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Schema-driven involuntary categoric memory in depression

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Abstract

Background: Overgeneral categoric memory is known as a vulnerability factor for depression, yet increased retrieval of categoric memories among depressed individuals has been observed in voluntary but not involuntary retrieval tasks. Here we propose that, increased categoric memory occurs during involuntary memory tasks when cued by schema-related stimuli, which tend to activate dysfunctional and negative self-schema in depression.

Methods: A vigilance task measuring involuntary memory was administered to 27 dysphoric, 26 past depressed, and 27 healthy control participants. Participants also responded to several questions measuring each memory characteristic (e.g., evoked emotion) and a dysfunctional schema scale.

Results: Results supported the hypothesis that dysphoric and past depressed groups reported more involuntary categoric memories for schema-related (particularly negative) stimuli relative to a healthy control group. Dysfunctional schema score was positively correlated with the number of involuntary categoric memories retrieved following schema-related negative stimuli. Involuntary categoric memory for schema-related stimuli was related to negative evoked emotion, and dysphoric participants experienced more negative emotion in response to positive stimuli.

Discussion and Conclusion: These findings suggest that schema-based involuntary categoric memory may be vulnerable to the persistence and relapse of depression.

Keywords: Involuntary memory; overgeneral memory; autobiographical memory specificity; depression; dysfunctional schema

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Introduction

The retrieval of general memories defined as summaries of repetitive and similar past events without specific contextual information (categoric memories) occurs as part of healthy cognition (Conway & Pleydell-Pearce, 2000; Renoult, Davidson, Palombo, Moscovitch, & Levine, 2012). However, overgeneral autobiographical memory (OGM), or an increased tendency to retrieve general memories when instructed to retrieve specific memories and relative to diagnoses free individuals is known to characterise psychiatric disorders (Barry, Hallford, & Takano, 2021). OGM is associated with depressive symptomatology (Liu, Li, Xiao, Yang, & Jiang, 2013; Ono, Devilly, & Shum, 2016; Sumner, 2012; Williams et al., 2007) and in particular, increased categoric memory is evident in individuals with current and past major depressive disorders (e.g., Kuyken & Dalgleish, 2011; Park et al., 2002). OGM predicts worsening depression longitudinally (Hallford, Rusanov, Yeow, & Barry, 2021; Sumner, Griffith, & Mineka, 2010) and persists following recovery from depression (Hallford, Rusanov, Yeow, & Barry, 2021, July 14).

The CaR-FA-X (capture and rumination, functional avoidance, and executive capacity and control) model (Williams et al., 2007), a representative theory of OGM, suggest that deficits in cognitive control disrupt strategic memory searches during voluntary retrieval with deliberate retrieval intention (i.e., *executive capacity and control hypothesis*). For example, difficulties suppressing information irrelevant to retrieval goals and overregulation when retrieving negative and/or traumatic memories to avoid negative impact on mood (see also Sumner, 2012 for a review). In line with this, robust associations between depression and overgeneral memory retrieval have been found in voluntary retrieval tasks using cue word methodologies (Williams & Broadbent, 1986, Williams et al., 2007). Conversely, no association between depression and OGM has been observed in studies of involuntary

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memory where memory retrieval occurs spontaneously and without retrieval intention (Watson et al., 2013; Kvavilashvili & Schlagman, 2011).

In addition to cognitive control playing an important role in voluntary memory retrieval, the CaR-FA-X model (Williams et al., 2007) suggests that once negative self-schemas are activated, individuals with emotional disorder tend to be captured by these self-schemas and related (over)general memories (i.e., *capture and rumination hypothesis*). In support of this, manipulation of cue self-relevance (Crane, Barnhofer, Mark, & Williams, 2007; Matsumoto & Mochizuki, 2017), increased endorsement of dysfunctional schemas (Matsumoto, Takahashi, & Kawaguchi, 2020; Spinhoven et al., 2007) and increased state and trait rumination increase the likelihood that overgeneral categoric memories will be retrieved in emotionally vulnerable groups (Park, Goodyer, & Teasdale, 2004; Sutherland & Bryant, 2007; Watkins & Roberts, 2020; Sumner, 2012; see Smets, Griffith, Wessel, Walschaerts, & Raes, 2013 for trait rumination among nonclinical populations). The use of schemas during memory retrieval leads to the activation of script-like or general memories (Bartlett, 1932) and depressed participants tend to form negative general memories common to several negative stimuli (Joormann, Teachman, & Gotlib, 2009). As such, the use of self-schemas during memory retrieval may account for the preferential access to general memory observed in the studies of emotionally vulnerable individuals outlined above.

However, based on current research, it is not clear whether associations between self-referential processing and categoric memory retrieval only occur within the context of voluntary memory retrieval or, if categoric memory retrieval can also arise directly in response to schema-related cues under conditions of involuntary retrieval, where self-referential processing may activate dysfunctional self-schemas. Dysfunctional schema (Power et al., 1994; Wiessman & Beck, 1978) are conceptualised as maladaptive assumptions about personal achievement, interpersonal relations, and self-control which are found to amplify self-referential processing and activate self-schema in emotionally vulnerable groups (Matsumoto et al., 2020; Spinhoven et al., 2007; Williams et al., 2007). When individuals with dysfunctional self-schema or emotional vulnerability encounter stimuli that activate their self-schema, they may be more likely to involuntarily access habitually retrieved nonspecific memories in response. For example, if an individual with low mood has habitually ruminated in the past on the idea that he or she is a failure, the categoric memory "I have always failed on exams" may be more likely to be retrieved involuntarily when stimuli related to "failure" are encountered in the present.

The present study aims to elucidate the relationship between depression and involuntary categoric memory using the vigilance task, a well-established paradigm for measuring involuntary memory (Schlagman & Kvavilashvili, 2008). The vigilance task requires participants to concentrate on the judgment of whether lines presented on a screen are vertical or horizontal. Concurrently, participants are presented with a series of short sentences that induce involuntary memory retrieval. Previous studies employing the vigilance task have used stimuli that are unlikely to activate negative self-schema in depression (i.e., schema-unrelated stimuli) and did not find differences in involuntary memory specificity between dysphoric and control groups (Kvavilashvili & Schlagman, 2011). Here, we investigate the possibility that the presentation of schema-related stimuli may activate dysfunctional schema and self-schema in depression and be associated with a higher number of categoric memories during retrieval.

Previous studies have shown that priming of semantic and general autobiographical knowledge facilitates corresponding autobiographical memory retrieval (Barzykowski, & Niedźwieńska, 2018; Mace, McQueen, Hayslett, Stalely, & Welch, 2019; Mace & Unlu,

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2020). We suggest that increased categoric memory may be evident for negative stimuli in depression because negative stimuli are closely related to, and therefore likely to activate components of dysfunctional and negative self-schema. Similar findings have been demonstrated in a study of voluntary memory. Matsumoto et al. (2020) showed that depressed individuals often retrieve categoric memories in response to negative cues in a direct, associative manner, whereas categoric memories were reported for positive stimuli as a result of difficulties in generatively retrieving specific memories. Given that similar bottom-up processes (Berntsen, 2021) drive involuntary memory and automatic direct retrieval in voluntary memory, this finding may also be applicable to involuntary categoric memory in response to negative cues.

These arguments may also be extended to formerly depressed groups. Individuals with remitted depression hold latent dysfunctional schema, the activation of which leads to recurrence of depression (Segal et al., 2006). If involuntary categoric memories are retrieved during depressive remission, such retrieval may occur when negative cues directly activate latent dysfunctional schema. Semantic or emotional priming could provide a simple principle for involuntary categoric memories in individuals who are formerly depressed. In addition, if involuntary categoric memories are associated negative evoked emotions on retrieval, then involuntary categoric memory retrieval may act as a vulnerability factor contributing to depressive relapse.

In psychopathology research, categoric memories have traditionally been regarded as having less negative affect than specific memories and as resulting from avoidance of retrieval of specific memories that can lead to strong negative affect (i.e., *functional avoidance hypothesis* in the CaR-FA-X model; Raes, Hermans, de Decker, Eelen, & Williams, 2003; for reviews, Sumner, 2012; Williams et al., 2007). However, in contrast to categoric memories caused by avoidance, schema-driven categoric memories may lead to subsequent rumination (e.g., why do I always fail?), and further mood deterioration (Raes, Hermans, Williams, Geypen, & Eelen, 2006; Raes, Williams, & Hermans, 2009). In the long term, the interaction between high levels of overgeneral memory and rumination predicts depression (Hamlat et al., 2015). As whether the negative emotions evoked differ according to the pathways through which categoric memories arise has not yet been tested, we decided to test this hypothesis in the context of involuntary retrieval.

In summary, we predicted that individuals who are vulnerable to depression would be more likely to activate dysfunctional and/or negative self-schema in response to schema-related stimuli and thus experience more involuntary categoric memories, which would be associated with negative emotion. Specifically, we examined the main hypothesis that individuals with dysphoria or those in remission from MDEs (major depressive episode(s)) experience more involuntary categoric memories following schema-related stimuli relative to controls, and that this trend is also observed in schema-related negative stimuli condition. In contrast, we predicted that there would be no group differences in categoric memory for schema-unrelated stimuli used in the original vigilance task. Furthermore, we predicted that scores on an index of dysfunctional schema would be positively correlated with the number of involuntary categoric memories for schema-related stimuli, especially negative stimuli. Finally, we hypothesized that individuals with dysphoria and remitted MDEs would be more likely to experience negative emotion due to involuntary categoric memories for schema-related stimuli and that the degree of negative emotion evoked would be higher than categoric memories for schema-unrelated stimuli or when retrieving specific memories. Through these explorations, we aimed to provide preliminary evidence that involuntary categoric memory may be a vulnerability factor contributing to the worsening/relapse of depression.

