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The effects of mindfulness on executive processes and autobiographical memory specificity

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ABSTRACT

Previous studies have found that mindfulness training reduces overgeneral memories and increases autobiographical memory specificity (e.g., [Williams, J. M. G., Teasdale, J. D., Segal, Z. V., & Soulsby, J. (2000). Mindfulness-based cognitive therapy reduces overgeneral autobiographical memory in formerly depressed patients. *Journal of Abnormal Psychology, 109*, 150–155]). However, little work has investigated the mechanisms underlying this effect. The present study explored the role of executive processes as a mediator of MBCT effects in an unselected sample. An autobiographical memory task, a cognitive inhibition task, a motor inhibition task, a cognitive flexibility task and a motor flexibility task were administered before and after intervention. Compared to matched controls, MBCT participants showed increased autobiographical memory specificity, decreased overgenerality, and improved cognitive flexibility capacity and capacity to inhibit cognitive prepotent responses. Mediational analyses indicated that changes in cognitive flexibility partially mediate the impact of MBCT on overgeneral memories. Results are discussed in terms of Conway's [2005. Memory and the self. *Journal of Memory and Language, 53*, 594–628] autobiographical memory model.

A number of studies have demonstrated that individuals with emotional disturbances, especially patients with a history of depression, show difficulties in retrieving specific autobiographical memories and tend to recall categorical overgeneral memories (OGM; for a review, see Van Vreeswijk & de Wilde, 2004; Williams et al., 2007). More generally, several findings suggest that reduced autobiographical memory specificity is more than a cognitive curiosity and that it might be closely associated with other important aspects of psychological functioning. For instance, reduced specificity has been found to be associated with impaired social problem solving (e.g., Goddard, Dritchtel, & Burton, 1997), difficulties in generating specific simulations of future events (Williams et al., 1996), and thought to be not just a state characteristic of mood disturbance, but also a stable cognitive marker of depression (e.g., Brittlebank, Scott, Williams, & Ferrier, 1993). Finally, reduced specificity appears also as a marker of vulnerability to future depression (Gibbs & Rude, 2004; van Minnen, Wessel, Verhaak, & Smeenk, 2005) and delayed recovery from episodes of emotional disorders (Brittlebank et al., 1993; Peeters, Wessel, Merckelbach, & Boon-Vermeeren, 2002).

Several explanations have been proposed to account for OGM (for a review, see Williams et al., 2007). One explanation focuses on executive processes, which are necessary when a situation requires more than a routine execution of automatic and overlearned schemata (Burgess & Shallice, 1996). Several authors have postulated the existence of separate processes within executive function (e.g., Burgess & Shallice, 1996; Miyake, Friedman, Emerson, Witzki, & Howerther, 2000). Miyake et al. (2000) distinguished between inhibition of prepotent response (i.e., the capacity to deliberately inhibit dominant and automatic responses), mental flexibility (i.e., shifting back and forth between multiple tasks, operations or mental sets) and updating (updating and monitoring of working memory representations). With regards to autobiographical memory, recalling a specific autobiographical memory is considered to be a hierarchical process; here, an intermediate or generic description is first recollected (e.g., Haque & Conway, 2001). This intermediate description is then used to search for more specific events through iterative comparisons with the target. Thus, it is voluntarily recalling that is generative and requires effortful processing (e.g., Conway, 2005; Williams et al., 2006). During this process, generic descriptions are progressively inhibited to reach to a specific event (Conway & Pleydell-Pearce, 2000). However, if

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executive resources are insufficient, the process of specific retrieval is prematurely interrupted, leading to the recollection of a general memory (Haque & Conway, 2001; Williams et al., 2006). Indeed, research has shown that OGM is associated with poor performance on various executive functioning tasks (e.g., Dalgleish et al., 2007). More specifically, Williams and Dritschel (1992) have reported a negative correlation between OGM and a cognitive flexibility task (i.e., verbal fluency) and Dalgleish et al. (2007) have found a negative correlation between autobiographical memory specificity and number of generation task error scores.

