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Examining the Associations Between Nonbelieved Memories and Memory Distrust, Self-Esteem, and Rumination

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When beliefs in autobiographical memories are reduced while recollections remain relatively intact, a phenomenon termed nonbelieved memories (NBMs) unfolds. The current preregistered study ($N = 104$) used a 3-week longitudinal design to investigate the relationships between the frequency of recalled NBMs, memory distrust, rumination over autobiographical events, and self-esteem. Our analyses showed that memory distrust was a positive predictor for the initial recall of NBMs during the past 2 months at Time 1, but not for the follow-up recalls of NBMs during the past week at Times 2–4. Exploratory analyses showed that, at Time 1, self-esteem was negatively associated with the total number of NBMs. Furthermore, the tendency to report involuntary memories and rumination over memories was positively associated with the total number of NBMs. In addition, (in)voluntary autobiographical memory recall tendency was also a significant positive predictor for the total number of NBMs at Times 2–4. Our study is one of the first to show that NBMs might be uniquely tied to specific individual markers.

Keywords: nonbelieved memories, memory distrust, rumination, involuntary memory recall

People lend credence to their memories to various degrees. This simple and intuitive notion has increased academic interest since Mazzoni et al. (2010) surveyed people's memories for which they have reduced their beliefs, which are termed nonbelieved memories (NBMs). One famous example of such an NBM is from the renowned developmental psychologist Jean Piaget. Piaget was convinced about an incident where he was almost kidnapped as an infant while going out with his nurse. He reported having vivid recollections concerning the experience but stopped believing in it after he found that this event had never happened (Piaget, 1951, as cited in Mazzoni et al., 2010).

Research on NBMs clearly shows that autobiographic beliefs and recollections are largely independent and may occur in absence of the other (Otgaar et al., 2014). That is, in addition to believed memories with both vivid recollections and high autobiographical beliefs, there are also believed-not-remembered events (low recollection but high belief) and NBMs (high recollective characteristics but low or no belief). In addition to surveying naturally occurring NBMs, using negative social feedback (i.e., by telling the participants that they falsely remembered something), researchers have experimentally reduced participants' autobiographical beliefs for both

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All research data and analyses scripts are publicly available at https://osf.io/5jzw4/.

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true and false memories, inducing NBMs for word lists (Otgaar et al., 2017; Wang et al., 2017), scenes (Otgaar et al., 2018), actions (Li et al., 2020; Mazzoni et al., 2014), and childhood events (Otgaar et al., 2013), providing additional evidence that beliefs and recollection do not necessarily go hand in hand.

Prevalence of NBM and Reasons for Belief Reduction

Among the first studies estimating the prevalence of NBMs, Mazzoni et al. (2010) provided university students with an example of NBM and then asked if they have an NBM. They found that 20% ($n = 98$) of participants reported an NBM. Similar percentages have been found in other studies (e.g., Brédart & Bouffier, 2016; Vanootighem et al., 2019). Apart from examining the prevalence of NBMs, research has also examined why people reduced their beliefs in the occurrence of specific events.

Mazzoni et al. (2010) reported three major categories of reasons for belief reduction: Negative social feedback (e.g., being told by family or friends that this event did not happen or happened to another person), contradictory evidence (nonsocial evidence suggesting that the event recollected did not happen), and implausibility (considering the event recollected was unlikely to have happened). Follow-up studies have shown similar results (Brédart & Bouffier, 2016; Vanootighem et al., 2019). For example, Otgaar et al. (2020) examined the memory reports from the False Memory Archive, an art website collecting experiences of false memories from the general population (https://www.falsememoryarchive.com/), and found that a large proportion ($n = 208$, 41.6%) of reports could be classified as NBMs (i.e., fitting in with the high recollection and low belief in occurrence pattern). More importantly, these NBM reports contained similar reasons for why belief was reduced as in previous studies.

Individual Differences and NBM

Although NBMs are not a rare or unique phenomenon, not all memories will turn into NBMs when being challenged (Li et al., 2020; Otgaar et al., 2016; Scoboria et al., 2018). For example, in their second study, Li et al. (2020) reported that when both social feedback and contradictory evidence were employed to challenge true memories, the NBM rate was 79.10% for bizarre actions and 68.33% for familiar actions. For challenged false memories, the NBM rate was 83.33% for bizarre actions and 79.10% for familiar actions. With experimental data where participants received multiple challenges to their memories, it has been shown that large individual differences exist in belief reduction (Otgaar et al., 2016; Scoboria et al., 2018). Specifically, Scoboria et al. (2018) found that around 25% of challenges resulted in the defense of the memory, that is, the maintenance or increase of belief. Moreover, around 14% of the participants ($n = 12$) always maintained or increased their autobiographical beliefs, while around 62% of the participants ($n = 53$) always relinquished their beliefs when challenged. These results suggest that there could be trait differences associated with the tendency of forming NBMs

According to the social-cognitive model of memory (Scoboria et al., 2018), when one's memory is being challenged, the individual can either deny the challenging information or reduce the belief in memory. The defense-or-relinquish response is influenced by the strategies one employs, the characteristics of the challenge, and the qualities of the memory. That is, external information (e.g., negative social feedback) interacts with appraisals of the memory to determine whether the belief in occurrence will be reduced. Therefore, the factors that could impact the evaluation of our memories are essential to the formation of NBMs. Since the occurrence of NBMs often involves a social component (i.e., receiving social feedback), researchers have examined whether certain individual differences tapping into such socially relevant constructs are linked to the formation of NBMs. However, attempts trying to link potential individual differences with NBM formation have been mostly unsuccessful. Specifically, Otgaar et al. (2017) examined the relationships between individual differences such as compliance as well as social desirability, and the formation of NBMs but did not find any relationship between them. Also, Li et al. (2020) examined the relation between suggestibility and NBM, and here too no link was detected.