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Method

Participants and Sample Size Requirement

We recruited Japanese (under)graduate students from Shinshu University via the SONA System and advertisement. Inclusion criteria were as follows: (a) The dysphoric group participants reported a current BDI-II (Beck Depression Inventory Second Edition; Beck, Steer, & Brown, 1996) score of 14 or more, which indicates the minimum boundary for mild depressive symptoms. (b) The remitted MDE group reported a current BDI-II score of less than 14, no current MDE, and at least one previous MDE. (c) The healthy control group participants reported no current or previous MDEs and a current BDI score of less than 14. See diagnosis section for information on diagnostic assessment methods. Exclusion criteria across all groups were as follows: the presence of neurological symptoms, psychosis, substance use disorders, and past and current bipolar episodes.

In a similar previous study examining directly retrieved categoric memories in response to negative cues, very large effect sizes were found between dysphoric/remitted MDE groups and a healthy control group (Matsumoto et al., 2020); thus, we expected large effect sizes in the schema-related conditions of the present study. Preliminary sample size analysis using G*Power, assuming a large effect size ($d = 0.80$) for group differences in the schema-related condition, required a sample size of 26 participants per group, based on a significance level (α) of 0.05 and power ($1-\beta$) of 0.80. Based on this calculation, we recruited participants using a stopping rule of 26 participants per group. As a result, among 108 potential participants who were assessed, 27 dysphoric, 26 remitted MDE, and 27 healthy control participants were included in the analysis (39 men, 41 women, 19.55±1.94 years old). In the dysphoric group, 4 participants met the criteria of current MDE, 16 participants met the criteria of past MDE, of which, 11 reported multiple past episodes. In the remitted MDE group, 14 participants reported multiple past episodes.

Measures

Depressive symptoms

We used the Japanese version of the BDI-II (Beck et al., 1996; In Japanese, Kojima & Furukawa, 2003) to assess depressive symptoms. The BDI-II includes 21 items on a 4-point scale ranging from 0 to 3. The internal consistency was good in this study (Cronbach's α = .92).

Diagnosis

Current and past major depressive episodes and comorbidities were assessed using the MDQ (Van der Does, 2002; In Japanese, Matsumoto et al., 2020) and the M.I.N.I. (Sheehan et al., 1998; In Japanese, Otsubo, Miyaoka, & Kamijima, 2003) test batteries. The MDQ consists of self-report questionnaires concerning current and past MDEs according to the diagnostic criteria of the DSM-IV-TR. The M.I.N.I. is a structured interview for the diagnosis of psychiatric disorders with the DSM-IV criteria. Notably, the Japanese version of M.I.N.I. does not include questions about past MDEs or difficulties in daily life due to psychiatric symptoms, trained clinicians referred to the MDQ answers and made additional assessments as necessary.

Dysfunctional schema

We used the Japanese version of the Dysfunctional Attitude Scale (DAS-24; Power et al., 1994; In Japanese, Tajima et al., 2007) to measure dysfunctional schema. The DAS-24 has

24 items rated on a 7-point scale ranging from 1 to 7. This scale consists of three subcomponents: achievement, dependency, and self-control. We used the total score to examine the primary hypotheses and used the subscales in an exploratory manner. In the current data, the internal consistencies were good for total items (α =.88), achievement (α =.82), dependency (α =.79), and self-control (α =.69).

Vigilance Task

The vigilance task (Schlagman & Kvavilashvili, 2008) is a well-established paradigm to measure involuntary memory in the laboratory. During the task, participants are asked to judge whether a set of lines appearing on a screen are vertical or horizontal and to respond "yes" verbally only when a vertical line appears. Concurrently, a short sentence is shown in the middle of the screen. Participants are instructed to ignore the sentence but are asked to report on any involuntary memories that come to mind. Because the task consists of over 600 trials and most lines are horizontal, the task is considered monotonous and induces considerable mind-wandering, including involuntary memory retrieval.

It is known that the majority of involuntary memories retrieved during the vigilance task are triggered by the short sentence stimuli (Schlagman & Kvavilashvili, 2008; Kvavilashvili & Schlagman, 2011). This emulates in the laboratory, the finding that involuntary memories are frequently elicited by external cues in daily life (Berntsen, 2021). Previous studies using this paradigm have used single sets of short sentences (600 or 800 sentences). Here, we additionally manipulated the cueing content of the sentence stimuli as has been done previously in studies examining the effect of dysfunctional schema on voluntary memory specificity (e.g., Crane et al., 2007; Spinhoven et al., 2007).

Schema-related and unrelated stimuli presentation

We prepared two blocks of experimental stimuli presentations, a schema-related block and a schema-unrelated block. Schema-relatedness was conceptualised as sentences found to be related to dysfunctional schemas as measured by the DAS-24 (Power et al., 1994). The schema-related stimuli were developed from previous data from the Autobiographical Memory Test (Williams & Broadbent, 1986) stored in our laboratory, while schema-unrelated stimuli were selected from the original vigilance task (Kvavilashvili & Schlagman, 2011; Schlagman & Kvavilashvili, 2008). Examples of stimuli translated from Japanese are as follows: “Achieving goals” (schema-related positive), “Unhappy life” (schema-related negative), “World peace” (schema-unrelated positive), and “Payment of fines” (schema-unrelated negative). 40 fixed sentences were presented as practice trials, these did not overlap with the main sentence stimuli. Additional information about stimuli development can be found in the supplementary materials.

Schema-related and unrelated trials were presented in counterbalanced blocks of 400 sentences (200 positive and 200 negative). Each stimulus was presented for 1.5 sec, and positive and negative stimuli within a block were presented in random order. Horizontal lines were presented on the majority of stimuli trials and vertical lines were presented 8 times randomly within in each block.

Vigilance task procedure

In this study, participants were first instructed that the experiment was designed to measure attention and that they should respond verbally "yes" only when vertical lines appeared. Participants then completed the 40 practice trials. After practice, participants were given an additional instruction that, in addition to responding to vertical lines, they should report any past events that involuntarily came to mind during the task. Participants were given definitions and examples of specific, categoric, and extended memory and were instructed to report on these memories. The content of instruction can alter the mental set and reported memory characteristics (Barzykowski, Niedźwieńska, & Mazzoni, 2019; Barzykowski & Staugaard, 2018), and instruction that allows any past event may facilitate the detection of categoric memories, as in voluntary memory tasks (Debeer, Hermans, & Raes, 2009; Matsumoto & Mochizuki, 2017). When participants experienced an involuntary memory during the task, they were asked to stop the task by pressing the spacebar, write down the recalled memory, and answer questions about the memory cue, their concentration on the task, and the emotion evoked. For the specification of involuntary memory cues, participants were asked to decide whether the memory cue was an internal thought, external stimulus within the environment including a short sentence presented on the screen, or nothing, and if it was an internal or external cue, to write down what it was. Concentration on the task (1 = not concentrating, 5 = very concentrated) and emotion evoked (1 = very negative, 3 = neutral, 5 = very positive) were each rated on a Likert scale. A short break was allocated between schema-related and unrelated blocks. After the vigilance task, participants were asked an additional 4 questions about each involuntary memory: specificity of the event (specific, categoric, extended, or other semantics), how old participants were when they experienced the event (age of memory), how frequently participants thought about/remembered the event (rehearsal; 1 = never, 5 = very), and how often the event occurred in daily life (unusualness; 1 = very usual, 5 = very unusual). As in the original study, these questions were asked after completion of the task, (Kvavilashvili & Schlagman, 2011) so as to minimize disruptions during the vigilance task. In cases where a memory spanned more than one year, the most recent time point was recorded as the age of memory. Participants were asked to rate their current mood on a 9-point scale (1=very negative, 9=very positive) three times: before the task, in the middle of the task (during a break) and on completion of the task. During the experiment, an experimenter stayed out of sight from participants and counted the number of verbal responses to the vigilance task ("yes").

Following the experiment, the specificity of memories was classified by two independent raters who were blinded to the experimental conditions and groups. This was done because participants' own ratings of specificity are sometimes inaccurate (Barry, Hallford, & Takano, 2021). The raters were informed of the content of memories, the cueing stimuli, and participants' own classifications of memory specificity. The coding rule was to follow the participant's own classifications in cases of uncertainty (i.e., if the raters could not decide whether a memory was specific or categoric, they would follow the participant's classification of it). Other coding procedures were the same as in previous studies on memory specificity (e.g., Raes, Hermans, Williams, & Eelen, 2007): specific memories referred to a past event that occurred at a particular time and place and lasted less than a day; categoric memories referred to memories that aggregated multiple events, extended memories referring to past events lasting longer than a day, and semantic associates not referring to past events. The agreement between the two raters was good (Cohen's kappa = .78), and the final coding was decided in consultation between the raters for those classifications that did not match.

Procedure

The experiment was carried out face-to-face and individually with each participant. All instructions and responses were conducted in Japanese. After informed consent, participants completed questionnaires (BDI-II, DAS-24, MDQ), followed by the M.I.N.I and finally, the vigilance task. Participants received 1,000 JPY (approximately $10 USD) or course credit for a clinical psychology course as compensation. The study was approved by the ethics committee in the Division of Psychology, Faculty of Arts, Shinshu University (assignment number: 20002). All the data is available from OSF (https://osf.io/kvqxe/).

