Emotion

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Online First Publication, June 3, 2013. doi: 10.1037/a0032492

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1528-3542/13/$12.00 DOI: 10.1037/a0032492

Negative Emotional Experiences Arouse Rumination and Affect Working Memory Capacity

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Following an emotional experience, individuals are confronted with the persistence of ruminative thoughts that disturb the undertaking of other activities. In the present study, we experimentally tested the idea that experiencing a negative emotion triggers a ruminative process that drains working memory (WM) resources normally devoted to other tasks. Undergraduate participants of high versus low WM capacity were administered the operation-word memory span test (OSPAN) as a measure of availability of WM resources preceding and following the presentation of negative emotional versus neutral material. Rumination was assessed immediately after the second OSPAN session and at a 24-hr delay. Results showed that both the individual's WM capacity and the emotional valence of the material influenced WM performance and the persistence of ruminative thoughts. Following the experimental induction, rumination mediated the relationship between the negative emotional state and the concomitant WM performance. Based on these results, we argue that ruminative processes deplete WM resources, making them less available for concurrent tasks; in addition, rumination tends to persist over time. These findings have implications for the theoretical modeling of the long-term effects of emotions in both daily life and clinical contexts.

Keywords: rumination, emotion, working memory, executive processes

In the present study, we experimentally tested the idea that, following a negative emotion, individuals engage in a cognitive elaboration that drains resources normally devoted to other tasks. This postemotional elaboration has been defined as *rumination* and corresponds to a class of conscious thoughts "that revolve around a common instrumental theme and that recur in the absence of immediate environmental demands requiring the thoughts" (Martin & Tesser, 1996, p. 1). We expected that the availability of cognitive resources would be crucial for the individual to be able to correctly complete an ongoing task without being overwhelmed by rumination.

It has been long documented that after exposure to a traumatic event, many people experience recurrent thoughts or images related to the event (e.g., Bownes, O'Gorman, & Sayers, 1991; McCammon, Durham, Allison, & Williamson, 1988; Tait & Silver, 1989; Weisaeth, 1989; Wilkinson, 1983). Such symptoms can manifest themselves for extensive periods of time. Literature reports many cases that provide evidence of this. For instance, among people who had lost either a child or a spouse in a car accident, more than 90% continued to experience event-related repetitive thoughts or mental images 4–7 years later (Lehman, Wortman, & Williams, 1987). Among older people interviewed about the worst event happening in their lives, 71% reported that they continued to experience, at least occasionally, thoughts about episodes that had occurred on average 23 years previously (Tait & Silver, 1989). Twenty-four percent of those individuals experienced such symptoms frequently or even almost continuously. Only 4% were free from these mental reminiscences.

As in the case for traumas, after experiencing daily life emotions, individuals are confronted with their reappearance in hours, days, and even years after their occurrence (Rimé, Philippot, Boca, & Mesquita, 1992). This ruminative process might be "unintended and difficult to eliminate" despite the individuals' attempting "to rid themselves of these thoughts" (Martin & Tesser, 1996, p. 1). One of the most influential approaches to rumination—the response styles theory (Nolen-Hoeksema, 1991)—emphasizes the dysfunctional nature of the phenomenon. Rumination is considered as a mode of repetitively and passively thinking about causes, consequences, and symptoms of distress (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). By ruminating, people remain fixed on their problems and feelings, which leads to an increase in their state of distress (Lyubomirsky & Nolen-Hoeksema, 1993; Nolen-Hoeksema et al., 2008).

The literature on posttraumatic stress disorder (PTSD) has provided an important contribution in disentangling the complexity of

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We gratefully acknowledge the help of Antonella Bianco, Giuseppe Cozzoli Poli, Carmen Favia, Nadia Saponara, Roberta Colella, Federica Liso, Nicoletta Grieco, Marina Morgese, Antonella Minutillo, Rosa Murgolo, Rosa Papeo, and Francesca Rella in collecting the data.

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the phenomenon by differentiating rumination as unwanted thoughts from unwanted memories or images (Ehlers & Clark, 2000; Evans, Ehlers, Mezey, & Clark, 2007). The former include evaluative thoughts concerning the traumatic experience, and the latter are referred to as visual images and sensory impressions that seem to be happening here and now (Hackmann, Ehlers, Speckens, & Clark, 2004). Both unwanted thoughts and memories might be disturbing (Cann et al., 2011; Lindstrom, Cann, Calhoun, & Tedeschi, 2013) and might be experienced for a long time after a dramatic event. Individuals suffering from depression, anxiety, and PTSD often report difficulties with everyday activities because a great amount of their cognitive resources are engaged in dealing with these emotionally laden thoughts and feelings not relevant for concurrent tasks (Mason et al., 2007; Schweizer & Dalgleish, 2011). Although less extreme, individuals exposed to daily life emotions might experience a similar disturbance because of the persistence of emotion-related thoughts (Rimé, 2009; Silver & Wortman, 1980; Tait & Silver, 1989).

The debate about the consequences of ruminative formations (Segerstrom, Stanton, Alden, & Shortridge, 2003; Smith & Alloy, 2009) is extensive and remains open. About 30 years ago, Horowitz (1986) suspected that the cognitive processing that usually results from an emotional episode would enter in the competition for cognitive resources. This author stated, "Assuming a limited capacity for processing, such codings will remain stored in active memory even when other programs . . . have priority in the hierarchy of claims for channels" (p. 95). Following this intuition, we set up the present study to directly assess the impact of rumination of an emotional experience on the execution of a concomitant cognitive performance. To this purpose, we defined *rumination* as a persistent cognitive activity that results from the enduring psychological impact of an emotion that might be disturbing and difficult to interrupt (Silver & Wortman, 1980; Tait & Silver, 1989). We assumed that rumination encompasses both thoughts and/or intrusive memories and images concerning the original experience. Our interest was indeed in rumination as an ordinary process following a negative emotion and not in depressive rumination or rumination associated with emotional disorders (see Watkins, 2008, for a review on different forms of repetitive thinking).

Executive Functioning and Emotional Processes

A core mechanism implicated in dealing with competing tasks is *working memory* (WM), which has been defined as a complex system acting under the supervision of a central executive and responsible for directing the individual's attention toward the central task, thereby inhibiting concurrent irrelevant information (Baddeley, 1986; Baddeley & Hitch, 1974). A number of studies have shown that emotional processing might have a detrimental effect on WM performance. To illustrate, in a correlational study, Klein and Boals (2001) showed that intrusive memories concerning stressful life events were associated with poor performance on WM tasks, and they argued that stressful events are analogous to a secondary task sharing WM resources with a primary WM capacity task. More recently, Schweizer and Dalgleish (2011) developed a complex span measure of emotional WM capacity and showed that individuals suffering from PTSD performed worse on this task compared with trauma-exposed controls without PTSD.

Research has also considered the relationship between executive functioning and rumination. For instance, in an experimental study, Watkins and Brown (2002) showed that, for depressed patients, thoughts concerning emotional problems occupied central executive resources required for random number generation. The authors employed an experimental manipulation of rumination versus distraction, and found that, compared with controls, depressed individuals in the rumination condition had higher self-reported scores of ruminative thoughts and a reduced number of random sequences in the task. In that study, ruminative processes seemed to be an obstacle to the correct execution of a WM task.

