has led researchers to postulate that there may be links between individual differences in rumination and in executive function (EF). Broadly speaking, EF is an umbrella term for higher

level cognitive processes that control and regulate lower level processes (e.g., perception, motor responses) to effortfully guide behavior toward a goal, especially in nonroutine situations (Banich, 2009). According to a highly influential framework proposed by Miyake et al. (Friedman et al., 2008; Miyake et al., 2000), EF is a general ability comprising three interrelated core processes. In the present study, we employ the term "EF" in reference to only the general factor of EF (i.e., the general latent ability enabling performance across EF task domains), and use core EF names only in reference to each specific function (Shields, Bonner, & Moons, 2015). The first core EF is inhibition, which involves suppressing or resisting a prepotent (automatic) response in favor of producing a less automatic but task-relevant response. The second EF, set-shifting, involves switching between task sets or response rules. The third EF, working memory, involves integrating new information with old information and maintaining it over time.

Theories of the relation between EFs and rumination agree that rumination should be associated with greater impairments in core EFs (Hertel, 2004; Koster, De Lissnyder, Derakshan, & De Raedt, 2011; Linville, 1996; Mor & Daches, 2015; Whitmer & Gotlib, 2013). Linville (1996) was the first to propose that deficits in the attentional mechanism of inhibition may underlie rumination. Deficits in inhibition, as argued by Linville, will increase the likelihood that internal thoughts will become repetitive, for example, by facilitating the retrieval of no longer relevant information from long-term memory and making it more difficult for ruminators to remove these thoughts from working memory.

Koster, De Lissnyder, Derakshan, and De Raedt (2011) proposed the impaired disengagement hypothesis to explain the control deficits exhibited by trait ruminators. This account posits that deficits in attentional control increase individuals' susceptibility to rumination when they are in a negative mood (Whitmer & Gotlib, 2013). More specifically, this account suggests that the vicious cycle of ruminative thinking and negative mood is maintained by an impaired ability to exert control when faced with negative stimuli and an inability to disengage from negative thoughts (Mor & Daches, 2015).

Additionally, a resource depletion account of rumination would predict that rumination would predict widespread difficulties on EF tasks (Philippot & Brutoux, 2008; Watkins & Brown, 2002). Ruminative thoughts may occupy attentional resources, thereby reducing available EF capabilities and impairing performance on concurrent tasks that require effortful processing.

Despite theoretical conceptualizations of rumination converge in positing that rumination should be associated with greater impairments in aspects of EFs, results have been inconsistent in studies examining working memory and set-shifting: some studies have found significant negative correlations between working memory or set-shifting and rumination (Altamirano, Miyake, & Whitmer, 2010; Bernblum & Mor, 2010; Davis & Nolen-Hoeksema, 2000; De Lissnyder, Koster, Derakshan & De Raedt, 2010, 2012; Dickson, 2015; Foxworth, 2014; Wagner, Alloy, & Abramson, 2015; Whitmer & Banich, 2007; Vergara-Lopez, Lopez-Vergara, & Roberts, 2016), whereas others found no correlation (Connolly et al., 2014; Demeyer, De Lissnyder, Koster, & De Raedt, 2012; Onraedt & Koster, 2014; Pe, Raes & Kuppens, 2013; Quinn & Joormann, 2015; Von Hippel, Vasey, Gonda, & Stern, 2008). Hence, it is still unclear if rumination is linked to set-shifting and working memory. In contrast, the negative association between rumination and inhibition is slightly more established (Berman et al., 2011; Daches & Mor, 2015; De Lissnyder, Derakshan, De Raedt, & Koster, 2011; Fawcett et al., 2015; Goeleven, De Raedt, Baert, & Koster, 2006; Hertel & Gerstle, 2003; Joormann, 2006; Joormann, Dkane, & Gotlib, 2006; Joormann & Gotlib, 2008; Joormann & Tran, 2009). Nonetheless, the strength of this relationship varies from low to medium across different studies (Harfmann, 2013; Joormann & Gotlib, 2010; Joormann et al., 2010; Lau, Christensen, Hawley, Gemar, & Segal, 2007; Vanderhasselt, Kühn, & De Raedt, 2011; Whitmer & Banich, 2010; Zetsche & Joormann, 2011; Zetsche, D'Avanzato, & Joormann, 2012). Taken together, no clear conclusions have yet been drawn.

Meta-analysis is an ideal method for addressing discrepancies between conflicting studies. In this paper, we performed a meta-analysis of the associations between rumination and core EFs to determine the true associations between rumination and core EFs.

1.2 | Measuring rumination and core EFs

The most common questionnaire instrument used to measure rumination is the Ruminative Response Scale (RRS; Nolen-Hoeksema & Morrow, 1991), which requires respondents to indicate the degree to which they experience ruminative symptoms when feeling upset. Factor analyses of the RRS have identified two distinct subtypes of rumination (Treynor, Gonzalez, & Nolen-Hoeksema, 2003). The first subtype, reflective pondering, is a purposeful turning inward to engage in cognitive problem solving in order to alleviate depressive symptoms. The second, depressive brooding, is characterized by a passive comparison of one's current situation with some unachieved standard. Although the vast majority of studies have used the RRS to measure rumination, investigators have also used other self-report questionnaires (Whitmer & Gotlib, 2013), such as the Anger Rumination Scale (ARS), which assesses rumination about experiences of anger (Sukhodolsky, Golub, & Cromwell, 2001), the Rumination subscale of the Rumination-Reflection Questionnaire (rumin-RRQ), which assesses rumination about past events regardless of affective state (Trapnell & Campbell, 1999), and the Rumination subscale of the Children's Response Styles Questionnaire (CRSQ), which assesses self-focused responses to sad mood (Abela, Vanderbilt, & Rochon, 2004).

Core EFs can be assessed using multiple performance tasks. For example, a common inhibition task in the rumination literature is the negative affective priming task, which requires participants to respond to a target stimulus by classifying it according to its valence (e.g., happy or sad) while ignoring a distractor stimulus (Joormann et al., 2010). If participants are actively inhibiting the distractors as instructed, they will typically exhibit a negative priming effect wherein they exhibit longer response latencies to a target stimulus presented as a distractor on a preceding trial than to a stimulus not presented on a preceding trial. The bias scores (composite averages of response latencies) are indicators of inhibitory difficulty. A common set-shifting

measure is the internal shift task that requires participants to perform a count depending on condition (emotional or gender; Demeyer, De Lissnyder, Koster, & De Raedt, 2012). For example, the emotion condition requires participants to count faces based on emotional features (e.g., number of angry or neutral), and the gender condition requires participants to count faces based on gender (the number of male and female). Participants press a button to indicate completion of the count for each trial. The switch cost, which is defined as the difference in reaction time between switch and no-switch trials, is an index of shifting impairment. Finally, a typical working memory task in the rumination literature is the *n*-back task, in which participants indicate if the stimulus (usually a letter or number) matches the stimulus *n* (e.g., 3) items back.

1.3 | The present study

A number of studies have investigated the associations between rumination and one or more core EFs. Although a number of theoretical reviews have been written in hopes of elucidating reasons behind these associations, no unbiased, data-driven analyses of these effects has been conducted if these associations do, in fact, exist and what conditions these effects might depend upon. Thus, our first aim is to aggregate these results using meta-analytic techniques to clarify the extent to which rumination is related to core EFs.

Whether or not there are significant associations between rumination and core EFs may depend on moderating factors. The moderators that we considered in this meta-analysis included sample size; participant age, sex, and depressive status; whether the task included an affective component; and whether the outcome was a reaction time- or performance-based measure. Hence, our second aim was to investigate whether the aforementioned potential moderators influenced the magnitude of the associations between rumination and core EFs.

This meta-analysis expands and extends prior research in several important ways. First, although researchers have made significant advances identifying and delineating the associations between rumination and EF (Koster, De Lissnyder, Derakshan, & De Raedt, 2011; Mor & Daches, 2015), no work has been done to synthesize these findings by meta-analysis. Second, this meta-analysis offers a comprehensive and data-driven evaluation of the associations between rumination and core EFs from all studies that provided information about these associations. Additionally, an extensive coding scheme was applied that extracted a great deal of information from the study reports about participant sample and EF task characteristics. Furthermore, newly developed meta-analytic techniques were applied to address the complexity and diversity of the correlations between rumination and core EFs reported in these studies. Given the multifaceted nature of EF, most studies often report more than one outcome for any given task that makes use of a core EF. Within any participant sample, these multiple outcomes are not statistically independent and, as such, create problems if analyzed together (Hedges, Tipton, & Johnson, 2010, Tanner-Smith, Wilson, & Lipsey, 2013). Rather than eliminate informative outcome data, we have retained all the associations between rumination and core EFs from each study in the analyses and applied the meta-analytic technique of robust variance estimation (RVE), a random effects meta-regression that can account for dependence between effect size estimates (Tipton, 2015).

