

The Prediction of Rumination on Positive Mood Change Using the Positive Memory App

Jasmin Geerts

s1003546

Supervisor: dr. Eni Becker

Behavioural Science Institute

Radboud University Nijmegen

Master thesis Gezondheidszorgpsychologie

Submission date: 31-1-2023



**Radboud
Universiteit
Nijmegen**

Abstract

Cognitive Bias Modification (CBM) in the form of memory training has become a more promising intervention for depression. However, existing literature has not yet sufficiently investigated the role that rumination might play in CBM, especially regarding the negativity bias and the overgeneralised autobiographical memory bias through positive memory training. The present study looked at the link between the amount of rumination and mood change using the positive memory training app. Specifically whether mood change was related to how well the app was used, by looking at its link with rumination and how many positive memories were recorded. A total of 30 students participated in this study. A questionnaire assessed their negative mood and rumination levels both before and after the positive memory app intervention, on which they kept track of positive memories throughout the week. Bootstrap mediation analysis was applied using the PROCESS macro. The results showed that no positive mood change was found as a result of the intervention and no relation was found between rumination and the amount of positive memories registered. In the end, the mediation effect of positive memories was also not significant. The study contributes to the growing body of literature on CBM as an intervention for depression, specifically on the use of positive memory training. Limitations of the study and suggestions for future reference are discussed as well.

Keywords: rumination, cognitive biases, cognitive bias modification, positive mood change, memory training app

Psychological interventions that reach many, are readily available and cost-effective are needed for depression, which has become a prevalent illness and affecting approximately 280 million people worldwide (WHO, 2021). Cognitive Bias Modification (CBM) might be such an intervention. CBM refers to a group of interventions that focus on modifying specific cognitive vulnerabilities by aiming to directly change cognitive biases, which have been shown to contribute to the maintenance and development of psychopathology (MacLeod & Matthews, 2012; Jones & Sharpe, 2017). CBM is a relatively new approach to psychological interventions and its usefulness had been under extensive research in the scientific field the past years.

Cognitive biases refer to an error that occurs both in the processing as well as interpretation of information in thinking, hereby creating representations which do not align with the objective reality but are rather systematically distorted (Haselton et al., 2015). Memory biases are types of cognitive biases that are common in depression (Williams et al., 2007; Wittekind et al., 2014). The memory is made up of two parts: long-term memory and working memory (Cowan, 2008). The long-term memory in depressed individuals shows a memory bias in the way that negative information is more easily remembered and positive memory is less easily remembered. This is what is called the negativity bias, or mood congruent memory (Rinck & Becker, 2005; Wittekind et al., 2014). In example: when being asked to remember facts, depressed individuals will remember more negative facts.

Additionally, the long-term memory also includes the autobiographical memory, which plays an important role in another memory bias prevalent in depression called the overgeneralised autobiographical memory (OGM) (Williams et al., 2007). The OGM refers to the occurrence of memory retrieval in which some people tend to be more over-general and less specific in their memory than other people (Williams et al., 2007). This means that when being asked about one's personal life, the memory of a depressed person gets hazy and over-general. So, for example: when a depressed person is asked to think of a specific memories associated with the word 'party', they would know that they attended parties during high school, but would be unable to recall any details of said events. In their study, Williams et al. (2007) found OGM to be a risk and vulnerability factor for depression in both clinical and non-clinical samples. They found that OGM predicted later onset of depression, as well as deterioration of depressed symptoms in both groups. A meta-analysis by Sumner et al. (2010) found similar results from various studies and also found that this predictive relationship was present in adolescence, as well adulthood and that the severity of the depressive symptoms increased with age. It is important to note that one memory bias does not exclude the other, and it is possible for both these biases - negativity bias and OGM - to occur simultaneously or go together, resulting in the remembrance of more negative incidents, but less specific and over-general. Referring back to the 'party' example, that would mean that depressed individuals would remember the lack of parties in their life or the fact that parties are always loud and uncomfortable, herein not being specific but still focussed on negative representations.

Working memory plays an important role in detecting and identifying information in our long-term memory (Deutsch & Strack, 2006; Logan, 1988; Schneider & Shiffrin, 1997). Logically, that would mean that an impaired working memory, results in processing errors (Evans & Stanovich, 2013). Thus, it can be deduced that for OGM that means that with an impaired working memory, which plays an important factor for initiating the search function in the memory, the tool itself is faulty. In a study about the underlying mechanisms for OGM in depression, Liu et al. (2017) found rumination to be a mediator between the relationship of OGM and depressive symptoms in a clinical sample. They found that individuals with higher levels of OGM showed a predisposition to engage in rumination, which in turn predicted more depressive symptoms (Liu et al., 2017). Rumination was also found to be a result of the negativity bias, especially in regard to increased internal attention to negative portrayals and images of the past (Gotlib & Joormann, 2010). Thus, rumination seems to be play a role in partially incapacitating the working memory and thereby contributing to OCM.

Considering the role these memory biases play in depression, it is important to consider (cost-) effective interventions to target them. CBM is a relatively new development in the field of psychological interventions and shows promising results in the treatment of anxiety (Cristea et al., 2018; Fodor et al., 2019) and addiction (Galdwin et al., 2016). However, there remains some ambiguity on the effects of CBM on depression, in which several meta-analysis have found contradicting results and the positive effects that were found were not significant and deemed more research to be necessary on both conceptual as well as clinical level (Cristea et al., 2018; Fodor et al., 2019, Koster & Hoorelbeke, 2015).

