Autobiographical memories – frequent retrieval and emotional intensity

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Abstract

The significant role memory plays in our lives, and the consequences when it is disordered, calls for examination of the underlying mechanisms of memory and how memories are maintained. This study examines the effects of frequent retrieval on memory characteristics (emotional intensity, accessibility and centrality) and the relationships between these characteristics, guided by a model that visualizes the *Autobiographical Memory Theory*, proposed by Rubin et al. (2008). A 2x2 within-subjects experimental design is utilized, with the levels being retrieval frequency (frequent vs. no retrieval) and time (pre- vs. post-manipulation). Participants (n = 9) frequently retrieve a positive memory in the retrieval phase, upon notification from the m-Path application. Memory characteristics are measured with questionnaires (CES, IES-R and MEQ-SF) pre- and post-manipulation (frequent retrieval). Data was collected in Qualtrics. The results are largely inconclusive and should be interpreted with caution. Results showed relatively low change in emotional intensity (small variance and effect sizes) after frequent retrieval. Results showed medium to strong correlations between memory characteristics, with only the correlation between emotional intensity and centrality being statistically significant. Results also found that frequent retrieval of positive memories had no significant effect on the emotional intensity of negative memories in the current sample, with a small effect size. Because of the small sample size, no conclusions can be drawn from the current results.

Introduction

Post-traumatic stress disorder (PTSD) is widely considered a disorder of memory: those with PTSD suffer from memories of a shocking, stressful event posing threat of serious injury or death. In the DSM-5 criteria for PTSD, criterion B pertaining to intrusive symptoms, highlights disruptions in memory, for example recurrent, involuntary, intrusive distressing memories and flashbacks (American Psychiatric Association, 2013). Additionally, criterion C describes the avoidance of internal and external stimuli that cue memories of the traumatic event. This suggests a central role of autobiographical memory in PTSD.

Autobiographical memories

Autobiographical memories are defined as coherent and integrated recollections of personally experienced events contributing to sense of self (Conway & Pleydell-Pearce, 2000; Conway, 2005). It encompasses a collection of personal knowledge and experiences and serves as a knowledge base. This knowledge base is sensitive to cues from the environment; throughout everyday life, knowledge is remembered in response to cues. Conway and Pleydell-Pearce (2000) identified 3 levels of knowledge, differing in specificity: lifetime periods, general events and event-specific knowledge. Lifetime periods represent knowledge of a specific time period (e.g. the last year of high school). General events encompass both repeated and sequences of separate events linked together by a theme (e.g. driving lessons). Event specific knowledge (ESK) is detailed information about individual events (e.g. catching a bouquet at a wedding), in which visual imagery has been found to play a central role (Conway & Pleydell-Pearce, 2000). The distressing memories and flashbacks experienced by people with PTSD can be considered as recalling ESK in a vivid and visual way. The ‘working self’ combines personal goals and self-concepts to control cognition and behavior, so the self can operate effectively in the environment (Conway & Pleydell-Pearce, 2000). When emotional memories are recalled and again cause an emotional reaction, this could reinstate past signals for action and the ‘working self’ is disrupted. For those suffering from PTSD, traumatic ESK can re-induce emotions and disrupt effective interaction with their environment.

Much like Conway and Pleydell-Pearce (2000), Bluck (2003) states how autobiographical memory serves a directive function through guiding future behavior and problem solving; memories of past experiences guide us towards successful functioning and allow us to learn from failure (Bluck, 2003). Additionally, autobiographical memory may influence how we imagine future experiences; Schacter and Addis (2007) found similar neural processes involved in the recall of past autobiographical memories are also involved in

imagining future events, and that the memory system draws on previous experiences to simulate future events. Thus, autobiographical memory influences not only the present, but also the future, through shaping expectations of future events. Considering the large role autobiographical memory plays in our lives, and the consequences when it is disordered, it seems crucial to examine the underlying mechanisms and how (traumatic) memories are maintained.

Special mechanisms and basic mechanisms

Two contrasting views exist on autobiographical memory in PTSD; the special mechanism and the basic mechanisms view (Berntsen & Rubin, 2006, 2007; Rubin et al., 2008). Both emphasize the importance of memory in PTSD, but with different implications. The special mechanism view states traumatic experiences disrupt normal memory processes, and are encoded in a unique, highly vivid, incoherent and fragmented way, due to their intense emotional and physiological impact (Rubin et al., 2008). This would result in voluntary recall (controlled and goal-directed) of the traumatic memory being impaired, whereas involuntary recall (uncontrolled) is enhanced. The basic mechanisms view, on the other hand, states that traumatic memories are processed within the general memory system (Rubin et al., 2008). According to the basic mechanisms view, the increased emotional arousal and schema violations accompanying a traumatic event, lead to enhanced (rather than disrupted) encoding and enhanced accessibility of both voluntary and involuntary memories of the event (Rubin et al., 2008). In their studies, Rubin et al. (2008) indeed found an increased accessibility of both involuntary and voluntary memories, inconsistent with the special mechanisms view. No increase in fragmentation in participants with PTSD was found. Similar results were produced in a later study of Rubin et al. (2011); in participants with PTSD they found increased emotional intensity, higher frequency of retrieval (both voluntary and involuntary), higher centrality to the life story, but no decrease in coherence. In 2016, Rubin et al. found differences in the coherence of traumatic memories, but no consistent decrease; some traumatic memories were less coherent, some more coherent than other memories of importance to the individual. Rubin et al. (2008, 2011, 2016) concluded no special mechanism was at play in producing their results and that memories of traumatic experiences can be understood in terms of general memory processes.

The accessibility of memories

An important factor in understanding how traumatic memories function within the general memory process, is *accessibility*. Not all personal memories are recalled with the same level of ease; they differ in their degree of *accessibility*. The accessibility of certain

memories can influence our decisions and mood. For example, research has shown that negative mood can be alleviated by accessing positive information about the self or thinking about past successes (Josephson et al., 1996; Speer & Delgado, 2017). This information, however, must be somewhat easily accessible. Those diagnosed with PTSD appear to have greater difficulties recalling specific positive autobiographical memories compared to individuals without PTSD, whereas negative self cognitions are often more accessible (McNally et al., 1994). This way, the accessibility of negative memories can lead to a negative mood and self-concept. If making positive memories more accessible can alleviate negative mood, this could have important clinical implications.

Autobiographical Memory Theory

How can the degree of accessibility of memories be determined? Rubin et al. developed the *Autobiographical Memory Theory* (2008; 2011), that can potentially answer this question by providing a framework for understanding how personal memories are organized, stored, and retrieved. This theory predicts the effects of (recalling) an extremely stressful or traumatic event on a person. A visualization of the *Autobiographical Memory Theory* (Rubin et al., 2008; 2011) was created as a foundation for the study overarching the current study (Figure 1). In this model, frequent retrieval, distinctiveness and emotionality influence the degree of accessibility of a memory. It is then assumed that a higher degree of accessibility leads to a higher degree of centrality; the extent to which the event is integrated into one's identity, is viewed as a turning point in one's life story and becomes a reference point for other events (Berntsen & Rubin, 2007). This is assumed to influence the degree of involuntary memories of an event, supported by findings from longitudinal research, in which event centrality predicts involuntary memories (Boals & Ruggero, 2016; Grau et al., 2021).

In their *Autobiographical Memory Theory*, Rubin et al. (2011) suggest that autobiographical memories, whether traumatic or not, are more accessible when the memory (1) has high emotional intensity, (2) has frequently been retrieved, and (3) is central to someone's identity or life story. Memories of traumatic events usually meet these conditions. According to Rubin et al. (2011), these three components augment each other. They suggest frequent retrieval and the increased centrality, in turn, help maintain the memory and its emotional intensity (Rubin et al., 2011), however, they do not further elaborate. If true, this indicates a feedback loop in the proposed theoretical model (Figure 1), reinforcing the ability to recall and emotional intensity. Could frequent retrieval affect the emotional intensity of autobiographical memories?