In recent years, evidence has been accumulated concerning the association of rumination with failures and biases in executive functions. Davis and Nolen-Hoeksema (2000) found that ruminators committed significantly more perseverative errors and failed to shift mental set significantly more often than nonruminators on the Wisconsin Card Sorting Test. Whitmer and Banich (2007) ran two experiments showing that the tendency to engage in depressive rumination is highly associated with difficulties in inhibiting previously relevant mental settings. Joormann (2006) employed a negative priming paradigm to demonstrate that individuals with a tendency to ruminate have difficulties in inhibiting irrelevant emotional information being incidentally processed. Bernblum and Mor (2010) examined rumination-related biases in refreshing, a component process of memory updating, and showed that brooders—that is, individuals engaging in a maladaptive type of rumination—exhibited more biases in refreshing when task-relevant and task-irrelevant words were presented as compared with nonbrooders.

The studies so far reviewed have considered the effects of depressive rumination or rumination associated with emotional disorders on executive performances. Another line of research has focused on *mind wandering*, a ubiquitous tendency to flutter from one thought to another (Smallwood & Schooler, 2006; Watkins, 2008). Whereas Smallwood and Schooler (2006) maintained that mind wandering consumes executive resources normally devoted to other tasks, McVay and Kane (2010, 2012) proposed that the phenomenon arises from a failure of executive control over automatically generated thoughts. In general, studies on mind wandering have the merit of drawing researchers' attention to the relationship between an ordinary, nonpathological form of repetitive thinking and executive functioning. In our study, we moved from this evidence and from the above-reviewed results of studies on depressive rumination, and we assumed that repetitive thinking resulting from exposure to an emotional event would have a disturbing potential that might significantly impair concurrent executive performances.

Overview and Hypotheses

In the present study, we empirically tested the idea that negative emotional experiences would bring on a cognitive elaboration, and that this process would load on WM resources normally devoted to the execution of other tasks. Failures in WM performance following a negative emotion would then point to the persistence of an enduring postemotional cognitive activity taking the form of rumination. The novelty of our study is that we adopted a direct control on the individual's availability of WM resources and on the way it interferes with emotional processes. To our knowledge, no studies have so far experimentally investigated the connection between executive processes and ruminative thoughts after controlling for the individual's WM capacities.

To put into practice our ideas, we designed an experiment with two groups of individuals with low versus high WM capacity selected on the basis of their executive resources (Baddeley, 1986) through the administration of the Random Number Generation (RNG) task (Ginsburg & Karpiuk, 1994). The Ruminative Response Scale (RRS; Treynor, Gonzalez, & Nolen-Hoeksema, 2003) was preliminarily administered to participants to exclude any effect of the individual's dispositional tendency to engage in depressive rumination. Participants were then administered the operation-word memory span test (OSPAN; Turner & Engle, 1989) preceding and following the experimental presentation of negative emotional versus neutral material. The OSPAN was employed as a prototypical measure of WM capacity able to capture variations in sustaining attention and resisting interference (Rosen & Engle, 1998).[1] In accordance with studies on emotional processing and WM, we expected that, if experiencing a negative emotion results in a high load on WM resources, then a concurrent OSPAN performance would be more impaired than that for nonemotional experiences. Furthermore, we suggested that the individual's availability of WM resources would influence the performance on OSPAN tasks proposed shortly after this experience. More important, we expected an interaction effect of emotional valence by WM capacity in that individuals with low WM resources exposed to emotional material would have the worst OSPAN performance. We also predicted that the competition for resources created in the experiment would increase the need for the individual to complete the emotional elaboration in the long run. It follows that, compared with high WM capacity individuals, low WM capacity individuals would be more repetitively confronted with unprocessed material in the hours following the emotional induction, experiencing massive ruminative thoughts (Rimé, Mesquita, Philippot, & Boca, 1991; Rimé et al., 1992). Finally, and in line with studies on the association of rumination with failures in executive functions, the presence of ruminative thoughts was expected to mediate the effects of the emotional state on the concomitant WM performance. For the purposes of the present study, in assessing rumination, we paralleled the distinction between ruminative thoughts and intrusive memories proposed by Evans and colleagues (2007). The former construct was assessed through self-report indices inspired by the original work of Tait and Silver (1989) and Martin and Tesser (1996), referring to the duration and frequency of thoughts related to the emotional experience and their disturbing nature; the latter construct was assessed through the Impact of Event Scale—Revised (IES–R; Weiss, & Marmar, 1996), an instrument specifically intended to measure the amount of distress associated with a specific event in the forms of intrusion and avoidance.

Method

Participants and Design

A total of 100 participants (70% women; M_{age} = 27.23 years, SD = 8.75) were involved in the study. The study adopted a 2 × 2 between-subjects design, with WM capacity (high vs. low) and emotional valence (negative vs. neutral) as independent variables. The dependent variables of the study were (a) an index of individual performance on a WM task (OSPAN; Turner & Engle, 1989), (b) self-report indices of ruminative thoughts (i.e., rumination; Martin & Tesser, 1996; Rimé, Finkenauer, Luminet, Zech, & Philippot, 1998; Rimé et al., 1991, 1992; Tait & Silver, 1989), and (c) self-report indices of intrusion (IES-R; Weiss & Marmar, 1996).

Procedure

Participants were recruited through a snowball sampling method (Biernacki & Waldorf, 1981): Ten undergraduate students were involved in the study as a part of their assignment and, unaware of the research hypotheses, were asked to identify other individuals willing to take part in a study on general cognitive abilities. The process was reiterated until a large number of participants was obtained (N = 341; 55.1% women; M_{age} = 30.67 years, SD = 10.45). Preliminarily, RNG was administered to this sample of subjects and, after an inspection of the frequency distributions of the RNG scores, 50 individuals scoring below the first quartile and 50 scoring above the last quartile of the distribution were selected for the present study, representing two groups of, respectively, low versus high WM capacity (76% and 64% women, respectively). They were tested individually, and the whole session lasted 50 min on average.

On arriving in the lab, participants were administered the RRS and Differential Emotion Scale (DES; Izard, Dougherty, Bloxom, & Kotsch, 1974).[2] They were then seated in a quiet room in front of a computer, and the experimental session started with instructions presented on the screen through SuperLab Pro v4.0 software. As a first step, participants were administered the OSPAN test. They were then requested to read a two-page excerpt of either negative emotional or neutral valence. The negative condition consisted of an excerpt from the novel *The Wind-Up Bird Chronicle* by Haruki Murakami, which contained a realistic description of the torture of a prisoner of war by Mongolian soldiers. The neutral condition consisted of a description of the history and rules of the Game of the Goose, taken from Wikipedia. The two excerpts were tested in previous pilot studies as potential elicitors of negative versus neutral mood reactions. Participants were randomly assigned to one of the two emotional conditions, matched for gender, so that 25 high WM capacity and 25 low WM capacity individuals read the emotional excerpt and 25 high WM capacity

[1] The process of random number generation has been demonstrated to reflect the limited capacity of the executive system (see Baddeley, 1996), and a task built on this process, such as the RNG, appeared useful to us to select participants on the basis of their executive resources. We instead used OSPAN in the experimental phase because this task has been proven to directly engage the executive system by requiring the individual to keep task-relevant information active and accessible in memory during the execution of complex cognitive tasks (Conway et al., 2005). RNG and OSPAN tasks have been administered together in a previous investigation concerning the association between cognitive control and intrusive thoughts (Wessel, Overwijk, Verwoerd, & de Vrieze, 2008).