A type of CBM which considers both the negativity bias and OGM is positive memory training interventions. Positive memory training focuses on increasing the quality of positive memories to repair negative moods and acute sadness (Arditte Hall et al., 2017). Research has shown that there is an association between positive memory specificity and a reduces vulnerability for depression, meaning that increased memory specificity is associated with lower levels of depressive symptoms (Askelund et al., 2019). The results by Askelund et al. (2019) imply that the recollection of specific positive life events could be a resilience factor which aids in the reduction of depressive vulnerability. A study by Adritte Hall et al. (2017) investigated the effect of positive memory training for individuals suffering from a major depressive disorder, by training positive memory specificity to repair negative moods. The

training consisted of the recollection of both negative and positive autobiographical events based off of certain cues, however for the positive memories the researchers asked the participants detailed questions about the positive events in order to make them relive the memory as best as possible and the participants were asked to try and conjure up a vivid picture of the event. In the control condition for the study, participants were asked to recall a neutral events. Results showed that people in the experimental condition showed higher levels of positive memory specificity, however the sadness and happiness ratings between the groups did not differ in the end after the intervention. Another study by Steel et al. (2017) who studied the effects of positive memory training in depression, used similar methods, however their protocol consisted of 8 to 12 sessions of 1 hour with a therapist and focussed primarily on the recollection of positive memories and positive self-representation. They found that the group who received the positive memory training showed higher levels of reduced depressive symptoms in compared to the control group. Whilst both studies found support for increased positive memory specificity, only the latter found effects regarding the repair of negative mood. One possible explanation could be the duration of the intervention: several sessions as opposed to one session.

In the previous studies on the effect of CBM on depression, the role of rumination has not yet been sufficiently investigated. Not only is it important when considering its part in incapacitating part of the working memory, but also because rumination itself is a factor which has been generally shown to predict bad treatment outcome (Raes et al., 2006) and has transdiagnostic effects (Nolen-Hoeksema & Watkins, 2011).

Researchers at the Behavioural Science Institute (BSI) at the Radboud University have developed a CBM intervention in the form of a positive memory training app (Van Eindhoven, 2022). The form in which the intervention is presented would mean that it is something that could be easily incorporated into individuals their daily lives, as in today's society many people own and carry around a smartphone, thus potentially being widely and readily available and cost-effective.

The current study aims to investigate the link between rumination and the effectiveness of the positive memory training for positive mood change. Specifically, the mediation effects of the amount of registered positive memories. The first hypothesis is that there is a positive mood change as a result of the positive memory intervention, hereby

predicting higher scores for depressed mood before the intervention and lower scores for depressed mood after the intervention. The second hypothesis is that there is a negative association between rumination and mood, hereby predicting that a higher score for rumination is associated with a decreased positive mood change. The third hypothesis is that there is a negative association between rumination and the number of positive memories registered, hereby predicting that a higher score on rumination relates to less registered positive memories. Lastly, it is hypothesized that higher levels of rumination will lead to less registered positive memories, which in turn leads to a decreased mood change and thus, it is predicted that the number of registered positive memories mediates the relationship between rumination and mood change.

The goal of this study is to contribute to the growing body of literature on CBM as a successful intervention for depression, specifically on the use of positive memory training and to aid in the further development of a training that might be used in clinical populations.

Methods

Participants

This study was part of a larger study for which a total of 70 participants were recruited via a convenient sample. Recruitment took place on a voluntary basis via the online Radboud SONA system. Participants had to be students at the Radboud University. They needed to own an Android mobile device due compatibility with the created Memory Intervention App. However, for the current study there were a total of 35 participants who could be included, as they were part of the experimental group. A number of 5 participants were excluded from the data due to technical failure of the app and due to not (correctly) entering their SONA ID number for the post-measurements. Hence, the final data set included 30 participants (6 males, 24 females) between the ages of 17 and 30 ($M = 20.57$, $SD = 2.62$). Participants who had successfully completed the study were awarded 9 course credits as compensation. For this study to have 80% power to detect an effect of 10%, with a significance level of .05, 50 participants were required. The final sample did not meet these requirements.

Materials

Positive Mood Change was measured using the Depression, Anxiety and Stress Scale – 21 items (DASS-21; Lovibond & Lovibond, 1995). The DASS-21 is a self-report questionnaire to depict negative emotions. The questionnaire consists of 21 items (i.e., ‘I felt that life was meaningless’), that are rated using a 4-point Likert scale ranging from 0 (*Did not apply to me at all*) to (*Applied to me very much or most of the time*). The questionnaire has 3 scales: depressive, anxiety and stress symptoms, each containing 7 items. The symptoms are classified by severity, from ‘normal’ to ‘extremely severe’. The total score ranges from 0 to 56 and was computed by adding all the individual item scores together for the data analysis. There were no missing item scores. A study by Coker et al. (2018) on the reliability of DASS-21 showed to have excellent consistency (Cronbach’s alpha = .89), as well as the internal consistency, concurrent and convergent validities were found to be excellent.

Rumination was measured using the Ruminative Response Scale (RSS; Nolen-Hoeksema & Morrow, 1991). The RRS is a self-report questionnaire, which measures ruminative thoughts in response to depressed mood. It consists of 22 items (i.e., ‘Why can’t I handle things better?’), that are rated using a 4-point Likert scale ranging from 1 (*never*) to 4 (*always*). The total score can range from 22 to 88 and is computed by adding all the individual item scores together. The internal consistency was found to be good (Cronbach’s alpha = .90; Nolen-Hoeksema & Morrow, 1991), but also the convergent validity was rated as good (Özgür Erdur-Baker & Bugay, 2010).

Registered positive memories was measured by extracting the media files that were uploaded to the Memory Intervention App that was designed for this study (Van Eindhoven, 2022). They were quantified, so a total number of registered photos remains for each participant which will be used for the data analysis.

Procedure

As priorly stated, the current study (within-subject design, non-experiment) was part of a larger study (experimental design). The participant recruitment took place during 1.5 month and the participants partook in the study over a period of 1 week. Upon signing themselves up for the first timeslot, they immediately had to choose the timeslots for the follow-up, that way it was assured that they came back for the follow-up within the period of a week. Both the first meeting and the follow-up took place at the BSI lab of the Radboud

University. Upon the first meeting the participants were randomly assigned to either the experimental or control group.