Recent studies have focused on trait memory distrust as a potential individual marker being tied

to the creation of NBMs (Nash et al., 2022; Zhang, Otgaar, et al., 2022). Memory distrust was first coined to describe a mental state where people develop profound distrust toward their own memories and is oftentimes mentioned in discussions on how false confessions can occur (Gudjonsson, 2017). But it is also conceptualized as an individual difference, reflecting one's appraisal of memory functioning (van Bergen et al., 2010). The similarity between trait memory distrust and NBM is striking in that in both phenomena, people have a metacognitive appraisal (i.e., cognition about one's cognition, Proust, 2010) that their mental representation of an experience might be incorrect. Researchers have argued that trait memory distrust might be a pathway for why people reduce belief in the occurrence of events. Zhang, Otgaar, et al. (2022) were the first to examine the link between memory distrust and NBMs and reported a positive association between memory distrust and NBM. In this study, memory distrust was conceptualized as a stable individual difference measured with the Squire Subjective Memory Questionnaire (SSMQ; van Bergen et al., 2010) and was found to be a positive predictor of the self-reported number of NBMs. In addition, Zhang and colleagues also showed that self-esteem was negatively related to both memory distrust and self-reported NBMs, consistent with research showing that self-affirmation techniques boosting self-esteem can reduce the likelihood of accepting suggestive information about witnessed events (Szpitalak & Polczyk, 2015, 2019).

In addition to memory distrust, which more focuses on autobiographical belief, the occurrence of NBMs can also be linked to other individual differences that are more closely related to recollective features of memory, specifically, the tendency for rumination over autobiographical events. Rumination has been defined as repetitively and recurrently thinking about an experienced event which can also lead to an increase in people's state of distress (Curci et al., 2013; Nolen-Hoeksema et al., 2008). The pondering over experiences can either be voluntary or involuntary. Research has shown that individuals vary in their tendency to ruminate and that this individual difference can affect individuals' memories (e.g., Watkins & Teasdale, 2001). More specifically, rumination can have a double-edged effect on memory traces. On one hand, it can strengthen the memory traces thus promoting better retrieval (Daprati et al., 2013). On the other hand, rumination tendency is also negatively associated with memory performance for contextual information (Forner-Phillips et al., 2020), which could lead to worsened source monitoring. Therefore, the combination of better retrieval and worse source monitoring could lead to the recall of more NBMs. This line of reasoning also received support from research on repeated checking behaviors (Radomsky & Alcolado, 2010; Radomsky et al., 2006). Previous research has shown that repeated checking behavior, including mere mental checking (i.e., merely imagining checking), is associated with reduced metamemory such as confidence in one's memory (Radomsky & Alcolado, 2010; Radomsky et al., 2006) as a result of promoting conceptual processing, inhibiting perceptual processing, and difficulty of source monitoring (van den Hout & Kindt, 2003). Mental checking shares similarities with rumination over autobiographical events in that both are describing a psychological state where one replays certain autobiographical events. Therefore, it is reasonable to assume that rumination tendency over autobiographical events could be associated with memory distrust and NBMs

Overview of the Present Study

Building on Zhang, Otgaar, et al. (2022), the present study aimed to further examine the link between memory distrust and NBMs. Specifically, we improved and extended our design by using a 3-week longitudinal design to further examine the relationship between memory distrust, self-esteem, and NBMs. We asked participants to recall NBMs for the last 2 months in Time 1 and then NBMs for the past week in Times 2–4 (1 week after the previous time point). The longitudinal design with repeated measures allowed us to examine the individual difference in naturally occurring NBMs (i.e., the propensity of forming NBMs over time), complementing the results from experimental studies (e.g., Otgaar et al., 2014; Scoboria et al., 2018). In addition, we added exploratory measures that could reflect an individual's difference in rumination over autobiographical events aiming to bridge the gap between checking behavior and NBMs.

The primary research question was whether memory distrust was positively related to the number of NBMs in a fixed period (2 months in Time 1 or 1 week in Time 2–4). More specifically, we hypothesized that high trait memory distrust would be associated with a larger total number of NBMs compared with low memory distrust counterparts (Hypothesis 1).

In addition, we measured the reasons (i.e., negative social feedback, objective evidence, implausibility, and others) for belief reductions and the number of NBMs due to each reason reported by participants and examined the associations between the number of NBMs due to each reason and traits. Taking into consideration the importance of negative social feedback on the formation of NBMs (Mazzoni et al., 2010; Otgaar et al., 2020) and that the concept of memory distrust also stresses the reliance on others when individuals have a higher level of memory distrust (van Bergen et al., 2010), we hypothesized that high trait memory distrust would be associated with a greater number of NBMs due to social feedback compared with low memory distrust (Hypothesis 2).

We also added the self-esteem measure to replicate previous results (e.g., Zhang, Otgaar, et al., 2022). We expected that self-esteem would have a negative relationship with the frequency of NBMs (Hypothesis 3). However, we have no clear hypothesis regarding the relationship between self-esteem and NBMs due to different reasons. Furthermore, based on prior evidence showing a link between repeated checking and memory distrust (van den Hout & Kindt, 2003), we explored how memory distrust was related to traits associated with rumination over memories.

Method

Participants

Participants were undergraduate students from the Faculty of Psychology and Neuroscience at Maastricht University recruited via the SONA credit system, a research participation and management system (https://www.sona-systems.com/default.aspx). To participate, people had to be 18 years old (or older) and proficient in English. Finally, our participants received a compensation of one SONA credit if they participated in all parts of the study and 0.5 SONA if they finished at least the first part but not all of them. Data collection started in November 2021 and ended in March 2022. The present study obtained external ethical approval (HR1-1068-2020) at East China Normal University and has also been approved by the Ethics Review Committee Psychology and Neuroscience at Maastricht University. The present study was preregistered (https://osf.io/rb6cj) and the data and materials can be found on https://osf.io/5jzw4/ (Zhang, Battista, et al., 2022).

Sample Size Justification

We performed an a priori power analysis for one-sided Poisson regression with memory distrust as the independent variable and the number of NBM as the dependent variable (see https://osf.io/rb6cj, for the protocol) using G*Power (Faul et al., 2009). We used a one-tailed test because we hypothesized a positive relationship between high trait memory distrust and the frequency of nonbelieved memories (see Zhang, Otgaar, et al., 2022). Previous research has already established weak, $r(280) = .12$ to medium, $r(77) = .36$ positive correlations between the variables of interest (Zhang, Otgaar, et al., 2022). Hence, we expected a medium effect size in Cohen's terms (Cohen, 1962). To detect a medium effect size ($\beta_1 = 1.30$, $\beta_0 = 0.85$), with a statistical power ($1-\beta$) of .80, and a significance level of $\alpha = .05$, the required sample size was $N = 103$. We planned to recruit a sample of 110 participants in case of possible dropouts.