2 | MATERIALS AND METHODS

2.1 | Search strategy and inclusion criteria

Three systematic search strategies (conducted between July 2014 and January 2015 and an updated search was conducted in April 2016) were used to obtain a representative sample of studies of associations between rumination and core EFs. First, key electronic databases (ISI Web of Knowledge, PubMed, and ProQuest Theses and Dissertations) were systematically searched for relevant studies using the keyword "rumination" paired with "executive function," "cognitive control," "working memory," "inhibition," "shifting," or "switching" for studies published in English at any time prior to the search date. Second, to confirm no studies had been overlooked, the same search terms were used to examine key journals (*Journal of Abnormal Psychology, Cognition and Emotion*, *Emotion*) in the field. Third, we created an alert on Google Scholar using the keyword rumination, and this strategy allowed us to obtain new studies on rumination before conducting the final data analysis.

We included articles in the analysis if they met the following criteria (the flow chart of the article selection process is depicted in Fig. 1): (1) an explicit sample size; (2) the data were complete, consisting of an explicit report on the Pearson's product–moment correlation coefficient or a *t* or *F*-value that could be transformed into *r*; (3) at least one measure of rumination; (4) at least one experimental measure of core EFs; and (5) replicated data would be used only if it also appeared in an academic journal. In all, 34 articles (31 of which were published) satisfied the selection criteria.

2.2 | Research coding

Tasks relying on EF processes were first categorized as one of the three core EFs (inhibition, set-shifting, or working memory) on the basis of previous theory and/or empirical findings, indicating that a given task loaded primarily on one of the factors.

Next, three basic study features were coded as continuous variables, including sample size, average age of participants, and percentage of females in the sample. If mean participant age was not reported, median participant age was used; if neither statistic was presented, the midpoint of the reported age range was used.

Furthermore, three potential moderators were dummy coded: (1) the affective component of EF tasks (tasks were considered to include an affective component if the task employed affective characteristics or if the task incorporated faces as stimuli), (2) the outcome of EF tasks (reaction time- or performance-based measure); and (3) depressive status of the sample (depressed vs. nondepressed). Because of the diversity of depression measures reported and the lack of detailed depression reporting in many studies, continuous measures of depressive symptoms could not be analyzed. Instead, the presence of depression or depressive symptoms in the sample was coded

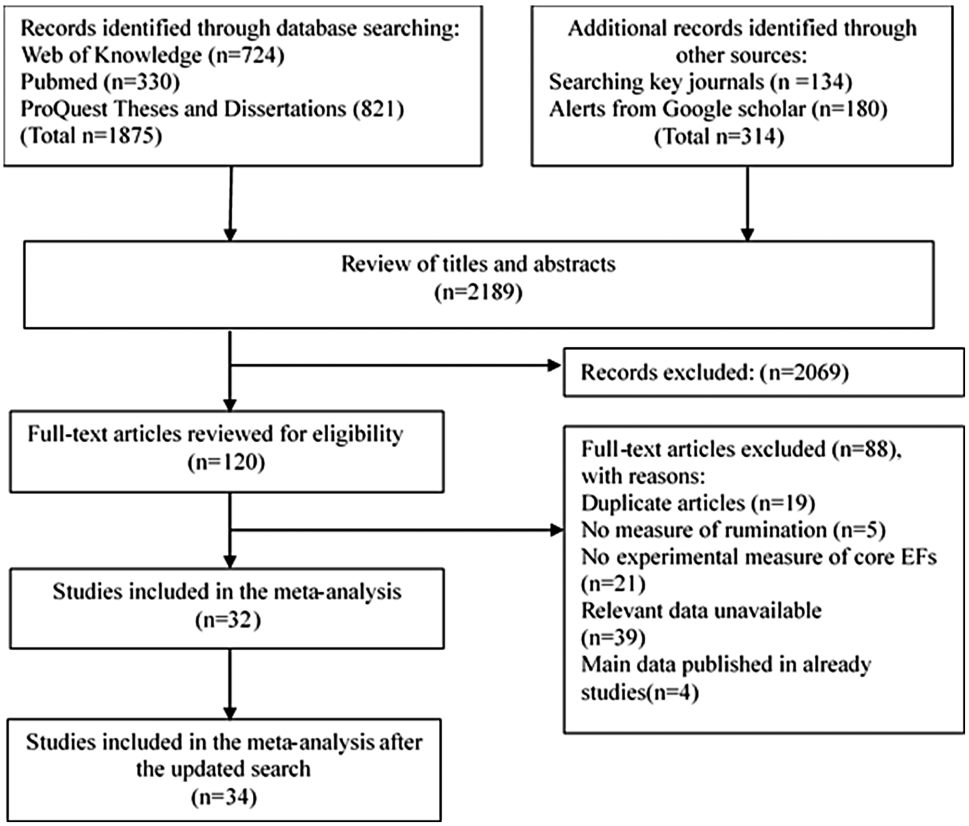

FIGURE 1 Flowchart of the results of the literature search

as a categorical variable (Snyder, Kaiser, Warren, & Heller, 2015). The sample was coded as containing individuals with co-occurring depression or depressive symptoms if (1) participants were reported to have a depressive disorder or (2) mean depressive symptoms on a standard depression questionnaire were reported to be in the clinical range. The sample was coded as containing participants without depression only if neither of these prerequisites were met. The clinical range was defined as follows, using published cut-point norms: Beck Depression Inventory (>9; Beck, 1978), Beck Depression Inventory II (>13; Beck, Steer, & Brown, 1996), Center for Epidemiological Studies Depression Scale (>16; Poulin, Hand, & Boudreau, 2005), and Children's Depression Inventory (>12; Kovacs, 1983).

Finally, the study quality was assessed using the quality of the journal the study was published in. As an approximation of study quality, the journal caliber was categorized into top, middle, and low tier using the quartile that journals belong to in the 2014 Journal Citation Reports of ISI Web of Knowledge (quartile 1 as top tier; quartile 2 as middle tier; quartile 3 or 4 and unpublished studies as low tier).

2.3 | Data processing and analysis

The meta-analysis method of related coefficients was adopted to analyze the selected studies. Toward this purpose, we used the Pearson's product–moment correlation coefficient *r* as the effect size, with *r* transformed through Fisher's *z* transformation. If *r* values were not reported, we used *t* or one-way *F* statistics to calculate *r*. The above processes were conducted using Comprehensive Meta-Analysis Version 2 (Borenstein, Hedges, Higgins, & Rothstein, 2005).

Then, *z*-transformed correlation coefficients and potential predictors were analyzed using meta-regression models with the RVE approach and small sample adjustments (Tipton, 2015). We employed the robu() function of the *robumeta* package in R, version 3.2.2, to conduct these analyses. To account for dependency between the effect sizes, ρ was set to the recommended .80 (Tanner-Smith, Wilson, & Lipsey, 2013). The Satterwaite approximation was used to estimate the degrees of freedom for all analyses, where $df = 2/cv^2$ and *cv* represents the coefficient of variation, as simulation studies have indicated that this method of estimating degrees of freedom is most analytically valid with the RVE meta-analytic technique (Shields, Bonner, & Moons, 2015).