During the first meeting, which took approximately 45 minutes, participants were welcomed by the researcher and led to an individual room with a computer for the debriefing to take place and to give informed consent. This was done prior to the official start of the experiment. Upon giving their informed consent, the researcher could begin the testing. The participants first filled out some general demographic information (such as age, gender, native language), their individual SONA ID, the DASS-21 and the RRS through an online form, depending on their native language this was either in Dutch or English. Both questionnaires were filled-out online using Qualtrics (Qualtrics, 2022), which is the online system the Radboud University uses for questionnaires. Both questionnaires, including the consent form, can be found in Appendix 1. Secondly, the participants also completed a Stroop task and a memory retrieval task, but these were not part of the current study and were incorporated as part of the larger study. Lastly, participants downloaded and paired the Memory Intervention App on their phones via a QR-code using the MovisensSX app. Depending on whether they were randomly assigned to the control group or experimental group they got different apps. For the experimental group they were required to fill out a mood rating on different moments during the day, based on random push notifications. They additionally had to take pictures throughout the day of moments that they experienced as pleasant or made them happy and reflect on them at the end of the day. The following consecutive five days, the participants had to use the app. At the fifth and final day of using the app, the participants received a special code at the first meeting that they had to enter, in order to save their results.

The follow-up meeting took place a week after and lasted approximately 45 minutes. Upon arriving at the BSI lab, the students were once again asked to complete the DASS-21 and RRS through an online questionnaire and they had to fill in their SONA ID, in order for the results to be paired to their pre-intervention measurements. As a part of the larger study, they again had to complete the Stroop task. After completion of the follow-up measurements, the participants were awarded their compensation.

Data analysis

To prepare the data, the different datafiles were merged and incomplete cases were excluded from the dataset. The incomplete cases included 4 cases where the participants did not enter their SONA ID number for the post-measurements and could therefore not be linked to their pre-measurement scores and 1 incomplete case was due to the participant having technical problems for the app and quit the study prematurely. The quantity of photos that were uploaded in the app by each participant were computed and added to the dataset to account for the predictor variable *Registered positive memories*. Then the RSS pre-measurements were calculated in order to create a baseline score for rumination on the first day. Additionally, the DASS-21 pre- and post-measurements total scores were first calculated and in turn used to compute a difference score by subtracting the post-measurement from the pre-measurement, which accounts for the variable *Positive mood change*. Ultimately, several statistical analyses were conducted. Firstly, a correlation analysis (Pearson correlation coefficient) was conducted for the following three variables (Rumination, Positive Memories and Positive Mood Change) using IBM SPSS Statistics (Version 29) (IBM corp., 2022). Secondly, a paired-sample t-test was conducted to compare depressed mood before and after the intervention, again using IBM SPSS Statistics (Version 29) (IBM corp., 2022).

Lastly, a regression and mediation analysis using the PROCESS macro in SPSS was performed created by Hayes (2013). The following design was used: The outcome variable was positive mood change (quantitative: 0-56), the predictor was the baseline score for rumination on the first day (quantitative: range 22-88), and the mediator variable was the amount of registered positive photo memories (quantitative: range 0-∞).

Results

The descriptive statistics, mean scores, SDs, minimum and maximum scores for each of the variables (i.e. Registered positive memories, Depressed Mood pre- and post-test, Mood change and Rumination) are presented in Table 1. Notably, the data seems to be more spread out regarding the mood measurements, with large differences between students.

The Pearson correlations of three variables (Rumination, Positive Memories and Positive Mood Change) are presented in Table 2. Rumination was not significantly correlated with Registered Positive Memories and Positive Mood change. Likewise, no significant correlation was found between Registered Positive Memories and Positive Mood Change.

A paired-samples t-test was conducted to compare depressed mood before and after the intervention. Contrary to expectations, there was no significant difference in depressed mood before and after the intervention, $t(29) = 1.380, p = 0.178$. The effect size was small (*Cohen's d* = 0.252).

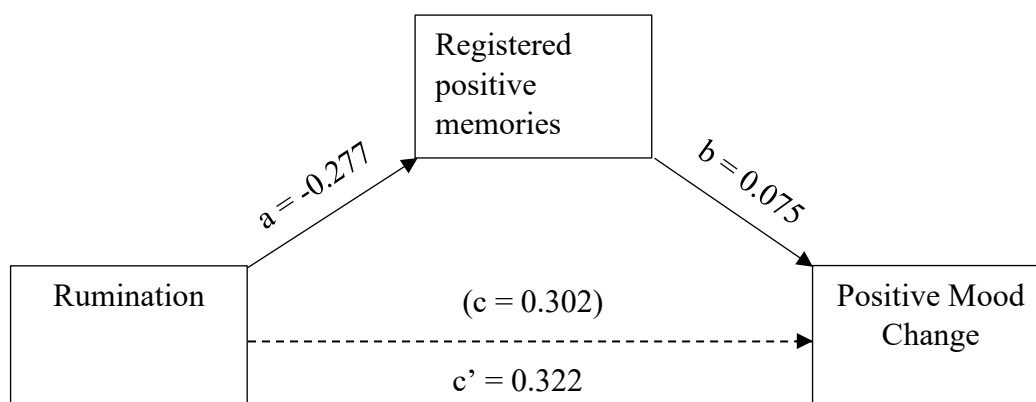
The current study assessed the mediating role of the amount of Registered positive memories on the relationship between Rumination and Positive Mood Change. Contrary to expectations, no significant results were found. The mediation model is presented in Figure 1. The results showed a nonsignificant negative effect for the a-path between Rumination of Registered Positive Memories ($b = -0.277, SE = 0.181, p = .136$). For the b-path between the amount of Registered Positive Memories and Positive Mood Change a nonsignificant result was also found ($b = 0.075, SE = 0.37, p = .842$). Furthermore, the results did not reveal a significant indirect effect of the impact of Rumination on Positive Mood Change ($b = -0.020, BootSE = 0.106, 95\% CI [-.274 to .161]$). Additionally, the direct effect of Rumination on Positive Mood Change was also found to be statistically nonsignificant ($b = 0.332, SE = 0.368, p = .390$). Lastly, the total effect of Rumination on Positive Mood Change was found to be statistically nonsignificant ($b = .302, SE = .348, p = .393$).