Statistical Analysis

The numbers of involuntary specific, categoric, extended memories, and semantic associates in the vigilance task were calculated for each schema-relatedness condition. To evaluate the effect of stimuli valence on involuntary memory, we also calculated each number of responses for positive stimuli and negative stimuli during each condition. Here, we considered an involuntary memory for positive stimuli when participants reported that the memory was triggered by an external stimulus and specified a positive sentence. Involuntary memories for negative stimuli were specified in the same way. Note that the number of involuntary memories for positive and negative stimuli does not equal the total number of involuntary memories because some involuntary memories were judged to be triggered by internal stimuli or coming to mind without a cue.

Before testing the hypotheses, preliminary analyses were conducted. First, descriptive statistics were calculated to examine group differences in depressive symptoms and other variables. Then, following a previous study (Kvavilashvili & Schlagman, 2011), we tested whether there were group or condition differences in the types of involuntary memory triggers reported by participants. We used js-star (https://www.kisnet.or.jp/nappa/software/star/index.htm) for this test, which allows a three-way model selection with generalized linear modelling, a likelihood ratio test and Wald test for regression coefficients.

All main analyses were conducted using JASP. Based on the hypotheses, we performed a number of planned analyses. Planned analyses are recommended and take advantage of a priori power analyses to investigate specific hypotheses (Brooks, Gordon, & George, 2011) while minimising Type I errors (Ruxton & Beauchamp, 2008). We carried out one-way ANOVAs examining (a) whether more categoric memories in the schema-related condition were found in the dysphoric and remitted MDE groups than in the control group and (b) whether these differences emerged in response to negative stimuli in particular. We then conducted correlation analyses examining (c) whether the number of categoric memories in schema-related condition and for negative stimuli were correlated with dysfunctional schema. Finally, we conducted a three-way ANOVA (group * schema-relatedness * memory specificity: specific or categoric) for evoked emotion at recall to examine (d) whether categoric memory retrieval in response to schema-related (and particularly negative) stimuli evoked more negative emotion among dysphoric and remitted MDE participants relative to controls, in schema-unrelated condition, and/or specific memory retrieval. In this analysis, as we were interested in the differences in evoked emotion related to categoric and specific memory retrieval, only trials in which these memories were retrieved were used in the analysis. We conducted the analysis using a between-subjects design, with each trial representing a participant. Although a linear mixed model could be considered in this analysis, it should be noted that the number of memories retrieved by each participant varied considerably (i.e., a number of participants had zero or very few memories), hampering the application of linear mixed models[1].

Next, we conducted a series of exploratory analyses. First, we examined whether the number of categoric memories in schema-related condition and for negative stimuli were associated with depressive symptom severity and past MDEs. Second, we examined if group

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[1] In a supplementary file, we noted the results of linear mixed model for evoked emotion as a reference for readers.

or schema-relatedness were associated with the frequency of specific memories during involuntary retrieval. We performed two-way ANOVA (group * schema-relatedness) for the number of specific memories and the additional analysis using the same design and for specific memories in response to positive or negative stimuli. Finally, we examined whether memory other characteristics (rehearsal, unusualness, concentration on task, and memory age) differed as a function of group, schema-relatedness, and memory specificity. Here, we used the same design as planned analysis for evoked emotion.

Across all analyses, the Holm method was used for multiple comparison corrections.

Results

Descriptive Statistics and Preliminary Analysis

Descriptives of each group are shown in Table 1. The number of memories reported by participants averaged 14.49 (*SD* = 14.45) across all trials, 6.25 (*SD* = 6.67) in the schema-related condition, and 8.24 (*SD* = 8.89) in the schema-unrelated condition. Although a one-way ANOVA indicated a significant group difference in the number of memories reported, no significance differences were evident between the three groups in post hoc analyses ($ps > .059$). Among 16 trials presenting vertical lines in the vigilance task, participants responded 15.24 (*SD* = 1.66) times on average, and there was no significant difference among groups ($ps > .19$), demonstrating that participants were equally attentive when completing the vigilance task across the three groups.

The BDI-II score was higher in the dysphoric group than in the remitted MDE group ($t = 9.34$, $d = 2.14$, $p < .001$) and the control group ($t = 12.03$, $d = 2.89$, $p < .001$), and the score in the remitted MDE group was higher than in the control group ($t = 2.57$, $d = 1.36$, $p = .012$). The dysfunctional schema score was higher in the dysphoric group than in the

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remitted MDE group (t = 3.15, d = 0.84, p = .005) and the control group (t = 4.84, d = 1.23, p < .001). There was no significant difference in dysfunctional schema scores between the remitted MDE group and the control group (t = 1.64, d = 0.51, p = .11). Across groups, the BDI-II and dysfunctional schema score was highly correlated (r = .57, p < .001). There was no difference in mood between groups at the beginning and the end of the experiment. During the break in the experiment (when the conditions were switched), the dysphoric group reported more negative mood than did the control group (t = 3.13, d = 0.84, p = .007).

Table 1.

Descriptive statistics of age, sex, depressive symptoms, dysfunctional schema, and the number of involuntary memories and mood ratings during the experiment for each group

	1. Dysphoria (n = 27)		2. Remitted MDE (n = 26)		3. Control (n = 27)		ANOVAs	
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*	Group differences
Age	19.37	1.71	20.19	2.48	19.11	1.37	2.32	
Men/Women	12/15		14/12		13/14		χ^2 = 10.06	
BDI-II	21.37	8.1	8.04	3.36	4.37	1.84	79.89 ***	1>2>3
DAS-24	107.37	20.81	92.15	14.67	84.22	16.62	12.07 ***	1>2=3
Achievement	35.93	9.97	29.92	6.73	24.85	7.01	12.79 ***	1>2>3
Dependency	36.89	7.63	31.31	7.16	30.48	7.63	5.84 **	1>2=3
Self-Control	34.56	7.05	30.92	6.18	28.89	7.02	4.85 *	1>3
Involuntary memories	17.59	13.63	17.46	18.32	8.52	8.39	3.71 *	
Responses to vertical line	14.85	2.21	15.42	0.86	15.44	1.60	1.10	
Mood T1	5.11	1.42	5.31	0.93	5.70	1.07	1.82	
Mood T2	4.30	1.20	4.81	1.02	5.19	0.88	4.94 **	3>1
Mood T3	4.58	1.30	4.67	0.96	5.12	0.77	2.00	

Note. BDI-II: Beck Depression Inventory Second Edition; DAS: Dysfunctional Attitudes Scale; T1: Beginning of the experiment; T2: During the break in the experiment (when the conditions were switched); T3: End of the experiment.

The number of triggers for involuntary memories

Table 2 summarizes the frequency of triggers identified in each condition for each group. Of all memories, the majority, 84.0% were triggered by external stimuli (schema-related condition, 81.7%, schema-unrelated condition, 85.7%). This result was comparable to previous research (Kvavilashvili & Schlagman, 2011; 83%). Following model selection using the stepwise increase/decrease method and BIC (Bayesian Information Criteria), a model consisting of the main effect of group, schema-relatedness, and type of trigger and the interaction between group and type of trigger was adopted. The likelihood ratio test showed that the interaction between group and type of trigger ($\chi^2(4) = 40.415$, adjusted $p < .001$) and the effect of schema-relatedness were significant ($\chi^2(1) = 24.088$, adjusted $p < .001$). The Wald test demonstrated that in the group by trigger type interaction, the proportion of memories invoked by external stimuli in the remitted MDE group was significantly greater than in the dysphoria group ($b = 0.69$, $Z = 2.69$, adjusted $p = .042$, 95%CI [0.195-1.201]). In terms of schema-relatedness, the proportion of memories by external stimuli in the schema-unrelated condition was significantly greater than that in the schema-related condition ($b = 0.29$, $Z = 4.88$, adjusted $p < .001$, 95%CI [0.175-0.408]).

Table 2.
The number of and proportion of triggers for involuntary memories in each group and condition

	Dysphoria (*n* = 27)	Remitted MDE (*n* = 26)	Control (*n* = 27)
	n (%)	*n* (%)	*n* (%)
Schema-related			
Internal	20 (10.5%)	14 (6.8%)	4 (4.2%)
External	147 (77.0%)	180 (87.8%)	74 (77.9%)
Nothing	24 (12.6%)	11 (5.4%)	17 (17.9%)
Schema-unrelated			
Internal	26 (9.3%)	12 (4.8%)	6 (4.8%)
External	221 (78.6%)	234 (93.2%)	108 (86.4%)
Nothing	34 (12.1%)	5 (2.0%)	11 (8.8%)

Planned Analysis

Categoric Memory in Schema-related Condition

To examine group differences in the number of categoric memories in the schema-related condition, we carried out a one-way ANOVA. The results showed that there was a significant difference among the groups (F (2, 77) = 4.90, p = .01, η_p^2 = 0.11), and the post hoc test revealed that, as predicted, compared with the control group, the dysphoric group (t = 2.42, p = .036, d = 0.81) and remitted MDE group (t = 2.92, p = .014, d = 0.81) generated more categoric memories. No significant differences were found between the dysphoric group and the remitted MDE group (t = 0.53, p = .60, d = 0.12). In the schema-unrelated condition, one-way ANOVA for the group did not reach significance (F (2, 77) = 2.72, p = .07, η_p^2 = 0.07), showing medium sizes between the dysphoric group and the control group (t = 1.99, p = .13, d = 0.62) and between the remitted MDE group and the control group (t = 2.05, p = .13, d = 0.56), respectively.