From an intervention perspective, however, mindfulness-based cognitive therapy (MBCT) increases autobiographical memory specificity and reduces OGM (Williams, Teasdale, Segal, & Soulsby, 2000). MBCT is a manualized intervention, which trains participants to maintain their attention on a particular present experience, without judging or analytically processing it (Kabat-Zinn, 1982). Weekly training sessions occur and consist of meditative exercises and subsequent group discussion on the clients' experiences of the exercises. Furthermore, the clients, as part of MBCT, are also given daily 45-min homework exercises.

Few studies have investigated processes underlying the effect of mindfulness training on autobiographical memory. As suggested by Bishop et al. (2004), mindfulness training may be associated with improvements in the suppression of elaborative processing and in cognitive flexibility. In fact, during mindfulness training, attention is directed back from intrusive thoughts to an arbitrary focus (e.g., breathing sensations), thereby preventing further elaboration. This focus, Bishop et al. (2004) argue, should inhibit secondary elaborative processing of the thoughts, feelings, and sensations that arise in the stream of consciousness (i.e., cognitive inhibition). In addition, mindfulness training involves flexibility of attention as it requires shifting the focus of attention to different objects. Indeed, Alexander, Langer, Neman, Chandler, and Davies (1989) have found that both transcendental meditation and mindfulness exercises are associated with improvements in cognitive flexibility (e.g., lower Stroop interference scores) in comparison to relaxation and no-treatment conditions. Thus, mindfulness training might be associated with improvements in executive processes, particularly at the level of stimulus selection.

The effects of mindfulness training on autobiographical memory have not yet been replicated, so the first task of this paper is to see whether the reduction of OGM following mindfulness training is reliable. We propose that mindfulness training may have similar effects on OGM as with cognitive inhibition and cognitive flexibility. The present study explored the role of executive processes in the relationship between mindfulness training and OGM in an unselected sample. Our main hypothesis is that the improvement of executive processes mediates the impact of mindfulness training on OGM. We predict that (a) mindfulness training improves autobiographical memory specificity and reduces OGM, and (b) mindfulness training increases the performance on cognitive inhibition and flexibility tasks. Additionally, motor inhibition and flexibility tasks were given as control tasks to make sure the effect is specific to cognitive executive component applied at the level of stimulus selection. Finally, we will also test the mediational role of executive processes on the impact of mindfulness training on specificity.

Method

Participants

The study was a quasi-experimental mixed design with a between-subjects variable (Mindfulness group vs. Matched group) and a within-subject variable (Pre-test vs. Post-test). For the Mindfulness group, the study was advertised during information sessions for individuals interested in an 8 session mindfulness program and presented as an investigation of the impact of mindfulness training on different cognitive functions. Twenty-six people who responded to this advertisement were informed of the procedure, exclusion criteria, and ethical considerations.

Exclusion criteria were reported (a) prior mindfulness or another form of meditation training, (b) other planned psychological interventions during the course of the study, (c) active drug dependency or abuse, (d) known cerebral lesion, cerebral tumor or neurological disease, and (e) use of psychopharmacotherapy. Three participants from treatment group met the exclusion criteria and, thus, were dropped from the study in the beginning. One participant dropped out at the first training session and two participants were excluded from the analyses, because they missed two training sessions. For the Mindfulness group, all analyses were conducted on the remaining 18 participants (15 women) who completed all of the study sessions. Participants ($M = 54.28$ years old, $SD = 13.62$, $Min = 27$, $Max = 75$) all had at least a secondary school degree and were predominantly university graduates.

A control group was constituted by pairing individually each treatment group participant with a control participant, matching for age (±12 months), gender, education and manual laterality (Matched group). The same exclusion criteria than those used for the treatment group were applied in the selection of the control participants. Participants in the Matched group were recruited in the same population as one of the treatment group. The study was presented as an investigation of different cognitive functions among people presenting some specific characteristics. The individual characteristic profiles needed for the matching and the exclusion criteria were mentioned in the advertisement.