Table 1. Descriptive Statistics of five measured variables (N= 30)

	Minimum	Maximum	Mean	Std. Deviation
Registered Positive Memories	2	21	9.83	4.379
Depressed mood pre-test	24	74	37.97	10.733
Depressed mood post-test	26	66	35.90	9.935
Positive Mood Change	-12	32	2.07	8.204
Rumination	13	28	21.87	4.400

Table 2. *Correlations between three measured variables (N = 30)*

		1	2	3
1. Rumination	Pearson Correlation	-	-0.279	0.162
	Sig. (two-tailed)		0.136	0.393
2. Registered Positive Memories	Pearson Correlation		-	-0.008
	Sig. (two-tailed)			0.965
3. Positive Mood Change	Pearson Correlation			-
	Sig. (two-tailed)			

Figure 1. *Mediation Model*

Simple mediation model for rumination and positive mood change via registered positive memories.

Discussion

The present study investigated the relation between rumination and the effectiveness of positive memory training on positive mood change. Furthermore, the mediation effects of the amount of registered positive memories were explored. In previous studies on the effect of CBM on depression, the role of rumination has not yet been sufficiently investigated, even though it has been generally shown to predict bad treatment outcome (Raes et al., 2006). The results indicated no effects of the positive memory intervention on positive mood change and neither did it show a relation between rumination and registered positive memories or between rumination and positive mood change, nor was there any indication of a mediation effect of registered positive memories on the latter relation.

Thus, the results contradict the hypothesis that there would be a positive mood change as a result of the positive memory intervention. The positive memory intervention held no relation to a positive mood change before and after the use of the app. The results do not seem to align with the study by Steel et al. (2017), which found that the group who received positive memory training showed higher levels of reduced depressed symptoms compared to the control group. However, they do seem to align with the findings by Arditte Hall et al. (2017), who found no difference happiness and sadness ratings for both the group that received the positive memory intervention and those who did not. Considering the findings of the present study and the abovementioned literature, a possible explanation could be the duration of the intervention. Participants in the present study only used the intervention app for five consecutive days and in the study by Steel et al. (2017) the intervention took place over a period of 8 to 12 sessions of 1 hour each. It could be possible that in order for the intervention to take effect on depressed mood, the duration of the intervention needs to be increased. It has been shown that a positive memory intervention of one week can successfully change the OGM bias and increase memory specificity, however it is not enough time to change negative moods (Arditte Hall et al., 2017).

Another explanation could be that the conceptualisation of the depressed mood variable was not specific enough. The DASS-21 was used, however these consist mood ratings for depression as well as anxiety and stress, therefore having a total score of combined negative moods. It could be possible that the usage of another measuring instrument only used for depression would give a different and more reliable outcome for positive mood change in depression by only looking at the decrease in depressive symptoms. This could be done by either only incorporating the DASS-21 depression subscale items or by using questionnaires such as the Beck Depression Inventory 2 (BDI-2; Beck et al., 1996) or the Inventory of Depressive Symptomatology – Self Rated (IDS-SR; Rush et al., 1996).

Secondly, the hypothesis that there would be a negative association between rumination and mood, was rejected. The results did not indicate that a higher score for rumination was associated with a decreased positive mood change. The hypothesis was based on the fact that rumination has been found to predict bad treatment outcome (Raes et al., 2006) and has transdiagnostic effects (Nolen-Hoeksema & Watkins, 2011). The relation was not significant and it also was not in the expected direction. While this is in contrast with the

hypothesis, it could possibly indicate a positive outcome for the memory intervention app, meaning that that with a larger sample size the intervention could help people suffering from ruminative thoughts with their depressed mood, without the rumination being an implication itself. On the other side, however, it could also indicate that with a larger sample size the association could become towards negative, which would be in line with research by Raes et al., 2006).

Thirdly, it was hypothesised that there would be a negative association between rumination and the number of positive memories registered. Although the results showed that higher levels of rumination seemed to go together with lower numbers of registered positive memories, the association was not significant and therefore the hypothesis is rejected.

Even though the association was not significant, this could be the basis to further exploration in research. A possible explanation might be due to the tendency to overthink that is linked to rumination (Watkins & Roberts, 2020; Xie, 2022). The positive memory intervention requires participants to take pictures throughout the day of things, moments or situations that bring them joy and have a positive meaning as they occur. It could be that due to their tendency to overthink, that they experience increasing trouble with the assessment of the situation itself. This could be heavily influenced by the negative interpretation bias that seems to be rather prevalent in rumination (Mor et al., 2014), which could in turn result in the situation being interpreted more negatively and therefore not registered at all.

Lastly, it was expected that the number of registered positive memories mediates the relationship between rumination and mood change. However, contrary to expectations, no mediation effect was found for registered positive memories. A possible explanation could be that registered positive memories was not correctly operationalised. For the purpose of the study, only the number of registered memories were regarded and this was done by looking at the number of jpeg documents that were uploaded per participant. At the moment, we have no information about the nature of the photos. Therefore, it is not known whether they followed the instructions of the app and if the registered memories were meaningful or valenced. It would be better to have more knowledge on this matter, however due to privacy reasons it was not allowed to view the contents of the photos. This could also be considered as a possible limitation of the present study. Additionally, it could be that there was another mediator at present.