The emotional intensity of memories

The notion that emotion significantly influences memory processes has been broadly supported in the literature (for example, Cahill & McGaugh, 1995) and widely recognized within the field of cognitive neuroscience and psychology. An event that elicits emotional arousal is more likely to be remembered vividly, for a long time (Holland & Kensinger, 2010) and is remembered better and integrated better into autobiographical memory (Conway & Pleydell-Pearce, 2000; Rubin et al., 2011). When an autobiographical memory is retrieved, it returns to a labile state, in which it can be strengthened, weakened or remain unchanged (Nader et al., 2000; Monfils & Holmes, 2018). Without added manipulations, a highly emotional memory might once again lead to arousal and cause this response to be incorporated into the memory as it reconsolidates (Monfils & Holmes, 2018); thus retrieval enhancing emotional intensity. Frequently retrieved events generally show less affective fading (Walker et al., 2009); memories that are frequently recalled tend to retain vividness and emotional intensity longer compared to rarely recalled memories. This all raises the question; does frequent retrieval maintain or even enhance the emotional intensity of an autobiographical memory?

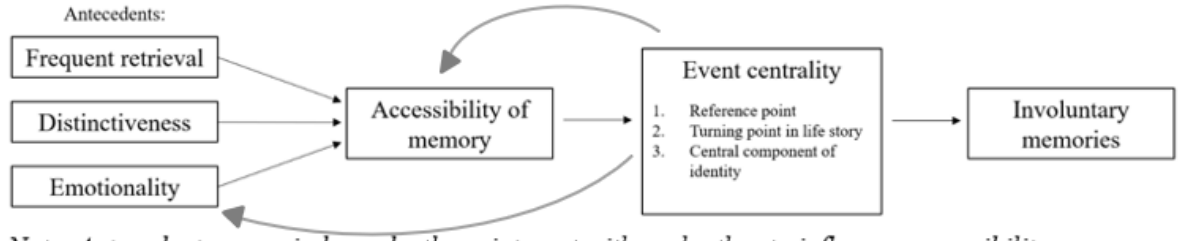
The current study

This study is part of a broader study into event centrality and involuntary memories. The current study focusses on emotional intensity, one of the antecedents in the proposed theoretical model (Figure 1). To investigate the relations in this model and the suspected feedback loop (reinforcing accessibility and emotional intensity), an experiment will be performed, in which participants recall personal memories. Recalling autobiographical memories requires a certain degree of re-experiencing past events. This recall often produces an emotional response similar to the one experienced when the event originally occurred. In PTSD, the recall of a traumatic experience can cause the person to feel or act as if the event were recurring (DSM-5; American Psychiatric Association, 2013). Similarly, recalling a positive memory often produces the same positive emotions as when the event was experienced. Rubin et al. (2011) propose that no special memory processes exist for traumatic memories; they are not processed differently from other autobiographical memories. Therefore, participants in the current study will be asked to repeatedly retrieve positive memories, due to ethical considerations to reduce potential harm. In addition, this allows for exploration of the effects of increasing the accessibility of positive memories on the accessibility and emotional intensity of negative, potentially traumatic memories. Increasing specific positive memory recall may serve as a resilience factor in PTSD when coping with

stressors (Contractor et al., 2019). This seems in line with the notion that negative mood can be regulated by accessing positive information about the self (Josephson et al., 1996). If increased frequent retrieval of positive memories decreases the accessibility and emotional intensity of traumatic memories, this could potentially be used in the treatment of PTSD.

The current study examines whether (1) frequent retrieval increases the emotional intensity of positive memories over time, compared to no retrieval and if (2) emotional intensity, accessibility and centrality correlate with each other. Additionally, it explores whether (3) increasing frequent retrieval of positive memories decreases the ability to recall and the emotional intensity of negative, potentially traumatic memories.

Figure 1.
Proposed Theoretical Model



Note. Antecedents occur independently or interact with each other to influence accessibility.

Method

Transparency

The study overarching the current study was preregistered in the Open Science Framework in November of 2024 (OSF; osf.io/grm64). The preregistration included the theoretical framework, hypotheses, design, and analysis plan. Hypotheses and dependent variables in this thesis differ from the overarching study, to focus on emotional intensity, accessibility and centrality. Only information that is relevant to (the focus of) this thesis will be reported.

Ethical approval

This research project (PSY-2324-S-0425) has been approved by the Ethics Committee of the Faculty of Behavioural and Social Sciences (EC-BSS) of the University of Groningen on the 21st of November of 2024.

Design

A 2x2 within-subjects experimental design was utilized, with the levels being retrieval frequency (frequent vs. no retrieval) and time (pre- vs. post-manipulation). The follow-up of the overarching study was not used in the analysis of this study. An a priori power analysis indicated a sample size of 88 ($n = 88$) to detect an effect size of 0.25 with a power of 0.80 ($\alpha = 0.0167$), based on a 2x2 RM MANOVA, aiming to detect a moderate effect size.

Participants

Participants were recruited via the SONA-pool of first-year psychology students at the University of Groningen. Exclusion criteria in the online SONA advertisement explicitly stated that individuals were ineligible to participate if diagnosed with a mental illness (in particular a depressive disorder, anxiety disorder or bipolar disorder) in the past 6 months and/or are in treatment with a certified therapist. Additionally, participants were screened to assess eligibility. They were considered eligible if they scored < 6 on the Trauma Screening Questionnaire (TSQ; Brewin et al., 2002). One participant was excluded during the pre-screening phase according to this cut-off score. Unfortunately, only 10 eligible participants could be recruited, with 9 of them completing all sessions in the experiment. Participant data was collected in November and December of 2024. The mean age of these participants was 19.6 years old (SD = 1.78), with 70% identifying as female and 30% identifying as male.

Material

Trauma Screening Questionnaire (TSQ)

The Trauma Screening Questionnaire (TSQ; Brewin et al., 2002) was used for screening. The TSQ is a 10-item self-report measure designed to screen for PTSD symptoms following

exposure to a traumatic event. It assesses re-experiencing and arousal symptoms based on DSM criteria. A score above 6 indicates a need for further PTSD assessment.

Centrality of Events Scale (CES)

The shortened, 7-item version of the Centrality of Events Scale (CES; Berntsen & Rubin, 2006) was used to assess the degree to which the described event has become central to the participants' identity and life story. The items of this questionnaire are scored on a scale of 1 (totally agree) to 5 (totally disagree). The total score ranges from 7 to 35, with higher scores indicating higher centrality of the event. The reliability of the CES for the current sample was found to be high ($\alpha = 0.945$).

Impact of Event Scale-Revised (IES-R)

The 8-item Intrusion subscale of the Impact of Event Scale-Revised (IES-R; Weiss & Marmar, 1997), was used to assess the extent to which an individual experiences intrusive thoughts, memories, or images related to the reported event. Items are scored on a scale of 1 (not at all) to 5 (extremely). The total score ranges from 8 to 40, with higher scores indicating a higher degree of intrusions. The Intrusion subscale has been found to have high within-scale correlations with matching subscales of other trauma-questionnaires (like the CAPS and PSS-SR; Beck et al., 2007). In the current sample, the reliability was found to be high ($\alpha = 0.971$).

Memory Experiences Questionnaire – Short Form (MEQ-SF)

Self-developed items based on the Memory Experiences Questionnaire - Short Form (MEQ-SF; Luchetti &. Sutin, 2016) were used to target memory characteristics; accessibility, vividness, emotional intensity, valence, distinctiveness and coherence. For each reported memory, these characteristics were measured with a single item on a slider scale of 1 (not at all) to 100 (extremely). For each characteristic, the question was as follows; Accessibility: "*This memory came to mind easily*", Vividness: "*My memory for this event is vivid*", Emotional intensity: "*My emotions are intense concerning this event*", Valence: "*The overall tone of my memory is positive/negative*", Distinctiveness: *"This memory stands out from other similar memories*", Coherence: *"The order of events in the memory is clear"*.

Procedure

The experimental phase contained three sessions. To ensure consistency, participants were guided by the experimenter using a script. They were asked for their SONA-ID for credit purposes, which was saved in a separate document to ensure anonymity. Written memories and questionnaire scores were recorded in Qualtrics and exported to a secured drive within the servers of University of Groningen.