The final sample for Time 1 consisted of data from $N = 120$ participants, 13 of whom did not complete the first survey and only offered data about the number of NBMs but not trait measures and demographics. Three participants submitted the first survey two times and the second-time entries were removed from analyses. The data of three participants who failed at least one attention check were also dropped for all analyses. Therefore, at Time 1, there were a total of 117 participants reported NBMs, and 104 reported NBMs, traits, and demographics. There are attritions at the follow-up surveys on Times 2–4 (see Table 1, for demographic data).

Table 1
Age and Gender Statistics of the Samples at Times 1–4

Demographics	Time 1 (N = 104)	Time 2 (N = 86)	Time 3 (N = 66)	Time 4 (N = 62)
Age	20.7 (2.14)	20.6 (1.90)	20.8 (2.00)	20.8 (1.97)
Gender				
Female	89 (85.6%)	65 (75.6%)	49 (74.2%)	49 (79%)
Male	15 (14.4%)	9 (10.5%)	8 (12.1%)	7 (11.3%)
Missing	0 (0%)	12 (13.8%)	9 (13.4%)	6 (9.7%)

Note. For sample statistics of age, the numbers outside and inside the parentheses are the means and *SD*s, respectively.

Materials

Memory Distrust

Memory distrust was measured with the adapted version of the SSMQ (van Bergen et al., 2010), which consists of 18 items tapping into one factor reflecting one's appraisal of memory functioning, or one's perceived ability to remember past events (e.g., my ability to recall things when I really try is). Participants answered the SSMQ on a Likert scale from 1 = *disastrous* to 9 = *perfect*. We reverse-coded the scores and then calculated the mean of the items so that a higher score reflects a higher level of trait memory distrust.

Self-Esteem

Self-esteem was measured using the Rosenberg Self-Esteem Scale (RSES; Rosenberg, 1979). The scale contains 10 items (e.g., "On the whole, I am satisfied with myself") answered on a 4-point scale from 0 = *strongly disagree* to 3 = *strongly agree*. Self-esteem was operationalized as the mean rating of the 10 items after reverse coding half of the items, with a higher rating indicating higher self-esteem.

Belief and Memory Ratings

Autobiographical recollection and belief were each measured with three items following Scoboria et al. (2014). The three items measuring autobiographical recollection were: (a) Do you actually remember experiencing this event? (1 = *no memory of event at all*, 8 = *clear and complete memory of event*); (b) How strong is your memory for this event (whether or not you believe the event occurred)? (1 = *no memory*, 7 = *strong memory*); (c) Sometimes people know something happened to them without being able to actually remember it. As I think about the event, I can actually remember it rather than just knowing that it happened (1 = *not at all*, 7 = *as much as any memory*). The three items measuring autobiographical belief were: (a) How likely is it that you personally did in fact experience this event? (1 = *definitely did not happen*, 8 = *definitely did happen*); (b) How strong is your belief that this event actually occurred (whether or not you remember the event)? (1 = *no belief*, 7 = *strong belief*); (c) It is true that this event occurred to me (1 = *not at all true*, 7 = *extremely true*). Because the items were on different scales, we first rescaled the scores of the 8-point items to a 7-point scale (i.e., multiplied by 0.875) and then averaged the three items for belief and memory respectively. A higher score would indicate a higher belief or memory rating for that memory.

Memory Characteristics

The Memory Characteristics Questionnaire (MCQ; Mazzoni et al., 2010) was used to assess a wide range of recollective (e.g., visual details and locations) as well as other qualities (e.g., emotional intensity, valence, significance) of the recalled NBM. Participants rated the recalled NBM on the 26 items using 7-point scales with varying anchors (see https://osf.io/s6x35, for details).

Exploratory Measures

Involuntary Memories Tendency

The Involuntary Autobiographical Memory Inventory (IAMI; Berntsen et al., 2015) is a 20-item scale that examined the frequency of involuntary autobiographical memory recall and thus reflects memory recall without deliberate attempts of retrieval. Ten items ask about past events, while the other 10 items address future

events. Participants completed the inventory (e.g., "Imaginary future events pop into my mind by themselves—without me consciously trying to evoke them") on a 5-point rating scale from 1 = *never* to 5 = *once an hour or more*. We calculated the mean of the 20 items as an indicator of involuntary autobiographical memory recall, with a higher scoring implying a higher frequency of involuntary recall. Alongside the IAMI, Berntsen et al. (2015) also reported 10 items measuring the frequency of voluntary autobiographic memory recall (e.g., "After an event has happened, I willfully and deliberately think back to it in my mind and try to remember it"). We thus also included the voluntary recall questions Voluntary Autobiographical Memory Inventory (VAMI) to have a comparison between deliberate and unwilling retrieval. The rating scale was the same as the one for the IAMI. We calculated the mean of the 10 items, with a higher value indicating a higher frequency of voluntary recall.

Furthermore, we also included the Event-Related Rumination Inventory (ERRI; Cann et al., 2011), which measures individual differences in rumination over past events. The ERRI consists of two sets of 10 statements that address the recall of memories without trying (e.g., "I thought about the event when I did not mean to") versus deliberate rumination (e.g., "I thought about whether I have learned anything as a result of my experience."). Participants completed this inventory on a scale from 0 = *not at all* to 3 = *often*. We calculated the means for each of the subscales, with a higher value indicating a greater tendency for intrusive or deliberative rumination. All scales employed showed good reliability in the current sample (see Table 2).

Procedure

Participants first read the information letter describing the tasks, compensation, and voluntary participation as well as data privacy (see https://osf.io/8f6ts) and proceeded to the study only if they provided informed consent (see Figure 1, for procedures). In the Time 1 survey (https://osf.io/8f6ts), participants first received a definition of NBMs (i.e., vivid memory recollections for which there is a reduced belief in the occurrence) and then indicated how many times they experienced an NBM in the last 2 months. To aid the recall process, we provided them with a list of locations (e.g., library, gym, friends' place) where daily activities could happen. Then we asked participants to report the reasons for their belief reduction using a multiple-choice format (i.e., objective evidence, social feedback, implausibility, and other reasons) and the number of NBMs due to each reason. For the three specified reasons, we offered a short explanation with an example (e.g., for social feedback, "Being told that the event did not happen or it happened in a way that is different from what you remembered"). Note that when answering the number of NBMs due to different reasons, some participants only selected the reasons but failed to fill in the numbers. Therefore, the data for NBM due to each reason can be less accurate than we initially expected.