Taken together the abovementioned limitation and the consideration of another mediator, it could be interesting to further explore the specificity of the registered memory as a mediator, as research has shown that the increased specificity of memory plays an important role in overcoming the OGB bias (Arditte Hall et al., 2017) as well as mood outcome (Steel et al, 2017) in CBM. A way to overcome this limitation could be that instead of asking the participants to take a moment to reflect on the pictures they have taken at the end of the day, they could be asked to write their reflection down.

It is important to acknowledge that the study did not have enough power, as a result of sample size that was too small. Thus, a larger sample size is needed to be able to find significance effects. Furthermore, the present study only included healthy to moderately depressed participants, while the previously discussed literature that found results were conducted within a clinical sample (Arditte Hall et al. 2017; Steel et al, 2017).

It could be that in the non-clinical sample, the participants might not have had the cognitive memory biases that are present in depressed individuals and therefore could not be changed by the targeted intervention. Another explanation regarding the non-clinical sample could be due to ceiling effects, meaning that everyone was already relatively happy and therefore there was little room to improve their mood.

Finally, recommendations for future research are to examine additional mediating factors that could affect the positive mood outcome when using the positive memory app. Possible mediators that could be interesting to explore are brooding and self-reflection abilities, as a study by Yansong et al. (2020) has shown these factors to be positively correlated with depression as well as rumination and OGM. Another interesting mediator would be the specificity of the memory, which was already discussed above. Furthermore, future research could explore the possibilities of an experimental study design. The current research design was non-experimental, in which they would add a control groups in which they would receive an intervention focussed on neutral event registration and one where they receive no form of intervention, as could be seen in both studies by Arditte Hall et al. (2017 and Steel et al. (2017). Furthermore, future research on the positive memory training app could consider expanding their research to a clinical sample.

In conclusion, although the results did not indicate that registered positive memories mediated the relation between rumination and positive mood change, the present study did

contribute to the growing body of literature on CBM as an intervention for depression and provided some insight in the role of rumination in positive mood outcome. Additionally, the present study has contributed to the further development and exploration of the positive memory intervention app that was created by researchers at the Radboud University BSI lab (Van Eindhoven, 2022). It is hoped that perhaps it could eventually aid to open the way for further modernising the concept of CBM in clinical practice and creating an intervention for depression that is cost-effective and readily available to many.

References

- Arditte Hall, K. A., De Raedt, R., Timpano, K. R., & Joormann, J. (2018). Positive memory enhancement training for individuals with major depressive disorder. *Cognitive Behaviour Therapy, 47*(2), 155-168. <https://doi.org/10.1080/16506073.2017.1364291>
- Askelund, A. D., Schweizer, S., Goodyer, I. M., & Van Harmelen, A. (2019). Positive memory specificity is associated with reduced vulnerability to depression. *Nature Human Behaviour, 3*(3), 265-273. <https://doi.org/10.1038/s41562-018-0504-3>
- Beck, A. T., Brown, G. K., & Steer, R. A. (1996). *Beck Depression Inventory-II (BDI-II): Technical manual*. Pearson.
- Coker, A., Coker, O., & Sanni, D. (2018). Psychometric properties of the 21-item depression anxiety stress scale (DASS-21). *African Research Review, 12*(2), 135. <https://doi.org/10.4314/afrrrev.v12i2.13>
- Cowan, N. (2008). Chapter 20 what are the differences between long-term, short-term, and working memory? *Progress in Brain Research, 169*, 323-338. [https://doi.org/10.1016/s0079-6123\(07\)00020-9](https://doi.org/10.1016/s0079-6123(07)00020-9)
- Cristea, I. A., Kok, R. N., & Cuijpers, P. (2018). Efficacy of cognitive bias modification interventions in anxiety and depression: Meta-analysis. *British Journal of Psychiatry, 206*(1), 7-16. <https://doi.org/10.1192/bjp.bp.114.146761>
- Erdur-Baker, Ö., & Bugay, A. (2010). The short version of ruminative response scale: Reliability, validity and its relation to psychological symptoms. *Procedia - Social and Behavioral Sciences, 5*, 2178-2181. <https://doi.org/10.1016/j.sbspro.2010.07.433>
- Evans, J. S., & Stanovich, K. E. (2013). Dual-process theories of higher cognition. *Perspectives on Psychological Science, 8*(3), 223-241. <https://doi.org/10.1177/1745691612460685>
- Fodor, L. A., Georgescu, R., Cuijpers, P., Szamoskozi, S., David, D., Furukawa, T. A., & Cristea, I. A. (2019). The effectiveness of cognitive bias modification interventions in anxiety and depressive disorders: A network meta-analysis. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3506199>
- Gladwin, T. E., Wiers, C. E., & Wiers, R. W. (2016). Cognitive neuroscience of cognitive retraining for addiction medicine. *Progress in Brain Research, 323*-344. <https://doi.org/10.1016/bs.pbr.2015.07.021>