Categoric Memory for Negative Cues in Schema-related Condition

To examine the hypothesis that dysphoric and remitted MDE groups generated more categoric memories in response to schema-related negative cues, a one-way ANOVA for the number of categoric memories for negative stimuli in the schema-related condition was performed. As expected, the results demonstrated a significant effect of group (F (2, 77) = 4.63, p = .013, η_p^2 = 0.11), and post hoc tests showed that, compared with the control group, the dysphoric group (t = 2.83, p = .018, d = 0.89) and remitted MDE group (t = 2.37, p = .04, d = 0.72) generated more categoric memories in response to negative stimuli presented in the schema-related condition (Table 3 and Figure 1). A one-way ANOVA for the number of categoric memories in response to schema-related positive stimuli did not yield significant differences (F (2, 77) = 2.97, p = .057, η_p^2 = 0.07), with a small effect size between the dysphoric group and the control group (t = 0.58, p = .56, d = 0.27) and a medium effect size between the remitted MDE group and the control group (t = 2.34, p = .065, d = 0.55).

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Table 3.
Memory specificity within group level (total number of memories) and Individual level (mean number of memories)

	Dysphoria (n = 27)				Remitted MDE (n = 26)				Control (n = 27)			
	Schema-related		Schema-unrelated		Schema-related		Schema-unrelated		Schema-related		Schema-unrelated	
	n (%)	M (SD)	n (%)	M (SD)	n (%)	M (SD)	n (%)	M (SD)	n (%)	M (SD)	n (%)	M (SD)
Overall												
Specific	76 (39.4%)	2.81 (2.45)	171 (60.9%)	6.33 (6.52)	70 (34.1%)	2.65 (3.84)	140 (55.6%)	5.38 (6.47)	47 (49.5%)	1.96 (2.05)	78 (61.9%)	2.93 (3.62)
Categoric	80 (41.5%)	2.96 (2.98)	63 (22.4%)	2.33 (2.34)	89 (43.4%)	3.38 (3.81)	62 (24.6%)	2.38 (2.84)	27 (28.4%)	1.04 (1.58)	29 (23.0%)	1.07 (1.69)
Extended	24 (12.4%)	0.93 (1.27)	26 (9.3%)	0.96 (0.98)	24 (11.7%)	0.92 (1.47)	27 (10.7%)	1.00 (1.10)	13 (13.7%)	0.48 (0.70)	10 (7.9%)	0.37 (0.74)
Semantic	13 (6.7%)	0.48 (1.19)	21 (7.5%)	0.78 (1.25)	22 (10.7%)	0.85 (1.32)	23 (9.1%)	0.88 (1.86)	8 (8.4%)	0.33 (0.73)	9 (7.1%)	0.33 (0.88)
For Positive Stimuli												
Specific	13 (32.5%)	0.48 (0.75)	56 (62.9%)	2.07 (2.00)	31 (35.6%)	1.19 (2.10)	59 (54.1%)	2.27 (2.92)	17 (45.6%)	0.63 (0.97)	33 (60.0%)	1.22 (1.99)
Categoric	19 (47.5%)	0.70 (0.91)	18 (20.2%)	0.67 (0.88)	39 (44.8%)	1.50 (2.52)	26 (23.9%)	1.00 (1.58)	12 (32.4%)	0.44 (1.01)	14 (25.5%)	0.52 (1.22)
Extended	6 (15.0%)	0.22 (0.51)	7 (7.9%)	0.26 (0.53)	8 (9.2%)	0.31 (0.55)	10 (9.2%)	0.38 (0.70)	5 (13.5%)	0.19 (0.40)	3 (5.5%)	0.11 (0.32)
Semantic	2 (5.0%)	0.07 (0.27)	8 (9.0%)	0.30 (0.54)	9 (10.3%)	0.31 (0.68)	14 (12.8%)	0.54 (1.24)	3 (8.1%)	0.11 (0.58)	5 (9.1%)	0.19 (0.62)
For Negative Stimuli												
Specific	36 (36.4%)	1.33 (1.36)	71 (60.6%)	2.63 (3.09)	26 (32.1%)	0.96 (1.78)	66 (55.5%)	2.54 (4.07)	19 (61.3%)	0.70 (0.78)	30 (69.8%)	1.04 (1.68)
Categoric	44 (44.4%)	1.63 (2.00)	25 (21.4%)	0.89 (1.48)	38 (46.9%)	1.42 (2.14)	33 (27.7%)	1.27 (1.59)	8 (25.8%)	0.30 (0.67)	6 (14.0%)	0.22 (0.42)
Extended	11 (11.1%)	0.41 (0.64)	15 (12.8%)	0.56 (0.64)	13 (16.0%)	0.50 (1.03)	14 (11.8%)	0.54 (0.81)	4 (12.9%)	0.15 (0.46)	5 (11.6%)	0.19 (0.48)
Semantic	8 (8.1%)	0.30 (0.82)	6 (5.1%)	0.22 (0.51)	4 (4.9%)	0.15 (0.37)	6 (5.0%)	0.23 (0.65)	0 (0.0%)	0.00 (0.00)	2 (4.7%)	0.07 (0.27)

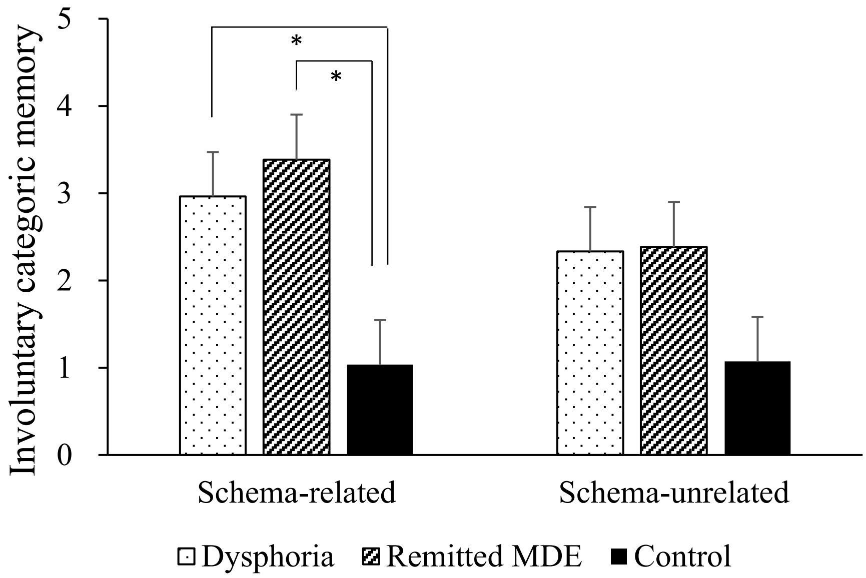

Figure 1. Number of involuntary categoric memories in each schema-relatedness condition and group (* $p < .05$). The error bars indicate standard errors.

Correlations between Dysfunctional Schema and Categoric Memory

We examined the associations between dysfunctional schema as measured by the DAS-24 and the number of categoric memories in the schema-related condition in response to negative cues. The results showed that as expected, dysfunctional schema was positively correlated with the number of categoric memories for negative cues in the schema-related condition (r = .29, p = .009). In contrast, dysfunctional schema was not correlated with the number of categoric memories for positive cues in the schema-related condition (r = -.05, p = .68) or with overall categoric memory in the schema-related condition (r = .16, p = .17). In the schema-unrelated condition, dysfunctional schema was not significantly correlated with the total number of categoric memories (r = .04, p = .75), or those for positive cues (r = -.06, p = .58) or negative cues (r = -.03, p = .82).

Evoked Emotion due to Involuntary Specific and Categoric Memories

We then examined the impact of participant group, schema-relatedness, and memory specificity on evoked emotion (Figure 2). We did not assume a multilevel structure for the data (see Statistical Analysis section) and carried out three-way ANOVAs with a between-participants design, considering as participants the trials in which specific or categoric memories were retrieved (n = 932). To avoid complicating the results presentation, only significant effects are reported below. Main effects of group (F (2, 915) = 19.46, p < .001, η_p^2 = 0.04), schema-relatedness (F (1, 915) = 23.77, p < .001, η_p^2 = 0.03), and memory specificity (F (1, 915) = 4.76, p = .029, η_p^2 = 0.01) were significant. More negative emotions were evoked in the dysphoric group compared with the remitted MDE group (t = 4.87, p < .001, d = 0.36) and the control group (t = 5.49, p < .001, d = 0.48), for schema-related stimuli (vs. schema-unrelated stimuli), and for categoric memory (vs. specific memory). Moreover, interactions between group and schema-relatedness (F (2, 915) = 5.33, p = .005, η_p^2 = 0.01) and group and memory specificity (F (2, 915) = 3.30, p = .037, η_p^2 = 0.01) were also significant.

Regarding the group interaction with schema-relatedness: memories to schema-related stimuli were associated with more negative evoked emotion in the dysphoric group

(M = 2.27) relative to the remitted MDE group (*M* = 2.89, *t* = 5.56, *p* < .001) and the control group (*M* = 2.95, *t* = 4.68, *p* < .001). For schema-unrelated stimuli, memories were associated with more negative evoked emotion in the dysphoric group relative to the control group (*Ms* = 2.96 vs. 3.26, *t* = 3.02, *p* = .026). Finally, in the dysphoric group, memories to schema-related stimuli were associated with more negative evoked emotion than schema-unrelated stimuli (*Ms* = 2.27 vs. 2.96, *t* = 5.77, *p* < .001).

Regarding the group interaction with memory specificity: in the dysphoric group, categoric memory retrieval was associated with more negative evoked emotion than specific memory retrieval (*Ms* = 2.34 vs. 2.89, *t* = 3.76, *p* = .002), and in categoric memory retrieval, the dysphoric group reported more negative evoked emotion compared with the remitted MDE group (*M* = 2.87, *t* = 4.29, *p* < .001) and the control group (*M* = 3.16, *t* = 4.93, *p* < .001).

