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Memory bias training by means of the emotional short-term memory task

Abstract: *According to major cognitive theories of emotional disorders cognitive biases are partly responsible for their onset and maintenance. The direct test of this assumption is possible only if experimental method capable of altering a given form of cognitive bias is available. The purpose of the study was to examine the effectiveness of a novel implicit memory bias training procedure based on the emotional version of the classical Sternberg's short-term memory task with negative, neutral and positive words. 108 participants, who completed the PANAS and the CES-D questionnaires, were randomly assigned to the control group (n = 33), the No-Negative group (n = 36), in which the target words in the Sternberg's task were either positive or neutral but never negative or the Negative-New group (n = 39) in which the negative target words in the modified Sternberg's task were always new. This training was followed by the recollection stage. Only one of the training protocols resulted in significant effects at the recall stage - individuals in the No-Negative group recalled more positive words and fewer negative words than those in the control group. These results show that it may be possible to experimentally induce memory bias characteristic of non-depressed individuals.*
Key words: *memory bias, mood congruent memory, depression, cognitive bias modification*

According to major cognitive theories of depression and affective disorders, memory bias is a risk factor responsible for the onset and maintenance of these disorders (Clark, Beck, 1999; Mathews & MacLeod, 1994; Williams, Watts, MacLeod & Mathews, 1997; Blaut, Paulewicz, 2011). In fact a specific form of memory bias, namely mood congruent memory (MCM) is considered a robust phenomenon in depression. The MCM effect manifests itself in the subclinically depressed as the lack of the improved recall of positive versus negative information characteristic of the non-depressed individuals. In the clinically depressed MCM takes the form of better memory for the negative than for the positive information (Matt, Vázquez, & Campbell, 1992; Kircanski, Joormann, & Gotlib, 2012; Gotlib & Joormann, 2010).

The pivotal study by MacLeod, Rutherford, Campbell, Ebsworthy & Holker (2002) gave rise to the emergence of a group of methods collectively referred to as Cognitive Bias Modification (CBM, see MacLeod 2012, for a review). These methods use experimental procedures of cognitive psychology in order to change the direction or intensity of a given form of cognitive bias. It has been established that the attentional (e.g., tendency to attend to threatening stimuli) and the interpretive (e.g., tendency to interpret ambiguous information in a negative way) cognitive biases can be experimentally altered and that such changes can lead to nontrivial, persistent therapeutic effects (Hakamata et al., 2010; Beard, Sawyer, & Hofmann, 2012; Hallion & Ruscio, 2011; Kłosowska, Kłosowska, Blaut & Paulewicz, 2015). A good illustration of how CBM works is attentional bias modification with a modified dot-probe task. We will describe this method here because our novel method of memory bias training is based on the same underlying logic.

The dot-probe task (MacLeod, Matthews & Tata, 1986) consists of a series of trials during which emotional

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and neutral cues simultaneously presented one above the other are replaced by an abstract target stimulus (a probe) appearing in place of the preceding emotional (congruent position) or neutral (incongruent position) stimulus. Directing attention towards a given stimulus class results in differences in an average reaction time for congruent and incongruent trials – an attentional bias effect. If, however, congruent position probability is significantly lower than .5, it is beneficial for task performance to direct attention away from emotional or towards neutral stimuli. It has been repeatedly shown that participants engaging in this latter training version of the dot-probe task learn to direct their attention in accordance with the imposed contingency (MacLeod, 2012).

So far the most promising results in terms of the therapeutic effects were obtained in the case of attentional and interpretative bias training in anxious individuals, whereas the results of cognitive bias training in depressed individuals proved far less impressive (Hallion & Ruscio, 2011; Mogoaşe, David, & Koster, 2014). According to some authors (e.g., Williams, Watts, MacLeod & Mathews, 1988) depression seems to be related to a greater extent to memory bias than to attentional bias, however, so far there have been no published attempts at using implicit methods of memory bias training that we are aware of.

To the best of our knowledge those few published examples of memory bias training involved explicit training (e.g., Joormann, Hertel, LeMoult, & Gotlib, 2009) i.e., in these studies participants were informed about the purpose of training. This brings about the possibility that by knowing the objective of a test its participants will simulate the changes expected by the researcher. Also, unless automatization occurs, the participants will use thus acquired strategy only when they remember to do so, and when they have enough resources, therefore the training effect may not become sufficiently generalized. However, as we will explain shortly, by using an analogical rationale to the one present in the design of typical attentional bias training tasks, a method of memory bias training that avoids the aforementioned pitfalls of explicit methods can be created.