[2] Along with RRS and DES, at the test session participants were also administered the Thought Control Questionnaire (TCQ; Wells & Davies, 1994), assessing individual differences in controlling unwanted thoughts. Evidence concerning TCQ is not considered in the present article because the corresponding construct is of limited interest for the purposes of our work, and no significant effects of the predictor variables of the design were found on these scales.

and 25 low WM capacity individuals read the neutral description.[3] Immediately after the reading, participants took a new OSPAN test (with different equations and words, but with the same procedure), then provided a short description of the excerpt, answered questions concerning its emotional intensity, and retook the DES and rumination measures. Once at home, participants received a questionnaire by e-mail containing measures of rumination at a 24-hr interval and the IES–R. They were instructed to fill it in exactly 24 hr after their participation in the lab session and to send it back by e-mail. All participants returned the questionnaire by the due time. Neither data exclusion nor additional manipulations were run. One week after the lab session, participants were debriefed either individually or by e-mail.

Measures and Materials

Screening measures.

RNG (Ginsburg & Karpiuk, 1994). The RNG consists of a complex cognitive task able to load the central executive of WM system (Baddeley, 1986). It requires participants to say aloud a random sequence of 50 numbers (from 0 to 9), at a rate of one per second. RNG scores were calculated as the sum of the squared length of each nonrandom sequence of two or more digits. Higher the RNG score, the lower the individual's WM capacity.

RRS (Treynor et al., 2003). This scale requires participants to rate on twenty-two 4-point scales (1 = *never*, 4 = *always*) how often they engage in ruminative responses following sad or depressive feelings. Items were averaged into three composite indices of brooding (Cronbach's $\alpha = .82$), depression (Cronbach's $\alpha = .77$), and reflection (Cronbach's $\alpha = .70$).

Experimental phase.

DES (Izard et al., 1974; Izard, Libero, Putnam, & Haynes, 1993). Participants rated on 7-point scales (0 = *not at all*, 6 = *very much*) the degree to which they had felt eight basic emotions (joy, sadness, anger, fear, disgust, anxiety, shame, and happiness) at the moment of scale completion. Scores on Items joy and happiness were averaged to get the positive emotions index. In addition, scores on all other items were averaged to get the negative emotions index. The DES was administered twice, before and after the experimental manipulation, with Cronbach's alphas ranging from .78 to .88.

OSPAN (Turner & Engle, 1989). This test was adapted into Italian from the original procedure by Turner and Engle (1989), which has been proven to have high internal consistency (.75) and reliability (.88; Klein & Fiss, 1999). Participants read on a computer screen 60 strings, each composed of a simple mathematical equation (i.e., $[3 \times 4] - 5 = 7$) followed by a two-syllable word (i.e., *water*). The participants had to press a different key if they rated the answer to the equation as correct or incorrect. At the same time, they were requested to read out the word presented after the equation. The experimental phase was preceded by three practice trials. In the experimental phase, the strings were grouped into three blocks of five trials. After each trial, participants were requested to remember and write down as many words as possible from the strings. If the participant correctly identified the right and wrong equations in a given trial and, at the same time, remembered all words in the trial in the same order of presentation, a score corresponding to the number of strings of the trial was assigned to that participant. The total OSPAN scores in the present study ranged from 0 to 60.[4]

Emotional intensity. Participants were first requested to provide a short description of the excerpt read during the experimental phase and then to rate the intensity of the emotion experienced during the reading on an 11-point scale (0 = *not at all*, 10 = *the highest emotion in life*).

Rumination. Rumination was assessed through self-report indices inspired by the original work by Tait and Silver (1989) and Martin and Tesser (1996) and as elaborated by Rimé and colleagues (1991, 1992, 1998). Participants rated on 5-point scales ranging from 1 = *never* to 5 = *very often* (a) how long they had been thinking about the narrative excerpt, (b) the frequency of thoughts related to the reading, (c) how these thoughts were disturbing their concurrent activity, (d) the attempts to eliminate these thoughts, and (e) the difficulty in performing an ongoing activity since these thoughts (Martin & Tesser, 1996; Rimé et al., 1992; Tait & Silver, 1989). Items b, c, d, and e were proposed both at the end of the lab session and after a 24-hr delay, and Item a was administered only after the 24-hr delay because it explicitly assessed the prolongation of the phenomenon over time. Two composite scores of rumination were then obtained by averaging Items b, c, d, and e taken at the end of the lab session (Cronbach's $\alpha =$ .92) and by averaging Items a, b, c, d, and e taken after the 24-hr delay (Cronbach's $\alpha = .82$).

IES–R (Weiss & Marmar, 1996). An adapted version of the IES–R was administered, assessing participants' responses to the exposure to emotional material in the 24-hr delay from their participation in the lab session, rather than in the last 7 days as was the case in the original version. The IES–R comprises twenty-two 5-point scales ranging from 0 = *not at all* to 4 = *very much*. All items were summed into a total IES–R score (Cronbach's $\alpha =$ .91). In addition, two subdimensions of intrusion (Cronbach's $\alpha =$ .79) and avoidance (Cronbach's $\alpha = .71$) were computed from two subsets of items of the scale.

Results

Screening Analysis

Preliminarily, scores on the RNG index were compared across the conditions of the design through a 2×2 analysis of variance

[3] The sample size for each cell of the design ($n = 25$) was determined following the guidelines by J. Cohen (1988) by setting the significance level at $p = .05$, numeration degrees of freedom for interaction effects = 1, desired power = .80, and ANOVA effect size $f = .40$ (i.e., $\eta^2 = .14$). Indeed, the strict application of Cohen's formula gave us the value of $n =$ 26, which was then approximated to 25.

[4] It is also possible to compute the operation OSPAN score by considering the correct identification of equations in the strings and the word OSPAN score by considering only the recollection of the words of the strings in the same order of presentation (Turner & Engle, 1989). The operation and word OSPAN scores also ranged from 0 to 60. In the present study, only the results concerning the total OSPAN scores are reported because this score appeared as a more valid index of WM functioning given that it requires a correct recollection of both components (operation and words) of the OSPAN test. In addition, findings concerning the operation and word OSPAN indices substantially replicated the findings of the total OSPAN index. They are not reported to avoid redundancies in the presentation of results.

(ANOVA), with emotional valence (negative vs. neutral) and WM capacity (high vs. low) as between-subjects factors. As shown in Table 1, neither the main effect of emotional valence nor the interaction effect was significant. The only significant effect was for WM capacity: High WM capacity participants scored lower (M = 27.40, SD = 16.36) than low WM capacity participants (M = 50.32, SD = 56.07). These results provided confirmation for the screening procedure adopted to select high and low WM capacity individuals from the total sample, and allowed us to exclude any confounding concerning participants' WM ability on the two conditions of the emotional valence factor.