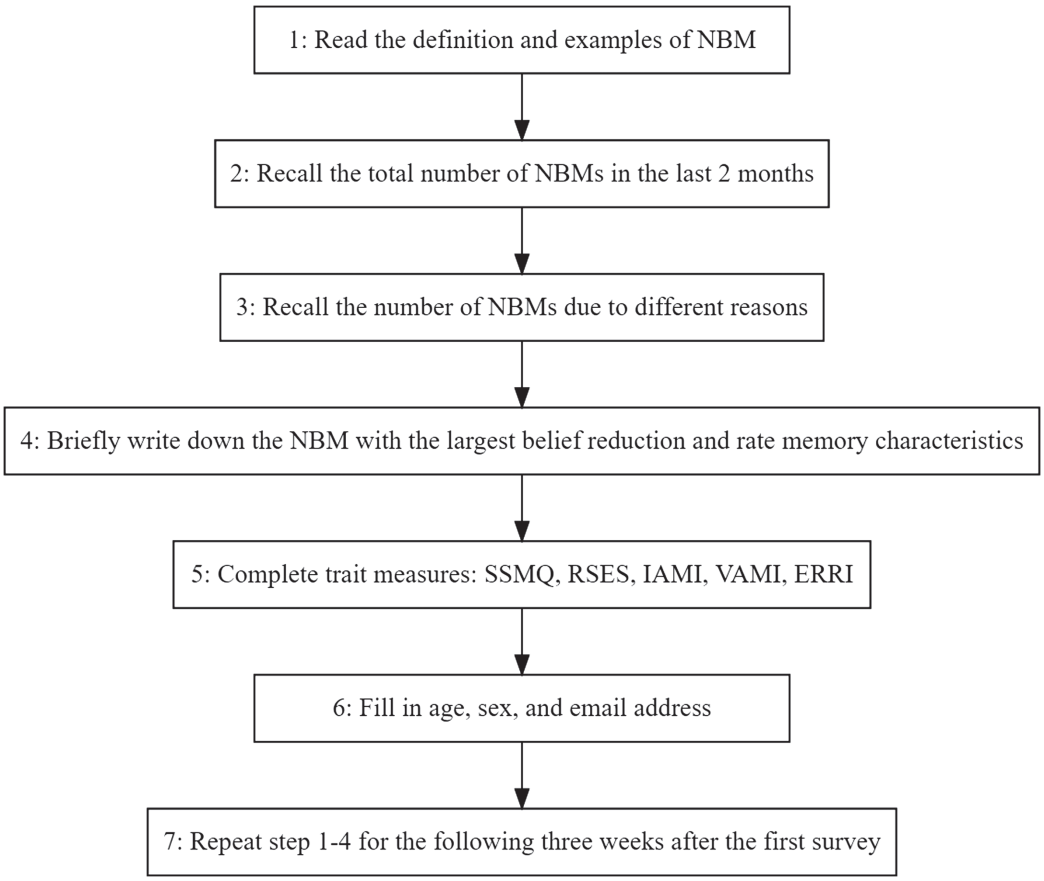
Then, participants were asked to provide a brief description of only one recalled NBM, specifically the one for which the belief in the

Table 2
Correlation Matrix for Individual Difference Measures (Time 1)

Variable	1	2	3	4	5	6	*M*	*SD*
1. Memory distrust	.89	−.43***	.04	−.05	.20*	.10	4.02	0.99
2. Self-esteem	—	.88	−.08	−.11	−.36***	−.22*	1.88	0.50
3. IAMI		—	.90	.41***	.35***	.30***	2.35	0.54
4. VAMI			—	.86	.07	.12	2.22	0.68
5. ERRI-Intrusion				—	.91	.55***	1.51	0.67
6. ERRI-Deliberation					—	.91	1.48	0.71

Note. Internal consistency (Cronbach's α) was reported on the diagonal. Memory distrust was measured with the SSMQ. Self-esteem was measured with the RSES. All scales were positively coded with a higher score indicating a higher level of memory distrust, self-esteem, autobiographical memory recall, and rumination respectively. IAMI = Involuntary Autobiographical Memory Inventory; VAMI = Voluntary Autobiographical Memory Inventory; ERRI = Event-Related Rumination Inventory; SSMQ = Squire Subjective Memory Questionnaire; RSES = Rosenberg Self-Esteem Scale.
* $p < .05$. *** $p < .001$.

Figure 1
Procedures of the Present Study



Note. NBMs = nonbelieved memories; SSMQ = Squire Subjective Memory Questionnaire; RSES = Rosenberg Self-Esteem Scale; IAMI = Involuntary Autobiographical Memory Inventory; VAMI = Voluntary Autobiographical Memory Inventory; ERRI = Event-Related Rumination Inventory.

occurrence had been reduced the most. Next, participants completed the ratings of memory characteristics (i.e., belief, recollection, and the MCQ) based on this NBM.

After the recall and appraisal of memory, participants completed the SSMQ, the RSES, the IAMI, the VAMI, and ERRI in the presented order. Finally, participants reported demographic information including sex, age, and brain injury history. Their email addresses were collected to provide participants with the links for three follow-up surveys. These 5-min questionnaires were sent weekly for 3 weeks after the completion of the first online survey. The follow-up surveys included only NBM recall and appraisals in the same way as the first survey. Participants were instructed to recall if they had (an) NBM(s) during the past week and rate the memory characteristics for the NBM with the most significant belief reduction. Individual differences were not measured in the follow-ups.

Statistical Analyses

Both data cleaning and statistical analyses were carried out using R (R Core Team, 2021). We first assessed the internal consistency (i.e., Cronbach's α) of the scales employed in the present study. Next, we ran Pearson correlations between the traits for the whole sample as well as the belief and memory ratings for the subsample reporting NBMs.