Next, to test the above effects in negative or positive stimuli, we carried out analyses restricted to trials in which categoric or specific retrieval occurred for negative or positive stimuli. With trials in which specific or categoric memories were retrieved in response to negative stimuli as the dependent variable (*n* = 402), the main effects of group (F (2, 387) = 3.93, p = .02, η_p^2 = 0.02), schema-relatedness (F (1, 387) = 14.45, p < .001, η_p^2 = 0.04), and memory specificity (F (1, 387) = 4.41, p = .036, η_p^2 = 0.01) were significant, in the same direction as outlined above. Although the main effect of group was significant, post hoc comparison did not yield significant differences between groups (*ps* > .069).

With trials for positive stimuli as the dependent variable (*n* = 337), the main effects of group (F (2, 325) = 6.32, p = .002, η_p^2 = 0.04) and schema-relatedness (F (1, 325) = 10.42, p = .001, η_p^2 = 0.03) and the interaction between group and schema-relatedness (F (2, 325) = 4.37, p = .013, η_p^2 = 0.03) were significant. Post hoc comparison revealed that in the dysphoric group, memories in response to schema-related stimuli were associated with more negative evoked emotion than schema-unrelated stimuli ($M = 2.50$ vs. 3.37, $t = 4.07$, $p < .001$), and in the schema-related condition, memories in the dysphoric group were associated with more negative evoked emotion than memories in the remitted MDE group ($M = 3.30$, $t = 3.83$, $p = .002$) and in the control group ($M = 3.35$, $t = 3.47$, $p = .007$) regardless of memory specificity.

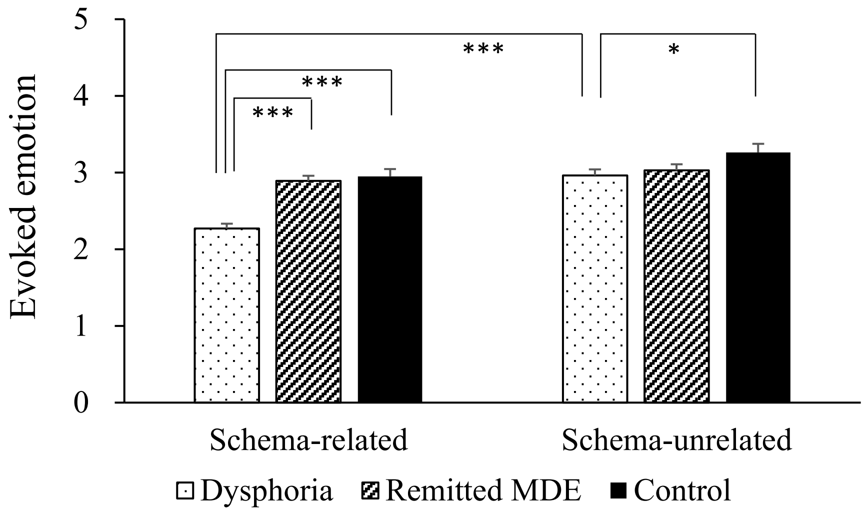

Figure 2. The group differences of evoked emotion as a function of schema-relatedness. Higher values mean positive emotion and lower values mean negative emotion ($^{***}p < .001$, $^{*}p < .05$). The error bars indicate standard errors.

Exploratory Analysis

Current Depressive Symptoms, Past MDEs, and Categoric Memories

We examined the correlations between involuntary categoric memories and depressive symptom severity or the presence/absence of past MDEs regardless of group. Depressive symptom severity was positively correlated with the number of categoric memories in schema-related condition (r = .25, p = .027) and for negative stimuli in schema-related condition (r = .40, p < .001). The presence of past MDE episodes was also positively correlated with the number of categoric memories in schema-related condition (r = .33, p = .003) and for negative stimuli in schema-related condition (r = .31, p = .005).

Next, hierarchical multiple regression analysis was performed to examine whether there is trait effect of past MDEs on categoric memories even if controlling for current depressive symptom severity. In Step 1, BDI-II was entered into the model. In Step 2, the presence/absence of past MDEs was entered. In Step 1, the model reached significance (R^2 = .06, p = .027) and the effect of BDI-II was significant (β = .25, t = 2.25, p = .027). In Step 2, there is a significant model improvement (ΔR^2 = .07, p = .016) and the overall model was also significant (R^2 = .13, p = .005). The effect of past MDEs were significant (t = 2.45, p = .016), but the effect of BDI-II was no longer significant (β = .15, t = 1.34, p = .18).

Specific Memory

Apart from the planned analyses, we carried out an exploratory analysis to examine differences in the number of specific memories in each group and condition. The two-way ANOVA (group * schema-relatedness) showed a significant effect of schema-relatedness (F (1, 77) = 23.62, p < .001, η_p^2 = 0.24), meaning that in the schema-unrelated condition, participants yielded more specific memories than in the schema-related condition. This potentially results from the high imageability (Williams, Healy, & Ellis, 1999) of schema-unrelated stimuli, which was not assessed in the current study. Qualities of the stimuli that were assessed during stimuli development are outlined in the supplementary materials and additional OSF documentation (https://osf.io/kvqxe/). The effect of group (F (2, 77) = 2.14, p = .13, η_p^2 = 0.05) and interaction (F (2, 77) = 2.36, p = .10, η_p^2 = 0.06) were not significant[2]. When stimuli valence was considered, for specific memories in response to negative stimuli, the effect of schema-relatedness was also significant in the same direction as outlined above (F (1, 77) = 16.06, p < .001, η_p^2 = 0.17), and the effect of group (F (2, 77) = 2.16, p = .12, η_p^2 = 0.05) and interaction were not significant (F (2, 77) = 2.00, p = .14, η_p^2 = 0.05). For specific memories in response to positive stimuli, again, the effect of schema-relatedness was significant in the same direction as outlined above (F (1, 77) = 29.26, p < .001, η_p^2 = 0.28), and the effect of group (F (2, 77) = 1.49, p = .23, η_p^2 = 0.04) and interaction were not significant (F (2, 77) = 2.09, p = .13, η_p^2 = 0.05).

Memory Characteristics: Rehearsal

We examined the effects of group, schema-relatedness, and memory specificity on memory characteristics for all memories recorded and then for memories retrieved in response to negative and positive cues. Only results related to *rehearsal* are presented here and other results are described in the Supplementary file.

For all memories, main effects of group (F (2, 885) = 6.75, p = .001, η_p^2 = 0.02), schema-relatedness (F (1, 885) = 13.59, p < .001, η_p^2 = 0.02, schema-related > schema-

[2] There was an observable group difference in the number of specific memories in the schema-unrelated condition. However, a two-way ANOVA failed to detect any significant group differences. While additional analyses of group differences in specific memory in the schema-unrelated condition were also nonsignificant moderate effect sizes were observed between the dysphoric and control group (*Ms* = 6.33 vs. 2.93, p = .09, d = 0.65) and remitted MDE group and control group (*Ms* = 5.39 vs. 2.93, p = .24, d = 0.47). In addition, self-reflections of some participants in the dysphoric and past MDE groups reported that they could not ignore the sentences and thus images and thoughts popped into mind. These findings potentially support the lack of cognitive inhibition hypothesis of involuntary memory (Barzykowski et al., 2019), which is worthy of further exploration.

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unrelated), and memory specificity (F (1, 885) = 25.48, p < .001, η_p^2 = 0.03, categoric > specific) on *rehearsal* were evident. Post-hoc tests revealed that rehearsal was higher for the dysphoric group compared with the remitted MDE group (t = 2.39, p = .034) and the control group (t = 3.51, p = .001). Similar findings were observed in the analysis of memories for negative stimuli (see the Supplementary file).

Discussion

We examined the hypothesis that (negative) schema-related stimuli, which may be more likely to activate dysfunctional and negative self-schema, would promote involuntarily retrieved categoric memory, in individuals with dysphoria and remitted MDEs. We also examined whether the number of involuntary categoric memories retrieved in response to (negative) schema-related stimuli would be related to an index of dysfunctional schema activation and that involuntary categoric memories in response to schema-related stimuli would be associated with negative evoked emotion.

As predicted, dysphoric and remitted MDE groups reported more categoric memories for schema-related stimuli than the control group, and this trend was also shown for negatively-valenced schema-related stimuli. In addition, the dysfunctional schema index was positively correlated with the number of categoric memories retrieved following negatively-valenced schema-related stimuli. This novel but cumulative evidence indicates that individuals who are vulnerable to depression are likely to involuntarily retrieve categoric memories when their dysfunctional schema is activated. These findings extend the literature that semantic priming facilitates involuntary retrieval of relevant autobiographical memories (Barzykowski, & Niedźwieńska, 2018; Mace et al., 2019; Mace & Unlu, 2020) to the pathological mechanisms underlying depression.

Similar to previous studies (e.g., Hamilton & Abramson, 1983), dysphoric participants reported high levels of dysfunctional schema while individuals in remission from MDE reported low levels of dysfunctional schema comparable to the control group. Nevertheless, the remitted MDE group experienced more involuntary categoric memory compared with the control group and the association between the presence of past MDEs and involuntary categoric memory was significant, even controlling for current depressive symptom severity. In sum, finding provide preliminary evidence supporting the view that semantic priming of schema-related information is associated with that the activation of dysfunctional schema and involuntary categoric memory retrieval in the context of depression and as such may play a role in maintaining emotional vulnerability.