Subsequently, a multivariate analysis of variance was run on the three indices of RRS, with emotional valence (negative vs. neutral) and WM capacity (high vs. low) as independent variables. None of the multivariate tests was found to be significant (Pillai's trace ranged from .03 to .05, Fs < 1.65, *ns*, partial $\eta^2 < .05$). Neither the main nor interaction effects for the univariate tests reached the significance level (see Table 1). It follows that participants did not differ in their tendency toward depressive rumination as assessed by the RRS, so that all selected individuals were included in the final sample.

Manipulation Checks

To exclude individual differences in the emotional state before the experimental manipulation and to verify the effect of the emotional induction, we analyzed positive and negative DES scores through 2 × 2 × 2 mixed design ANOVAs, with emotional valence (negative vs. neutral) and WM capacity (high vs. low) as between-subjects factors and test–retest as a within-subjects factor (see Table 2). For the positive DES index, the main effect of test–retest was significant in that scores significantly decreased at retest (M_{test} = 2.84, SD = 1.68; M_{retest} = 0.67, SD = 1.22). The interaction of test–retest by emotional valence was also significant (see Figure 1, left panel). Simple effect analyses run to examine this interaction showed that the positive DES scores significantly differed in the two emotional valence conditions at retest, $F(1, 98) = 9.80$, $p < .005$, partial $\eta^2 = .09$, with lower scores reported in the negative condition than in the neutral one, whereas no significant difference was found at test, $F(1, 98) = 0.22$, *ns*, partial $\eta^2 = .00$ (see average DES scores in Table 2). Neither the other main nor interaction effects reached the significance level.

With respect to negative emotion scores, the main effects of emotional valence and test–retest were significant (see Table 2): The negative DES indices appeared to increase at retest (M_{test} = 0.84, SD = 0.94; M_{retest} = 1.37, SD = 1.49), and these scores were higher for the negative than for the neutral condition ($M_{negative}$ = 1.65, SD = 0.82; $M_{neutral}$ = 0.57, SD = 0.65). The interaction effect of test–retest by emotional valence was also significant (see Figure 1, right panel). Neither the other main nor interaction effects reached the significance level. Simple effect analyses to examine the interaction showed that the negative DES scores significantly differed in the two emotional valence conditions at retest, $F(1, 98) = 109.41$, $p < .001$, partial $\eta^2 = .53$, with higher scores reported in the negative condition than in the neutral one, whereas no significant difference was found at test, $F(1, 98) = 0.00$, *ns*, partial $\eta^2 = .00$ (see average DES scores in Table 2). Findings on positive and negative DES scores, jointly considered, allowed us to run the subsequent analyses for the whole sample of participants because no significant differences were found in their emotional state before the experimental induction. Furthermore, these findings confirmed that the experimental manipulation of participants' emotional state was successful. As compared with reading the neutral excerpt, reading the negative emotional excerpt had the effect of significantly increasing the negative and decreasing the positive emotional state in our sample.

The index of emotional intensity was analyzed in a 2 × 2 between-subjects design ANOVA, with emotional valence (negative vs. neutral) and WM capacity (high vs. low) as between-subjects factors (see Table 1). The only significant effect was of emotional valence, with individuals in the negative condition scoring significantly higher than individuals in the neutral condition ($M_{negative}$ = 6.22, SD = 2.48; $M_{neutral}$ = 0.60, SD = 1.32). Neither the other main nor the interaction effects were found to be significant. These findings provided further confirmation for the efficacy of our manipulation.

Analyses on WM Performance Indices

To test the hypothesis that the availability of WM resources would be reduced after a negative emotional experience as compared with a neutral one especially for low WM capacity individuals, we entered OSPAN total scores in a 2 × 2 × 2 mixed design ANOVA, with emotional valence (negative vs. neutral) and WM

Table 1
Effect of Emotional Valence and WM Capacity on RNG, RRS, and Emotional Intensity Scores

	Neutral emotional valence Mean (*SD*)		Negative emotional valence Mean (*SD*)		F (partial η^2)		
Measure (range)	Low WM	High WM	Low WM	High WM	Emotional valence (*a*)	WM capacity (*b*)	*a* × *b*
RNG (0–328)	52.96 (52.04)	31.09 (19.31)	47.68 (60.80)	24.50 (13.27)	0.35 (.00)	7.57* (.07)	0.00 (.00)
RRS—Brooding (1–4)	2.00 (0.49)	1.99 (0.43)	2.05 (0.49)	2.37 (0.56)	4.00 (.04)	2.97 (.03)	2.27 (.02)
RRS—Depression (1–4)	2.02 (0.72)	1.93 (0.49)	2.01 (0.47)	2.29 (0.62)	1.86 (.02)	0.93 (.01)	2.02 (.02)
RRS—Reflection (1–4)	1.81 (0.61)	1.97 (0.77)	1.92 (0.52)	2.08 (0.64)	0.19 (.00)	1.74 (.01)	0.19 (.00)
Emotional intensity (0–10)	0.48 (0.96)	0.41 (0.96)	5.80 (2.45)	6.25 (2.80)	199.99** (.68)	1.85 (.02)	0.57 (.01)

Note. WM = working memory; RNG = Random Number Generation task; RRS = Ruminative Response Scale. Maximum RNG scores derive from the empirical distribution. Degrees of freedom for Fisher's F statistics = 1, 96.
* $p < .01$. ** $p < .001$.

Table 2
Effect of Emotional Valence, WM Capacity, and Test–Retest on DES Scores

Measure (range)	Neutral emotional valence Mean (*SD*)		Negative emotional valence Mean (*SD*)		F (partial η^2)						
	Low WM	High WM	Low WM	High WM	Emotional valence (*a*)	WM capacity (*b*)	Test–retest (*c*)	$a \times b$	$a \times c$	$b \times c$	$a \times b \times c$
Positive DES test (0–6)	2.56 (1.76)	2.98 (1.66)	2.64 (1.70)	3.16 (1.64)	1.14 (.01)	0.53 (.01)	178.61** (.65)	.02 (.00)	7.48* (.07)	3.51 (.04)	.50 (.01)
Positive DES retest (0–6)	1.02 (1.49)	1.18 (1.47)	0.44 (1.03)	0.14 (0.40)							
Negative DES test (0–6)	1.27 (1.17)	0.46 (0.57)	0.90 (0.99)	0.71 (0.79)	55.55** (.37)	2.98 (.03)	16.64** (.15)	2.60 (.03)	67.39** (.41)	3.13 (.03)	1.27 (.01)
Negative DES retest (0–6)	0.35 (0.83)	0.15 (0.25)	2.41 (1.18)	2.32 (1.45)							

Note. WM = working memory; DES = Differential Emotion Scale. Degrees of freedom for Fisher's F statistics = 1, 96.
* $p < .01$. ** $p < .001$.