Primary Hypothesis Testing

For the Time 1 data, we employed generalized linear models (GLM) to examine the associations between the frequency of NBMs and the individual trait measure of memory distrust as well as self-esteem. More specifically, Poisson regressions were used to model the relationship, and the dependent variable, the number of NBMs, involved count data. For the Times 2–4 data, generalized linear mixed models (GLMM) using the lme4 package (Bates et al., 2015) to examine the relationship between memory distrust as well as self-esteem and the number of recalled NBMs for a period of 1 week. More specifically, because of the overdispersion of the data, we used negative binomial models with memory distrust as a fixed effect. For random effects, we had participant IDs as random intercepts.

Exploratory Analyses

In addition to the total number of NBMs, we also performed GLM (Poisson) and GLMM (negative binomial) to examine how NBMs due to different reasons (e.g., social feedback) were associated with memory distrust and other personality traits (i.e., (in)voluntary memory recall tendency). For all the regression models for both hypothesis testing and exploratory analyses, we only included one independent variable in each model without controlling for any other variables that were measured.

Results

Number of NBMs

Among the 117 participants who completed the recall of NBMs at Time 1, 35 reported no NBMs for the past 2 months, 80 reported at least one NBM, and two were coded as missing values due to wrong entry. A case with 60 NBMs heavily deviated from the rest of the sample and was categorized as an outlier and removed from all analyses. The mean number of NBMs reported was 3.17 while the median was 2, ranging from 0 to 25. For Times 2–4 data, the rate of reporting at least one NBM was 54.65% ($n = 47$), 53.03% ($n = 35$), and 46.77% ($n = 29$), respectively. The mean number of NBMs reported was 1.27 (max = 8) in Time 2, 0.89 (max = 5) in Time 3, and 0.90 (max = 8) in Time 4.

Reasons to Reduce Belief

As for the reasons for belief reduction, the percentages for selecting objective evidence, social feedback, implausibility, and other reasons are presented in Table 3. The sums of the percentages are more than 100% since participants could have identified multiple reasons why they reduced their belief in a specific memory. A paired-samples *t*-test examining the difference between belief ($M = 4.76$, $SD = 1.95$) and memory ratings ($M = 4.75$, $SD = 1.19$) at Time 1 reported no significant difference, $t(70) = 0.06$, $p = .95$, Cohen's $d = .009$. Belief and memory ratings at Time 2–4 also did not differ significantly from each other (all $ps > .24$, Cohen's $ds < .18$, for detailed output, please see HTML file Daily_NBM_P234_script_R1). This surprising outcome could be a result of some participants interpreting the questions regarding the autobiographical event as questions asking about the belief reduction experience of that memory (i.e., to what extent do they remember/believe they had an NBM). Alternatively, it may be the case that some participants increased their beliefs after gaining corroborating evidence (e.g., checking) and reported the updated beliefs. Therefore, the data were, unfortunately, uninformative and we did not conduct and report analyses on belief and memory ratings in the article.

Table 3
Descriptive Statistics for Reasons for Belief Reductions

Time	Reporting NBM	Objective evidence	Social Feedback	Implausibility	Other reasons
1. ($N = 117$)	80	24 (30%)	50 (62.5%)	43 (53.25%)	21 (26.25%)
2. ($N = 86$)	47	11 (21.28%)	16 (34.04%)	27 (57.45%)	7 (14.89%)
3. ($N = 66$)	35	11 (31.43%)	11 (31.43%)	20 (57.14%)	4 (11.43%)
4. ($N = 62$)	29	8 (27.59%)	10 (34.48%)	12 (41.38%)	5 (17.24%)

Note. NBM = nonbelieved memories.

Correlational Analyses Between Individual Differences Measures

At Time 1, we measured participants' traits and the correlations between these traits are presented in Table 2. Trait memory distrust was negatively correlated with self-esteem and positively correlated with the ERRI-Intrusion scale. Self-esteem had a negative correlation with both ERRI-Intrusion and ERRI-Deliberation. IAMI had moderate positive correlations with VAMI, ERRI-Intrusion, and ERRI-Deliberation. VAMI, on the other hand, had no significant correlations with both subscales of the ERRI. Correlation matrices for Times 2–4 subsamples showed a similar pattern to that of Time 1 and can be accessed at (https://osf.io/8f6ts).

The Association Between NBM and Memory Distrust as Well as Self-Esteem

Memory Distrust Time 1

The Poisson regression with memory distrust as the independent variable and the total number of NBMs as the dependent variable revealed that memory distrust was a significant positive predictor, $B = 0.11$, $SE = 0.05$, $p = .03$, 95% CI [0.01, 0.21], supporting our first hypothesis. The models examining memory distrust and NBMs due to different reasons showed that memory distrust was a significant positive predictor for NBMs due to implausibility, $B = 0.29$, $SE = 0.08$, $p < .001$, 95% CI [0.14, 0.44], and other reasons, $B = 0.34$, $SE = 0.08$, $p < .001$, 95% CI [0.18, 0.49]. However, memory distrust did not predict NBM due to objective evidence, $B = -0.29$, $SE = .19$, $p = .12$, 95% CI [−0.69, 0.05], or social feedback, $B = .16$, $SE = .09$, $p = .10$, 95% CI [−0.04, 0.33]. The second hypothesis thus did not receive sufficient support based on the Time 1 data.

Memory Distrust Times 2–4

For the Times 2–4 data, we ran GLMM for the total number of NBMs and the number of NBMs due to each reason with memory distrust as the fixed effect and participant ID as the random intercept. Because the data were overdispersed, we used negative binomial models instead of Poisson models. Results showed that in none of the models, memory distrust was a significant predictor of NBMs (see Table 4). Therefore, our two hypotheses were not supported by the data at Times 2–4. The intraclass correlations indicated that there were large individual differences in the total number of NBMs, the number of NBMs due to social feedback, due to implausibility, and due to other reasons.