Interestingly, involuntary categoric memories were reported with higher levels of rehearsal than specific memories and, schema-related stimuli were reported to be more rehearsed than schema-unrelated memories. These findings indicate that some schema-based categoric memories may be available as highly accessible autobiographical knowledge (Barzykowski & Staugaard, 2016, 2018). That is, there may be schematic categoric memories (e.g., I always fail) that are habitually retrieved *through involuntarily* cognitive processing. Schematic knowledge influences how we perceive the external world (Bartlett, 1932; Gilboa & Marlatte, 2017), and when it is biased towards the negative, such as due to the onset of depression, people tend to interpret events negatively (Everaert, 2021; Everaert, Bronstein, Castro, Cannon, & Joormann, 2020; Nieto, Robles, & Vazquez, 2020). Indeed, predictions about the external world based on negative beliefs can create a negative bias in our cognition (Kube, Kirchner, Lemmer, Glombiewski, 2021; Kube, Schwarting, Rozenkrantz, Glombiewski, & Rief, 2020). In line with this view, individuals reporting current depressive symptoms in the present study experienced higher levels of negative evoked emotion relative to remitted MDE and control groups both in relation to schema-related stimuli and categoric memories. Within the framework of depressive information processing that assumes selective attention to negative stimuli, negative interpretation for ambiguous stimuli, and memory consolidation of those negative stimuli (Sanchez, Duque, Romero, & Vazquez, 2017; Farb, Irving, Anderson, & Segal, 2015), involuntary categoric memory can be positioned as a factor that amplifies negative abstract cognitive processing that goes beyond the boundaries of cognitive control. Of particular importance is that involuntary categoric memory in response to an event may propagate its activation to nodes in the semantic network, leading to further involuntary retrieval of other negative events and to the activation of negative self-knowledge and thoughts (rumination), which may then be consolidated and anchored in memory (Farb et al., 2015). As mentioned earlier, once a schematic memory is formed, the tendency for information processing according to it becomes stronger (Bartlett, 1932, Joormann et al., 2009). Thus, categoric memory may be a central construct in depressive information processing, and its habitual involuntarily retrieval or stored as schematic autobiographical knowledge could be a psychopathology of depression.

Schema-related stimuli tended to evoke more negative emotion than schema-unrelated stimuli, and all groups experienced more negative emotion compared with the theoretical median for negative schema-related stimuli. In terms of group differences, participants in the dysphoric group experienced more negative emotion due to involuntary (categoric) memory, especially in response to positive schema-related stimuli, whereas there was no such statistical evidence in the remitted MDE group. This finding extends to involuntary memory the finding that individuals vulnerable to depression are less likely to retrieve positive memories in response to positive cues in voluntary memory tasks (Young, Erickson, & Drevets, 2012). For positive schema-related stimuli (e.g., warm family), participants in the dysphoric group sometimes experienced negative involuntary memory with the opposite meaning to the cue (e.g., days of crying alone because my parents yelled at me) and sometimes experienced involuntary memory that emphasized the contrast between past and present (e.g., "I was told I was smart until I was in secondary school" for the cue "smart"). This may be due to mood congruent memory (Blaney, 1986), which promotes the recall of memories that are congruent with the current negative mood, and the mood contrast effect (Joormann, Siemer, & Gotlib, 2007; Watson, Berntsen, Kuyken, & Watkins, 2012), in which the discrepancy between the past self in memories and the current self produces a negative mood. Schema-related stimuli can activate semantic networks (e.g., autobiographical knowledge about "family"), and negative or depressive mood facilitates involuntary negative memories and thoughts in autobiographical knowledge. Greater negative emotion evoked was found in the dysphoric group compared with the remitted MDE and control groups, potentially due to current depressive mood driving these associative processes. Although the above discussion concerns the pathology of dysphoric group rather than remitted MDE group, frequent experience of involuntary categoric memory for negative schema-related stimuli is still potentially problematic in the remitted MDE group because they experienced at least more negative emotion than the theoretical median (although not significantly more than dysphoric and control groups) following involuntary categoric memory. This suggests that frequent responses to negative schema-related stimuli remains a risk factor for the recurrence of depression.

The CaR-FA-X model posited that OGM serves as a form of emotion regulation in response to emotions generated by the retrieval of specific memories of negative events, which become entrenched in individuals as a generalized retrieval style (Williams et al., 2007). Several studies have found that memory overgenerality, as measured by voluntary

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memory tasks, is related to lower emotional impact following stressful experiences (e.g., Raes et al., 2003). However, consistent with the finding that involuntary memory has less opportunity to be mediated by voluntary cognitive control (Watson et al., 2013), this hypothesis seems less relevant within the context of involuntary memory. In support of this, the present study showed that stronger negative emotion occurred following involuntary categoric memories, particularly for negative cues, than for involuntary specific memories. Although the functional avoidance hypothesis (Williams, 1996; Williams et al., 2007) has been favoured by findings that individuals with trauma history show high levels of overgeneral memory (Barry, Lenaert, Hermans, Raes, & Griffith, 2018; Moore & Zoellner, 2007; Ono et al., 2016), those findings may be partially explained by negative schema held by trauma victims (Ehlers & Clark, 2000; LoSavio, Dillon, & Resick, 2017), which increase accessibility to categoric memory. Indeed, in a naturalistic diary study, Schönfeld & Ehlers (2017) found that, PTSD patients had fewer involuntary specific memories and more involuntary general (categoric) memories, relative to controls and these memories were important to their life themes. We do not argue that the functional avoidance hypothesis for voluntary retrieval is inaccurate but rather that it does not necessarily apply within the context of involuntary retrieval.

No significant group differences were found for the number of specific memories, which is consistent with previous findings that there is no association between the number or proportion of specific memories and depression in involuntary retrieval (Kvavilashvili & Schlagman, 2011; Watson et al., 2013). There is robust evidence that individuals with depression demonstrate reduced voluntary retrieval of specific memories (Barry et al., 2021; Williams et al., 2007), but this would not necessarily apply to involuntary retrieval. Although the CaR-FA-X model (Williams et al., 2007) posited that avoidance of specific memory

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retrieval or impaired executive control is responsible for OGM, such cognitive control is less likely to be involved in involuntary retrieval. The CaR-FA-X model also suggests that in voluntary retrieval, activation of self-schemas forms abstract and generalized chain of thoughts (termed *mnemonic interlock*), which interfere with retrieval of specific memories. However, as involuntary retrieval is not goal-oriented search process, it is unlikely that retrieval of specific memories is required despite the situation in which the chain of thoughts occurs. Thus, the three key mechanisms proposed in the CaR-FA-X model (capture and rumination, functional avoidance, and executive capacity and control) would not necessarily apply to involuntary retrieval of specific memories.

In summary, our data highlight increased accessibility for involuntary categoric memories in individuals vulnerable to depression. This extends previous findings that, in voluntary retrieval, these individuals are more likely to retrieve categoric memories directly in response to negative cues (Matsumoto et al., 2020). These findings emphasize the importance of considering the accessibility of general autobiographical knowledge, with or without retrieval intention, as a factor of overgeneral memory, in addition to generative retrieval difficulties of specific memories, which have been addressed by traditional theories (Williams et al., 2007).

Clinical Implications

While previous studies have focused on involuntary retrieval of specific past events, particularly in the context of trauma and intrusive memory (Berntsen, 2015; Brewin, Gregory, Lipton, & Burgess, 2010; James et al., 2016), our findings shed light on broader involuntary cognition (Krans, de Bree, & Moulds, 2015), particularly on the contribution of involuntary categoric memories to developing psychopathology. To prevent the worsening of mood induced by involuntary categoric memories, which may exacerbate depression in the long term, we suggest two possible interventions: controlling involuntary memory itself and reducing the emotional impact induced by involuntary memory retrieval.

We have shown that one form of overgeneral memory, traditionally regarded as a product of abnormal voluntary retrieval, is also generated through involuntary retrieval. Conventional interventions have demonstrated some improvement of depressive symptoms through repeated training on retrieving specific memories (Memory Specificity Training: MeST: Barry, Sze, & Raes, 2019, Barry, Hallford, Hitchcock, Takano, & Raes, 2021; Raes et al., 2009). However, it is possible that the intrinsic target that leads to depression is not solely difficulties in retrieval of specific memories but increased accessibility to categoric memories. Difficulties in retrieval of specific memories, as well as increased overgeneral (categoric) memory, have been shown to worsen depression (Hallford et al., 2021; Sumner et al., 2010), potentially because preferential access to categoric memory overshadows specific memory retrieval, reducing reporting of specific memories. Training programs such as MeST have shown some effects on depression symptoms which may arise from indirect modifications of memory representations. For example, research suggests that retrieval-induced forgetting occurs between general and specific memories (Matsumoto, Mochizuki, Marsh, & Kawaguchi, 2021), and retrieval practice of specific memories may suppress competing general memory representations. Hitchcock et al. (2019) also found that depressed individuals have difficulty retrieving positive memories that contradict their negative self, suggesting that retrieval practice of positive specific memories may buffer negative autobiographical knowledge. The process variables of how MeST may have a positive impact on mental health are largely unexplored (Barry et al., 2021); therefore, interventions from a variety of perspectives beyond the retrieval practice of specific memories need to be devised (Hitchcock et al., 2018; Korrelboom, IJdema, Karreman, van der Gaag, 2022) and features of involuntary memory remain largely unexplored within this area.

A greater focus on emotion regulation after involuntary memory retrieval may also reap benefits. Involuntary memory leads to greater emotional impact than voluntary memory (Berntsen, 2021), and depressed individuals are particularly prone to respond emotionally to involuntary memories and to use maladaptive emotion regulation strategies such as rumination and thought suppression (del Palacio-Gonzalez, Berntsen, & Watson, 2017; del Palacio-Gonzalez & O'Toole, 2022). On the other hand, Isham, del Palacio-Gonzalez, & Dritschel (2020) have shown that mindfulness traits can help with emotional regulation after experiencing involuntary memory. Mindfulness helps to free the mind from negative, schematic higher-order information processing by focusing attention on present sensations (Segal, Williams, & Teasdale, 2002; Teasdale, 1999) and may also prevent their processing being cascaded by involuntary category memories based on dysfunctional or negative self-schema activation.