In the first session, participants were welcomed, informed and given the time and

privacy to read the digital information letter and consent form in their cubicle. Participants were explicitly told they could stop or withdraw their consent at any point in the experiment. If participants agreed to participate and gave their informed consent, they proceeded to the digital pre-screening. If eligible according to the pre-screening, they were further informed about the experiment. In their private cubicle, they wrote down 3 negative and 3 positive memories consecutively. A keyword was chosen for each memory by participants themselves, to cue this memory at the start of each questionnaire. An experimenter was available to address any questions or concerns when the participant opened their cubicle door. After completing baseline questionnaires about memory characteristics, participants were guided by experimenters to install the m-Path app, used during the at-home retrieval phase following session 1. During this phase, participants recalled one randomly selected positive memory at notification from the m-Path mobile application for 6 days (5 times a day).

In the second session at the lab (one week after the first session), participants completed questionnaires about memory characteristics of all memories. Once again, the participant is asked for their SONA-ID and led to their private cubicle to complete the questionnaires in Qualtrics. Questionnaires were linked to each memory by the keyword chosen in session one.

For the third session, the same procedure was repeated. Finally, participants were thanked for their participation and asked about their experiences and presumed purpose of the study, followed by a debriefing.

A visual overview of sessions was provided to participants (Figure G1, Appendix G).

Analysis

Data preparation

Raw data from Qualtrics was exported to SPSS (within the secure University of Groningen servers) and cleaned. Initially, 11 participants started the experiment. One participant who had been deemed ineligible after the screening and one drop-out after session 1 were removed (resulting in a final sample of 9 participants). For the remaining participants, randomized memories of session 1 and 2 had to be manually linked by writing the appropriate syntax; because the purpose of the analysis was to compare memory characteristics of frequently retrieved and non-retrieved memories, the specific memories of session 2 had to match the memories of session 1, which was not encoded in advance. Additionally, mean variables were created for each memory characteristic, for the purpose of testing correlations in the second hypothesis.

Hypothesis 1

To examine the effect of frequent retrieval on emotional intensity over time and to detect a potential interaction effect, an RM-ANOVA was performed. The RM-ANOVA, with emotional intensity as the dependent variable, had 2 within-subject factors, each with 2 levels: retrieval frequency (frequent vs. no retrieval) and time (session 1 vs. session 2). The normality assumption was checked beforehand with a Shapiro-Wilk test, QQ-plot and kurtosis.

Hypothesis 2

To obtain a clear overview of the relationships between the memory characteristics, a correlation matrix was created, displaying the correlations between emotional intensity, accessibility and centrality. Before the matrix was created, the normality assumption was checked with a Shapiro-Wilk test and the linearity assumption was checked with scatterplots.

Hypothesis 3

To examine the effect of frequent retrieval of positive memories on negative memories, another RM-ANOVA was performed for the last hypothesis, with 2 within-subject factors and 1 level: time (session 1 vs. session 2). Prior, the normality assumption was checked with a Shapiro-Wilk test and QQ-plot.

Results

Memory characteristic descriptives

Means and standard deviations of emotional intensity, accessibility and centrality for session 1 and 2 are displayed in Table 1 below.

Table A1

Means (SDs) of memory characteristics in session 1 (n=9).

Session	Memory characteristic		Mean (SD)
1	Emotional intensity	Positive (retrieved)	52,8 (26,4)
		Positive (non-retrieved)	59,1 (16,2)
		Negative	63,5 (11,6)
	Accessibility	Positive (retrieved)	57,6 (28,5)
		Positive (non-retrieved)	76,3 (14,8)
		Negative	71,7 (9,4)
	Centrality	Positive (retrieved)	19,1 (7,1)
		Positive (non-retrieved)	23,0 (6,4)
		Negative	21,6 (3,7)
2	Emotional intensity	Positive (retrieved)	52,9 (26,3)
		Positive (non-retrieved)	56,4 (19,5)
		Negative	67,5 (19,1)
	Accessibility	Positive (retrieved)	67,0 (13,9)
		Positive (non-retrieved)	71,8 (20,6)
		Negative	70,6 (16,8)
	Centrality	Positive (retrieved)	19,1 (5,3)
		Positive (non-retrieved)	22,8 (3,6)
		Negative	23,3 (4,2)

At-home retrieval in the m-path application

Response rates to the notifications of the m-path app were analysed. Mean response rates per day (day 1 to 6) showed a decline in responses over time (Figure F1, Appendix F). Additionally, self-reported engagement levels were analysed. A plot of mean engagement levels showed a slight decline (Figure F3, Appendix F).

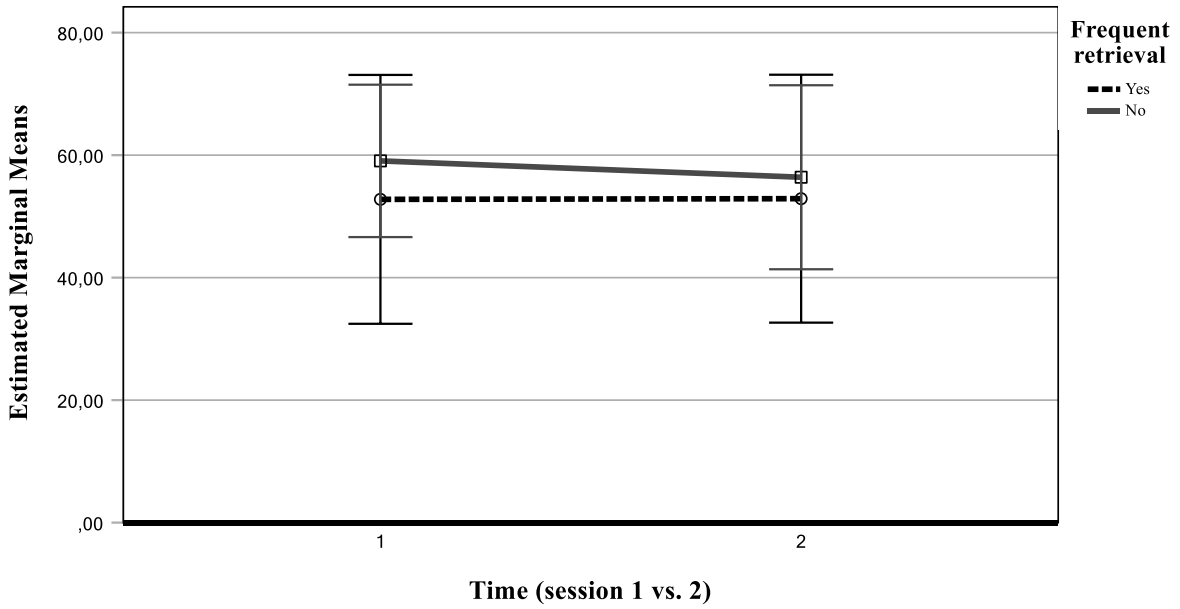
Hypothesis 1

Hypothesis 1 stated frequent retrieval would increase the emotional intensity of positive memories in session 2, compared to no retrieval. To test this hypothesis, a 2x2 RM-ANOVA with factors *retrieval frequency* and *time* (frequent vs. no retrieval, pre- vs. post-manipulation) was performed, and the assumptions of a continuous dependent variable and categorical independent variables were met. However, the assumption of univariate normality was not met for one variable (retrieved memory in session 2), according to the Shapiro-Wilk test ($W = 0.803$, $p = 0.022$; Table A1, Appendix A). The QQ-plot (Figure B1, Appendix B) for this variable looks acceptable and with a kurtosis of 0.771, it is considered not outside of the range of normality. The assumption of normality was met for the remaining variables according to the Shapiro-Wilk test and kurtosis scores.