Self-Esteem

For the Time 1 data, GLM showed that self-esteem was negatively associated with the total number of NBMs, $B = -0.24$, $SE = 0.11$, $p = .02$, 95% CI [−0.46, −0.03] and the number of NBMs due to other reasons, $B = -1.06$, $SE = 0.20$, $p < .001$, 95% CI [−1.45, −0.68]. Self-esteem was not a significant predictor for the number of NBMs due to objective evidence, $B = 0.34$, $SE = 0.32$, $p = .30$, 95% CI [−0.29, 0.98], social feedback, $B = -0.20$, $SE = 0.20$, $p = 0.33$, 95% CI [−0.59, 0.20], or implausibility, $B = 0.07$, $SE = 0.18$, $p = .69$, 95% CI [−0.28, 0.43]. When both memory distrust and self-esteem were entered in the regression for the total number of NBMs, neither predictors reached statistical

Table 4
Memory Distrust and the Number of NBMs at Times 2–4

Model statistics	Total NBM	Objective evidence	Social feedback	Implausibility	Other reasons
B-memory distrust	0.10	0.13	−0.07	0.09	0.24
SE-memory distrust	0.14	0.23	0.22	0.19	0.40
p-memory distrust	.46	.57	.75	.63	.55
ICC	.52	.13	.42	.60	1.00
Pseudo-R^2 (fixed effects/total)	.01/.50	.00/.32	.00/.36	.00/.50	.00/.80

Note. ICC refers to intraclass correlation with a higher value indicating greater correlations within each cluster (i.e., participants). NBMs = nonbelieved memories; *SE* = standard error; ICC = intraclass correlations.

significance (Memory distrust: $B = 0.07$, $SE = 0.05$, $p = 0.23$, 95% CI [−0.04, 0.18]; Self-esteem: $B = -0.18$, $SE = 0.12$, $p = 0.14$, 95% CI [−0.42, 0.06]).

For the data at Times 2–4, negative binomial models with self-esteem as the fixed effect and participant ID as the random intercept revealed that self-esteem was not a significant predictor for the total number of NBMs, $B = 0.09$, $SE = 0.25$, $p = .72$, the number of NBMs due to objective evidence, $B = 0.10$, $SE = 0.40$, $p = .80$, social feedback, $B = -0.34$, $SE = 0.33$, $p = .31$, implausibility, $B = -0.06$, $SE = 0.30$, $p = .84$, or other reasons, $B = -0.26$, $SE = 0.63$, $p = .68$ (see https://osf.io/b4tmh, for detailed model outputs).

Exploratory Analyses

For other trait measures, we ran similar GLM and GLMM models to examine their relationships with NBMs.

Involuntary and Voluntary Autobiographical Memory Recall

For the Time 1 data, GLM showed that IAMI was positively associated with the total number of NBMs, $B = 0.74$, $SE = 0.10$, $p < .001$, 95% CI [0.54, 0.94], the number of NBMs due to social feedback, $B = 0.79$, $SE = 0.19$, $p < .001$, 95% CI [0.42, 1.17], due to implausibility, $B = 1.09$, $SE = 0.17$, $p < .001$, 95% CI [0.76, 1.41], and due to other reasons, $B = 1.15$, $SE = 0.18$, $p < .001$, 95% CI [0.80, 1.50]. IAMI was not a significant predictor for the number of NBMs due to objective evidence, $B = -0.51$, $SE = 0.28$, $p = .07$, 95% CI [−1.05, 0.05]. A similar pattern emerged for VAMI. VAMI was positively associated with the total number of NBMs, $B = 0.54$, $SE = 0.09$, $p < .001$, 95% CI [0.37, 0.71], the number of NBMs due to implausibility, $B = 0.38$, $SE = 0.14$, $p = .006$, 95% CI [0.11, 0.66], and due to other reasons, $B = 0.83$, $SE = 0.16$, $p < .001$, 95% CI [0.52, 1.14]. VAMI was not a significant predictor for the number of NBMs due to objective evidence, $B = -0.19$, $SE = 0.23$, $p = .40$, 95% CI [−0.63, 0.26] or due to social feedback, $B = 0.23$, $SE = 0.16$, $p = .14$, 95% CI [−0.07, 0.54].

For the Times 2–4 data, negative binomial models with IAMI as the fixed effect and participant ID as the random intercept revealed that IAMI was a significant predictor for the total number of NBMs, $B = 0.53$, $SE = 0.24$, $p = .03$, the number of NBMs due to implausibility, $B = 0.86$, $SE = 0.37$, $p = .02$. IAMI did not predict the number of NBMs due to objective evidence, $B = 0.12$, $SE = 0.43$, $p = .77$, due to social feedback, $B = -0.41$, $SE = 0.38$, $p = .29$, or due to other reasons, $B = 0.00$, $SE = 0.58$, $p = .99$. Models with VAMI as the fixed effect showed that VAMI was a significant predictor for the total number of NBMs, $B = 0.47$, $SE = 0.20$, $p = .02$, the number of NBMs due to implausibility, $B = 1.01$, $SE = 0.32$, $p = .001$. IAMI did not predict the number of NBMs due to objective evidence, $B = -0.25$, $SE = 0.37$, $p = .50$, due to social feedback, $B = 0.26$, $SE = 0.32$, $p = .42$, or due to other reasons, $B = 0.42$, $SE = 0.56$, $p = .46$ (see https://osf.io/b4tmh, for detailed model outputs).

Event-Related Rumination

For the Time 1 data, GLM showed that ERRI-Intrusion was positively associated with the total number of NBMs, $B = 0.27$, $SE = 0.08$, $p = .001$, 95% CI [0.11, 0.43], the number of NBMs due to implausibility, $B = 0.63$, $SE = 0.14$, $p < .001$, 95% CI [0.36, 0.91], and due to other reasons, $B = 0.69$, $SE = 0.15$, $p < .001$, 95% CI [0.40, 0.98]. ERRI-Intrusion was negatively associated with the number of NBMs due to objective reason, $B = -1.00$, $SE = 0.24$, $p < .001$, 95% CI [−1.48, −0.52] and did not have a significant relationship with the number of NBMs due to social feedback, $B = 0.28$, $SE = 0.16$, $p = .07$, 95% CI [−0.02, 0.59]. On the other hand, ERRI-Deliberation had no significant relationship with the total number of NBMs, $B = 0.08$, $SE = 0.08$, $p = .33$, 95% CI [−0.08, 0.23], the number of NBMs due to objective evidence, $B = -0.28$, $SE = 0.23$, $p = .22$, 95% CI [−0.74, 0.17], due to social feedback, $B = 0.09$, $SE = 0.15$, $p = .51$, 95% CI [−0.19, 0.39], due to implausibility, $B = 0.25$, $SE = 0.13$, $p = .06$, 95% CI [−0.01, 0.50], or due to other reasons, $B = 0.20$, $SE = 0.14$, $p = .14$, 95% CI [−0.07, 0.48].