In order to assess the equivalence between the two groups, all participants were asked to complete, only at the Pre-test, the Trait Anxiety Inventory (STAI-Trait; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), the Beck Depression Inventory (BDI-II; Beck, Steer, & Brown, 1996), and the Symptom Check-List-90-R (SCL-90-R; Derogatis, 1977).

Measures

Autobiographical Memory Test (AMT)

This is a validated French version (Neumann & Philippot, 2006) of the AMT (Williams & Broadbent, 1986) consisting of two lists of 10 emotional cue words (five negative, five positive). The cues were presented in a fixed order alternating positive (e.g., *lucky*) and negative (e.g., *guilty*) words. The two lists of cues were counterbalanced across participants. Participants were required to retrieve a specific memory in response to each cue word. Before the task, a practice trial was run involving two cue words to ensure comprehension of the instructions. If it was necessary, an additional example was presented to the participant until a correct response was given.

During the task, participants were given 30 s for each cue. If no memory was recalled within 30 s, the trial was noted as an omission and the examiner gave the next cue word. Each first response to all cue words was coded on specificity. Memories retrieved were categorized either as specific memories (i.e., referring to personal past events that had happened at a particular place and time that had lasted less than a day; for example, when I sang at the wedding day of my sister), categorical memories (i.e., referring to repeated past events; for example, each morning when I am taking the train), extended memories (i.e., referring to past events that lasted longer than a day; for example, a week-end to Paris with my girlfriend), or as omissions (failures to recall a specific memory within the time limit). A sample of 20% of the responses was rated by a second independent rater, and an inter-rater reliability of 97% ($k = .97$) was obtained.

Hayling Task

Hayling Task (Burgess & Shallice, 1996; French adapted version, Meulemans, Steyaert, & Vincent, 2001) was used to assess the capacity to inhibit cognitive prepotent responses. There were two conditions (automatic and inhibition), for which two different sets of 15 sentences were assigned. In the automatic condition, the experimenter read aloud each sentence to the participant. The participant had to listen to the sentence and to complete it with the appropriate word as quickly as possible. In the inhibition condition, participants were instructed to complete the sentence with an unrelated, nonsensical word that as quickly as possible. Two examples for each sentence were given to participants prior to the task. For all trials, if a participant gave an erroneous response, the examiner repeated the instructions. No time limit was given for responding. Two dependent variables were measured: response latency and error rate. Response latencies were recorded using a stop-watch, beginning when the last word was pronounced by the examiner and ending when the participant began to respond. Burgess and Shallice's (1996) scoring system was used to measure response accuracy in the inhibition condition. Three points were given to participants when they completed the sentence with an appropriate word (e.g., "the captain wanted to stay with the sinking boat"), one point when participants gave an antonym, a semantically related word, or a word that made a vague reference to the target word, and zero points when an unrelated response was provided. A sample of 20% of the responses was rated by a second independent rater. Inter-rater agreement of 88% ($k = .88$) was obtained.

Trail Making Test

Trail Making Test (TMT; Army Individual Test Battery, 1944) was used to assess behavioural flexibility. TMT is given in two parts: Part A (TMT-A) involves drawing a line connecting consecutive numbers from 1 to 25, and Part B (TMT-B) involves drawing a similar line that connects alternating numbers and letters in sequence (i.e., 1-A-2-B and so on). Before each part, a practice trial involving a few numbers and/or letters was conducted to ensure that instructions were understood. TMT-A performance was assumed to provide a baseline for motor and visual control and speed, against which to compare the time cost of executive control. TMT-B performance was associated with set-switching cost. From TMT-A and TMT-B, the B/A ratio was calculated. The B/A ratio score has been previously observed to be a good indicator of executive control (Arbuthnott & Frank, 2000).