The RM-ANOVA revealed no significant main effect for time and an effect size that could be considered trivial (F [1, 8] = 0.043, $p = 0.840$, $\eta^2 = 0.005$). For retrieval frequency too, no significant main effect was observed and a small effect size was found (F [1, 8] = 0.189, $p = 0.675$, $\eta^2 = 0.023$). Although a profile plot shows an interaction effect (see Figure 1 below), no statistically significant interaction effect between time and retrieval frequency was found, and the effect size for this interaction was small (F [1, 8] = 0.197, $p = 0.669$, $\eta^2 = 0.024$). Additionally, the change in mean emotionality does not seem to indicate a clear increase ($M = 52.8$ pre-manipulation vs. $M = 52.9$ post-manipulation; Table 1). Overall, results showed relatively low change (small variance and effect sizes) between sessions. Therefore, little support is found for frequent retrieval increasing the emotional intensity of positive memories over time, compared to no retrieval, in the current sample.

Figure 1

Estimated marginal means of emotional intensity of retrieved versus non-retrieved positive memory, pre- and post-manipulation (session 1 – session 2), displaying an interaction effect.



Note. Error bars: 95% confidence intervals.

Hypothesis 2

Hypothesis 2 stated that the emotional intensity, accessibility and centrality of memories positively correlate. The assumption of related pairs has been met due to the design of the current study. The assumptions of continuous variables, linearity, and univariate normality (Table C1, Appendix C) have also been met.

To test the hypothesized relationships, a correlation matrix was computed. Emotional intensity showed a moderate positive correlation with accessibility, however, this correlation was not found significant in the current sample ($r = 0.577$, $p = 0.081$). Accessibility and centrality also showed a moderate positive correlation, but again, this correlation was not found significant in this sample ($r = 0.501$, $p = 0.140$). Emotional intensity and centrality were found to be significantly and strongly positively correlated ($r = 0.680$, $p = 0.031$). Overall, moderate to large effects were found. These results provide some support for the hypothesis, though the strength of this evidence is limited. See Appendix D for scatterplots displaying the relations between emotional intensity, accessibility and centrality.

Hypothesis 3

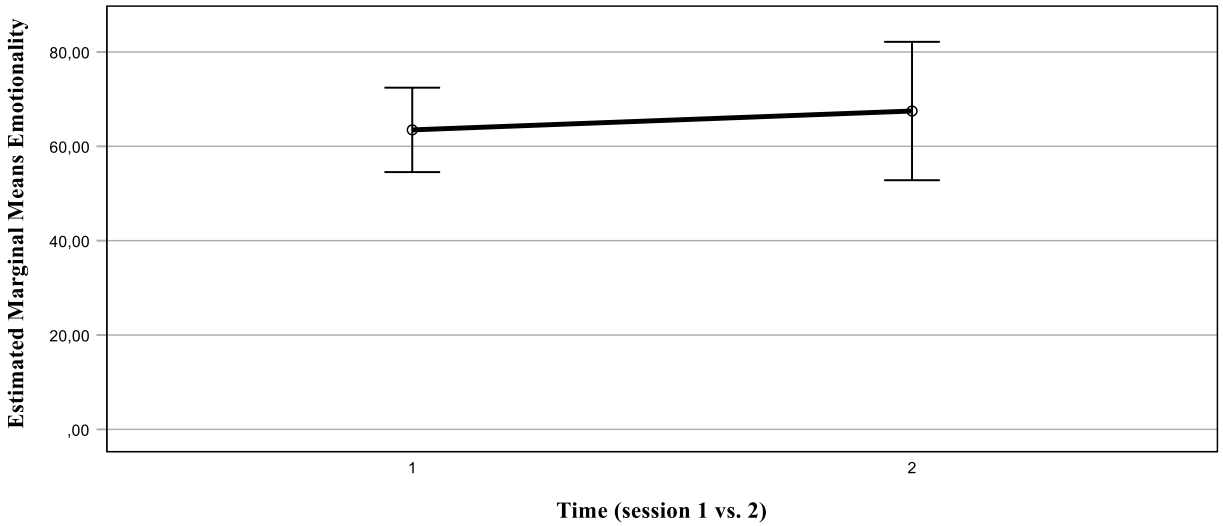
Hypothesis 3 stated that frequent retrieval of positive memories decreases the accessibility and the emotional intensity of negative memories. To test this hypothesis, an RM-ANOVA

was performed, with the factor of *time* (pre- vs. post-manipulation). The assumptions of continuous dependent variables, a categorical independent variable and univariate normality are met (Shapiro-Wilk test: Table E1, Appendix E). Once again, because the RM-ANOVA has two dependent variables, sphericity does not apply.

The RM-ANOVA revealed a small, but non-significant effect of time for emotionality, with a small to moderate effect size (F [1, 8] = 0.337, p = 0.578, η^2 = 0.040). As for accessibility, the RM-ANOVA revealed an effect that could be considered negligible (F [1, 8] = 0.049, p = 0.830, η^2 = 0.006). Plots suggest a slight increase in mean emotionality of negative memories after frequent retrieval (Figure 2), compared to a slight decrease in mean accessibility of negative memories (Figure 3). Considering the small effect size and variability, these results provide little support for the hypothesis, but remain inconclusive due to limited power.

Figure 2

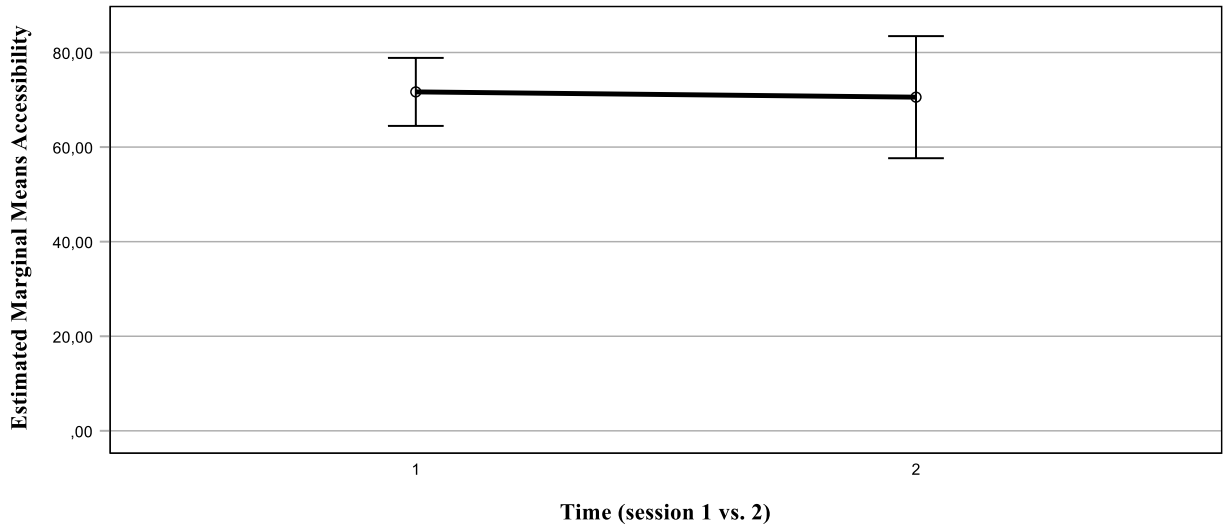
Estimated marginal means of emotionality pre- and post-manipulation (session 1 – session 2).



Note. Error bars: 95% CI.

Figure 3

Estimated marginal means of accessibility pre- and post-manipulation (session 1 – session 2).



Note. Error bars: 95% CI.

Discussion

In this study, the effects of frequent retrieval of positive autobiographical memories on emotional intensity, accessibility and centrality were examined. The results are inconclusive regarding the first hypothesis that frequent retrieval increases the emotional intensity of positive memories in session 2. Hypothesis 2, regarding the positive correlations emotional intensity, accessibility and centrality, requires some nuance in interpretation; moderate to large effects were found, with only the correlation between emotional intensity and centrality being significant. As for hypothesis 3, which posits that frequent retrieval of positive memories decreases the accessibility and the emotional intensity of negative memories, results are again inconclusive.

With current data, no conclusions can be drawn on whether frequent retrieval enhances emotional intensity, as suggested by the feedback loop in the proposed model of this study. Interestingly, the accompanying plot (Figure 1) does show an interaction effect. Had this study had sufficient power, a similar finding would not have provided support for frequent retrieval increasing the emotional intensity of positive memories, but would have provided support for frequent retrieval maintaining emotional intensity compared to no retrieval (visualized in Figure 1). This finding contrasts findings by Monfils & Holmes (2018) showing arousal at recall is incorporated into a memory as it reconsolidates, leading to increased emotionality, but would have been in line with a maintenance effect of frequent retrieval on emotional intensity, suggested by Rubin et al. (2011). This study, however, could not accurately detect a significant interaction effect between time and frequent retrieval and findings can only be considered inconclusive.