3 | RESULTS

3.1 | Study characteristics and assessment of publication bias

In total, 34 studies including 3,066 participants were analyzed in this meta-analysis. Each of these studies is represented by *m*. The mean age of all participants was 28 years. Most of the studies (91%) were published in peer-reviewed journals, with an average publication date of 2011 (Table 1 contains detailed characteristics of these studies). There were 82 total effect sizes, each of which is represented by *k*. Of these

TABLE 1 Characteristics of the 34 studies included in the meta-analysis

Author Name and Year	Core EF Assessed	Measures Used to Assess Outcome	Time or Accuracy Outcome	Emotional Component to Task	*N*	Percent Female	Participant Age	Depression	Measurement of Rumination	Number of Effects	Study Quality
Altamirano, Miyake and Whitmer (2010)	Set-shifting	Letter-naming task	Accuracy	No	88	33.6	–	Absent	RRS	1	Top
Berman et al. (2011)	Inhibition	Modified Sternberg task	Time	Yes	30	70	24.4	Both	RRS	1	Top
Bernblum and Mor (2010)	Working memory	Refreshing task	Time	Both	34	–	24	Absent	RRS:brooding	1	Top
Connolly et al. (2014)	Set-shifting	Creature counting task	Accuracy	No	200	56.5	12.4	Absent	CRSQ-rumin	4	Middle
	Working memory	Digit span									
Daches and Mor (2015)	Inhibition	Negative affective priming	Time	Yes	128	64.8	23.6	Both	RRS:brooding	1	Middle
Davis and Nolen-Hoeksema (2000)	Set-shifting	Wisconsin card sorting test	Accuracy	No	62	50.0	20.3	Absent	RRS	1	Low
De Lissnyder, Koster, Derakshan and De Raedt (2010)	Inhibition	Affective shift task	Time	Yes	96	86.5	19	Both	RRS	2	Middle
	Set-shifting										
De Lissnyder, Derakshan, De Raedt and Koster (2011)	Inhibition	Mixed antisaccade task	Time	No	46	62.5	28	Both	RRS	1	Middle
De Lissnyder et al. (2012)	Set-shifting	Internal shift task	Time	Yes	40	57.5	42.5	Possible	RRS	1	Middle
Demeyer, De Lissnyder, Koster and De Raedt (2012)	Set-shifting	Internal shift task	Time	Yes	30	–	–	Absent	RRS	3	Top
Dickson (2015)	Set-shifting	Wisconsin card sorting test	Accuracy	No	86	64.0	17.8	Absent	RRS	1	Low
Fawcett et al. (2015)	Inhibition	Think/no-think	Accuracy	No	96	57.3	–	Absent	RRS	1	Middle
Foxworth (2014)	Working memory	Letter number sequencing task	Accuracy	No	148	77.7	19.7	Absent	RRS:brooding	1	Low
Goeleven, De Raedt, Baert and Koster (2006)	Inhibiton	Negative affective priming	Time	Yes	60	63.3	43.3	Possible	RRS	2	Middle
Harfmann (2013)	Inhibition	Go/no-go	Time	Yes	30	53.3/43.3	19.5/19.4	Both	RRS	4	Low

(*Continued*)

TABLE 1 *(Continued)*

Author Name and Year	Core EF Assessed	Measures Used to Assess Outcome	Time or Accuracy Outcome	Emotional Component to Task	*N*	Percent Female	Participant Age	Depression	Measurement of Rumination	Number of Effects	Study Quality
Hertel and Gerstle (2003)	Inhibtion	Think/no-think	Accuracy	No	64	50	–	Absent	RRS	1	Top
Joormann (2006)	Inhibition	Negative priming task	Time	Yes	52	76.9	26.3	Absent	RRS	1	Low
Joormann, Dkane and Gotlib (2006)	Inhibition	Dot-probe	Time	Yes	34	82.3	34	Possible	RRS	3	Top
Joormann and Gotlib (2008)	Inhibition	Modified Sternberg task	Time	Yes	23/40	69.9/65	35.5/34.5	Both	RRS	4	Top
Joormann and Tran (2009)	Inhibition	Directed forgetting task	Accuracy	Yes	33	25.9	40	Absent	RRS	1	Middle
Joormann and Gotlib (2010)	Inhibition	Negative priming task	Time	Yes	21/45	72.7/63.8	36/35.9	Both	RRS	4	Middle
Joormann, Nee, Berman, Jonides and Gotlib (2010)	Inhibition	Ignore/suppress task	Time	Yes	47	68	37.0	Possible	RRS	2	Top
Lau et al. (2007)	Inhibition	Prose distraction task	Time	Yes	43	58.1	39.2	Possible	RRS	1	Top
Onraedt and Koster (2014)	Set-shifting	Internal shift task	Time	Both	72	87.5	20.3	Absent	RRS	3	Top
	Working memory	O-span	Accuracy	No	45	87.5	15.6	Absent	RRS		
Pe, Raes and Kuppens (2013)	Working memory	N-back	Accuracy	Yes	221	83.3	18.7	Absent	RRS	1	Top
Quinn and Joormann (2015)	Working memory	N-back	Accuracy	Yes	92	67.4	18.6	Absent	RRS:brooding	1	Top
Vanderhasselt, Kühn and De Raedt (2011)	Inhibition	Go/no-go	Accuracy	Yes	34	73.5	21.6	Absent	RRS:brooding	2	Top
Vergara-Lopez, Lopez-Vergara and Roberts (2016)	Set-shifting	Wisconsin card sorting test	Accuracy	No	185	56.2	–	Absent	RRS	6	Middle
	Set-shifting	Internal shift task	Time	Both							
	Set-shifting	Emotional card sorting test	Time	Both							
Von Hippel, Vasey, Gonda, and Stern (2008)	Inhibition	Stroop task	Time	No	44	86.4	82.2	Possible	RRS	2	Low
	Working memory	Working memory task	Accuracy	No							

(*Continued*)

TABLE 1 (*Continued*)

Author Name and Year	Core EF Assessed	Measures Used to Assess Outcome	Time or Accuracy Outcome	Emotional Component to Task	*N*	Percent Female	Participant Age	Depression	Measurement of Rumination	Number of Effects	Study Quality
Wagner, Alloy and Abramson (2015)	Set-shifting	Creature counting task	Time and accuracy	No	486	52.7	12.9	Absent	CRSQ-rumin	3	Middle
	Working memory	Digit span	Accuracy								
Whitmer and Banich (2007)	Inhibition set-shifting	Backward inhibition paradigm	Time	No	40/48	-	-	Absent	RRS ARS RRQ-rumin	8	Top
Whitmer and Banich (2010)	Inhibition	Retrieval induced forgetting task	Accuracy	No	67	56.7	-	Absent	RRS ARS RRQ-rumin	3	Middle
Zetsche and Joormann (2011)	Inhibition	Negative priming task	Time	Yes	111	67.6	20	Absent		7	Middle
	Inhibition	Flanker task									
Zetsche, D'Avanzato and Joormann (2012)	Inhibition	Modified Sternberg task	Accuracy	Yes	45	57.8	41.5	Possible	RRS	4	Middle
	Inhibition	Flanker task									

ARS, Anger Rumination Scale; CRSQ-rumin, rumination portion of Children's Response Styles Questionnaire; RRS, Ruminative Responses Scale; RRQ-rumin, rumination portion of the Rumination-Reflection.

studies, 21 assessed inhibition ($k = 49$), 11 assessed set-shifting ($k = 24$), and 8 assessed working memory ($k = 9$).

A mixed effects meta-regression model in the *metafor* package in R was used to conduct the publication bias test on each core EF individually. The test for publication bias returned nonsignificant for inhibition, $Z = -.95$, $P = .34$; set-shifting, $Z = -1.45$, $P = .15$; and working memory, $Z = 0.27$, $P = .79$, indicating a lack of observed bias. In addition, we conducted a trim and fill analysis in order to estimate the number of missing studies and their effect sizes. The trim and fill analyses estimated no missing studies on either side of the distribution for each EF (see Fig. 2). These results indicated stability and reliability in the associations between rumination and core EFs in the current meta-analysis.

3.2 | Primary analyses

3.2.1 | Inhibition

To establish the magnitude of the association between rumination and inhibition, we analyzed effects presented in 21 studies. The estimated meta-analytic correlation between rumination and inhibition was –.23, 95% CI [–.31 to –.15] (Fig. 3), and this effect was significantly greater than zero, $t(19.0) = -6.25$, $P < .001$. There was moderate heterogeneity within studies, $I^2 = 54\%$, with relatively low between-study heterogeneity, $\tau^2 = .02$. This heterogeneity indicates that the correlation of rumination and inhibition was relatively consistent both within and between studies.

We performed a meta-regression analysis to examine potential continuous moderators of the association between inhibition and rumination. Sample size, average participant age, and percentage of females in the sample were not significant moderators of this association (all *p*s > .23; Table 2).