GoStop Paradigm

GoStop Paradigm (Version 1.01, Dougherty, Mathias, & Marsh, 2003) was used to assess inhibition of motor behavior. This task features randomly generated 5-digit numbers presented in rapid succession (i.e., 500 ms on, 1500 ms off), and requires participants to respond when a target *go* signal appears, and to withhold responding when a *stop* signal appears. Compared to other stop paradigms, the GoStop presents both *go* and *stop* signals in the same stimulus modality (i.e., visual) and, therefore, provides added clarity in the interpretations of comparisons between response times to no-*stop* and *stop* trials (Dougherty et al., 2003). Half of the 5-digit numbers are target trials (identical matches) and other half are filler trials (random non-matches). Additionally, half of target trials (25% of total trial presentations) change in color from black to red at 50- to 350-ms intervals after appearing on the monitor, indicating the stop signal. The duration before the changing color has an equal probability of one of four delays: 50, 150, 250, or 350 ms. These combined probabilities result in 18–20 target-stop trials for each stop delay interval across the entire 12-min session. Participants are instructed to respond to identical matching numbers on the computer screen unless that number turns red. The number of on-time and late responses for target and target-stop trials are tracked and recorded separately. The proportion of inhibited responses of the total number of *stop* trials for each delay condition (i.e., the measure of the ability to inhibit responding when a stop signal is presented) was measured.

Verbal fluency tasks

Verbal fluency tasks were used to assess cognitive flexibility. Each participant completed three separate verbal fluency tasks: A Semantic Word Fluency (SWF) task using the category animal; a Phonemic Word Fluency (PWF) task using the letter *P*; and a Verb's Word Fluency (VWF) task. Participants were initially told the relevant fluency prompt and then allowed 120 s to produce as many exemplars as possible. This procedure was repeated for each of the three tasks. For SWF task, participants were asked to generate word within the category *animal*. For the PWF task, participants were asked to generate as many words that begin with the letter *P* and were instructed not to use proper nouns nor to make simple variations on words (e.g., "pragmatic" and "pragmatism"). For the VWF task, participants were asked to generate as many verbs as possible. For each task, the number of items correct (belonging to the category and not repeated) as well as the number of errors were calculated.

Procedure

For mindfulness training, the manual was derived from Segal, Teasdale, and Williams (2002). The original manual, designed for the prevention of depressive relapse, was adapted in the following ways. First, the content relative to psychoeducation of depression relapse was deleted and adapted to the psychological consequences of stress in general. This deletion concerns mostly the content from sessions 4 and 7 of the original program. All the sessions were very similar to the original program: They comprised exactly the same exercises, but (a) referred to dealing with the adversity of stress rather than with depression relapse, (b) did not present the psychoeducative part of the fourth session, and (c) extended exercises dealing with relapse prevention to how to take care of oneself and prevent stress. Aspects of the last session evaluating the program were maintained.

For the Mindfulness group, Pre-test was held before the intervention and Post-test was held after intervention ($M = 52.77$ days, $SD = 9.99$), while the two sessions for the Matched group were held at a similar time-interval ($M = 57.44$ days, $SD = 7.61$). There were no differences between groups in inter-session time, $t(34) = 1.58$, $p = .12$. In addition to the other dependent measures, the BDI-II, the STAI-trait and the SCL-90-R were completed during the first session, which were presented in a random order. Upon completion of the entire study, participants were fully debriefed.

Results

Group equivalence

Preliminary analyses indicated no difference between Mindfulness group and Matched group at Pre-test on STAI-trait, $t(34) = .49$,

Table 1
Participants characteristics as a function of group assignment (standard deviations in parentheses).

	Mindfulness group	Matched control group
Age	54.28 (13.62)	54.67 (14.32)
Years of education	15.78 (2.13)	15.56 (2.12)
BDI-II	9.83 (10.76)	7.22 (4.62)
STAI	42.94 (11.59)	41.39 (7.04)
SCL-90-R (GSI)	.56 (.43)	.49 (.32)

Note. BDI-II is Beck Depression Inventory, STAI is only Trait Anxiety Inventory, SCL-90-R is Symptoms Check-List-90 Revised (Global Score Index).

Table 2
Autobiographical memory specificity as a function of group and time (standard deviations in parentheses).