The proposed memory bias training task was designed to satisfy several important requirements. It can be safely assumed that the CBM methods, being typically based on some form of associative learning, require a substantial number of trials. This implies that the memory bias training task cannot directly operate at the level of long term memory because conducting a series of trials with long retention intervals would in that case be too time-consuming. For the same reason it is essential that the encoding and the recall/recognition stages also be short.

The proposed method of memory bias training fulfilling these criteria is a modification of the classical Sternberg's short term memory task (Sternberg, 1969). At each trial of the classical version of this task a small stimulus set is presented sequentially on the screen. Shortly after, a test stimulus appears which is either ("an old stimulus") or is not ("a new stimulus") previously presented in the set. The main purpose of this study was to test if a modified version of this task could induce what we refer to as the target memory bias, i.e., a better memory for the positive than the negative words. In order to implement the rationale of the dot-probe attentional bias training procedure in the Sternberg's task the procedure has to be modified in a way that makes the target memory bias essential to the task performance. This means that the task should be easier for the participants in the training group, as compared to the control group, if and only if the target encoding, retention or recollection rule is used. Just as an improvement in the training version of the dot-probe task is possible if and only if the participants guide their attention based on the emotional valence of the cues which in most of the studies means directing attention away from negative information.

In our opinion it is not a correct approach to change the proportion of negative, neutral or positive words in memory sets. If there were more of the positive than negative and neutral words introduced in the memory set, the target memory bias would be beneficial to task performance. However, in order to exploit the fact that there are more positive words in the memory set it is not necessary to treat differently the positive words as such. Investing more resources in encoding or retention of those kinds of words that are more abundant in the memory set - regardless of their valence - would be sufficient. In other words, changing the proportion of negative or positive words in the memory set makes the target memory bias sufficient but not necessary for the improvement in the task performance. That is why we decided that every memory set in the modified Sternberg's task would contain an equal number of negative, neutral and positive words.

If, on the other hand, in every memory set there was an equal number of words in each valence category but the valence categories differed with respect to how often each type of word appears as a *target* stimulus, then in order to exploit this fact it would be necessary to pay attention to the valence of the target words. In fact at least two different types of training protocols based on the manipulation of the target stimulus properties seem valid. One approach stems from the observation that if no negative word would ever be used as a target then the participants could exploit this fact only by investing fewer resources in the encoding or retention of the negative words as such. Yet another approach would be to present negative words only as new targets. Not ignoring the negative words would possibly also create an additional cost since an exhaustive search is necessary to correctly answer whether a new stimulus was presented. We hypothesized that either or both training protocols would alter the memory bias in the expected way. This in turn should result in the differences in the ability to later recall the positive and the negative words.

Method

Overview of the procedure

There were two experimental groups apart from the control group. In all the groups every memory set in the emotional version of the Sternberg's short term memory

task consisted of an equal number of negative, neutral and positive words. The groups differed only in the proportion of the types of target words. In the No-Negative training group the target word was never negative. It was positive for 66 percent of the trials and for the remaining 34 percent of the trials the target word was neutral. In this group both positive and neutral targets were equally likely to be new or old. In the Negative-New training group the target word was equally likely to be negative, neutral or positive but negative targets were always new, whereas positive and neutral targets were new half of the time. In both training groups the task's difficulty necessarily depends on whether participants try to remember all the words from the set or mostly the positive and the neutral ones. This way a particular memory strategy (e. g., 'don't memorize negative words', or 'positive words are more important') is rewarded during successive trials by virtue of making the task easier. Since they are not informed about these contingencies we can hope to avoid the problems associated with explicit methods of memory bias training.

Participant characteristics

Participants were 108 undergraduate students (79 female and 29 male, mean age = 21, *sd* = 1.9), who completed the study in exchange for a small fee. They were assigned either to the Negative-New ($n = 39$), the No-Negative ($n = 36$) or the control group ($n = 33$). Assignment to the groups was random and the experimenter was blind to condition.