The results provide an interesting distinction between correlations predicted in hypothesis 2; emotional intensity, accessibility and centrality seem to be moderately to strongly positively related, although only the relationship between emotional intensity and centrality was found significant. Notable however, is that for the two remaining relationships (emotional intensity – accessibility and centrality – accessibility), moderate effect sizes were found, suggesting existing relationships that could not be detected as significant in the current sample. Either way, results provide some valuable information about the presumed feedback loop in the proposed theoretical model. If emotional intensity, accessibility and centrality in fact do have strong direct influence on each other, strong, significant correlations between all variables are to be expected. Current findings in a study with sufficient power might indicate, instead of a direct influence of the variables on each other, an indirect or moderating influence. Further investigation is needed to determine the existence of the suspected

feedback loop. As yet, there is only evidence for an influential relationship between emotional intensity and centrality.

The results of hypothesis 3 too, were inconclusive. Whether frequent retrieval of positive memories decreases the accessibility and the emotional intensity of negative memories cannot be determined. Notable is the slight decrease in accessibility of negative memories after frequent retrieval, suggesting a potentially meaningful effect for accessibility that may have been impacted by the current sample size. However, the effect size was negligible and results may have been influenced by random fluctuations and coincidence. As for emotionality, the current results in a study with sufficient power would indicate that, although accessing positive information about the self can regulate negative mood (Josephson et al., 1996), it does not reduce the intensity of emotions that accompany an already acquired negative memory. Negative memories may be resistant to modification through positive retrieval. Further investigation is needed to determine the effect of frequent retrieval of positive memories on negative memories.

This study is subject to several limitations. First, and perhaps most impactful of all, the sample size of this study turned out to be substantially smaller than the a priori power analysis indicated was desirable. This was a consequence of few sign-ups and time constraints. An additional phase of testing is planned after this thesis was finalized. It was decided to continue the analysis for educational purposes. With a sample consisting of just 9 participants, it is safe to assume the findings of this study do not accurately represent the broader population, limiting external validity. Because of the violation of normality that occurred, the estimations of significance or effect size in hypothesis 1 are less reliable and should be interpreted with caution. Additionally, because of the statistical power being reduced, results are likely to be biased by random and systematic errors (the likelihood of a Type II error increased) and possibly existing (interaction) effects may have gone undetected. Another possible limitation in this study concerns participant engagement. Attentive memory retrieval in the at-home retrieval phase with the m-path application cannot be ensured. It was only required of participants to open the app and respond to the prompt with a short confirmation after retrieval. However, they received these notifications 5 times a day, 6 days consecutively, and boredom effects might have affected their efforts to attentively retrieve the cued memory. According to Meier et al. (2024), boredom can impair participants' attention, can make study participation more effortful, cause participants to be less engaged with the study, and consequently, bias study outcomes. Response rates in the m-path application varied for the participants. Participants did not respond to all of the notifications and mean response

rates showed a decline of responses over time (Figure F1 and F2, Appendix F). In reporting their engagement with the cued memory, some individual participants showed relatively high engagement the first day(s), which somewhat declined over time (Figure F3, Appendix F). Although difficult to determine, reduced engagement in the retrieval phase could have produced slight differences in the retrieval frequency among participants. This too should be taken into consideration for the interpretation and the generalization of the results of this study.

Although findings of this study remain inconclusive, some interesting insights have been acquired about the newly developed method this study used for testing the frequent retrieval of autobiographical memories. The use of a script in the lab-sessions to ensure equal experiences for all participants was efficient and practical for the experimenters and accepted by all participants. Something that can be improved in this method to facilitate data processing and analysis, is the encoding of randomized memories. In the current dataset, randomized memories of session 1 and 2 had to be manually linked to each other, which proved to be rather time consuming. Another point of interest for future use of the questionnaires in this method, is that the IES-R asks participants to “indicate how distressing each difficulty has been" for them, also when in reference to positive memories. This caused confusion for some participants. Although the IES-R is suitable for measuring involuntary positive memories, the phrasing of the questions should be carefully considered when adapting them to positive memory recall. Aside from these minor issues, this method proved to be a convenient and practical way to assess various memory characteristics over time in one, structured experiment.

Some future directions for studying memory characteristics pertain to increasing the sample size, examining maintenance of effects of frequent retrieval rather than an increase, including PTSD and improving the method. In this study, the effects of frequent retrieval on memory characteristics of autobiographical memories were investigated in a sample of only 9 participants. Clearly, future studies into the effects of frequent retrieval on memory characteristics of autobiographical memories should employ larger samples to yield more power and reliable, generalizable results. Furthermore, although the current study found an influential relationship for emotional intensity with centrality, the feedback loop in the model should be further investigated in a larger sample, to gather more evidence to reject or support the hypothesized feedback loop. Next, the notion that frequent retrieval helps maintain (but not increase) emotional intensity (Rubin et al., 2011) has not yet been investigated. Current results in a study with sufficient power would have provided support for frequent retrieval

maintaining emotional intensity. Future research could focus on examining this maintaining effect instead of an enhancing effect. Furthermore, future samples could, if possible and ethically responsible, include participants with PTSD and a (non-PTSD) comparison group. Although there is substantial evidence that memories of traumatic experiences can be understood in terms of general memory processes, traumatic memories of those with PTSD often show increased emotional intensity and higher centrality (Rubin et al., 2011). Investigating whether similar effects of frequent retrieval are found with higher baseline scores on these memory characteristics could provide valuable insights into whether the frequent retrieval of positive memories influences the accessibility and emotionality of negative memories for those suffering from PTSD. Considering increasing specific positive memory recall may serve as a resilience factor in PTSD when coping with stressors (Contractor et al., 2019), this could be particularly relevant for clinical application; patient research could ensure clinical applicability and efficacy of retrieving positive memories as a treatment strategy. Lastly, to ensure reliable effects of frequent retrieval, the aforementioned potential boredom effects of frequent at-home retrieval through a mobile application could be examined. To facilitate the data-analysis phase, it would be advised to introduce unique identifiers that link randomized memories of session 1 and 2, or sort the dataset in a way that responses for the same memory collected in different sessions are grouped together.

Taken together, results of this study show negligible change in emotional intensity after frequent retrieval of a positive memory. Medium to strong correlations are found between emotional intensity, accessibility and centrality, with only the correlation between emotional intensity and centrality being statistically significant. Additionally, no strong evidence was found for an effect of frequent retrieval of positive memories on the emotional intensity of negative memories in the current sample. The additional phase of testing and further research may shed more light on the effects of frequent retrieval on the memory characteristics of autobiographical memories.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

Berntsen, D., & Rubin, D. C. (2006). The centrality of event scale: A measure of integrating a trauma into one's identity and its relation to post-traumatic stress disorder symptoms. *Behaviour Research And Therapy*, *44*(2), 219–231. https://doi.org/10.1016/j.brat.2005.01.009

Berntsen, D., & Rubin, D. C. (2007). When a trauma becomes a key to identity: enhanced integration of trauma memories predicts posttraumatic stress disorder symptoms. *Applied Cognitive Psychology*, *21*(4), 417–431. https://doi.org/10.1002/acp.1290

Bluck, S. (2003). Autobiographical memory: Exploring its functions in everyday life. *Memory*, *11*(2), 113–123. https://doi.org/10.1080/741938206

Boals, A., & Ruggero, C. (2016). Event centrality prospectively predicts PTSD symptoms. *Anxiety Stress & Coping*, *29*(5), 533–541. https://doi.org/10.1080/10615806.2015.1080822

Brewin, C. R., Rose, S., Andrews, B., Green, J., Tata, P., McEvedy, C., Turner, S., & Foa, E. B. (2002). Brief screening instrument for post-traumatic stress disorder. *The British Journal Of Psychiatry*, *181*(2), 158–162. https://doi.org/10.1192/bjp.181.2.158