- Gotlib, I. H., & Joormann, J. (2010). Cognition and depression: Current status and future directions. *Annual Review of Clinical Psychology*, 6(1), 285-312. <https://doi.org/10.1146/annurev.clinpsy.121208.131305>
- Haselton, M. G., Nettle, D., & Murray, D. R. (2015). The evolution of cognitive bias. *The handbook of evolutionary psychology*, 1-20.
- Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. Guilford Publications.
- IBM Corp. (2022). IBM SPSS Statistics for Windows (Version 29.0). IBM Corp.
- Jones, E. B., & Sharpe, L. (2017). Cognitive bias modification: A review of meta-analyses. *Journal of Affective Disorders*, 223, 175-183. <https://doi.org/10.1016/j.jad.2017.07.034>
- Koster, E. H. W., & K. Hoorelbeke. (2015). Cognitive bias modification for depression. *Current opinion in psychology*, 4, 119-123. <https://doi.org/10.1016/j.copsyc.2014.11.012>
- Lovibond, S.H. & Lovibond, P.F. (1995). *Manual for the Depression Anxiety & Stress Scales*. (2nd Ed.) Sydney: Psychology Foundation.
- Liu, Y., Yu, X., Yang, B., Zhang, F., Zou, W., Na, A., Zhao, X., & Yin, G. (2017). Rumination mediates the relationship between overgeneral autobiographical memory and depression in patients with major depressive disorder. *BMC Psychiatry*, 17(1). <https://doi.org/10.1186/s12888-017-1264-8>
- MacLeod, C., & Mathews, A. (2012). Cognitive bias modification approaches to anxiety. *Annual review of clinical psychology*, 8, 189-217.
- Mor, N., Hertel, P., Ngo, T. A., Shachar, T., & Redak, S. (2014). Interpretation bias characterizes trait rumination. *Journal of Behavior Therapy and Experimental Psychiatry*, 45(1), 67-73. <https://doi.org/10.1016/j.jbtep.2013.08.002>
- Nolen-Hoeksema, S., & Watkins, E. R. (2011). A heuristic for developing transdiagnostic models of psychopathology. *Perspectives on Psychological Science*, 6(6), 589-609. <https://doi.org/10.1177/1745691611419672>
- Raes, F., Hermans, D., Williams, J. M. G., Beyers, W., Eelen, P., & Brunfaut, E. (2006). Reduced autobiographical memory specificity and rumination in predicting the course

- of depression. *Journal of Abnormal Psychology*, *115*(4), 699–704. <https://doi.org/10.1037/0021-843X.115.4.699>
- Rinck, M., & Becker, E. S. (2005). A comparison of attentional biases and memory biases in women with social phobia and major depression. *Journal of Abnormal Psychology*, *114*(1), 62-74. <https://doi.org/10.1037/0021-843x.114.1.62>
- Rush, A. J., Gullion, C. M., Basco, M. R., Jarrett, R. B., & Trivedi, M. H. (1996). The Inventory of Depressive Symptomatology (IDS): Psychometric properties. *Psychological Medicine*, *26*(3), 477–486. <https://doi.org/10.1017/S0033291700035558>
- Qualtrics (Version 2020) [Computer software]. Provo, Utah: Qualtrics. Available at <https://www.qualtrics.com/>
- Van Eindhoven, C. (2022). Participants' evaluation of a new positive memory training app – a qualitative study. Unpublished master thesis.
- Watkins, E. R., & Roberts, H. (2020). Reflecting on rumination: Consequences, causes, mechanisms and treatment of rumination. *Behaviour Research and Therapy*, *127*, 103573. <https://doi.org/10.1016/j.brat.2020.103573>
- Williams, J. M., Barnhofer, T., Crane, C., Herman, D., Raes, F., Watkins, E., & Dalgleish, T. (2007). Autobiographical memory specificity and emotional disorder. *Psychological Bulletin*, *133*(1), 122-148. <https://doi.org/10.1037/0033-2909.133.1.122>
- Wittekind, C. E., Terfehr, K., Otte, C., Jelinek, L., Hinkelmann, K., & Moritz, S. (2014). Mood-congruent memory in depression – The influence of personal relevance and emotional context. *Psychiatry Research*, *215*(3), 606-613. <https://doi.org/10.1016/j.psychres.2013.11.027>
- World Health Organisation (WHO). (2021, September 13). *Depression*. <https://www.who.int/news-room/fact-sheets/detail/depression>
- Xie, Y., Kong, Y., Yang, J., & Chen, F. (2019). Perfectionism, worry, rumination, and distress: A meta-analysis of the evidence for the perfectionism cognition theory. *Personality and Individual Differences*, *139*, 301-312. <https://doi.org/10.1016/j.paid.2018.11.028>

Appendix 1: Questionnaire of the study

Block 1

Radboud Universiteit



Information Letter for participating in scientific research: Memory in daily life (MEM app)

1a. Introduction/Aim of the research

The Behavioural Science Institute (BSI) of Radboud University, together with the Radboudumc, is conducting scientific research on memory and mood using a newly developed application for mobile phones. For five days, the app will request you to take a picture when something pleasant happens, and every evening, it will use the pictures to remind you of the pleasant events of the day. Because the app is still new, we will ask you to evaluate it at the end of the study. We hope that your feedback will help us to improve the app before it is used regularly.

1b. The research

The study will consist of three parts.

1. First appointment: This meeting takes place in the BSI lab, if the COVID regulations allow. If not, we will meet online. We will explain in detail what the study will look like, you will fill in some questionnaires that measure stress, anxiety, depression, and rumination, and you will complete two short computer tasks. For the purposes of the study a part of the meeting will be recorded. Then we will show you the mobile phone application and we will practice its use with you. You can download the app on your own cell phone (if it works with Android), or we will give you a phone, whatever you prefer. This appointment will take about 45 minutes.

2. At home: This part of the study starts on the day after the appointment, and it lasts for five consecutive days. You can do this part of the study at home, and you do not need to change your activities or rhythm during the study. The app will ask you to record at least three positive events every day. For each event, you will be asked to type in a short description of the positive event and take a picture of a neutral object that was present during the event. Every evening, the app will ask you to recall the positive events of the day. The event descriptions and pictures will not be seen by anybody else; only you will know them. The app will also ask you to rate your mood in the morning, as well as before and after the recall task in the evening. The app will be used for five days, and it will not disturb you at night. If you have any questions during this week, you can always contact us.

3. Second appointment: We will meet at the BSI lab (or online) once more. This appointment will last about 45 minutes. During this appointment, we will ask you to complete a few more questionnaires, and to do a few short computer tasks. A part of the meeting will be recorded for the purposes of the study.

This study has been reviewed independently by the Ethics Committee Social Sciences (ECSS) of Radboud University, and there is no formal objection to this study.