We then focused on identifying whether the magnitude of this association varied as a function of potential categorical moderators. As shown in Table 3, the magnitude of the association for samples with possible depression was nonsignificantly larger than that for samples without depression ($r = -.22$ vs. –.19, respectively), $t(13.82) = .14$, $P = .89$. The magnitude of the association for inhibition tasks not employing an affective component was nonsignificantly larger than that for inhibition tasks employing an affective component ($r = -.28$ vs. –.20, respectively), $t(9.6) = 1.61$, $P = .14$. Finally, comparison of the outcome of inhibition tasks using reaction-time measures relative to those that used performance-based measures revealed no significant differences, $t(9.1) = .17$, $P = .88$.

3.2.2 | Set-shifting

To establish the magnitude of the association between rumination and set-shifting, we analyzed effects presented in 11 studies. The estimated meta-analytic correlation between rumination and set-shifting was –.19, 95% CI [–.32 to –.05] (Fig. 4), and this effect was significantly greater than zero, $t(9.57) = -3.00$, $P < .05$. There was substantial heterogeneity within studies, $I^2 = 77\%$, albeit with relatively low between-study heterogeneity, $\tau^2 = .03$. This level of heterogeneity indicates that correlations between rumination and set-shifting were discrepant

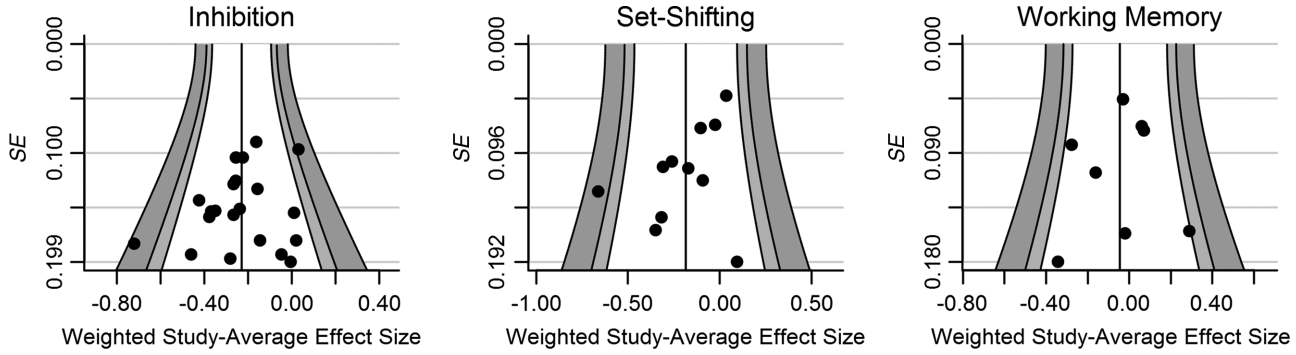

FIGURE 2 Funnel plot displaying effect sizes by *SE*s

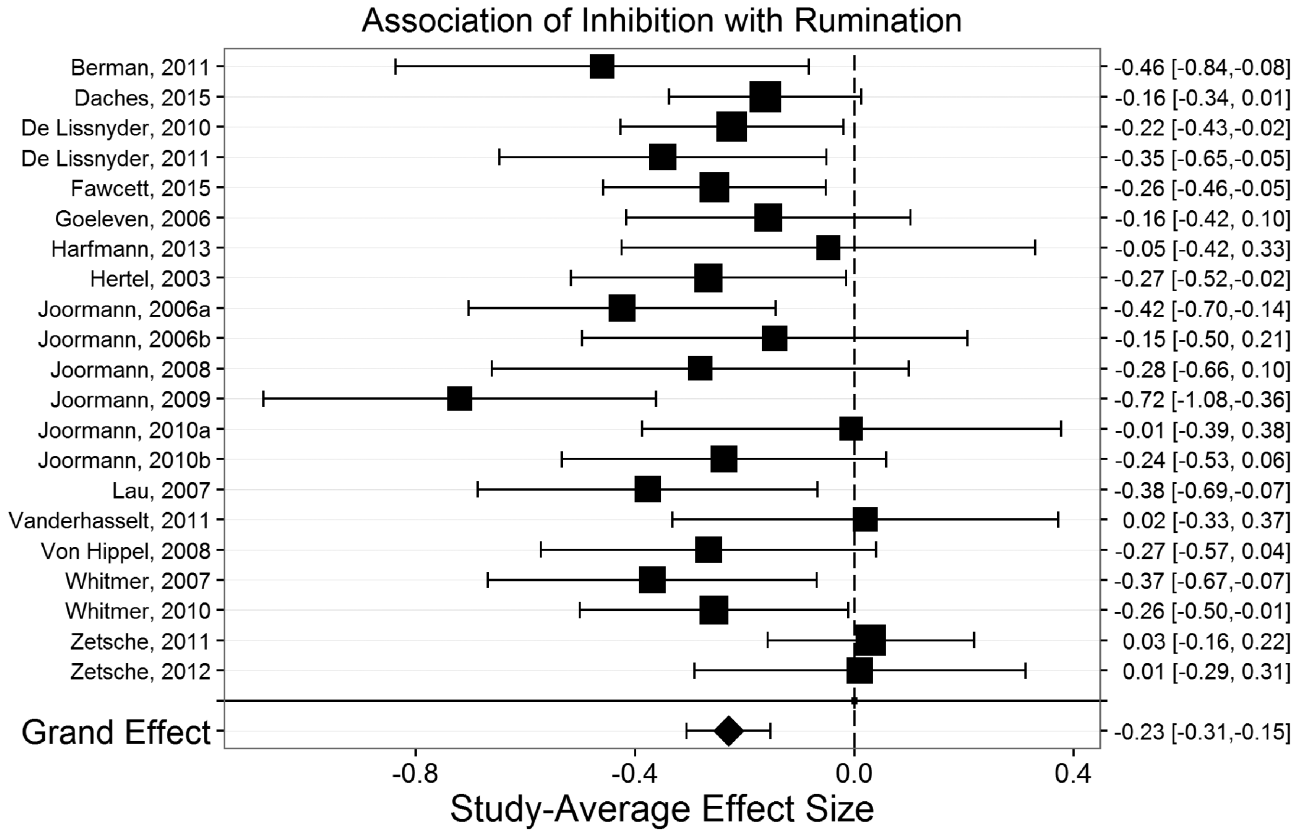

FIGURE 3 Forest plot of inhibition study-average effect sizes by weight

within but not across studies, as relatively similar correlations were observed between studies. There were no significant moderators of the effect size (Tables 2 and 3).

On the basis of the suggestions offered by Valentine, Pigott and Rothstein (2010), we found that the power to detect an effect with a small correlation coefficient of $r = .10$ with our average sample size and moderate heterogeneity was .56, and .84 to detect an effect of $r = .14$. Thus, we expected reasonable power to detect medium, and to a lesser certainty small effects.

3.2.3 | Working memory

Analyzing only the effect sizes related to working memory ($m = 8$, $k = 9$) revealed a negligible effect, $r = -.05$, 95% CI [−.19 to .10], $t(6.24) = -.77$, $P = .47$ (Fig. 5). There was moderate heterogeneity within studies, $I^2 = 68\%$, with low between-study heterogeneity, $\tau^2 = .02$. This heterogeneity illustrates that the correlation of rumination and working memory is relatively consistent both within and between studies. There were no significant moderators of the effect size (Tables 2 and 3).

We found that the power to detect an effect with a small correlation coefficient of $r = .10$ and moderate heterogeneity was low (< .50). Although we achieved .77 power assuming moderate heterogeneity to detect an effect that was still small but not near negligible, $r = .15$, and .82 power to detect effects of $r = .16$. Thus, it is possible we failed to detect very small correlations in working memory analyses (e.g., *r* between −.01 and −.15) due to a lack of power, but overall we had sufficient power to detect most effects of interest.