Materials

Questionnaires. Mood was measured by the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) and the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977; Dojka, Górkiewicz, Pająk, 2003) questionnaires. The PANAS is a 20-item self-report inventory that asks to rate the extent to which respondents have experienced 10 positive and 10 negative emotions within a given time period. The CES-D is a 20-item measure that asks respondents to rate how often over the past week they experienced depression-related symptoms. Both questionnaires have good reliability and validity in both healthy and subclinical samples.

Stimuli. The list of words used in the memory task comprised 278 adjectives and nouns of which there were 91 neutral, 93 negative and 94 positive items. These words were taken from a larger set of 345 neutral and affective Polish words preselected by the authors. This initial set was rated by 79 second and third-year psychology students, each of whom received half of the list. The students rated the words on an 8-point Likert scale with respect to how negative/positive their perceived meaning was (0 – extremely negative, 7 extremely positive) and how easy it was to imagine their content (0 – extremely hard to imagine, 7 extremely easy to imagine). Each word from the initial list was rated by 37 students on average. All those words for which the rated valence differed significantly from the assumed valence category center score (1.5 for the negative, 3.5 for the neutral and 5.5 for the positive category) were excluded. Some further ad hoc exclusions were necessary to make the three lists comparable with respect to imaginability, word length and frequency.

The memory task. The emotional version of the Sternberg's task consisted of 120 trials. The beginning of each trial was signaled by a white cross presented centrally for 1000ms. Words were presented sequentially in the center of the screen for 1000 ms each in random order. Two set sizes were used (3 and 6) and every set consisted of an equal number of positive, negative and neutral words. After the presentation of the last word there was a 1000 ms waiting period during which the screen was blank. The participants were instructed to respond as quickly and as accurately as possible using arrow keys to the target word presented immediately after the waiting period. At the typical distance of about 67cm from the screen , the words were about 0.3°high. The target words and the memory set words were randomized for each participant in such a way that a given word could be repeated only after the whole set was exhausted.

Filler task. A filler task was presented between the short-term memory task and the recall stage to ensure that the differences in the proportion of recalled words were due to the long term memory effects. The filler task consisted of a series of trials during which a randomly chosen word (either 'RIGHT' or 'LEFT') was presented in the center of the computer screen. The participants were instructed to press arrow keys in response to directions named by the words. The filler task was stopped as soon as 5 minutes had passed.

Procedure

Separate groups of about 5 to 10 participants were tested in a sound-attenuated room. They were told that the purpose of the study was to examine the relationship between mood and memory. After being seated in front of the computer screen, participants filled out a written informed consent form, the PANAS and the CES-D questionnaires, in random order. After that, all the instructions were shown on the computer screen. The participants engaged in practice sessions for the memory task consisting of 6 trials. The groups differed only in the proportion of target word categories (valence and old vs. new). In the control group, the target stimulus was equally likely to be negative, neutral or positive, with each target type being new for half of the trials. In the No-Negative group the target word was never negative and it was positive for 66 percent of the trials. Both the positive and the negative targets were new for half of the trials. In the Negative-New group the target was equally likely to be negative, positive or neutral but when it was negative it was always new, whereas when the target was positive or neutral it was new for half of the trials. After the completion of the memory task the participants completed as many trials of the filler task as was necessary for it to take 5 minutes. After the filler task the participants were asked to write down as many words from the memory task as possible.

The recall stage was limited to 5 minutes after which the end of the experiment was signaled by the flashing screen. At the end of the session, before debriefing, participants were asked to guess the purpose of the procedure. No one guessed the exact purpose or the hypotheses correctly. Each experimental session took approximately 45 minutes to complete.

Results

Inter-group differences at pretesting. Inter-group differences at pretesting are summarized in Table 1. One-way ANOVA did not reveal any significant group effects with respect to the questionnaire scores ($F(2,100) \leq 2.5$).

Set size and target type effects in the memory task. Accuracy in the modified Sternberg's task was high ($\geq 93\%$). Linear mixed model was fitted to averaged correct reaction time data with set size, target type (new vs old) and their interaction as fixed effects and subject specific random intercept. The results showed that it took longer to respond to old targets when there were more items in the set ($t(299) = 9.6$; $p < 001$) and the response latencies were longer for the new targets ($t(299) = 3.5$; $p < .001$) but the interactive effect of set size and target type was not significant.