2a. Use of your personal data

For this research, it is necessary to collect anonymous personal data. The personal data will include your answers to the questionnaires, your mood ratings, and your reaction times in the computer tasks. The

26/01/2023, 11:41

Qualtrics Survey Software

collection of these data is necessary to determine the effects of using the app, and to evaluate its usefulness.

2b. Confidentiality of your data and data processing

The personal data collected for this study will be processed completely anonymously. It will not be possible to connect them to you as a person. We will know that the different personal data came from the same person, but not who that person was. Only the researchers involved in this project will have access to the data. The information you provide for the study will be treated with the utmost care and will be accessible to authorized staff only. In order to ensure your privacy, only anonymized research data will be used in reports and publications regarding the research.

2c. Retention period of your data

Research data must be kept for up to 15 years after the conclusion of the study. We keep these data in a secure place and they cannot be linked to you as a person. After this period, the research data will be destroyed. Only the researchers of this study will have access to the data. The consent form signed by you will be kept for 10 years upon completion of the research.

2d. Sharing of your data

Due to the importance of control, reuse and replication of research results, research data (including any anonymous personal data) are increasingly shared with or made available to other researchers. Your anonymized data will also be used in this form of sharing when it is requested. As in the original data, no one can connect these data to you as a person.

2e. Right of access by supervisory authorities to inspect the research's compliance with ruling guidelines

Some persons and organizations must have access to the research data. This is necessary in order to test whether the research has been carried out properly and reliably. These persons and supervisory authorities inspecting your data for verification include authorized persons within the Behavioral Science Institute or Radboud University (e.g., a dean, director or data officer) and (inter)national supervisory authorities (e.g., the Dutch Data Protection Authority and the Netherlands Board on Research Integrity). They are inspecting the anonymized data on a strictly confidential basis, and they will not be able to connect the data to you as a person.

2f. Additional information on your rights regarding the processing of your personal data

Radboud University is responsible for compliance with the General Data Protection Regulation (GDPR) when processing your personal data. The researcher ensures that your privacy and the conditions attached to it are safeguarded and they adhere to the Dutch code of conduct for scientific integrity and university policy regarding the storage and management of personal and research data when conducting this research. You have the right to withdraw your consent for the processing of your personal data at any time before they are anonymized. Your personal data will then be deleted. You can find the Radboud University Privacy Statement at: <https://www.ru.nl/english/vaste-onderdelen/privacy-statement-radboud-university/>. If you have any questions about your privacy, please contact the Privacy Officer Faculty of Social Sciences (P.Janssen@socsci.ru.nl). For general questions, please contact the office of the Data Protection Officer of Radboud University via privacy@ru.nl. More information about your rights in the processing of your personal data can be found at <https://www.ru.nl/privacy/english/protection-personal-data/data-subjects-rights/> and on the website of the Dutch Data Protection Authority (<https://autoriteitpersoonsgegevens.nl/en>).

3. Findings that may be of personal clinical interest

The research data of this study will not be viewed from a medical and/or clinical perspective. Therefore, your participation in the study cannot be considered a medical/clinical test. Since the current study is completely anonymous, any scores that are worrying and/or that may be of personal clinical significance cannot be related back to you. If you are concerned about your health as a result of the questions, we advise you to contact your general practitioner.

26/01/2023, 11:41

Qualtrics Survey Software

collection of these data is necessary to determine the effects of using the app, and to evaluate its usefulness.

2b. Confidentiality of your data and data processing

The personal data collected for this study will be processed completely anonymously. It will not be possible to connect them to you as a person. We will know that the different personal data came from the same person, but not who that person was. Only the researchers involved in this project will have access to the data. The information you provide for the study will be treated with the utmost care and will be accessible to authorized staff only. In order to ensure your privacy, only anonymized research data will be used in reports and publications regarding the research.

2c. Retention period of your data

Research data must be kept for up to 15 years after the conclusion of the study. We keep these data in a secure place and they cannot be linked to you as a person. After this period, the research data will be destroyed. Only the researchers of this study will have access to the data. The consent form signed by you will be kept for 10 years upon completion of the research.

2d. Sharing of your data

Due to the importance of control, reuse and replication of research results, research data (including any anonymous personal data) are increasingly shared with or made available to other researchers. Your anonymized data will also be used in this form of sharing when it is requested. As in the original data, no one can connect these data to you as a person.

2e. Right of access by supervisory authorities to inspect the research's compliance with ruling guidelines

Some persons and organizations must have access to the research data. This is necessary in order to test whether the research has been carried out properly and reliably. These persons and supervisory authorities inspecting your data for verification include authorized persons within the Behavioral Science Institute or Radboud University (e.g., a dean, director or data officer) and (inter)national supervisory authorities (e.g., the Dutch Data Protection Authority and the Netherlands Board on Research Integrity). They are inspecting the anonymized data on a strictly confidential basis, and they will not be able to connect the data to you as a person.

2f. Additional information on your rights regarding the processing of your personal data

Radboud University is responsible for compliance with the General Data Protection Regulation (GDPR) when processing your personal data. The researcher ensures that your privacy and the conditions attached to it are safeguarded and they adhere to the Dutch code of conduct for scientific integrity and university policy regarding the storage and management of personal and research data when conducting this research. You have the right to withdraw your consent for the processing of your personal data at any time before they are anonymized. Your personal data will then be deleted. You can find the Radboud University Privacy Statement at: <https://www.ru.nl/english/vaste-onderdelen/privacy-statement-radboud-university/>. If you have any questions about your privacy, please contact the Privacy Officer Faculty of Social Sciences (P.Janssen@socsci.ru.nl). For general questions, please contact the office of the Data Protection Officer of Radboud University via privacy@ru.nl. More information about your rights in the processing of your personal data can be found at <https://www.ru.nl/privacy/english/protection-personal-data/data-subjects-rights/> and on the website of the Dutch Data Protection Authority (<https://autoriteitpersoonsgegevens.nl/en>).