For the Times 2–4 data, negative binomial models with ERRI-Intrusion as the fixed effect and participant ID as the random intercepts revealed that ERRI-Intrusion was not a significant predictor for the total number of NBMs, $B = -0.05$, $SE = 0.23$, $p = .82$, the number of NBMs due to objective evidence, $B = -0.01$, $SE = 0.40$, $p = .98$, due to social feedback, $B = -0.05$,

$SE = 0.36$, $p = .90$, due to implausibility, $B = 0.36$, $SE = 0.34$, $p = .29$, or due to other reasons, $B = -0.03$, $SE = 0.59$, $p = .96$.

Models with ERRI-Deliberation as the fixed effect showed that ERRI-Deliberation did not significantly predict the number of NBMs in any of the models (the total number of NBMs: $B = 0.14$, $SE = 0.20$, $p = .50$; objective evidence: $B = 0.05$, $SE = 0.33$, $p = .88$; social feedback: $B = 0.38$, $SE = 0.33$, $p = .24$; implausibility: $B = 0.03$, $SE = 0.30$, $p = .91$; other reasons: $B = 0.61$, $SE = 0.69$, $p = .38$; Detailed outputs see https://osf.io/b4tmh).

Discussion

The present study used a longitudinal design to examine the relations between the occurrence of NBMs and several individual differences (e.g., memory distrust and rumination). Our findings can be cataloged as follows. First, and most importantly, the analyses showed that NBM occurrence was positively associated with memory distrust and rumination over autobiographical events and negatively associated with self-esteem. Second, the prevalence of NBMs in the current sample was higher compared with previous studies (e.g., Brédart & Bouffier, 2016; Vanootighem et al., 2019). In the following section, we will discuss the results and their implications in more depth.

The Association Between Memory Distrust and NBM

As in our previous study (Zhang, Otgaar, et al., 2022), memory distrust significantly predicted the total number of NBMs. However, we only found evidence for this effect at Time 1. One possible reason for this is that although memory distrust is a stable appraisal of one's memory function, it can still vary over time (test–retest reliability $r = .87$–$.90$ as reported in van Bergen et al., 2010). Another possible explanation is that the recall processes at Time 1 were different from that of Times 2–4. More specifically, participants in Times 2–4 knew that they would be asked to recall the memories every week and were cued to think about NBMs. They may have more actively verified their memories in this period. This notion receives some support from the current data as in Times 2–4, the most frequently mentioned reason for belief reduction was implausibility while in Time 1, the most frequent one was social feedback.

We did not find any support for our hypothesis that memory distrust was positively associated with NBMs due to negative social feedback (Hypothesis 2). Instead, memory distrust was a significant predictor of the number of NBMs that happened due to the implausibility of an event (as well as other reasons). This finding suggests that memory distrust as measured by the SSMQ may be connected with spontaneous belief reduction in memories. That is, individuals who scored high on memory distrust according to the SSMQ may doubt their memories in the absence of contradictory evidence or social feedback. However, some participants did not report any NBMs due to each reason despite having selected that reason, thus the analyses on NBM due to specific reasons should be interpreted with caution.

Self-Esteem and NBM

We partially replicated previous findings from Zhang, Otgaar, et al. (2022) that self-esteem was negatively associated with the number of recalled NBMs using a different scale from the previous study. The association was less robust in the sense that self-esteem only predicted the total number of NBMs and the number of NBMs due to other reasons at Time 1 but not at the follow-up measures. This pattern of results suggests that self-esteem may also be related to spontaneous belief reductions, similar to memory distrust. In addition, we did not find a significant association between self-esteem and the number of NBMs due to social feedback, despite previous findings from misinformation research showing that boosting self-esteem by self-affirmation can reduce the misinformation effect (Szpitalak & Polczyk, 2015, 2019). It could be that self-esteem on average was slightly high in our sample ($M = 1.88$, ceiling = 3), which did not offer enough variation to detect the association.

Voluntary and Involuntary Memory, Rumination, and NBM

To explore how ruminations over autobiographical events could be connected with NBM, we selected three scales measuring ruminations

and (in)voluntary memory. Interestingly, both involuntary and voluntary autobiographical memory recall, as well as intrusive thoughts about autobiographical events, were positive predictors of NBMs. However, the tendency to deliberate over the events such as thinking about the meaning of the event did not predict the number of NBMs. This suggests that the rehearsal or replay of autobiographical memories regardless of being voluntary or not is particularly related to NBM recall.

Specifically, the first interpretation is that the tendency to ruminate over autobiographical events is associated with more NBMs in daily life. Rumination over memories could provide internal feedback, which interacts with the quality of the recollections to influence the belief changes. This is consistent with research on checking/mental checking behavior's effect on metamemory in that checking can reduce confidence in one's memory (Radomsky & Alcolado, 2010). However, if our speculation reflects the real mechanisms underpinning our results, it would have been reasonable to find that (in)voluntary autobiographical memory recall would have been positively associated with memory distrust. However, our findings do not fully provide support in this respect. As a matter of fact, only intrusive thoughts over autobiographical events (i.e., ERRI-Intrusion) had a significant positive correlation with memory distrust (see Table 2).

Therefore, a second possibility is that people who more frequently ruminate over autobiographical events are better at recalling past events and thus report a greater number of NBMs. This interpretation is also consistent with the fact that involuntary and voluntary memory as well as intrusive memory were related to the number of NBMs because of several reasons (e.g., social feedback, implausibility, and other reasons), suggesting a connection with the recall process instead of the belief reduction process. To further put this hypothesis to test, future studies could examine the relationship between the number of recalled believed and NBMs and the propensity to engage in rumination and/or mental replay of autobiographical events.