Recalled words. Recalled words were classified as correct or incorrect recollections allowing for occasional spelling mistakes. The participants correctly recalled 12 words on average ($sd = 5.4$). In order to simplify the analysis all the recalled words were summarized by participant specific indices calculated as the ratio of the number of correctly recalled words in each valence category to the total number of correctly recalled words. The positive, the negative and the neutral recall indices were later used as separate dependent variables.

The effect of training and mood on the proportions of recalled words. In order to test if the proportion of correctly recalled words was influenced by the type of the training nine regression models (three recall indices × three questionnaire scales) were fitted to recall indices with group membership as the main predictor and mood measures as covariates. No significant effects were found for any of the mood measures with respect to any of the three recall indices. The only significant group effects found were a higher proportion of positive words and a lower proportion of negative words in the No-Negative training group as compared to the control group. Since these between-group effects were significant regardless of which mood measure was included as a covariate, the results summarized in Table 2 and 3 below represent the simplified models without the questionnaire terms.

As can be seen there was a lower proportion of negative words recalled in the No-Negative group as compared to the control group ($t(105) = -2.2$, $p = .03$). Participants in the same group also recalled a higher proportion of positive words as compared to the control group ($t(105) = 3$, $p = .003$). The same pattern of results was obtained when the ratio of negative words to positive words recalled was used as a dependent variable. On the other hand, no significant group effects were found for the proportion of the recalled neutral words.

Discussion

Our results indicate that the use of a modified version of the Sternberg's short-term memory task changes proportions of positive and negative words recalled later. Particularly when there are more positive test stimuli in a memory task, the pattern at recollection stage changes

Table 1. Participant Characteristics.

	Group		
	Negative-New	No-Negative	Control
		M (SD)	*M (SD)*
Age	22 (2.2)	21 (1.7)	21 (1.8)
Positive Affect	62 (16)	64 (12)	70 (13)
Negative Affect	43 (15)	40 (15)	39 (16)
CES-D	20 (13)	16 (11)	15 (10)
Gender ratio (f/m)	27/12	27/9	25/8

Table 2. Summary statistics of the proportion of negative words recalled regressed on group membership ($n = 108$).

Coefficient	Estimate	Std. Error	*t*	*p*
Intercept (control group)	0.29	0.02	12.1	< .001
Negative-New	0.01	0.03	0.0	0.70
No-Negative	**0.10**	**0.03**	**3.1**	**.003**

Table 3. Summary statistics of the proportion of positive words recalled regressed on group membership ($n = 108$).

Coefficient	Estimate	Std. Error	*t*	*p*
Intercept (control group)	0.44	0.03	15.7	< .001
Negative-New	0.00	0.04	0.0	0.99
No-Negative	**-0.09**	**0.04**	**-2.2**	**.03**

in such a way that it resembles more an asymmetry in recollection characteristic of non-depressed individuals. Such individuals seem to recall positive information with greater ease than negative, whereas subclinically depressed individuals seem to recall both negative and positive information equally well and clinically depressed seem to recall negative information better (Matt, Vázquez, & Campbell, 1992). The lack of significant results in the group where negative target stimuli were always new can result from the fact that response to a new target stimulus requires an exhaustive search. Therefore, it might be associated with greater uncertainty as to the correctness of one's reaction. Because of this the target memory rule for this group could be more difficult to detect. Furthermore, presenting a negative test stimulus as a new stimulus requires more frequent processing of the negative stimulus as it must be compared with each element stored by memory.

The results should be interpreted with caution because the effects observed in the No-Negative group could be explained by the exposure effect. It is possible that easier recollection of positive stimuli and weaker recollection of negative stimuli in this group resulted not so much from a greater tendency to remember positive information, as from the fact that the memory of positive stimuli was tested more frequently. The pattern observed could therefore result from a simple learning effect. Establishing the relative importance of this alternative explanation would require statistical control of the frequency of individual words appearing as test stimuli; regrettably, the program did not store this data. We believe this to be the most significant limitation of our study and that firmer conclusions may be drawn only after this limitation is eliminated.