Cahill, L., & McGaugh, J. L. (1995). A Novel Demonstration of Enhanced Memory Associated with Emotional Arousal. *Consciousness And Cognition*, *4*(4), 410–421. https://doi.org/10.1006/ccog.1995.1048

Contractor, A. A., Banducci, A. N., Dolan, M., Keegan, F., & Weiss, N. H. (2019). Relation of positive memory recall count and accessibility with post-trauma mental health. *Memory*, *27*(8), 1130–1143. https://doi.org/10.1080/09658211.2019.1628994

Conway, M. A., & Pleydell-Pearce, C. W. (2000). The construction of autobiographical memories in the self-memory system. *Psychological Review*, *107*(2), 261–288. https://doi.org/10.1037/0033-295x.107.2.261

Grau, P. P., Larsen, S. E., Lancaster, S. L., Garnier-Villarreal, M., & Wetterneck, C. T. (2021). Change in Event Centrality and Posttraumatic Stress Disorder Symptoms During Intensive Treatment. *Journal Of Traumatic Stress*, *34*(1), 116–123. https://doi.org/10.1002/jts.22541

Holland, A. C., & Kensinger, E. A. (2010). Emotion and autobiographical memory. *Physics Of Life Reviews*, *7*(1), 88–131. https://doi.org/10.1016/j.plrev.2010.01.006

Josephson, B. R. (1996). Mood Regulation and Memory: Repairing Sad Moods with Happy

Memories. *Cognition & Emotion*, *10*(4), 437–444. https://doi.org/10.1080/026999396380222

Luchetti, M., & Sutin, A. R. (2015). Measuring the phenomenology of autobiographical memory: A short form of the Memory Experiences Questionnaire. *Memory*, *24*(5), 592–602. https://doi.org/10.1080/09658211.2015.1031679

McNally, R. J., Litz, B. T., Prassas, A., Shin, L. M., & Weathers, F. W. (1994). Emotional priming of autobiographical memory in post-traumatic stress disorder. *Cognition & Emotion*, *8*(4), 351–367. https://doi.org/10.1080/02699939408408946

Meier, M., Martarelli, C. S., & Wolff, W. (2024). Is boredom a source of noise and/or a confound in behavioral science research? *Humanities And Social Sciences Communications*, *11*(1). https://doi.org/10.1057/s41599-024-02851-7

Monfils, M. H., & Holmes, E. A. (2018). Memory boundaries: opening a window inspired by reconsolidation to treat anxiety, trauma-related, and addiction disorders. *The Lancet Psychiatry*, *5*(12), 1032–1042. https://doi.org/10.1016/s2215-0366(18)30270-0

Nader, K., Schafe, G. E., & Doux, J. E. L. (2000). Fear memories require protein synthesis in the amygdala for reconsolidation after retrieval. *Nature*, *406*(6797), 722–726. https://doi.org/10.1038/35021052

Rubin, D. C., Boals, A., & Berntsen, D. (2008). Memory in posttraumatic stress disorder: Properties of voluntary and involuntary, traumatic and nontraumatic autobiographical memories in people with and without posttraumatic stress disorder symptoms. *Journal Of Experimental Psychology General*, *137*(4), 591–614. https://doi.org/10.1037/a0013165

Rubin, D. C., Deffler, S. A., Ogle, C. M., Dowell, N. M., Graesser, A. C., & Beckham, J. C. (2016). Participant, rater, and computer measures of coherence in posttraumatic stress disorder. *Journal Of Abnormal Psychology*, *125*(1), 11–25. https://doi.org/10.1037/abn0000126

Rubin, D. C., Dennis, M. F., & Beckham, J. C. (2011). Autobiographical memory for stressful events: The role of autobiographical memory in posttraumatic stress disorder. *Consciousness And Cognition*, *20*(3), 840–856. https://doi.org/10.1016/j.concog.2011.03.015

Schacter, D. L., Addis, D. R., & Szpunar, K. K. (2017). Escaping the Past: Contributions of the Hippocampus to Future Thinking and Imagination. In *Springer eBooks* (pp. 439–465). https://doi.org/10.1007/978-3-319-50406-3_14

Speer, M. E., & Delgado, M. R. (2017). Reminiscing about positive memories buffers acute

stress responses. *Nature Human Behaviour*, *1*(5). https://doi.org/10.1038/s41562-017-0093

Walker, W. R., Skowronski, J. J., Gibbons, J. A., Vogl, R. J., & Ritchie, T. D. (2009). Why people rehearse their memories: Frequency of use and relations to the intensity of emotions associated with autobiographical memories. *Memory*, *17*(7), 760–773. https://doi.org/10.1080/09658210903107846

Weiss, D. S., & Marmar, C. R. (1997). The Impact of Event Scale—Revised. In J. P. Wilson & T. M. Keane (Eds.), *Assessing psychological trauma and PTSD* (pp. 399–411). The Guilford Press.

Appendix A

Table A1

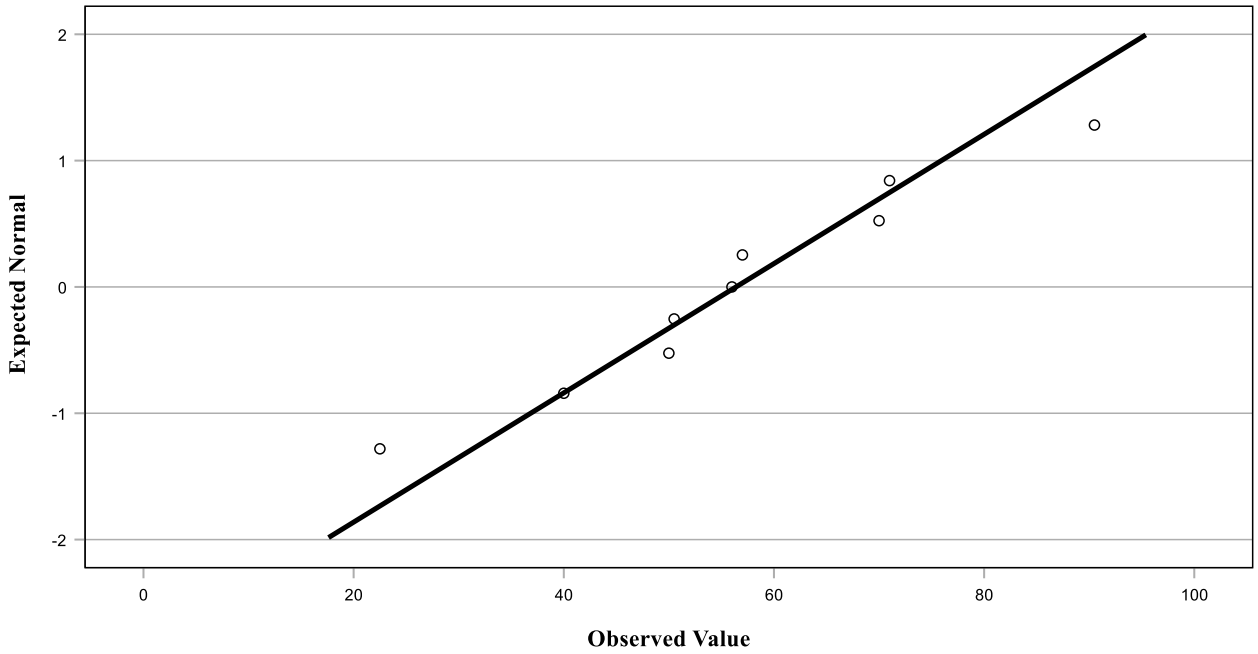
Shapiro-Wilk test for univariate normality of emotional intensity scores (positive memories; hypothesis 1).

	Shapiro-Wilk	
Variable	Statistic	Significance
Retrieved memory session 1	0.983	0.977
Non-retrieved memory session 1	0.889	0.194
Retrieved memory session 2	0.803	0.022
Non-retrieved memory session 2	0.978	0.953

Appendix B

Figure B1

Normal QQ-plot of emotional intensity score for non-retrieved positive memory in session 2.