3. Findings that may be of personal clinical interest

The research data of this study will not be viewed from a medical and/or clinical perspective. Therefore, your participation in the study cannot be considered a medical/clinical test. Since the current study is completely anonymous, any scores that are worrying and/or that may be of personal clinical significance cannot be related back to you. If you are concerned about your health as a result of the questions, we advise you to contact your general practitioner.

26/01/2023, 11:41

Qualtrics Survey Software

4. Voluntary participation

Your participation in this study is entirely voluntary. If you decide not to participate, there will be no consequences, and you don't have to explain why. If, during the course of the research, you wish to withdraw your consent and terminate your participation, you have every right to do so at all times. Again, there will be no adverse consequences for you.

5. Compensation or remuneration

Participation in this study requires a time commitment of approximately 9 hours distributed over one week. Most of the study will be done at home in your own environment. You will receive 9 SONA credit points for your participation.

6. Contact Information

If you have any questions, please contact Prof. Eni Becker (tel.: 024-36-12665, email eni.becker@ru.nl).

We sincerely hope that you would like to participate!

Kind regards,

Prof. Eni Becker

Radboud Universiteit

**Block 2**

Radboud Universiteit



Consent Form for participating in scientific research:

Memory in daily life (MEM app)

I herewith confirm that:

- I have been satisfactorily informed about the study.
- I have read the written information letter.
- I have been given the opportunity to ask questions about the study.
- my questions have been answered satisfactorily.
- I have been given ample opportunity to think carefully about participating in the study.
- I participate in the study entirely on a voluntary basis.

I understand that:

- I have the right to withdraw my consent at any time without having to state reasons and without fear of adverse consequences.
- my information will be processed anonymously.
- I will not and cannot be informed about my individual results because the data are anonymous.
- my personal data are processed in accordance with the applicable European privacy regulations and in accordance with the privacy statement of Radboud University (<https://www.ru.nl/english/vaste-onderdelen/privacy-statement-radboud-university/>).
- my personal data are processed in accordance with the applicable European privacy regulations.
- if the questionnaires cause worry in me, I should speak to my General Practitioner.
- the tests and questionnaires used are not

26/01/2023, 11:41

Qualtrics Survey Software

medical/clinical tests.

I agree that:

- my research data will be obtained for scientific purposes and will be available for verification, reuse and replication for 15 years;
- the signed consent form with my personal data is kept for 10 years;
- supervisory authorities may inspect my research data for the purpose of auditing the research.

Block 6

I agree to participate in the study

- Yes, I agree**
- No**

Block 6

Please type your unique code (SONA code)

26/01/2023, 11:41

Qualtrics Survey Software

Demographics

What is your gender

- Male**
- Female**
- Non-binary / third gender**
- Prefer not to say**

What is your age

What is your native language

What is your level of proficiency in English?

- poor**

26/01/2023, 11:41

Qualtrics Survey Software

- intermediate**
- advanced**
- near native**

Block 3

People think and do many different things when they feel depressed. Please read each of the items below and indicate whether you almost never, sometimes, often, or almost always think or do each one when you feel down, sad, or depressed. Please indicate what you generally do, not what you think you should do.

1 = almost never 2 = sometimes 3 = often 4 = almost always

	1= almost never	2= sometimes	3= often	4= almost always
think "What am I doing to deserve this?"	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
analyze recent events to try to understand why you are depressed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
think "Why do I always react this way?"	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

26/01/2023, 11:41

Qualtrics Survey Software

	1= almost never	2= sometimes	3= often	4= almost always
go away by yourself and think about why you feel this way	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
write down what you are thinking about and analyze it	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
think about a recent situation, wishing it had gone better	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
think "Why do I have problems other people don't have?"	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
think "Why can't I handle things better?"	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
analyze your personality to try to understand why you are depressed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
go someplace alone to think about your feelings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

DASS-21

Please read each statement and circle a number 0, 1, 2, or 3 which indicates how much the statement applied to you **over the past week**. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:

0: Did not apply to me at all

1: Applied to me to some degree, or some of the time

2: Applied to me to a considerable degree or a good part of time

3: Applied to me very much or most of the time

	0= did not apply to me at all	1= applied to me to some degree, or some of the time	2= applied to me to a considerable degree or a good part of time	3= applied to me very much or most of the time
I found it hard to wind down	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was aware of dryness of my mouth	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I couldn't seem to experience any positive feeling at all	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

26/01/2023, 11:41

Qualtrics Survey Software

	0= did not apply to me at all	1= applied to me to some degree, or some of the time	2= applied to me to a considerable degree or a good part of time	3= applied to me very much or most of the time
I experienced breathing difficulty (e.g. excessively rapid breathing, breathlessness in the absence of physical exertion)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found it difficult to work up the initiative to do things	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I tended to over-react to situations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I experienced trembling (e.g. in the hands)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt that I was using a lot of nervous energy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was worried about situations in which I might panic and make a fool of myself	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt that I had nothing to look forward to	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

26/01/2023, 11:41

Qualtrics Survey Software

	0= did not apply to me at all	1= applied to me to some degree, or some of the time	2= applied to me to a considerable degree or a good part of time	3= applied to me very much or most of the time
I found myself getting agitated	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found it difficult to relax	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt down- hearted and blue	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was intolerant of anything that kept me from getting on with what I was doing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt I was close to panic	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was unable to become enthusiastic about anything	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt I wasn't worth much as a person	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt that I was rather touchy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	0= did not apply to me at all	1= applied to me to some degree, or some of the time	2= applied to me to a considerable degree or a good part of time	3= applied to me very much or most of the time
I was aware of the action of my heart in absence of physical exertion (e.g. sense of heart rate increase, heart missing a beat)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt scared without any good reason	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt that life was meaningless	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>