capacity (high vs. low) as between-subjects factors and test–retest as a within-subjects factor. As shown in Table 3, the main effects of the WM capacity and the test–retest factors were significant, whereas the main effect of the emotional valence factor was not significant: Participants' OSPAN performance was generally poorer for low WM capacity individuals than for high WM capacity participants ($M_{\text{low WM}} = 15.44$, $SD = 9.69$; $M_{\text{high WM}} = 41.37$, $SD = 14.11$), and generally decreased at retest ($M_{\text{test}} = 32.79$, $SD = 17.57$; $M_{\text{retest}} = 24.02$, $SD = 20.01$). The two-way interactions of test–retest by emotional valence and by WM capacity were also significant, whereas the interaction effect of emotional valence by WM capacity did not approach significance. The significant two-way interactions were qualified by the three-way interaction that, in accordance with our predictions, was found to reach the significance level (see Figure 2). Simple effect analyses confirmed that for both low and high WM capacity individuals, OSPAN performance remained substantially stable in the neutral condition: respectively, $F(1, 98) = 0.49$, *ns*, partial $\eta^2 = .00$, and $F(1, 98) = 0.19$, *ns*, partial $\eta^2 = .00$, respectively. However, it exhibited a significant reduction after reading the negative excerpt: $F(1, 98) = 89.84$, $p < .001$, partial $\eta^2 = .48$, and $F(1, 98) = 14.90$, $p < .001$, partial $\eta^2 = .14$, respectively; this effect was observed at a much higher level of OSPAN scores for high WM capacity individuals than for low WM capacity individuals, Fs(1, 97) > 31.25, ps $< .001$, partial $\eta^2 > .24$ (see average OSPAN scores in Table 3).

Finally, to verify that the extent of the decline in OSPAN performance differed for low and high WM capacity participants after reading the negative excerpt, we subtracted OSPAN scores at retest from OSPAN scores at test and analyzed the difference through a 2 × 2 between-subjects ANOVA, with emotional valence (negative vs. neutral) and WM capacity (high vs. low) as independent factors (see Table 4). This analysis resulted in significant main effects of emotional valence and WM capacity, confirming that the difference in the OSPAN scores was higher following the emotional excerpt than after the presentation of neutral material ($M_{\text{negative}} = 16.14$, $SD = 13.05$; $M_{\text{neutral}} = 1.40$, $SD = 6.38$) and for individuals with low rather than high WM capacity ($M_{\text{low WM}} = 11.36$, $SD = 13.43$; $M_{\text{high WM}} = 6.18$, $SD = 11.31$). The interaction effect was also significant: In the negative emotional condition, the difference in the OSPAN scores was higher for low WM capacity individuals than it was for high WM capacity individuals, $F(1, 97) = 8.42$, $p < .005$, partial $\eta^2 = .07$ (see average OSPAN difference scores in Table 4), whereas no effect was found in the neutral condition, $F(1, 97) = 0.01$, *ns*, partial $\eta^2 = .00$.

Analyses on Rumination and IES–R

Two between-subjects ANOVAs were run on the scores of rumination collected at the end of the lab session and at a 24-hr delay, with emotional valence (negative vs. neutral) and WM capacity (high vs. low) as between-subjects factors (see Table 4). As regards the index of rumination after the lab session, the main effects of both emotional valence and WM capacity were significant: The scores for rumination were higher for the negative than for the neutral condition ($M_{\text{negative}} = 2.92$, $SD = 1.27$; $M_{\text{neutral}} = 1.55$, $SD = 0.72$) and for low than for high WM capacity participants ($M_{\text{low WM}} = 2.67$, $SD = 1.38$; $M_{\text{high WM}} = 1.80$, $SD = 0.89$). Furthermore, the interaction effect

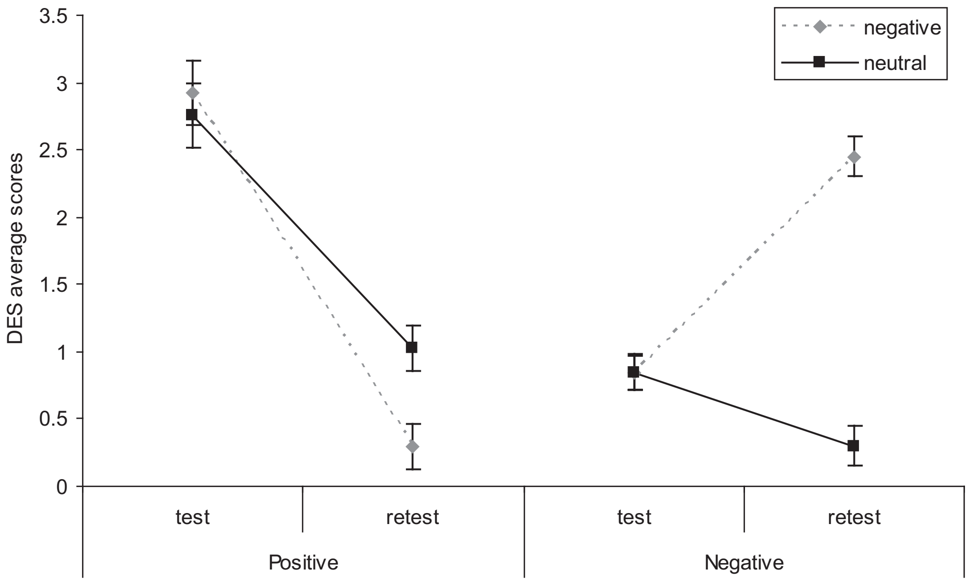

Figure 1. Two-way interaction effects of emotional valence by test–retest on Differential Emotion Scale (DES) scores. Error bars represent ±1 *SE*.

of emotional valence by WM capacity reached the significance level. The analysis of the simple effects of WM capacity within the two emotional valence conditions revealed a significant difference between low and high WM capacity participants reading the negative excerpt, $F(1, 97) = 19.46$, $p < .001$, partial $\eta^2 = .17$, whereas no difference was found in the neutral condition, $F(1, 97) = 0.99$, *ns*, partial $\eta^2 = .00$. Indeed, as Table 4 shows, low WM capacity participants in the negative condition reported the highest ratings of rumination after the lab session.

This pattern of results was replicated for ratings of rumination after the 24-hr delay (see Table 4), with significant main effects of emotional valence and WM capacity: Ruminative thoughts assessed after 24 hr were reported as more prevalent in the negative condition ($M_{\text{negative}} = 2.41$, $SD = 0.98$; $M_{\text{neutral}} = 1.88$, $SD = 0.57$) and by low WM capacity participants ($M_{\text{low WM}} = 2.46$, $SD = 1.00$; $M_{\text{high WM}} = 1.83$, $SD = .48$). The interaction effect also reached the significance level, and the analysis of the simple effects showed a significant difference between low and high WM capacity participants in the negative condition, $F(1, 97) = 18.39$, $p < .001$, partial $\eta^2 = .16$, whereas no difference was found in the neutral condition, $F(1, 97) = 2.26$, *ns*, partial $\eta^2 = .02$. Indeed, as shown in Table 4, the highest ratings of rumination after the 24-hr delay were obtained by low WM capacity participants assigned to the negative condition.