Note. Altough the normality assumption was violated according to the Shapiro-Wilk test, the QQ-plot for this variable looks acceptable, supported by a kurtosis of 0.771.

Appendix C

Table C1

Shapiro-Wilk test for univariate normality (positive memories; hypothesis 2).

	Shapiro-Wilk	
Variable	Statistic	Significance
Mean emotional intensity	0.979	0.959
Mean accessibility	0.970	0.890
Mean centrality	0.935	0.497

Appendix D

Figure D1

Scatterplot of emotionality by accessibility.

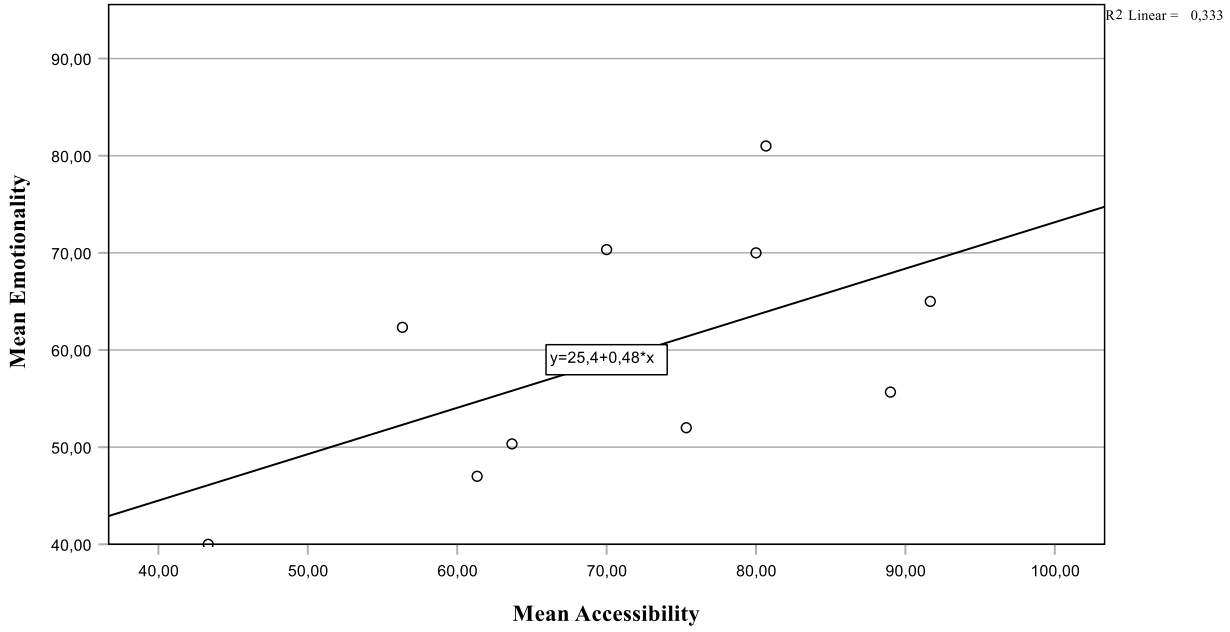


Figure D2

Scatterplot of emotionality by centrality.

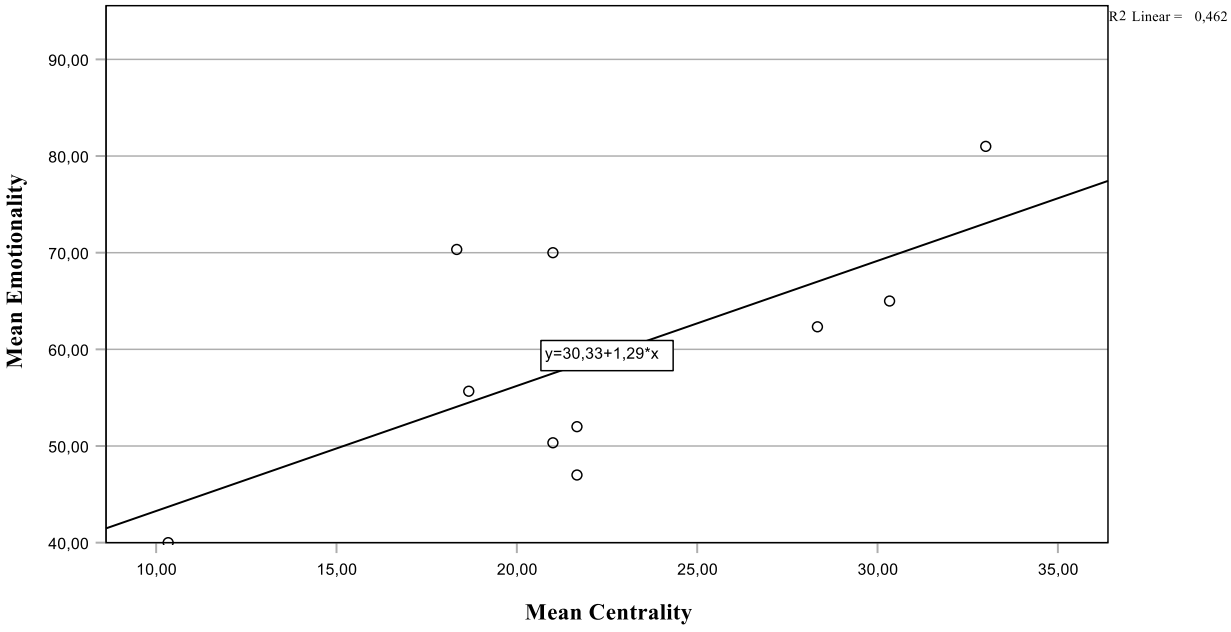
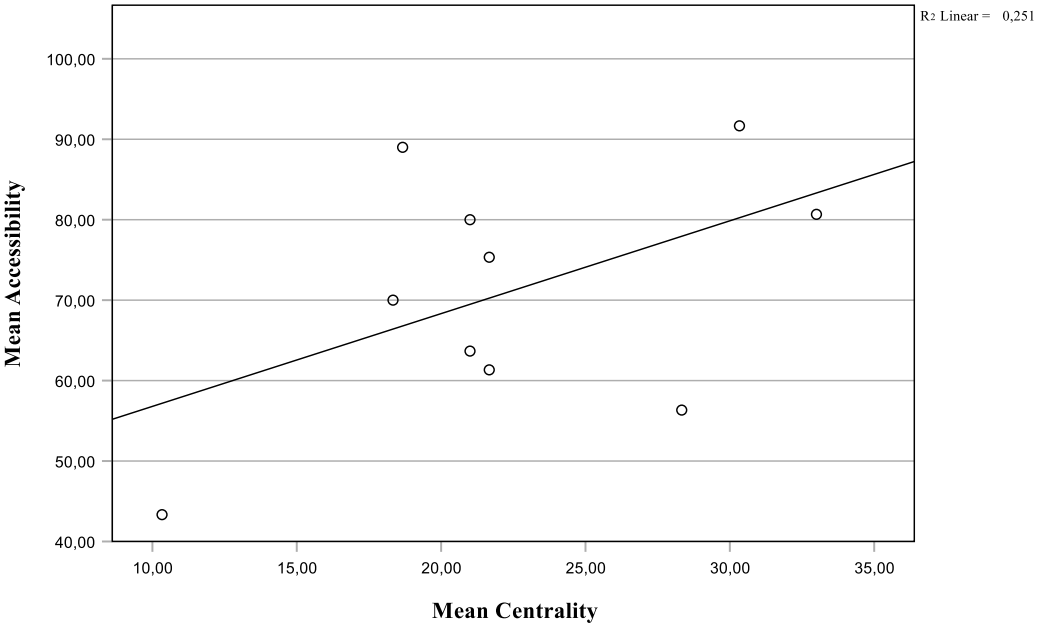


Figure D3

Scatterplot of accessibility by centrality.



Appendix E

Table E1

Shapiro-Wilk test for univariate normality (negative memories; hypothesis 3).

	Shapiro-Wilk	
Variable	Statistic	Significance
Mean emotional intensity session 1	0.945	0.638
Mean accessibility session 1	0.910	0.318
Mean emotional intensity session 2	0.941	0.589
Mean accessibility session 2	0.867	0.113

Appendix F

Figure F1

Mean percentage response rates per day (1-6), showing a decline in responses over time.