TABLE 2 Covariate effects on the relationships between rumination and core EFs

Variable	*B*	*β*	Point estimate (*SE*; Controlling for Covariate)	*t*	df	*P*
Inhibition						
Sample size	.002	.05		1.37	5.01	.23
Range: 21–128			−.24 (.04)	−6.23	18.79	<.001
Percent female participants	.004	.05		1.05	4.67	.34
Range: 25.9–86.5			−.22 (.04)	−5.81	16.91	<.001
Participant age	−.002	−.03		−0.96	2.14	.40
Range: 19–82.2			−.22 (.05)	−4.57	13.77	<.001
Set-shifting						
Sample size	<.001	.10		2.32	1.74	.17
Range: 30–486			−.19 (.05)	−3.75	8.57	.01
Percent female participants	.002	.03		0.74	2.45	.52
Range: 33.6–87.5			−.20 (.09)	−2.79	6.73	.03
Participant age	−.013	−.12		−1.00	1.40	.46
Range: 12.4–42.5			−.20 (.10)	−2.29	4.60	.08
Working memory						
Sample size	<−.001	−.02		0.42	1.92	.72
Range: 34–486			−.05 (.07)	−0.73	5.89	.50
Percent female participants	.002	.02		0.38	3.17	.73
Range: 52.7–87.5			−.02 (.07)	−0.34	4.56	.75
Participant age	<−.001	−.01		−0.09	1.20	.94
Range: 12.4–82.2			−.06 (.07)	−0.78	4.71	.48

Notes: B, unstandardized slope; *β*, standardized slope; Point estimate, effect size; *SE*, standard error of the effect size; *t*, *t*-test statistic for test determining whether the effect size differs from zero; df, degrees of freedom for *t*-test; *P*, *P*-value for *t*-test. If df < 4, there is up to a 10% risk of Type I error, given how df are estimated. Linear associations are reported without controlling for quadratic effects.

4 | DISCUSSION

4.1 | Inverse associations between rumination and core EFs

To our knowledge, this is the first comprehensive meta-analysis of associations between rumination and core EFs. Pooling data across 34 studies revealed significant inverse relationships between rumination and both inhibition and set-shifting. No significant association was observed between rumination and working memory. We observed low heterogeneity between studies (albeit with moderate within-study heterogeneity), indicating that the observed associations were largely consistent across studies. Thus, we observed remarkable consistency in the associations between rumination and core EFs.

These effects seem to coincide with previous accounts that rumination is related to inhibition deficits. As a cognitive gatekeeper, inhibition limits access to consciousness of irrelevant information or internal thoughts that compete for attention while pursuing a goal. Deficits in inhibitory control and consequent difficulty in preventing ruminative thoughts from entering consciousness might result in inefficient processing of one's current task due to ruminative thinking (Linville, 1996). Joormann and colleagues (Joormann, 2005; Joormann & Quinn, 2014, Joormann & Vanderlind, 2014) provided a detailed perspective on the role of multiple inhibitory processes (Friedman & Miyake, 2004) in rumination. Deficits in the application of inhibitory processes to control the contents of working memory may cause individuals to more easily attend to previously ignored content and to experience difficulties in both combating interference from information that is no longer relevant and halting prepotent responses. This, in turn, fosters rumination.

A growing number of studies have examined the associations between rumination and set-shifting and working memory. Deficits in set-shifting can impair switching to a new train of thought, thus contributing to becoming stuck in a set of recurring thoughts—often with a common, emotionally charged theme (Altamirano, Miyake, & Whitmer, 2010). Our results, indicating that set-shifting abilities are inversely related to rumination, support this idea.

We did not find a significant relationship between rumination and working memory. This result does not support the resource depletion account (Philippot & Brutoux, 2008; Watkins & Brown, 2002), since this suggests that the use of executive resources for rumination will cause widespread difficulties on EF tasks. However, this finding should be interpreted with caution, given only eight studies were included in the analysis. Nonetheless, a significant inverse association between set-shifting and rumination emerged with only 11 studies included in the analysis, lending credence to the idea that the association between working memory and rumination is weak, if it exists at all.

TABLE 3 Moderator analyses of the relationships between rumination and core EFs

Variable	Point Estimate	*SE*	df	*P*	*m*	*k*
Inhibition						
Emotive task						
Nonemotive	−.28	.02	4.48	< .001	6	11
Emotive	−.20	.05	13.4	< .01	15	38
Reaction time versus accuracy						
Reaction time	−.23	.04	13.2	< .001	15	37
Accuracy	−.24	.09	4.85	< .05	6	12
Depression[a]						
Absent	−.19	.08	9.84	< .05	10	26
Possible	−.22	.05	7.58	< .001	9	19
Set-shifting						
Emotive task						
Nonemotive	−.18	.08	6.83	.05	8	15
Emotive	−.16	.05	3.20	< .05	5	9
Reaction time versus accuracy						
Reaction time	−.12	.05	4.69	.09	7	14
Accuracy	−.18	.10	4.95	.13	6	10
Depression[a]						
Absent	−.08	.05	5.22	.15	7	17
Possible[b]	—	—	—	—	—	—
Working memory						
Emotive task						
Nonemotive	−.02	.08	3.66	.86	5	6
Emotive	−.04	.11	1.00	.80	2	2
Reaction time versus accuracy						
Reaction time[b]	—	—	—	—	—	—
Accuracy	−.02	.06	5.45	.70	7	8
Depression[a]						
Absent	−.05	.07	5.48	.50	7	8
Possible[b]	—	—	—	—	—	—

Notes: B, unstandardized slope; β, standardized slope; Point estimate, effect size; *SE*, standard error of the effect size; *t*, df, and *P* refer to a test of effect size against 0; *m*, number of studies in the analysis, *k*, number of effect sizes in the analysis. If df < 4, there is up to a 10% risk of Type I error, given how df are estimated. Linear associations are reported without controlling for quadratic effects.

[a]Depression possible indicates average depressive symptom questionnaire scores in clinical range or individuals with diagnosis of any depressive disorder. Depression absent indicates average depressive symptom questionnaire scores below clinical range and no participants with a diagnosed depressive disorder.

[b]Cannot be analyzed because of just one effect size.

Altogether, this meta-analysis suggested that ruminators may have specific deficits in inhibition or set-shifting. As an unproductive style of thinking, rumination is difficult to control or stop. This perseverative nature led researchers to postulate that EF deficits may contribute to ruminative thinking (Joormann & Vanderlind, 2014; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). The results of this meta-analysis support this idea, and further suggest that difficulty shifting attention between different cognitive representations or halting prepotent responses and resisting interference from task-irrelevant information may be particularly related to this perseverative nature, whereas integrating new and old information and maintaining it, posited to be reflected in the working memory facet (Miyake et al., 2000), is less related.

4.2 | Discussion of moderators

To further illuminate contextual factors that may influence the associations between rumination and core EFs, this meta-analysis examined the effects of additional moderators, including age, sex, depressive status of the sample, outcome measure of EF tasks, and type of stimuli (emotional or nonemotional). None of these variables emerged as moderators of the associations we observed (see Tables 2 and 3).

For example, meta-regression analysis was conducted to investigate moderating effects of sex. We found almost identical effect size estimates after controlling for the percentage of female participants. This result suggests that the associations between rumination and core EFs do not vary based on the presence of male or female gender. Similarly, we found no significant evidence for an effect of age on the magnitude of associations between rumination and core EFs, though there was little variability in the range of average participant ages across studies.

We did not find evidence indicating that depression moderates the association between rumination and inhibition. Although there was a larger effect size for samples with a depression diagnosis or clinically elevated depressive symptoms, this difference did not reach significance levels. Therefore, depression does not account for the relationship between rumination and inhibition. This finding should be interpreted with caution, given that the lack of depression reporting in many studies meant that there were only a few studies ($k = 9$) including participants with depression. These concerns also apply to samples examining set-shifting and working memory.

Finally, the emotionality of EF tasks was also not a significant moderator of the relationships between rumination and core EFs. Although our analysis cannot fully clarify if rumination is related to biases in the processing of emotional material, our results showed that rumination is inversely associated with inhibition and set-shifting regardless of whether the task involves an affective component or not. This result does not support the impaired disengagement hypothesis (Koster, De Lissnyder, Derakshan, & De Raedt, 2011), since this valence-specific account suggests that a tendency to ruminate is related to difficulty controlling attention to emotionally negative, but not neutral or positive, information. Future research should take further steps to examine the distinction between global EF impairments and EF that is specific to negative (or self-relevant) content in their effect on ruminative thinking. Clarifying this issue has important implications for understanding general links between cognition and emotion.