Another important note from the current results is that several of the measured traits were positively associated with the number of NBMs due to other reasons. A close examination of the reasons that participants provided revealed several themes. The first theme was related to a general skeptical view of one's memory (e.g., "because I did not trust myself," "doubting myself," and "not trusting my own memory"), which could explain the connection with trait memory distrust. The second theme emphasized the possible consequences of falsely remembering. For example, one participant wrote "The consequences for falsely trusting my memories would have been too big." This shows that belief reduction may be influenced not only by individual differences and external information but also by the gravity and importance of the event. People may tend to reduce their autobiographical beliefs if the event in question could have severe consequences. Finally, another theme tapped into the difficulty of source monitoring. Participants expressed that they may confuse it with other events ("confusing it with other moments") and memories of dreams ("Dreamed about something I thought to be true").

The Prevalence of NBM

The prevalence of self-reported NBMs was much higher than rates reported in previous studies, which are mostly around 20% (e.g., Brédart & Bouffier, 2016; Mazzoni et al., 2010; Vanootighem et al., 2019). At Time 1–3, a majority of participants reported having at least one NBM. Even in the Time 4 data, nearly half (46.78%; $n = 29$) of the participants indicated that they have had an NBM(s) in their last week. Despite the possibility of sampling error and overestimation, the discrepancy in results is more likely caused by differences in instructions for NBM recall between studies. That is, in our instructions, we explicitly told participants that NBMs can be about mundane experiences as well as personally meaningful events and offered participants an example of each (see Appendix Instructions, for NBM recall). The remembering process can be heavily influenced by the context. Indeed, Otgaar et al. (2014) argued that such discrepancy in NBM prevalence can be due to the specificity of instructions to recall NBMs. If instructions are highly specific and contain detailed examples, they can act as a strong retrieval cue for the recall of NBMs. Indeed, an examination of the content of the recalled NBMs revealed support for this possible

explanation. A significant portion of the "NBMs"[1] was about mundane life events such as checking behaviors (Time 1: 33.33%, $n = 24$; Time 2–4: 27.93%, $n = 31$),[2] indicating an effect from the instruction and the provided examples. Our results suggested that when taking into consideration of other types of autobiographical events that are not personally meaningful and less likely to be recalled in previous studies, the prevalence of belief reduction in memories could be much higher.

Limitations and Future Directions

One weakness of the present study is that the SSMQ might not cover all aspects of memory distrust. The weakness of relying on solely the SSMQ to measure memory distrust has recently been discussed by Nash et al. (2022). Specifically, they argued the SSMQ only focuses on memory distrust toward committing omission errors (i.e., forgetting about past experiences) while NBMs are more closely related to worrying about committing commission errors (i.e., remembering about events that did not happen in the past). In light of the limitations of the SSMQ, Nash et al. (2022) developed and validated a new scale for measuring memory distrust (Memory Distrust Scale) toward commission errors and it has shown superior predictive power for belief reduction compared with the SSMQ. However, the validation of this new scale was only available to us after the data collection has already finished. Therefore, we were unable to implement this measure in the present study and perform more rigorous tests for the hypotheses and our speculations. In addition, the questions measuring belief and recollection were perhaps ill phrased, which might have led to uninformative responses from the participants. The four categories of reasons for belief reduction were simple and not comprehensive categorizations as shown in our brief analyses of the "other reason" category. People may spontaneously reduce their beliefs as a function of the severity of committing commission errors.

A third limitation is that the participant population involved undergraduate students, who on average have a better memory and lower level of memory distrust than the general population (van Bergen et al., 2010). This could partially explain why the association between memory distrust and NBM was weak. Similar results were reported in Study 1 by Zhang, Otgaar, et al. (2022), which used a sample consisting of mostly university students.

The present study also raised our awareness of another important issue. That is, given the results of the instructed recall could be heavily influenced by the method (e.g., indirect cueing, Scoboria & Talarico, 2013) or the specific instructions and examples (e.g., the present study), it is important to also employ other methods such as lab experiments with standard recognition tests (e.g., Li et al., 2020; Otgaar et al., 2018) and diary methods (e.g., Schlagman & Kvavilashvili, 2008). Experimental data and dairy data will also allow researchers to test whether the individual differences related to NBM recall influence the formation or the recall of NBMs. Survey, diary method, and experimental design all have their relative strength and weakness in the case of memory research (Barzykowski, 2014), making multimethod research of NBM the future direction.

Concluding Remarks

Taken together, the present study provided evidence that recalled NBMs are associated with individual differences, such as memory distrust, self-esteem, and rumination over autobiographical events. Furthermore, our results allude to the possibility that when taking into account trivial events—such as checking behaviors—the prevalence of NBMs could be higher than previously thought. The present study contributes to our understanding of belief changes in memories, which have real-world implications in various domains of decision-making including the legal area. We hope that the present study will stimulate future research to advance our understanding of the dynamic changes in autobiographical beliefs and their individual difference markers.

[1] We find it difficult to validate some of the memories as NBMs because of the vagueness of the reports. However, we decided to not exclude any observations because it could be that participants did experience an NBM but failed to report it clearly.

[2] The first author coded whether the memories are about mundane checking behavior. Then the third author coded independently for Time 1 data. The interrater reliability was acceptable (Gwet's AC1 = .86). Therefore, we reported the coding result from the first author.

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(*Appendix follows*)

Appendix

Instructions for NBM Recall

It is often assumed that the recollection and belief in the occurrence of an event are closely related. That is, if we hold a vivid recollection of an event, we would also believe that it has happened in the past. However, recent research has shown that indeed recollections and beliefs are relatively independent. One can have a vivid recollection of an event without a belief that it happened. This type of memory (vivid recollection with no or reduced belief in occurrence) is referred to as a nonbelieved memory. Nonbelieved memories can be about mundane events as well as events that are very meaningful to us. For example, one may have a recollection of turning off the stove before leaving but does not believe the recollection and therefore recheck the kitchen once more. One may also have a recollection of an exciting childhood experience but stop believing it has happened when being told so by family or friends.

Now we would like to ask you to recall whether you have experienced any nonbelieved memories for the last 2 months, the events can be either trivial or significant and they could happen either in the past or within the 2-month interval. The central requirement is that you have reduced or eliminated the belief of these memories in the last 2 months.

I recall _ times in the last 2 months that I reduced or eliminated the belief of a memory. (please put your answer in the box below)

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