	Mindfulness group		Matched control group	
	Time 1	Time 2	Time 1	Time 2
Specific	3.83 (1.72)	8.22 (1.35)***	4.56 (1.38)	4.72 (1.40)
Categorical	2.33 (1.88)	.22 (.54)***	2.28 (1.88)	1.61 (.98)
Extended	1.50 (1.10)	.06 (.24)***	1.33 (.84)	2.00 (1.41)

Note. "*" indicates a significant difference between before and after intervention in that group according to paired *t*-tests comparisons. For all type of memories, there were no significant differences on the first session between MBCT group and Matched Control Group according to *t*-tests comparisons.
***$p < .001$.

Table 3
Cognitive inhibition as a function of group and time (standard deviations in parentheses).

	Mindfulness group		Matched control group	
	Before	After	Before	After
Total error score	8.83 (2.28)	.22 (.54)***	8.78 (1.73)	9.06 (2.15)
Correct responses	6.38 (2.32)	10.06 (3.02)***	6.17 (1.79)	5.94 (2.15)
One-point error	8.67 (2.38)	4.95 (3.02)***	8.78 (1.73)	9.06 (2.16)

Note. "*" indicates a significant difference between before and after intervention in that group according to paired *t*-tests comparisons. For all of these measures, there were no significant differences on the first session between MBCT group and Matched group according to *t*-tests comparisons.
***$p < .001$.

$p = .630$, BDI-II, $t(34) = .95$, $p = .354$, and SCL-90-R (Global Score Index), $t(34) = 1.03$, $p = .312$. Further analyses ascertained that there were no group differences for the sub-scales of the SCL-90-R. Both groups can thus be considered as equivalent. Groups' characteristics are displayed in Table 1.

General statistical analyses

The main analyses consisted of a 2 × 2 mixed-design ANOVAs with Group (Mindfulness vs. Matched) as between-subjects factor, and Time as within-subject factor (Pre-test vs. Post-test).[1]

AMT

Separate mixed-design ANOVAs were computed on the total number of specific memories, categorical memories and omission. For specific memories, the ANOVA revealed a main effect of Time, $F\,(1,34) = 50.9$, $p < .001$, $\eta^2 = .60$, qualified by an interaction with Group, $F\,(1,34) = 43.72$, $p < .001$, $\eta^2 = .56$. For categorical memories, the ANOVA showed a main effect of Time, $F\,(1,34) = 30.57$, $p < .001$, $\eta^2 = .47$, again qualified by an interaction with Group, $F\,(1,34) = 43.72$, $p < .008$, $\eta^2 = .19$. For extended memories, the ANOVA showed a main effect of Group, $F\,(1,34) = 16.55$, $p < .001$, $\eta^2 = .34$, qualified by an interaction with Time, $F\,(1,34) = 17.34$, $p < .001$, $\eta^2 = .34$. For omissions, no effects were significant. As reported in Table 2, follow-up analyses indicated that the Mindfulness group, which initially showed similar performances compared to the control group, recalled significantly more specific memories as well as less categorical, and less extended memories after intervention.

To check whether the pattern of results was not due to changes in latency to respond to cue words, the mean response latencies were analysed. Results of a 2 × 2 mixed-design ANOVA showed no significant main effect of Group, $F\,(1,34) = .01$, $p = .93$, $\eta^2 = .00$, or of Time, $F\,(1,34) = 4.03$, $p = .53$, $\eta^2 = .11$, neither was there a significant Group × Time interaction, $F\,(1,34) = 3.88$, $p = .57$, $\eta^2 = .10$.

Hayling Task

Separate mixed-design ANOVAs were computed on error score and response latencies. For total error score, the ANOVA revealed a main effect of Time, $F\,(1,34) = 29.62$, $p < .001$, $\eta^2 = .47$, moderated by Group, $F\,(1,34) = 37.24$, $p < .001$, $\eta^2 = .52$. As reported in Table 3, follow-up analyses indicated that the Mindfulness group, which initially showed similar performances compared to Matched group, reported significantly fewer errors after intervention.