The substantial heterogeneity of within-study effect sizes suggests moderation by additional variables. However, formal moderation testing did not yield any significant results, indicating that other variables not considered here may moderate associations between rumination and EFs. Nonetheless, our analyses were based on a medium-sized sample of studies ($m = 34$) and that many covariates were unbalanced,

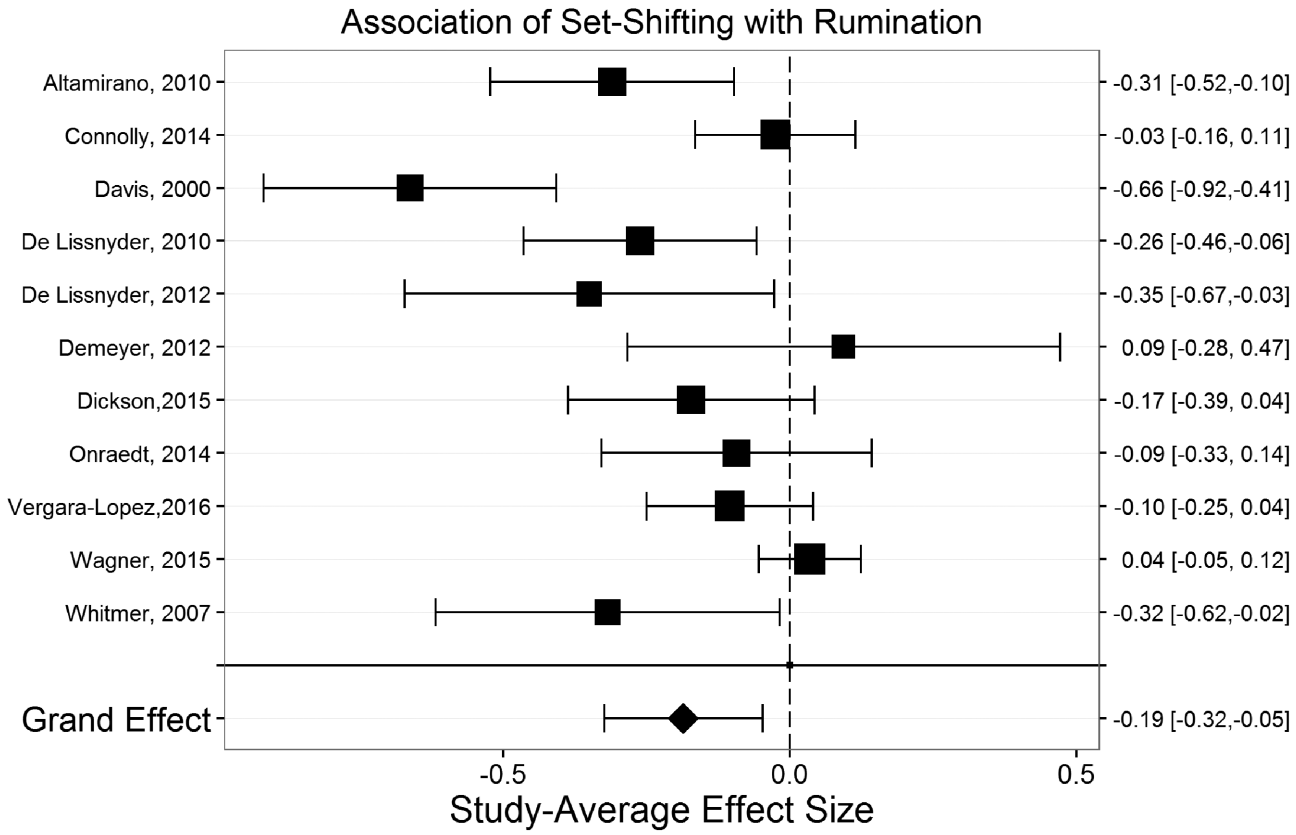

FIGURE 4 Forest plot of set-shifting study-average effect sizes by weight

possibly leading to power issues (Tanner-Smith, Wilson, & Lipsey, 2013; Tipton, 2015; Zahn et al., 2016). Additionally, we could not test the effects of all possible variables for the rumination-core EFs connection. For instance, it is important to note that the substantial variety in EF tasks remains a methodological challenge mostly due to task impurity (Miyake et al., 2000). EF measures differ in complexity as a result of different amount of loadings on executive and nonexecutive processes (Friedman et al., 2008). However, this meta-analysis does not provide a well-defined framework to categorize EF tasks by taking into account these levels of complexity. In sum, although small between-study heterogeneity in the analyses alleviates the concern of substantial heterogeneity of within-study effect sizes, further studies are needed to systematically examine the moderate factors that may influence the associations between rumination and core EFs.

4.3 | Limitations and implications

Several limitations must be considered when interpreting the results of our meta-analysis. First, there were small study set sizes that should be kept in mind when making inferences about the associations between rumination and set-shifting and working memory. The moderator analyses were limited by the small number of studies that reported data on certain variables, and sometimes by low variance in these moderators. Therefore, we need to be cautious in understanding the associations between rumination and set-shifting or working memory. Second, the diversity of tasks that make use of core EFs throughout the studies may have obscured potential effects on a specific task (Shields, Bonner, & Moons, 2015). Third, some might argue the need to examine different core EFs, as it is possible that different results may emerge from a different analytic strategy. However, the core EFs chosen for analysis are those detailed in a recent major review of EF (Diamond, 2013); consequently, although it is possible that a different analytical strategy may have produced different results, the strategy chosen for the present analysis is the most theoretically supported. Still, we could not examine a different approach due to a paucity of studies examining associations of alternative measures of EF—such as verbal fluency or problem solving–with rumination, and it is possible that a different relation than that seen in this analysis exists between these types of EF tasks and rumination. Fourth, co-occurring depression was coded as a categorical variable. This was necessary because the primary literature reports a variety of depression measures that cannot be easily converted into a single continuous measure (Snyder, Kaiser, Warren, & Heller, 2015). The categorical depression measure provides a conservative test that demonstrates that the inverse association between running and inhibition or set-shifting is present in nondepressed individuals. However, this categorical measure limits the ability to detect the extent to which co-occurring depression might contribute to this association. Finally, as this meta-analysis could not determine the causal direction of observed effects, future longitudinal or experimental studies should focus on this topic. Clarifying the causal direction of the relationships between rumination and core EFs will have important implications for both clinical understanding of and interventions for rumination.