In studies of involuntary and intrusive memory, some participants may have extremely high numbers of memories, which can lead to criticism about these outliers (Cristea & Naudet, 2019). In the present study, there was also large intra-individual variance in the number of involuntary memories, with a maximum of 88 memories. However, such outliers may represent individual differences in the ability to suppress autobiographical knowledge activated by stimuli. According to the lack of cognitive inhibition hypothesis of involuntary memory (Barzykowski, Radel, Niedźwieńska, & Kvavilashvili, 2019), cognitive inhibition ability prevents us from being flooded with involuntary memories. However, a lack of inhibition typical of individuals with psychiatric disorders may increase the likelihood of experiencing involuntary memories. It is well known that involuntary memory occurs through chaining, whereby one involuntary memory leads to retrieval of other involuntary memories (Mace, 2010; Mace, Clevinger, & Bernas, 2013). Individuals reporting high numbers of involuntary memories may be understood as those with strong chaining, which can be described as the easy activation of semantic networks. Rather than regarding these individuals as outliers, we can consider these individual characteristics and link them to interventions to improve mental health.

Limitations

First, the sample for this study was screened from university students, and therefore the results may not generalizable to a wider community or patient population. Second, with the exception of schema-relatedness manipulation, the cross-sectional nature of this study limits the ability to infer the causal relationship between depressive symptoms and/or dysfunctional schema and involuntary memory specificity. Depressive symptoms and dysfunctional schema are covariant and may be confounded. Third, higher memory specificity in the schema-unrelated condition compared to the schema-related condition suggests that the characteristics of cue words (e.g., imageability; Williams et al., 1999) may influence memory specificity, but this study did not focus on this difference. Fourth, because of our sample size design for based on calculations related to the planned analyses, tests involving interactions may have been underpowered. Fifth, we used an instruction that asked participants to report any memory that came to mind during the vigilance task, however instructions determine what participants monitor in their memory retrieval, therefore other instructions may have yielded different results (Barzykowski & Staugaard, 2018). Finally, the present study hypothesized that activated schema would induce involuntary categoric memory, and as in previous research (Spinhoven et al., 2007) an index of trait dysfunctional schema was used to test this hypothesis. However, since dysfunctional schema held by individuals with remission from MDEs tend to be activated during state-specific conditions rather than observed as a trait characteristic (Segal et al., 2006), state measures of dysfunctional schema may be relevant to consider in future research.

Conclusions

We demonstrated that some overgeneral categoric memories were involuntarily retrieved based on the activation of dysfunctional schema and that these were more frequently observed in individuals with dysphoria and remission from MDEs. Involuntary memories retrieved in response to negative schema-related stimuli evoked negative emotion; moreover, individuals with dysphoria particularly experienced negative emotion when categoric memories were retrieved for positive schema-related stimuli. These findings suggest that involuntary categoric memories could lead to the worsening or recurrence of depression. Future research should shed more light on involuntary categoric memories as well as involuntarily retrieved specific memories and on their control and coping.

Compliance with Ethical Standards

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

Ethical approval: All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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Supplementary file

The development of schema-related and unrelated stimuli

We conducted a preliminary online survey to assess the schema-relatedness and emotional valence of the 981 stimuli. We collected data regarding emotional valence (1 = positive, 5 = negative), self-relatedness (1 = not applicable, 5 = most applicable), and importance (1=not important, 5 = important) of sentences and examined whether these ratings were correlated with depressive symptoms (Patient Health Questionnaire: PHQ-9; Kroenke, Spitzer, & Williams, 2001) and dysfunctional schema (Dysfunctional Attitudes Scale: DAS-24; Power et al., 1994). Due to the large number of items, the experimental stimuli were divided into seven subsets, and participants were randomly assigned (*n* = 173-228) for the rating. Stimuli were selected as schema-related when the self-relatedness and/or importance ratings of the sentences correlated with the DAS-24 (negative correlations for positive stimuli and positive correlations for negative stimuli). Of these, 200 positive stimuli (*M* = 1.94, *SD* = 0.20) and 200 negative stimuli (*M* = 4.02, *SD* = 0.24) were selected based on ratings of emotional valence. For schema-unrelated stimuli, we selected sentences from Kvavilashvili & Schlagman's (2008) stimuli whose self-relatedness and importance did not correlate with the DAS-24 and selected 200 positive (*M* = 2.02, *SD* = 0.29) and 200 negative sentences (*M* = 4.21, *SD* = 0.29) based on ratings of emotional valence.

Three-way ANOVA for categoric and specific memories

Due to the planned analysis strategy, the results of three-way ANOVAs (group * schema-relatedness * stimuli valence) were not reported in the main text, but are presented here. Note that these analyses only included trials where involuntary memory cues were identified as external positive or negative sentences. The three-way ANOVA for categoric memory revealed that the effect of group (F (2, 77) = 4.80, p = .011, $\eta_p^2 = 0.11$) and interaction between group and stimuli valence were

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significant (*F* (2, 77) = 3.32, *p* = .041, $\eta_p^2 = 0.08$). Post hoc comparisons showed that the remitted MDE group generated more categoric memories for negative stimuli relative to controls (*t* = 3.17, *p* = .029). The difference between the dysphoric group and the control group did not reach significance (*t* = 2.95, *p* = .054). The three-way ANOVA for specific memory showed that the effect of schema-relatedness was significant (*F* (1, 77) = 28.06, *p* < .001, $\eta_p^2 = 0.27$), but other significant effects, including stimuli valence, were not detected (*Fs* < 2.70, *ps* > .07).

Memory Characteristics

Descriptives of memory characteristics are presented in Supplementary Table S1. We described the results separately for each main effect and interaction effect as follows:

Main effects of Group

Main effects of group were significant for *rehearsal* (*F* (2, 885) = 6.75, *p* = .001, η_p^2 = 0.02) and *concentration* (*F* (2, 912) = 7.82, *p* < .001, η_p^2 = 0.02). Post hoc comparison revealed that the dysphoric group were more concentrated on the task compared with the remitted MDE group (*t* = 2.87, *p* = .008) and the control group (*t* = 3.63, *p* < .001).

Main effects of Schema-Relatedness

Main effects of schema-relatedness were significant for *rehearsal* ((*F* (1, 885) = 13.59, *p* < .001, η_p^2 = 0.02, schema-related > schema-unrelated), *concentration* (*F* (1, 912) = 4.72, *p* = .03, η_p^2 = 0.01, schema-related > schema-unrelated) and *age of memory* (*F* (1, 878) = 14.33, *p* < .001, η_p^2 = 0.02, schema-unrelated>schema-related). Main effects of schema-relatedness on *rehearsal* were also evident for memories retrieved in response to negative (*F* (1, 384 = 4.71, *p* = .031, η_p^2 = 0.01, schema-related > schema-unrelated) and positive stimuli (*F* (1, 318) = 9.28, *p* = .003, η_p^2 = 0.03, schema-related > schema-unrelated). Whereas effects on *age of memory* were significant only for memories retrieved to negative stimuli (*F* (1, 381 = 6.78, *p* = .01, η_p^2 =

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0.02, schema-unrelated>schema-related) and effects of *concentration* were only significant for memories retrieved in response to positive stimuli, (*F* (1, 325) = 9.81, *p* = .002, η_p^2 = 0.03, schema-related > schema-unrelated).

Main effects of Specificity

Main effects of specificity were significant for *rehearsal (F* (1, 885) = 25.48, *p* < .001, η_p^2 = 0.03, categoric > specific), *unusualness* (*F* (1, 885) = 145.52, *p* < .001, η_p^2 = 0.14, specific > categoric) and *age of memory* (*F* (1, 878) = 5.08, *p* = .024, η_p^2 = 0.01, categoric > specific). Main effects of specificity on *rehearsal* and *unusualness* in the same direction, were also evident in memories retrieved in response to negative (*rehearsal*, *F* (1, 384 = 8.71, *p* = .003, η_p^2 = 0.02; *unusualness*, *F* (1, 384 = 59.15, *p* < .001, η_p^2 = 0.13) and positive (*rehearsal*, *F* (1, 318) = 5.95, *p* = .015, η_p^2 = 0.02; *unusualness*, *F* (1, 317) = 62.05, *p* < .001, η_p^2 = 0.16) stimuli.

Interactions

A two-way interaction between schema-relatedness and memory specificity was evident when *unusualness* was included as the dependent variable (*F* (2, 885) = 8.06, *p* = .005, η_p^2 = 0.01). The unusualness of specific memories in the schema-unrelated condition was higher than that of categoric memories in the schema-unrelated condition (*t* = 10.94, *p* < .001) and specific memories in the schema-related condition (*t* = 3.37, *p* = .002). In the schema-related condition, the unusualness of specific memories was higher than that of categoric memories (*t* = 6.30, *p* < .001).

For memories retrieved in response to negative stimuli, a two-way interaction between group and memory specificity on concentration was significant (*F* (2, 384 = 3.21, *p* = .041, η_p^2 = 0.02). Such that for categoric memory retrieval, the dysphoric group was more concentrated on the task than the remitted MDE group (*t* = 4.75, *p* < .001).

For memories retrieved in response to positive stimuli, the interaction between schema-relatedness and memory specificity was significant (F (2, 318) = 5.31, p = .022, η_p^2 = 0.02). Rehearsal was higher for categoric memory retrieval in the schema-related condition compared with specific memory retrieval (t = 3.51, p = .003) and in the schema-unrelated condition (t = 3.10, p = .008). No other two-way or three-way interactions reached significance (all F's < 2.83, all p's > .06, all η_p^2 's < 0.02).