The IES–R measures (total, intrusion, and avoidance scores) were also analyzed through 2 × 2 between-subjects design ANOVAs, with emotional valence (negative vs. neutral) and WM capacity (high vs. low) as between-subjects factors (see Table 4).[5] Only the main effect of emotional valence was found to be significant for the total IES–R score, as well as for the subdimensions of intrusion and avoidance, in that all of these measures scored higher in the negative than in the neutral condition (total IES–R scores: $M_{\text{negative}} = 12.80$, $SD = 11.50$; $M_{\text{neutral}} = 3.64$, $SD = 7.02$; intrusion: $M_{\text{negative}} = 5.74$, $SD = 4.57$; $M_{\text{neutral}} = 1.34$, $SD = 1.45$; avoidance, $M_{\text{negative}} = 3.52$, $SD = 3.40$; $M_{\text{neutral}} = 1.22$, $SD = 2.41$). Neither the main effect of WM capacity nor the interaction effect was found to be significant. This result demonstrates that the emotional impact of an experience is able to trigger intrusive images and sensory reexperiencing, whereas the individual's availability of WM resources does not play any role on these variables.

Relationship Between WM Performance and Rumination

The analyses reported in the two preceding sections showed that emotional valence and WM capacity interactively affected both WM performance (OSPAN) and rumination scores. Jointly considered, these effects seem to indicate that, after exposure to an emotional excerpt, rumination and WM tasks compete for resources so that people low in WM capacity respond to negative emotions by ruminating and this rumination depletes WM resources, making them less available for concurrent tasks. Indeed, this interpretation calls for testing a mediating model of rumination between the negative emotion induced by the excerpt and WM performance. To this purpose, we applied a mediator model (Preacher & Hayes, 2008) through the PROCESS SPSS computational tool (Hayes, 2012) on the indices of negative emotion (negative DES scores after the experimental induction; independent variable [IV]), WM performance (OSPAN retest scores; dependent variable [DV]), and rumination (rumination scores at the end of lab session; mediator [M]; see Figure 3). Given the limited sample size and to prevent the effects of violation of normal

[5] Given that IES–R scores appeared moderately skewed (skewness index ranging from 1.34 to 1.70), the analyses were repeated after running square-root transformations (skewness index ranging from 0.31 to 0.50, $SE = 0.24$). The pattern of results was repeated after these transformations, with significant main effects of the emotional valence, $Fs(1, 96) > 22.38$, $ps < .001$, partial $\eta^2 > .19$, and not significant effects of WM capacity and interaction effects, $Fs(1, 96) < 2.67$, *ns*, partial $\eta^2 < .03$.

Table 3
Effect of Emotional Valence, WM Capacity, and Test–Retest on OSPAN Scores

Measure (range)	Neutral emotional valence Mean (*SD*)		Negative emotional valence Mean (*SD*)		F (partial η^2)						
	Low WM	High WM	Low WM	High WM	Emotional valence (*a*)	WM capacity (*b*)	Test–retest (*c*)	$a \times b$	$a \times c$	$b \times c$	$a \times b \times c$
OSPAN test (0–60)	17.68 (11.96)	42.23 (16.22)	24.56 (11.10)	46.21 (12.53)	1.56 (.02)	114.26** (.54)	81.31** (.46)	0.00 (.00)	57.42** (.37)	7.09* (.07)	6.24* (.06)
OSPAN retest (0–60)	16.12 (12.67)	40.91 (15.70)	3.40 (5.61)	36.21 (16.37)							

Note. WM = working memory; OSPAN = operation-word memory span test. Degrees of freedom for Fisher's F statistics = 1, 96.
* $p < .01$. ** $p < .001$.

distribution assumptions, we used the nonparametric bootstrapping method as a robust estimation of both direct and indirect effects (Preacher & Hayes, 2008), which provided a confidence interval (CI) around the indirect effect of the IV on the DV via M. Mediation is significant if the interval between the upper limit and lower limit of a bootstrapped 95% CI does not contain zero, which means that the mediating effect is different from zero (Preacher & Hayes, 2008). As shown in Table 5, rumination at the end of the lab session fully mediated the link between negative DES scores and OSPAN performance at retest: In other words, our data showed that negative emotion leads to rumination, which in turn leads to impaired performance on a WM task. To rule out the alternative possibility that negative emotion leads to an increase in rumination, which is mediated by a reduction in WM resources, we also tested a mediation model in which negative DES scores after the experimental induction (IV) affect the OSPAN retest performance (M), which in turn influences rumination (DV). Table 6 displays the effects on rumination scores at the end of the lab session and after a 24-hr delay. None of these models was found to confirm this alternative view.[6]

Finally, one of the assumptions of the present work was that the availability of WM resources is inversely correlated with long-term rumination. This prediction was tested through a partial correlation analysis between the OSPAN and rumination scores after the 24-hr delay controlling for rumination at the lab session. This control was included to ensure that the findings concerning rumination were exclusively related to WM resources. Rumination after the 24-hr delay was significantly associated with OSPAN scores at both test ($r = -.29$, $p < .005$) and retest ($r = -.30$, $p < .005$). Furthermore, this association was found to be significant and much stronger in the negative condition (for OSPAN test, $r = -.45$, $p < .005$; for OSPAN retest, $r = -.42$, $p < .005$) than in the neutral one (for OSPAN test, $r = -.26$, *ns*; for OSPAN retest, $r = -.17$, *ns*). By contrast, a partial correlation analysis between OSPAN and IES–R scores controlling for rumination after the lab session resulted in nonsignificant associations ($r < .17$, *ns*). It follows that WM performance was inversely associated with the indices of persistence of long-term ruminative thoughts but not with the IES–R measures.

[6] One anonymous referee argued that the mediation effect of rumination between negative emotion and WM performance might be due to the fact that our composite index of rumination included items (e.g., c, d, e; see Measures section) reflecting cognitive interference and difficulty coping with this interference. To rule out this possibility, we ran all mediation analyses by excluding these items, and we obtained the same effects observed on the composite score of rumination: The relationship between negative emotion and WM performance was still mediated by rumination at the end of lab session: effect IV-M = 0.44 (0.08), $p < .001$, $R^2 = .22$, $F(1, 98) = 27.72$, $p < .001$; effect M-DV = −6.69 (1.45), $p < .001$, $R^2 = .21$, $F(1, 97) = 18.89$, $p < .001$; direct effect IV-DV = 0.34 (1.38), *ns*, indirect effect = −2.97 (0.98), $p < .001$, 95% CI [−5.09, 1.49]. However, rumination did not mediate the relationship between negative emotion and WM performance: for rumination at the end of the lab session: effect IV-M = −2.63 (1.33), $p < .05$, $R^2 = .04$, $F(1, 98) = 3.89$, $p < .05$; effect M-DV = −0.03 (0.01), $p < .001$, $R^2 = .36$, $F(1, 97) = 27.25$, $p < .001$; direct effect IV-DV = 0.37 (0.08), $p < .001$, indirect effect = 0.07 (0.04), *ns*, 95% CI [0.00, 0.16]; for rumination after 24 hr: effect IV-M = −2.63 (1.33), $p < .05$, $R^2 = .04$, $F(1, 98) = 3.89$, $p < .05$; effect M-DV = −0.02 (0.00), $p < .001$, $R^2 = .27$, $F(1, 97) = 16.74$, $p < .001$; direct effect IV-DV = 0.23 (0.06), $p < .001$, indirect effect = 0.04 (0.03), *ns*, 95% CI [0.01, 0.11]. The values within parentheses following effects and indirect effects are standard errors (SE).