Separate mixed-design ANOVAs were then computed on the number of correct responses, one-point error score and three-point error score. For correct responses, results showed a main effect of Group, $F\,(1,34) = 8.77$, $p < .001$, $\eta^2 = .21$, qualified by an interaction with Time, $F\,(1,34) = 10.00$, $p < .001$, $\eta^2 = .51$. For one-point error score, results showed a main effect of Group, $F\,(1,34) = 8.76$, $p < .001$, $\eta^2 = .51$, again qualified by an interaction with Time, $F\,(1,34) = 35.17$, $p < .001$, $\eta^2 = .51$. Not enough three-point scores were given to allow for further analysis.

To check whether the pattern of results was due to changes in reaction time, mean responses latencies for the two parts were analysed. No effects were significant for the *automatic* or for the *inhibition* condition.

GoStop Paradigm

A mixed-design ANOVA was conducted on the proportion of inhibited responses of the total number of stop trials for each delay condition. No effects were significant. Further, a 2 (Pre-test vs. Post-test) × 2 (Mindfulness group vs. Matched group) × 4 (stimulus onset condition: 50, 150, 250, 350 ms) MANOVA on the same measure was conducted to check if this pattern of results was not due to a moderator effect of stimulus onset delay. Results showed no main effect of Group, $F\,(3,32) = .07$, $p = .80$, $\eta^2 = .00$, or of Time, $F(3,32) = .66$, $p = .42$, $\eta^2 = .02$, of Group × stimulus onset condition, $F(3,32) = .79$, $p = .50$, $\eta^2 = .02$, or of Group × Time × stimulus onset condition, $F(3,32) = 1.24$, $p = .30$, $\eta^2 = .04$. However, results showed a main effect of stimulus onset condition, $F\,(3,32) = 156.68$, $p < .001$, $\eta^2 = .82$.

TMT

A mixed-design ANOVA was computed on the B/A ratio and on the TMT-B's error score. No effects were significant for the B/A ratio or for the TMT-B's error sore. No other effects were significant for TMT.

Verbal fluency

Separate mixed-design ANOVAs were computed on the number of correct items for SWF, PWF and VWF. For SWF, results showed a main effect of Time, $F\,(1,34) = 54.69$, $p < .001$, $\eta^2 = .62$, qualified by an interaction with group, $F\,(1,34) = 42.74$, $p < .001$, $\eta^2 = .56$. For PWF, results revealed a main effect of Time, $F\,(1,34) = 37.76$, $p < .001$, $\eta^2 = .29$, again qualified by an interaction with Group, $F\,(1,34) = 29.45$, $p < .001$, $\eta^2 = .46$. For VWF, results revealed a main effect of Time, $F\,(1,34) = 15.33$, $p < .001$, $\eta^2 = .31$, qualified by an interaction with Group, $F\,(1,34) = 15.35$, $p < .001$, $\eta^2 = .34$. As reported in Table 4, follow-up analyses indicated that the Mindfulness group, which initially showed similar performances compared to Matched group, reported significantly more correct items on SWF, PWF, and VWF tasks after intervention.

Mediational analyses

Mediational analyses were performed using criteria suggested by Baron and Kenny (1986), with a slight adaptation for

[1] Due to the small number of men among our samples, we also ran all analyses using only females. Results showed similar patterns.

Table 4
Cognitive flexibility as a function of group and time (standard deviations in parentheses).

	Mindfulness group		Matched control group	
	Before	After	Before	After
Semantic Word Fluency	35.78 (9.54)	49.56 (12.56)***	32.56 (5.36)	33.39 (5.10)
Phonemic Word Fluency	25.39 (9.05)	34.56 (7.04)***	25.06 (4.62)	23.33 (4.02)
Verb's Word Fluency	40.56 (12.48)	51.33 (12.01)***	37.78 (8.33)	37.44 (7.66)

Note: "*" indicates a significant difference between before and after intervention in that group according to paired t-tests comparisons. For all of these measures, there were no significant differences on the first session between MBCT group and Matched group according to t-tests comparisons.
$^{***}p < .001$.

within-subject design: For each dependent and mediator variable, a difference score was computed between the two times of measurements (Judd, Kenny, & McClelland, 2001).