According to major cognitive models of emotional disorders memory bias in the form of lack of positive asymmetry or better memory for negative than positive information can constitute one of the causes for these disorders. Direct evidence of the causative role of cognitive bias is possible only by experimentally modifying the bias of interest. Such methods are commonly used in attentional bias studies, however so far there were no promising attempts at modification of memory bias that we are aware of. In our opinion this could result from the fact that the memory bias modification methods used thus far (e.g., training forgetting of negative material by Joormann et al., 2009) required participants to be openly instructed of expected changes in the way memory works, which caused insufficient generalization and interpretation of collected results was hindered by the interpersonal expectancy effect in participants. Bearing in mind the limitation mentioned above we can state that the method suggested here is free of this shortcoming and suggests a promising direction of studies on the causative role of memory bias in emotional disorders.

References

Beard, C., Sawyer, A. T., & Hofmann, S. G. (2012). Efficacy of attention bias modification using threat and appetitive stimuli: a meta-analytic review. *Behavior Therapy, 43(4),* 724–40.

Blaut A, Paulewicz B. (2011). Poznawcza podatność na depresję. *Psychiatria Polska, 45*, 889-899.

Clark, D. A., & Beck, A. T. (1999). *Scientific foundations of cognitive theory and therapy of depression.* John Wiley & Sons

Dojka, E, Górkiewicz, M. & Pająk, M (2003). Wartość pomiarowa skali CES-D do oceny depresji w populacji polskiej. *Psychiatria Polska, 2,* 281-293.

Gotlib, I., & Joormann, J. (2010). Cognition and depression: current status and future directions. *Annual Review of Clinical Psychology,* 285–312.

Hakamata, Y., Lissek, S., Bar-Haim, Y., Britton, J. C., Fox, N. A., Leibenluft, E., Ernst, M., et al. (2010). Attention bias modification treatment: a meta-analysis toward the establishment of novel treatment for anxiety. *Biological Psychiatry, 68*, 982–990.

Hallion, L. S., & Ruscio, A. M. (2011). A meta-analysis of the effect of cognitive bias modification on anxiety and depression. *Psychological Bulletin, 137(6)*, 940–58.

Joormann, J., Hertel, P. T., LeMoult, J., & Gotlib, I. H. (2009). Training forgetting of negative material in depression. *Journal of Abnormal Psychology, 118(1)*, 34–43.

Kircanski, K., Joormann, J., & Gotlib, I. H. (2012). Cognitive aspects of depression. Wiley Interdisciplinary Reviews: *Cognitive Science, 3(3)*, 301–313.

Kłosowska J., Blaut A. & Paulewicz B. (2015). Trening tendencyjności uwagi w redukcji objawów lęku. *Psychiatria Polska, 49*, 57-66

MacLeod, C. (2012). Cognitive bias modification procedures in the management of mental disorders. *Current Opinions in Psychiatry, 25*, 114–120.

MacLeod, C., Matthews, A., & Tata, P. (1986). Attentional bias in emotional disorders. *Journal of Abnormal Psychology, 95*, 15–20.

MacLeod, C., Rutherford, E., Campbell, L., Ebsworthy, G., & Holker, L. (2002). Selective attention and emotional vulnerability: Assessing the causal basis of their association through the experimental manipulation of attentional bias. *Journal of Abnormal Psychology, 111*, 107–123.

Mathews, A., & MacLeod, C. (1994). Cognitive approaches to emotion and emotional disorders. *Annual Review of Psychology, 45*, 25–50.

Matt, G. E., Vázquez, C., & Campbell, W. K. (1992). Mood-congruent recall of affectively toned stimuli: A meta-analytic review. *Clinical Psychology Review, 12(2)*, 227–255.

Mogoaşe, C., David, D., & Koster, E. H. W. (2014). Clinical efficacy of attentional bias modification procedures: an updated meta-analysis. *Journal of Clinical Psychology, 70(12)*.

Sternberg, S. (1969). Memory-scanning: mental processes revealed by reaction-time experiments. *American Scientist, 57(4),* 421-57.

Radloff, L. S. (1977). The CES-D Scale: A Self-Report Depression Scale for Research in the General Population. *Applied Psychological Measurement, 1(3)*, 385–401.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of Personality and Social Psychology, 54(6)*, 1063–1070.

Williams, J. M. G., Watts, F. N., MacLeod, C., & Mathews, A. M. (1997). *Cognitive Psychology and Emotional Disorders* (2nd ed.). Chichester, England: Wiley