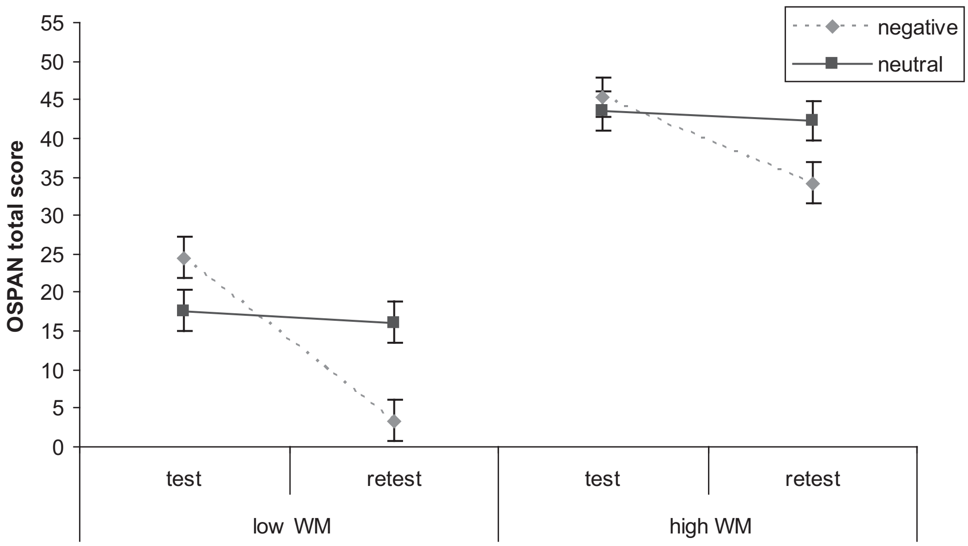

Figure 2. Three-way interaction effects of emotional valence by working memory (WM) capacity by test–retest on the operation-word memory span test (OSPAN) scores. Error bars represent ±1 *SE*.

Discussion

The present study empirically tested the idea that experiencing a negative emotion triggers a resource-consuming process competing with the execution of other WM tasks. Rumination was expected to arise following a negative event as a consequence of the individual's inability to effectively process his or her emotional experience. The findings of the present study confirmed our hypotheses: As compared with individuals with low WM capacity, individuals with high WM resources were found to be more successful in a WM task proposed shortly after the exposure to negative material and to ruminate to a lower extent at a longer delay. By contrast, the worst WM performance and the highest rates of ruminative thoughts were found for low WM capacity individuals assigned to the negative emotional condition. In sum, the present findings demonstrate that both the emotional valence of an experience and the individual's WM capacity are predictive of the performance on WM tasks proposed shortly after this experience, as well as of the ruminative thoughts supervening in the 24 hr to follow. In addition, the current results confirmed a mediation model in which ruminative thoughts elicited by the exposure to negative emotional experiences mediate the effects of the emotional impact of these experiences on concomitant WM performance.

At odds with rumination, no effects of participants' WM capacity were observed on the IES–R measures because these indices appeared influenced only by the emotional valence of the experience. In studies by Brewin and Beaton (2002) and Brewin and Smart (2005), the presence of intrusive formations was found to be negatively related to WM capacities only when participants were explicitly requested to suppress these formations. The authors concluded that the availability of WM resources is crucial when active control over mental processes is required. In the present study, no specific request to mentally suppress undesired material related to the experimental manipulation was proposed to participants: In this regard, our setting was more similar to a real-life situation in which individuals are free to think back on their

Table 4
Effect of Emotional Valence and WM Capacity on OSPAN Difference, Rumination, and IES–R Scores

Measure (range)	Neutral emotional valence Mean (*SD*)		Negative emotional valence Mean (*SD*)		*F* (partial η^2)		
	Low WM	High WM	Low WM	High WM	Emotional valence (*a*)	WM capacity (*b*)	*a* × *b*
OSPAN difference (–16 to 56)	1.56 (6.23)	1.24 (6.66)	21.16 (11.37)	11.12 (12.88)	57.42**** (.37)	7.09** (.07)	6.24* (.06)
Rumination lab session (1–5)	1.71 (0.77)	1.31 (0.58)	3.63 (1.18)	2.19 (0.92)	57.24**** (.37)	23.08**** (.19)	9.23*** (.09)
Rumination after 24 hr (1–5)	2.05 (0.65)	1.72 (0.44)	2.88 (1.12)	1.94 (0.50)	13.18**** (.12)	18.88**** (.16)	4.37* (.04)
IES–R total score (0–88)	3.48 (5.67)	4.05 (8.76)	14.96 (12.47)	9.71 (10.06)	23.26**** (.20)	1.11 (.01)	1.49 (.02)
IES–R—Intrusion (0–28)	1.24 (2.07)	1.50 (2.97)	6.04 (4.61)	4.96 (4.57)	35.42**** (.27)	0.07 (.00)	0.29 (.00)
IES–R—Avoidance (0–32)	1.40 (2.61)	1.09 (2.35)	4.40 (3.89)	2.43 (2.56)	15.66**** (.14)	3.33 (.03)	1.45 (.02)

Note. WM = working memory; OSPAN = operation-word memory span test; IES–R = Impact of Event Scale—Revised. Degrees of freedom for Fisher's *F* statistics = 1, 96.
* $p < .05$. ** $p < .01$. *** $p < .005$. **** $p < .001$.

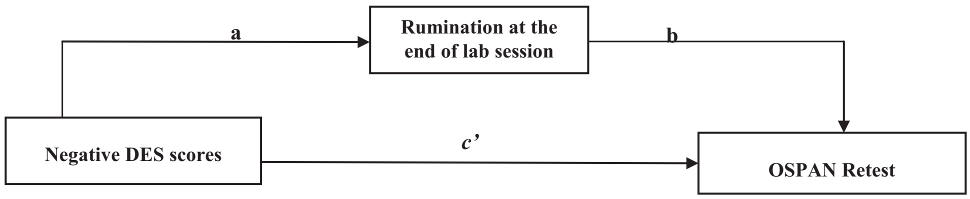

Figure 3. Theoretical model of mediation of rumination at the end of lab session between negative Differential Emotion Scale (DES) scores and operation-word memory span test (OSPAN) performance at retest.

emotional experiences without direct constraints on this process. Furthermore, and more important, our results provide support for the theoretical and empirical distinction between rumination and intrusion (Evans et al., 2007): The former appeared more like a cognitive process consisting in repetitively thinking about an emotional event and influenced by the individual's WM resources, whereas the latter mainly consisted of sensory impressions of short duration rapidly arising from the original experience as a consequence of its emotional impact (Ehlers & Clark, 2000; Hackmann et al., 2004).

An important strength of the present study is that it focused on ruminative processes elicited by ordinary (nontraumatic) emotional experiences. Previous research on rumination and cognitive functioning has mainly focused on the individual's ruminative style as a stable personality trait or as a pathological tendency (De Lissnyder et al., 2012; Joormann, 2006; Joorman & Gotlib, 2008; Whitmer & Banich, 2007). This made it difficult to draw conclusions on rumination of daily life emotions. In contrast, our results have evident implications for the investigation of emotional processes occurring in the real world and also shed some light on understanding rumination processes in clinical contexts.