Memory characteristics for all involuntary memory

While the main text reported memory characteristics for categoric and specific memories recalled, the Supplementary Table S2 shows memory characteristics for all involuntary memory.

Linear mixed model for evoked emotion

We firstly transformed the variables as follows: Memory specificity (Specific = 0.5, Categoric = -0.5), Schema-relatedness (Schema-related = 0.5, Schema-unrelated = -0.5), Dysphoria (Dysphoria = 0.5, Remitted MDE = -0.5, Control = -0.5), and Remitted MDE (Dysphoria = -0.5, Remitted MDE = 0.5, Control = -0.5). Namely we developed two dummy variables as between-group effects. These main effects and interactions excluding the interaction of the two dummy variables were entered into the model. Random slopes were not included in the model due to the small number of observed variables.

The results showed that the main effects of memory specificity (γ = 0.26, SE = 0.08, t = 3.48, p < .001), schema-relatedness (γ = -0.35, SE = 0.08, t = 4.67, p < .001), and dysphoria (γ = -0.50, SE = 0.13, t = 3.67, p < .001) were significant. These results indicated that, in alignment with the results from three-way ANOVA, categoric memory, schema-related stimuli, and dysphoric group were associated with more to negative evoked emotion compared with specific memory, schema-unrelated stimuli, and control or remitted MDE group. Again in line with the ANOVA, the interaction between memory specificity and dysphoria was also significant (γ = 0.41, *SE* = 0.19, *t* = 2.11, *p* = .035). Simple slope test revealed that the dysphoric group experienced more negative emotions compared with the control group when categoric memories were recalled (*t* = 4.25, *p* < .001) but not when specific memories were recalled (*t* = 1.14, *p* = .26; Figure S1).

For memories retrieved in response to negative stimuli, the results showed that the main effects of memory specificity (γ = 0.32, *SE* = 0.10, *t* = 3.07, *p* = .002), schema-relatedness (γ = -0.40, *SE* = 0.10, *t* = 3.92, *p* < .001), and dysphoria (γ = -0.37, *SE* = 0.17, *t* = 2.09, *p* = .038) were significant. The directions of significance were same as the results for all stimuli described above.

For memories retrieved in response to positive stimuli, only the main effect of schema-relatedness was significant (γ = -0.48, *SE* = 0.12, *t* = 3.90, *p* < .001), indicating that schema-related stimuli evoked more negative emotions.

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Supplementary Table S1.

Mean ratings of evoked emotion, rehearsal, frequency, and concentration at group level for specific and categoric memories recalled

	Dysphoria		Remitted MDE		Control	
	Schema-related	Schema-unrelated	Schema-related	Schema-unrelated	Schema-related	Schema-unrelated
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
Overall						
Evoked emotion	2.27 (1.03)	2.96 (1.19)	2.89 (0.87)	3.03 (0.82)	2.95 (0.97)	3.26 (0.93)
Rehearsal	2.85 (1.34)	2.33 (1.18)	2.66 (1.12)	2.10 (1.01)	2.19 (1.17)	2.18 (1.11)
Unusualness	2.82 (1.37)	3.33 (1.49)	2.77 (1.49)	3.48 (1.37)	3.04 (1.37)	3.07 (1.33)
Concentration	3.20 (1.03)	3.06 (1.07)	3.03 (0.92)	2.81 (0.84)	2.85 (0.83)	2.74 (0.75)
Age of memory	2.64 (3.17)	3.71 (4.14)	2.64 (3.37)	3.07 (4.06)	2.50 (2.92)	4.00 (4.14)
For Positive Stimuli						
Evoked emotion	2.50 (1.14)	3.36 (1.07)	3.30 (0.73)	3.39 (0.82)	3.34 (0.97)	3.53 (1.02)
Rehearsal	2.88 (1.34)	2.33 (1.17)	2.59 (1.03)	1.96 (0.97)	2.14 (1.03)	2.26 (1.07)
Unusualness	2.66 (1.31)	3.24 (1.50)	2.86 (1.54)	3.58 (1.34)	3.14 (1.43)	2.96 (1.40)
Concentration	3.16 (1.14)	2.81 (0.96)	3.29 (0.82)	2.82 (0.76)	2.97 (0.87)	2.72 (0.68)
Age of memory	3.28 (3.58)	2.77 (3.80)	2.80 (3.33)	3.11 (3.92)	2.76 (2.57)	4.55 (3.96)
For Negative Stimuli						
Evoked emotion	2.05 (0.92)	2.65 (1.10)	2.39 (0.79)	2.75 (0.75)	2.50 (0.86)	2.89 (0.76)
Rehearsal	2.70 (1.25)	2.18 (1.16)	3.06 (1.12)	2.26 (1.04)	2.11 (1.22)	2.06 (1.01)
Unusualness	2.90 (1.37)	3.46 (1.47)	2.79 (1.38)	3.37 (1.43)	3.15 (1.26)	3.31 (1.01)
Concentration	3.41 (0.97)	3.39 (0.98)	3.00 (0.94)	2.82 (0.92)	2.85 (0.88)	2.80 (0.80)
Age of memory	2.53 (3.16)	4.37 (4.20)	2.48 (3.43)	3.19 (4.28)	2.52 (3.45)	4.78 (4.65)

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Supplementary Table S2.

Mean ratings of evoked emotion, rehearsal, frequency, and concentration on task at group level

	Dysphoria		Remitted MDE		Control	
	Schema-related	Schema-unrelated	Schema-related	Schema-unrelated	Schema-related	Schema-unrelated
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
Overall						
Evoked emotion	2.32 (1.06)	2.99 (1.19)	2.88 (0.96)	3.07 (0.84)	2.97 (0.96)	3.22 (0.92)
Rehearsal	2.86 (1.35)	2.43 (1.21)	2.74 (1.19)	2.17 (1.06)	2.29 (1.17)	2.22 (1.13)
Unusualness	2.88 (1.38)	3.30 (1.48)	2.88 (1.51)	3.42 (1.39)	3.05 (1.32)	3.08 (1.35)
Concentration	3.20 (1.03)	3.09 (1.08)	3.00 (0.93)	2.84 (0.86)	2.86 (0.90)	2.74 (0.80)
Age of memory	2.59 (3.28)	3.69 (4.02)	2.58 (3.26)	3.17 (4.06)	2.80 (2.93)	4.29 (3.23)
For Positive Stimuli						
Evoked emotion	2.55 (1.11)	3.38 (1.11)	3.29 (0.82)	3.47 (0.82)	3.30 (0.97)	3.45 (1.05)
Rehearsal	2.80 (1.30)	2.41 (1.17)	2.64 (1.09)	2.14 (1.10)	2.24 (1.01)	2.38 (1.15)
Unusualness	2.55 (1.22)	3.23 (1.48)	2.94 (1.54)	3.49 (1.37)	3.14 (1.40)	2.93 (1.40)
Concentration	3.10 (1.15)	2.93 (1.01)	3.25 (0.85)	2.87 (0.81)	3.08 (0.95)	2.65 (0.73)
Age of memory	3.08 (3.49)	2.81 (3.68)	2.86 (3.21)	3.29 (4.06)	2.46 (2.36)	4.09 (3.92)
For Negative Stimuli						
Evoked emotion	2.08 (0.97)	2.66 (1.06)	2.33 (0.79)	2.76 (0.73)	2.53 (0.82)	2.88 (0.74)
Rehearsal	2.81 (1.31)	2.32 (1.22)	3.10 (1.15)	2.26 (1.06)	2.16 (1.19)	2.07 (1.03)
Unusualness	3.00 (1.40)	3.39 (1.48)	3.00 (1.46)	3.37 (1.43)	3.13 (1.23)	3.35 (1.09)
Concentration	3.41 (0.95)	3.37 (0.99)	3.00 (0.95)	2.82 (0.89)	2.90 (0.84)	2.79 (0.87)
Age of memory	2.26 (3.00)	4.34 (4.12)	2.39 (3.22)	3.19 (4.20)	2.52 (3.30)	4.86 (4.64)

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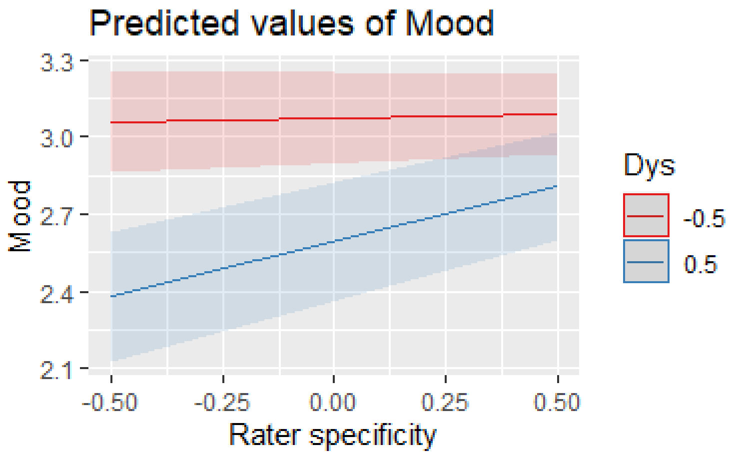

Figure S1. Predicted values of evoked mood and memory specificity as a function of dysphoria

Note. Rater specificity = -0.5 means categoric memory and Rater specificity = 0.5 means specific memory. Dys = 0.5 means dysphoric group and Dys = -0.5 means control or remitted MDE group.