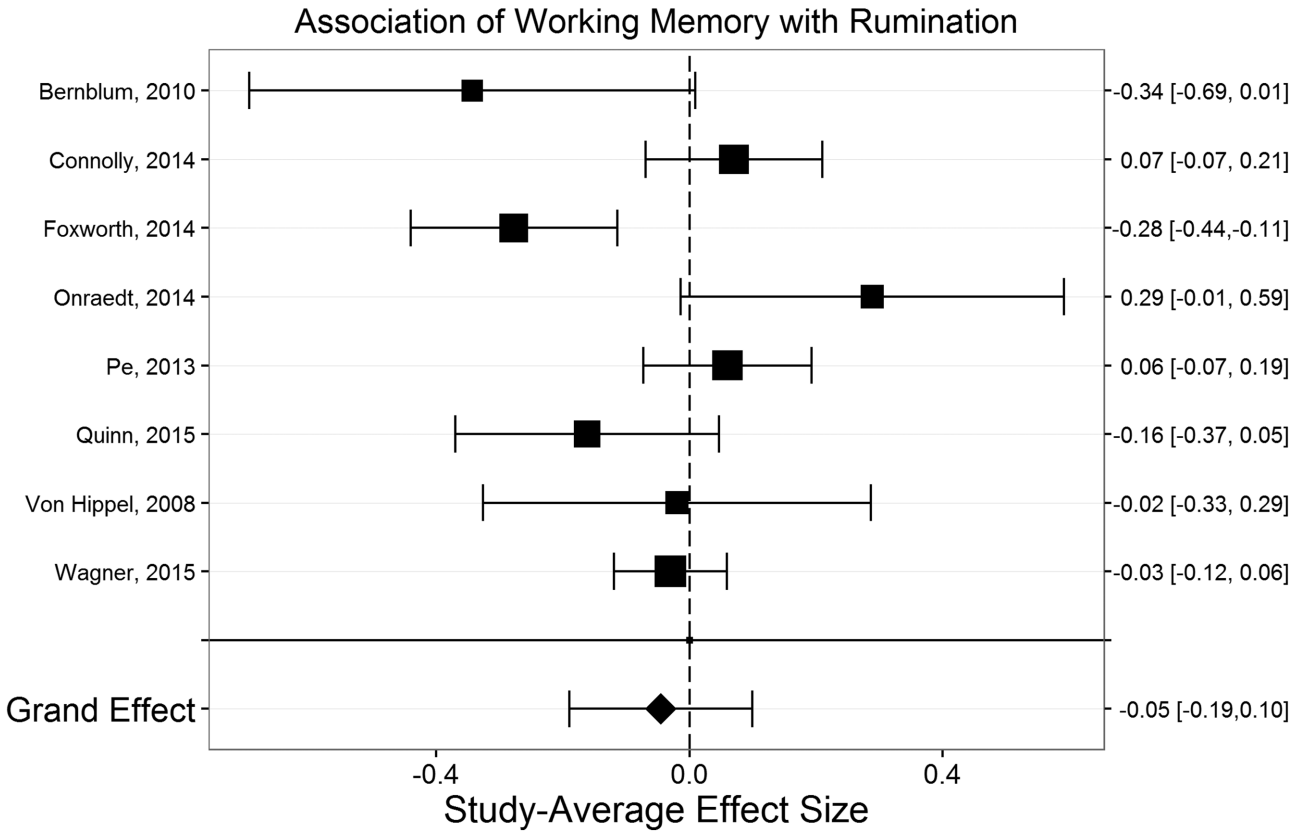

FIGURE 5 Forest plot of working memory study-average effect sizes by weight

5 | CONCLUSION

The present meta-analysis revealed significant negative associations between rumination and inhibition and set-shifting. There was no significant association between rumination and working memory. Future research should adopt multiple measures of EF to provide clear evidence on the associations between EF and rumination. A better understanding of this relationship may have important implications for intervention of rumination, such as training programs to improve EF or teach compensatory strategies to mitigate the effects of EF impairments.

ACKNOWLEDGMENTS

The funding source had no influence on the design or conduct of the review; the collection, management, analysis, or interpretation of the data; or in the preparation, review, or approval of the manuscript.

CONFLICT OF INTEREST

The authors declared that they had no conflicts of interest or financial disclosures with respect to their authorship or the publication of this article.

REFERENCES

Abela, J. R., Vanderbilt, E., & Rochon, A. (2004). A test of the integration of the response styles and social support theories of depression in third and seventh grade children. *Journal of Social and Clinical Psychology*, *23*(5), 653–674.

Altamirano, L. J., Miyake, A., & Whitmer, A. J. (2010). When mental inflexibility facilitates executive control beneficial side effects of ruminative tendencies on goal maintenance. *Psychological Science*, *21*(10), 1377–1382.

Banich, M. T. (2009). Executive function the search for an integrated account. *Current Directions in Psychological Science*, *18*(2), 89–94.

Beck, A. T. (1978). *Depression inventory*. Philadelphia, PA: Center for Cognitive Therapy.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Beck depression inventory manual* (2nd ed.). San Antonio, TX: Psychological Corporation.

Berman, M. G., Nee, D. E., Casement, M., Kim, H. S., Deldin, P., Kross, E., & Jonides, J. (2011). Neural and behavioral effects of interference resolution in depression and rumination. *Cognitive, Affective, & Behavioral Neuroscience*, *11*(1), 85–96.

Bernblum, R., & Mor, N. (2010). Rumination and emotion-related biases in refreshing information. *Emotion*, *10*(3), 423–432.

Borenstein, M., Hedges, L. V., Higgins, J. P., & Rothstein, H. R. (2005). *Comprehensive meta-analysis version 2*. Englewood, NJ: Biostat (104–104).

Connolly, S. L., Wagner, C. A., Shapero, B. G., Pendergast, L. L., Abramson, L. Y., & Alloy, L. B. (2014). Rumination prospectively predicts executive functioning impairments in adolescents. *Journal of Behavior Therapy and Experimental Psychiatry*, *45*(1), 46–56.

Daches, S., & Mor, N. (2015). Brooding moderates the link between reappraisal and inhibition of negative information. *Cognition and Emotion*, *29*(5), 923–934.

Davis, R. N., & Nolen-Hoeksema, S. (2000). Cognitive inflexibility among ruminators and nonruminators. *Cognitive Therapy and Research*, *24*(6), 699–711.

De Lissnyder, E., Derakshan, N., De Raedt, R., & Koster, E. H. (2011). Depressive symptoms and cognitive control in a mixed antisaccade task: Specific effects of depressive rumination. *Cognition & Emotion*, *25*(5), 886–897.

De Lissnyder, E., Koster, E. H., Derakshan, N., & De Raedt, R. (2010). The association between depressive symptoms and executive control impairments in response to emotional and non-emotional information. *Cognition and Emotion*, *24*(2), 264–280.

De Lissnyder, E., Koster, E. H., Everaert, J., Schacht, R., Van den Abeele, D., & De Raedt, R.(2012). Internal cognitive control in clinical depression: General but no emotion-specific impairments. *Psychiatry Research*, *199*(2), 124–30.

Demeyer, I., De Lissnyder, E., Koster, E. H., & De Raedt, R. (2012). Rumination mediates the associationship between impaired cognitive control for emotional information and depressive symptoms: A prospective study in remitted depressed adults. *Behaviour Research and Therapy*, *50*(5), 292–297.

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*, 135–168.

Dickson, K. S. (2015). *The role of executive function in adolescent rumination and depression*. (Unpublished doctoral dissertation). USA: University of Kent State.

Fawcett, J. M., Benoit, R. G., Gagnepain, P., Salman, A., Bartholdy, S., Bradley, C., & Anderson, M. C. (2015). The origins of repetitive thought in rumination: Separating cognitive style from deficits in inhibitory control over memory. *Journal of Behavior Therapy and Experimental Psychiatry*, *47*, 1–8.

Foxworth, T. (2014). *Rumination and inhibitory difficulties: Exploring the role of state rumination with emotionally self-relevant words.* (Unpublished doctoral dissertation). USA: University of North Carolina.

Friedman, N. P., & Miyake, A. (2004). The relations among inhibition and interference control functions: A latent-variable analysis. *Journal of Experimental Psychology: General*, *133*(1), 101–135.

Friedman, N. P., Miyake, A., Young, S. E., DeFries, J. C., Corley, R. P., & Hewitt, J. K. (2008). Individual differences in executive functions are almost entirely genetic in origin. *Journal of Experimental Psychology: General*, *137*(2), 201–225.

Goeleven, E., De Raedt, R., Baert, S., & Koster, E. H. (2006). Deficient inhibition of emotional information in depression. *Journal of Affective Disorders*, *93*(1), 149–157.

Harfmann, E. J. (2013). *An investigation of maintenance and the correlates of depression: Rumination, emotion regulation, cognitive inhibition, sleep, and diet (Unpublished master's dissertation)*. USA: University of Kansa.

Hedges, L. V., Tipton, E., & Johnson, M. C. (2010). Robust variance estimation in meta-regression with dependent effect size estimates. *Research synthesis methods*, *1*(1), 39–65.

Hertel, P. T. (2004). Memory for emotional and non-emotional events in depression: A question of habit. In D. Reisberg & P. Hertel (Eds.), *Memory and emotion* (pp. 186–216). NewYork, NY: Oxford University Press.

Hertel, P. T., & Gerstle, M. (2003). Depressive deficits in forgetting. *Psychological Science*, *14*(6), 573–578.

Hilt, L. M., Cha, C. B., & Nolen-Hoeksema, S. (2008). Nonsuicidal self-injury in young adolescent girls: Moderators of the distress-function relationship. *Journal of Consulting and Clinical Psychology*, *76*(1), 63–71.

Joormann, J. (2005). Inhibition, rumination, and mood regulation in depression. In R. W. Engle, G. Sedak, U. von Hecker, & D. N. McIntosh (Eds.),*Cognitive limitations in aging and psychopathology: Attention, working memory, and executive functions* (pp. 275–312). New York: Cambridge University Press.

Joormann, J. (2006). Differential effects of rumination and dysphoria on the inhibition of irrelevant emotional material: Evidence from a negative priming task. *Cognitive Therapy and Research*, *30*(2), 149–160.

Joormann, J., Dkane, M., & Gotlib, I. H. (2006). Adaptive and maladaptive components of rumination? Diagnostic specificity and relationship to depressive biases. *Behavior Therapy*, *37*(3), 269–280.

Joormann, J., & Gotlib, I. H. (2008). Updating the contents of working memory in depression: Interference from irrelevant negative material. *Journal of Abnormal Psychology*, *117*(1), 182–192.