The current findings provide a contribution to the investigation of the relationship between the cognitive and emotional systems, for which two alternative accounts have been proposed in literature. The first relies on a model of WM as a limited capacity system: When individuals experience stressful events, the associated cognitive representations compete for attentional resources with other task demands (Antrobus, 1968; Teasdale et al., 1995). Following this account, Klein and Boals (2001) showed that intrusive formations concerning stressful experiences are associated with a poor WM performance because the processing of these experiences share the same resources required to perform the WM task.

In contrast, other studies have suggested that the emotional and executive systems are mutually interacting and the same mechanisms are shared across functions (Pessoa, 2009) so that when executive resources are required, responses to emotional stimuli might be actively suppressed. Following these accounts, N. Cohen, Henik, and Mor (2010) and N. Cohen, Henik, and Moyal (2011) experimentally showed that negative emotional cues interfered with participants' performance on the Attentional Network Test when no executive conflict was present (e.g., when participants were requested to process congruent stimuli), not when enhanced executive control was required (e.g., when participants were asked to process incongruent stimuli).

Testing specific expectations deriving from each of the two accounts was beyond the scope of the current study. We proposed that rumination is a process able to deplete executive resources, which endures over time as a consequence of this exhaustion of resources. Our work has the merit of being the first to submit these ideas to experimental scrutiny, and the above-reported results from ANOVAs, mediation, and correlation analyses offer support to the various aspects of our reasoning.

We acknowledge that the present study has some limitations. First, the emotional event chosen as a stimulus for the present study was an excerpt from a novel. It is possible that the two excerpts may have differed not only in the emotional reaction they elicited but also in their complexity and influence on the cognitive load imposed on our participants. This confounding might indeed be avoided by asking individuals to think about their own autobiographical experiences. In addition, personal events could have a stronger emotional impact, thus increasing the ecological validity of the research. However, given the high variability of individuals' emotional lives, personally relevant events might not represent standardized elicitors for the process under investigation. A specifically intended control procedure over this variability could be helpful in this regard.

Second, in the present study, we did not consider why individuals might initially have low WM capacity. The work of Klein and Boals (2001) suggested that this might be because of their exposure to current life stress; other studies have considered the role of anxiety in affecting cognitive performance (see, for a review, Eysenck, Derakshan, Santos, & Calvo, 2007). Furthermore, administering the RRS at the beginning of the experimental session might have served to prime participants' negative mood differentially for the different experimental groups. Future studies should control for dispositional characteristics of participants and minimize the risk of confounding in experimental setting.

Third, future research should provide a deeper investigation into the modality-specific interference of emotional material processed during a concurrent WM task (Kemps & Tiggemann, 2007). According to Baddeley's (1986; Baddeley & Hitch, 1974) model of WM, two slave subsystems work under the supervision of the central executive: the phonological loop and the visuospatial sketchpad. Visual images selectively load the visuospatial sketchpad, and auditory material specifically loads the WM phonological loop, and this modality-specific interference has been proven to affect the ratings of vividness and emotionality of trauma-related images (Andrade, Kavanagh, & Baddeley, 1997; Baddeley & Andrade, 2000). In our study, only the role of the central executive system was considered, independent of the involvement of the two WM slave subsystems. It is possible that both difficulties in WM performance and long-term rumination would be more dramatic when the emotional

Table 5
Summary of Mediation Analysis of Rumination at the End of Lab Session Between Negative DES Scores and OSPAN Performance at Retest (5,000 Bootstraps)

Independent variable (IV)	Mediator (M)	Dependent variable (DV)	Effect of IV on M (*a*) $R^2 = .25^{**}$ $F(1, 98) = 32.60^{**}$	Effect of M on DV (*b*) $R^2 = .27^{**}$ $F(2, 97) = 17.60^{**}$	Direct effect (*c′*)	Indirect effect: $a \times b$	Indirect effect: 95% CI	Total effect (*c*)
Negative emotions	Rumination end of lab session	OSPAN retest	0.42 (*SE* = 0.07)**	−8.90 (*SE* = 1.62)**	1.08 (*SE* = 1.35)	−3.72 (*SE* = 0.94)**	[−5.86, −2.26]	−2.63 (*SE* = 1.33)*

Note. DES = Differential Emotion Scale; OSPAN = operation-word memory span test.
* $p < .05$. ** $p < .001$.

Table 6
Summary of Mediation Analysis of OSPAN Retest Scores Between Negative DES Scores and Rumination at the End of the Lab Session and After the 24-Hr Delay (5,000 Bootstraps)

Independent variable (IV)	Mediator (M)	Dependent variable (DV)	Effect of IV on M (*a*)	Effect of M on DV (*b*)	Direct effect (*c′*)	Indirect effect: $a \times b$	Indirect effect: 95% CI	Total effect (*c*)
			$R^2 = .04^{*}$ $F(1, 98) = 3.87^{*}$	$R^2 = .43^{**}$ $F(2, 97) = 36.23^{**}$				
Negative emotions	OSPAN retest	Rumination end of lab session	−2.63 (*SE* = 1.33)*	−0.03 (*SE* = 0.00)**	0.35 (*SE* = 0.06)**	0.07 (*SE* = 0.94)	[0.005, 0.15]	.42 (*SE* = .07)**
			$R^2 = .04^{*}$ $F(1, 98) = 3.89^{*}$	$R^2 = .28^{**}$ $F(2, 97) = 18.99^{**}$				
Negative emotions	OSPAN retest	Rumination after 24 hr	−2.63 (*SE* = 1.33)*	−0.02 (*SE* = 0.00)**	0.17 (*SE* = 0.06)**	0.05 (*SE* = 0.03)	[0.003, 0.13]	0.23 (*SE* = 0.06)**

Note. OSPAN = operation-word memory span test; DES = Differential Emotion Scale.
* $p < .05$. ** $p < .001$.

material to be processed shares the same sensory modality with the content of the concurred WM task, thus requiring a selective activation of one of the two WM subsystems.

Finally, in the current research, we took into account only negatively valenced emotional experiences as elicitors of rumination. Negative emotional experiences and their cognitive consequences represent a higher disruption to be processed as compared with positive experiences, thus engaging more cognitive resources both immediately after and at a long-term delay (Silver, Boon, & Stones, 1983; Tait & Silver, 1989). It is reasonable to expect that the observed effects would not be replicated for positively valenced emotional stimuli.

To conclude, in this study, theory-based predictions on cognitive consequences of negative experiences were tested in an experimental design. Our findings establish that the mere exposure to a negative emotion significantly and durably affected participants' cognitive activity. This leads to a serious consideration of theories according to which current life emotional episodes entail significant cognitive consequences lasting far beyond the episode itself (e.g., Martin & Tesser, 1996; Rimé, 2009). Until now, such consequences were considered to be the result of exposure to traumatic experiences. Our results clearly indicate that this consideration might also be extended to daily life emotional situations. Findings concerning the cognitive predictors of rumination could have important implications for the general understanding of the emotion regulation process. Studies on this topic have considered thought suppression and rumination among the maladaptive emotion regulation strategies (Dalgleish, Hauer, & Kuyken, 2008; Gross, 2007). Future research should attempt to integrate the idea of the WM load in triggering rumination into a more comprehensive model of emotional regulation (Gross, 2007) in both clinical and nonclinical contexts.

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Received May 17, 2012
Revision received January 22, 2013
Accepted March 5, 2013 ■