Cognitive inhibition as a mediator

To examine whether changes in autobiographical memory specificity were mediated by cognitive inhibition, we performed regression analyses in a model containing Hayling Task's total error score as a mediator variable, the number of specific memories as a criterion, and condition (contrast coded: matched control group = −1, Mindfulness group = 1) as a predictor. When condition and Hayling Task's total error were simultaneously used as predictors, multiple regression analyses revealed no statistically significant predictions of Hayling Task's total error and a statistically significant prediction of condition, $\beta = .83$, $B = 2.34$, $SE_B = .47$, $t(34) = 4.98$, $p < .001$. This pattern did not support the presence of a mediational effect.

In addition, we performed regression analyses in the model using similar predictors and number of categorical memories as a criterion. Multiple regression analyses revealed no statistically significant predictions of Hayling Task's total error score and a statistically significant prediction of condition, $\beta = .50$, $B = 1.44$, $SE_B = .63$, $t(34) = 2.27$, $p < .05$. This pattern did not support the presence of a mediational effect.

Cognitive flexibility as a mediator

To examine whether changes in autobiographical memory specificity were mediated by changes in cognitive flexibility, we performed regression analyses in a model containing the sum of each verbal fluency tasks score as a mediator and number of specific memories as a criterion and condition (contrast coded: matched control group = −1, Mindfulness group = 1) as a predictor. When predictors were simultaneously used, multiple regression analyses revealed no statistically significant predictions of verbal fluency, $\beta = .06$, $B = .01$, $SE_B = .03$, $t(34) = .29$, $p = .772$, and a statistically significant prediction of condition, $\beta = .70$, $B = 1.98$, $SE_B = .56$, $t(34) = 3.50$, $p < .005$. This pattern of results did not support the presence of a mediational effect.

In addition, we performed several regression analyses in a model containing similar predictors and the number of categorical memories as a criterion. When predictors were simultaneously used, multiple regression analyses revealed statistically significant predictions of verbal fluency task's total score, $\beta = .58$, $B = .05$, $SE_B = .02$, $t(34) = 2.30$, $p < .05$, and a statistically significant prediction of condition, $\beta = -.92$, $B = -1.50$, $SE_B = .41$, $t(34) = 3.62$, $p < .005$, on categorical memories. The Sobel (1982) test also proved statistically significant, $Z = 2.17$, $p < .05$. This pattern of results is indicative of the presence of a partial mediation: Cognitive flexibility partially mediates the impact of mindfulness training on OGM (Fig. 1).

We also ran regression analyses on all of the mediational models by centering the data of mediator and dependent variables. Results showed similar patterns.

Discussion

The aim of this study was to examine the role of executive processes on the impact of mindfulness on autobiographical memory specificity. In general, our hypotheses were confirmed. First, the study replicates Williams et al. (2000) observation and extends them to a non-depressed sample. Our data reveal that mindfulness training increases specific and decreases general (i.e., extended and categorical) autobiographical memories retrieval. Second, this study also finds that mindfulness training improves the capacity to inhibit prepotent responses and to switch between different cognitive sets. It should be noted that mindfulness training is not associated with changes on motor inhibition and motor flexibility, suggesting that MBCT specifically affects cognitive executive components. This pattern of results supports the notion that mindfulness training might inhibit secondary elaborative processing of thoughts, feelings and sensations that arise in one's stream of consciousness (e.g., Bishop et al., 2004). These results also support previous suggestions (e.g., Roemer & Orsillo, 2003) that mindfulness training may be used to change habitual cognitive patterns of responding with intentional, flexible responses that are voluntarily chosen rather than automatic. Third, it was found that changes in one of our cognitive tasks, cognitive flexibility, partially mediate the impact of mindfulness training on overgeneral (categoric) memories.