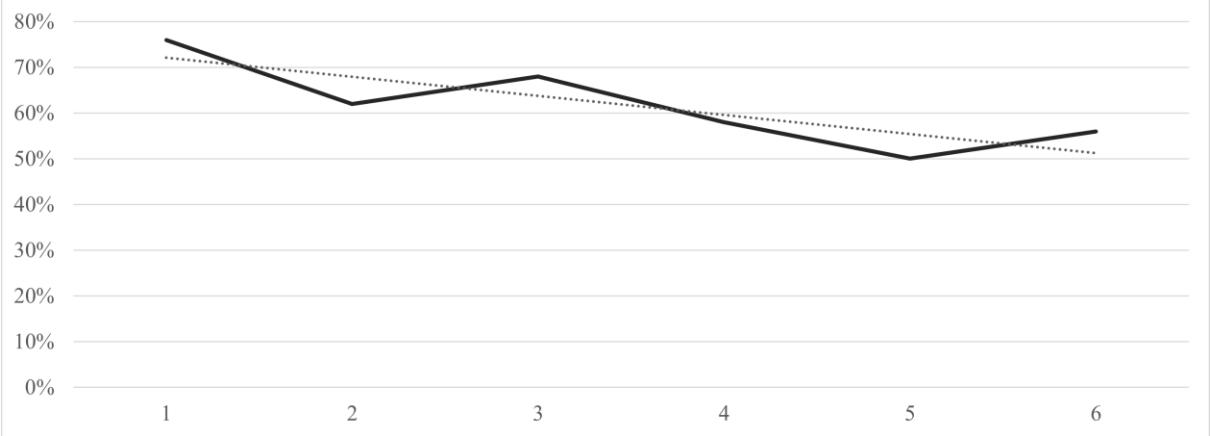
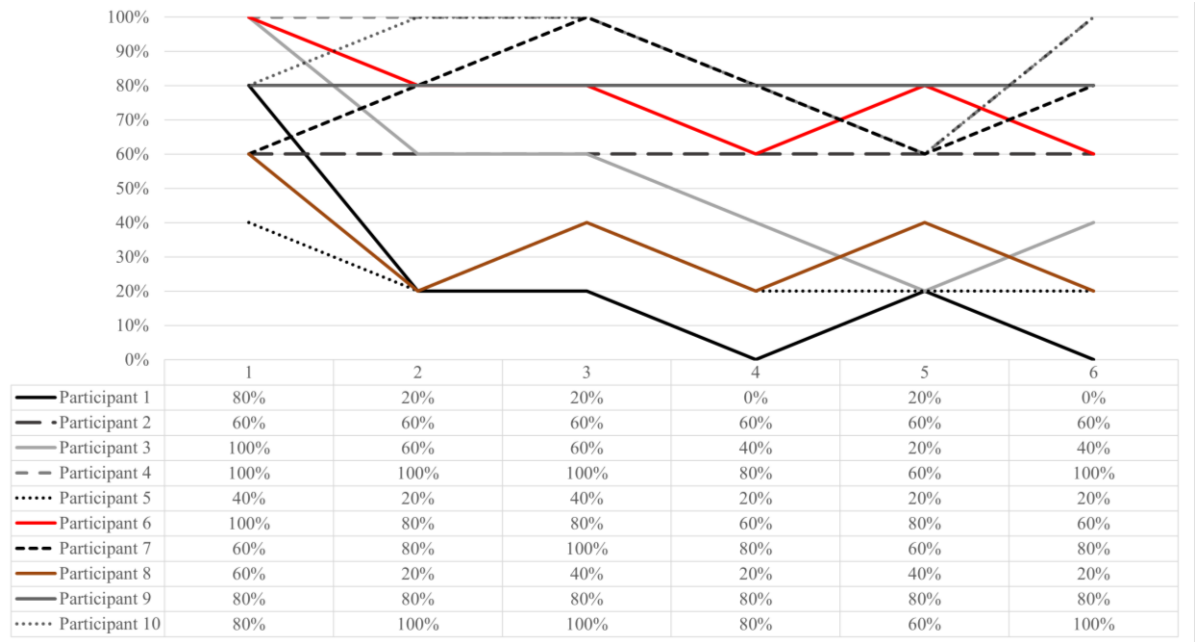


Figure F2

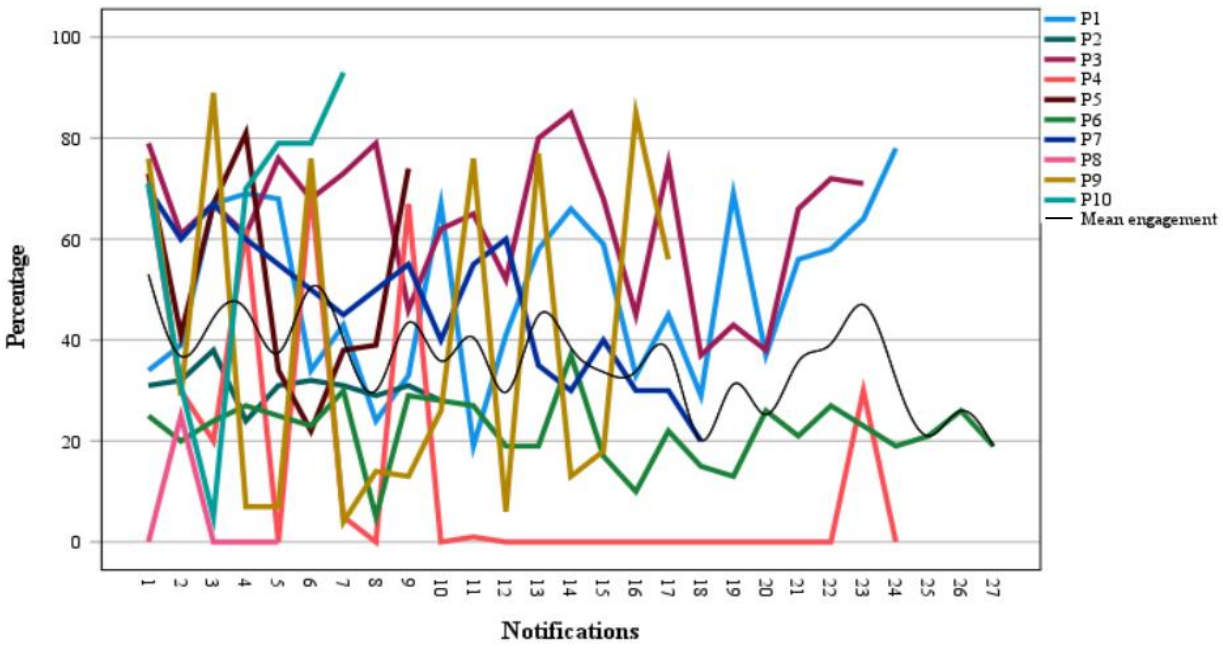
Visualization of response rates per participant.



	1	2	3	4	5	6
Participant 1	80%	20%	20%	0%	20%	0%
Participant 2	60%	60%	60%	60%	60%	60%
Participant 3	100%	60%	60%	40%	20%	40%
Participant 4	100%	100%	100%	80%	60%	100%
Participant 5	40%	20%	40%	20%	20%	20%
Participant 6	100%	80%	80%	60%	80%	60%
Participant 7	60%	80%	100%	80%	60%	80%
Participant 8	60%	20%	40%	20%	40%	20%
Participant 9	80%	80%	80%	80%	80%	80%
Participant 10	80%	100%	100%	80%	60%	100%

Figure F3

Self-reported engagement over time (of notifications that were responded to).



Note. Overall engagement was measured with available responses over time. Engagement of participants who failed to at notifications could not be taken into account. For example, notification 23 was only completed by participants 1, 3, 4 and 6. Consequently, the mean engagement for notification 23 is based on these four participants.

Appendix G

Figure G1

A visualization of the sessions of the experiment, provided to participants in their cubicle to clarify the schedule and expectations.