Joormann, J., & Gotlib, I. H. (2010). Emotion regulation in depression: Relationship to cognitive inhibition. *Cognition and Emotion*, *24*(2), 281–298.

Joormann, J., Nee, D. E., Berman, M. G., Jonides, J., & Gotlib, I. H. (2010). Interference resolution in major depression. *Cognitive, Affective, & Behavioral Neuroscience*, *10*(1), 21–33.

Joormann, J., & Quinn, M. E. (2014). Cognitive processes and emotion regulation in depression. *Depression and anxiety*, *31*(4), 308–315.

Joormann, J., & Tran, T. B. (2009). Rumination and intentional forgetting of emotional material. *Cognition and Emotion*, *23*(6), 1233–1246.

Joormann, J., & Vanderlind, W. M. (2014). Emotion regulation in depression: The role of biased cognition and reduced cognitive control. *Clinical Psychological Science*, *2*(4), 402–421.

Koster, E. H., De Lissnyder, E., Derakshan, N., & De Raedt, R. (2011). Understanding depressive rumination from a cognitive science perspective: The impaired disengagement hypothesis. *Clinical Psychology Review*, *31*(1), 138–145.

Kovacs, M. (1983). *The children's depression inventory: A self-rated depression scale for school-aged youngsters* (Unpublished manuscript). Department of Psychology, University of Pittsburgh, Pittsburgh, PA.

Lau, M. A., Christensen, B. K., Hawley, L. L., Gemar, M. S., & Segal, Z. V. (2007). Inhibitory deficits for negative information in persons with major depressive disorder. *Psychological Medicine*, *37*(09), 1249–1259.

Linville, P. (1996). Attention inhibition: Does it underlie ruminative thought? In R. S. Wyer, Jr. (Ed.), *Ruminative thoughts: Advances in social cognition* (Vol. *9*, pp. 121–133). Mahwah, NJ: Erlbaum.

Lyubomirsky, S., & Nolen-Hoeksema, S. (1995). Effects of self-focused rumination on negative thinking and interpersonal problem solving. *Journal of personality and social psychology*, *69*(1), 176–190.

Mellings, T. M., & Alden, L. E. (2000). Cognitive processes in social anxiety: The effects of self-focus, rumination and anticipatory processing. *Behaviour Research and Therapy*, *38*(3), 243–257.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*(1), 49–100.

Mor, N., & Daches, S. (2015). Ruminative thinking: Lessons learned from cognitive training. *Clinical Psychological Science*, *3*(4), 574–592.

Nolen-Hoeksema, S., & Morrow, J. (1991). A prospective study of depression and posttraumatic stress symptoms after a natural disaster: The 1989 Loma Prieta earthquake. *Journal of Personality and Social Psychology*, *61*(1), 115–121.

Nolen-Hoeksema, S., Stice, E., Wade, E., & Bohon, C. (2007). Reciprocal relations between rumination and bulimic, substance abuse, and depressive symptoms in female adolescents. *Journal of Abnormal Psychology*, *116*(1), 198–207.

Nolen-Hoeksema, S., & Watkins, E. R. (2011). A heuristic for developing transdiagnostic models of psychopathology explaining multifinality and divergent trajectories. *Perspectives on Psychological Science*, *6*(6), 589–609.

Nolen-Hoeksema, S., Wisco, B. E., & Lyubomirsky, S. (2008). Rethinking rumination. *Perspectives on Psychological Science*, *3*(5), 400–424.

Onraedt, T., & Koster, E. H. (2014). Training working memory to reduce rumination. *PloS One*, *9*(3), e90634.

Pe, M. L., Raes, F., & Kuppens, P. (2013). The cognitive building blocks of emotion regulation: Ability to update working memory moderates the efficacy of rumination and reappraisal on emotion. *PloS One*, *8*(7), e69071.

Philippot, P., & Brutoux, F. (2008). Induced rumination dampens executive processes in dysphoric young adults. *Journal of Behavior Therapy and Experimental Psychiatry*, *39*, 219–227.

Poulin, C., Hand, D., & Boudreau, B. (2005). Validity of a 12–item version of the CES-D used in the National Longitudinal Study of Children and Youth. *Chronic Diseases in Canada*, *26*, 65–72.

Quinn, M. E., & Joormann, J. (2015). Stress-induced changes in executive control are associated with depression symptoms examining the role of rumination. *Clinical Psychological Science*, *3*(4), 628–636.

Shields, G. S., Bonner, J. C., & Moons, W. G. (2015). Does cortisol influence core executive functions? A meta-analysis of acute cortisol administration effects on working memory, inhibition, and set-shifting. *Psychoneuroendocrinology*, *58*, 91–103.

Snyder, H. R., Kaiser, R. H., Warren, S. L., & Heller, W. (2015). Obsessive–compulsive disorder is associated with broad impairments in executive function: A meta-analysis. *Clinical Psychological Science*, *3*(2), 301–330.

Sukhodolsky, D. G., Golub, A., & Cromwell, E. N. (2001). Development and validation of the anger rumination scale. *Personality and Individual Differences*, *31*(5), 689–700.

Tanner-Smith, E. E., Wilson, S. J., & Lipsey, M. W. (2013). The comparative effectiveness of outpatient treatment for adolescent substance abuse: A meta-analysis. *Journal of Substance Abuse Treatment*, *44*(2), 145–158.

Tipton, E. (2015). Small sample adjustments for robust variance estimation with meta-regression. *Psychological Methods*, *20*(3), 375–393.

Trapnell, P. D., & Campbell, J. D. (1999). Private self-consciousness and the five-factor model of personality: Distinguishing rumination from reflection. *Journal of Personality and Social Psychology*, *76*(2), 284–304.

Treynor, W., Gonzalez, R., & Nolen-Hoeksema, S. (2003). Rumination reconsidered: A psychometric analysis. *Cognitive Therapy and Research*, *27*(3), 247–259.

Valentine, J. C., Pigott, T. D., & Rothstein, H. R. (2010). How many studies do you need? A primer on statistical power for meta-analysis. *Journal of Educational and Behavioral Statistics*, *35*(2), 215–247.

Vanderhasselt, M. A., Kühn, S., & De Raedt, R. (2011). Healthy brooders employ more attentional resources when disengaging from the negative: An event-related fMRI study. *Cognitive, Affective, & Behavioral Neuroscience*, *11*(2), 207–216.

Vergara-Lopez, C., Lopez-Vergara, H. I., & Roberts, J. E. (2016). Testing a "content meets process" model of depression vulnerability and rumination: Exploring the moderating role of set-shifting deficits. *Journal of Behavior Therapy and Experimental Psychiatry*, *50*, 201–208.

Von Hippel, W., Vasey, M. W., Gonda, T., & Stern, T. (2008). Executive function deficits, rumination and late-onset depressive symptoms in older adults. *Cognitive Therapy and Research*, *34*(4), 474–487.

Wagner, C. A., Alloy, L. B., & Abramson, L. Y. (2015). Trait rumination, depression, and executive functions in early adolescence. *Journal of Youth and Adolescence*, *44*(1), 18–36.

Watkins, E., & Brown, R. G. (2002). Rumination and executive function in depression: An experimental study. *Journal of Neurology Neurosurgery and Psychiatry*, *72*, 400–402.

Whitmer, A. J., & Banich, M. T. (2007). Inhibition versus switching deficits in different forms of rumination. *Psychological Science*, *18*(6), 546–553.

Whitmer, A. J., & Banich, M. T. (2010). Trait rumination and inhibitory deficits in long-term memory. *Cognition and Emotion*, *24*(1), 168–179.

Whitmer, A. J., & Gotlib, I. H. (2013). An attentional scope model of rumination. *Psychological Bulletin*, *139*(5), 1036–1061.

Zahn, D., Adams, J., Krohn, J., Wenzel, M., Mann, C. G., Gomille, L. K., & Kubiak, T. (2016). Heart rate variability and self-control—A meta-analysis. *Biological Psychology*, *115*, 9–26.

Zetsche, U., D'Avanzato, C., & Joormann, J. (2012). Depression and rumination: Relationship to components of inhibition. *Cognition &Emotion*, *26*(4), 758–767.

Zetsche, U., & Joormann, J. (2011). Components of interference control predict depressive symptoms and rumination cross-sectionally and at six months follow-up. *Journal of Behavior Therapy and Experimental Psychiatry*, *42*(1), 65–73.

SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.