At the theoretical level, these results support the notion that executive processes are implicated in OGM. Indeed, because of its general and repeated nature, OGM is cognitively more accessible than specific information. Previous studies have observed an automatic attentional capture by more general and repeated information (e.g., Mogg & Bradley, 1999). As a consequence, the retrieval of a specific episode requires important executive resources to maintain the attention on specific and unique information (Conway, 2005; Williams et al., 2006), while attention is automatically attracted to general information. Additionally, the present study suggests that reducing OGM bias might involve increasing cognitive flexibility. The absence of mediating effect of

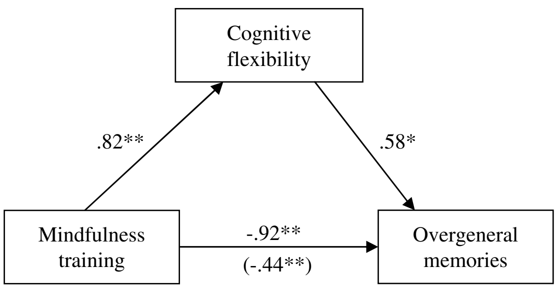

Fig. 1. Cognitive flexibility as a mediator on effects of mindfulness training on overgeneral memories. *Note.* Coefficients appearing above lines are β weights for uncorrected paths. Coefficient in parentheses appearing below lines is β weight for corrected path. $^{*}p < .05$; $^{**}p < .01$.

cognitive inhibition on OGM changes might be due to the fact that only cognitive flexibility mediates the reduction of overgenerality. The enhancement of cognitive flexibility capacities to disengage attention from more general and repeated information and engage focus on specific and unique information might be the capacity specifically involved in reducing OGM.

At a clinical level, these data confirm previous studies (e.g., Serrano, Latorre, Gatz, & Montannes, 2004; Williams et al., 2000) demonstrating that OGM bias can be changed by psychological interventions. Furthermore, as suggested by Wells (2000), a lack of cognitive executive resources contributes to cognitive vulnerability and the prolongation of psychological disorders. It was observed that increasing these capacities was associated with a reduction in several emotional disorders, such as depression (e.g., Siegle, Ghinasi, & Thase, 2007), panic disorder and social phobia (e.g., Wells, White, & Carter, 1997). Some studies have observed that mindfulness training has the same positive effect on other emotional disorders (for a review, see Baer, 2003). The present pattern of results on the effects of mindfulness training on cognitive executive processes suggests the importance of the active processes underlying mindfulness intervention. The study findings are in line with recent developments in experimental psychopathology; for instance, recent findings suggest the utility of attentional retraining interventions (e.g., Wells, 2000; Yiend & Mackintosh, 2004).

The present study suffers from several limitations. First, as there was no plausible treatment comparison group, a placebo effect cannot be excluded. Second, although a great care was allocated in matching participants on all relevant dimensions, they were not randomly allocated to conditions. One cannot exclude, for instance, that some differences observed might result from the fact that the matched participants were not interested in mindfulness training. Third, although the assessor didn't conduct the mindfulness training sessions, he was not blind to group allocation. The impact of this limitation is however limited by the high standardization of the testing. Fourth, the samples were small. Although significant effects were clearly observed with a limited sample size, indicating that the effects were large, there should be caution in generalizing these results. Five, due to the small number of men among our participants, it is unclear whether these results can be generalized to males. A final limitation is the use of verbal fluency tasks as indicators of cognitive flexibility. Although verbal fluency task is regarded as a broad measure of executive control (e.g., Rosen & Engle, 1997), and of cognitive flexibility (e.g., Eslinger & Grattan, 1993), there should also be caution in generalizing its mediational effect on OGM. More specifically, an alternative explanation for the findings would be that Autobiographical Memory Test and verbal fluency tasks use similar semantic and verbal cognitive components. Future studies should thus use non-verbal cognitive flexibility tasks (e.g., graphical fluency tasks; Lee, Strauss, Loring, McCloskey, & Haworth, 1997).

To conclude, the present findings support the notion that mindfulness training reduces OGM and increases autobiographical memory specificity. In line with previous experimental researches, it suggests that one of mechanisms underlying this effect is the mediational influence of executive processes. Further, the study suggests that effects of mindfulness training are enhanced by cognitive flexibility.

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