Overcoming Fixed Mindsets: The Role of Affect

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Overcoming Fixed Mindsets: The Role of Affect

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Abstract

When there is an established strategy to solve a problem, we often approach the problem with a mindset that makes us blind for more efficient solutions. We examined the role of affect in overcoming such blinding effects of mindsets. As positive affect is known to broaden and negative affect to narrow thought-action repertoires, we speculated that positive affect facilitates and negative affect impedes the overcoming of a current mindset. To induce a mindset, participants initially solved 60 similar problems which were only solvable using the same complex strategy. After a short break in which positive or negative affect was induced, participants continued to work on the problems. Critically, there now was an additional simple way to solve the problems. Participants experiencing positive affect were more likely to detect the simple solution than participants experiencing negative affect. These findings reveal that affect modulates how much we are constrained by current mindsets.

Keywords: emotions, insight, mental set, mood, problem solving, mental fixation
Overcoming Fixed Mindsets: The Role of Affect

When approaching a problem, it would be a good advice to consider different solutions in order to determine the best way to solve the problem. However, numerous studies have demonstrated that people rarely follow this advice when there is already an established way to solve a problem. In such situations, people typically approach a problem with a mindset that focuses processing on information that is relevant for the established solution strategy while neglecting information that is irrelevant for the established solution strategy (see Schultz & Searleman, 2002, for a review). Such a processing style may often be an efficient way to solve recurring problems, because an activated mindset sensitizes us to that parts of the available information that have enabled us to successfully solve the problems in the past. However, since long it is known that this beneficial effect can come at the cost of making us “blind” when more simple or elegant solutions are available, an effect called the Einstellung or mental set effect.

Probably the most famous example for a mental set effect are the so-called water jar problems originally developed by Luchins (1942). Participants try to solve a series of problems in which the task is to measure out a specific amount of water using three different-sized jars. The first problems can only be solved using a fixed complicated strategy which is quickly learned. Then, a problem is given which can be solved using the complicated strategy, but also in a much easier way. Typically, the vast majority of participants continue to use the complicated strategy instead of the simple one, whereas almost nobody fails to apply the simple strategy when not having initially practiced the complicated strategy. The mental set effect has been demonstrated both in laboratory and real-life settings using a range of different problem-solving tasks (see Schultz & Searleman, 2002, for a review), and seems to increase with increased practice, with almost everybody sticking with the complicated strategy after intense practice (Crooks & McNeil, 2008).
One question of previous research has been how to overcome the blinding effect of an activated mindset, and a variety of interventions have been tried, such as having participants to write down “don’t be blind”, rewarding participants for correct solutions, or introducing a break (e.g., Luchins & Luchins, 1950; McGraw & McCullers, 1979). Although these interventions reduced the continued use of the complicated strategy to some extent, all of them failed for a substantial number of participants. For instance, even after a break of one month, 27% of the participants still showed a mental set effect (Luchins & Luchins, 1950).

However, there is one factor that may strongly determine whether a current mindset blocks the realization of new and simpler solutions to a problem: affective state. According to the broaden-and-build theory (Fredrickson, 1998), affect modulates the breadth of people's momentary thought–action repertoires. Specifically, it is assumed that negative affect narrows the array of thoughts and actions that come to mind in order to promote quick and decisive actions. By contrast, positive affect is assumed to broaden a person’s thought-action repertoire in order to build personal resources by making people more open-minded and more sensible for new opportunities in the environment. Accordingly, affect may influence whether one sticks with the currently activated mindset or detects the existence of available easy solutions. Indeed, a recent study demonstrated that affect at least modulates the developing of a fixed mindset (Gasper, 2003). Participants in whom positive affect was induced before practicing an instructed solution strategy were less likely to fixate on the practiced strategy than participants in whom negative affect was induced. However, the influence of affect on problem solving in situations where people already have a fixed mindset for solving a problem has, to our knowledge, not been examined in previous research.

The aim of the present study was to examine whether affective state modulates the overcoming of a fixed mindset. In order to establish a strong mindset, we used a modified
version of the Number Reduction Task (see Fig. 1A; Thurstone & Thurstone, 1941) which allows both an intense training of a complicated solving strategy and the introduction of an easy solution, the detection of which can be exactly measured (Haider & Rose, 2007; Wagner, Gais, Haider, Verleger, & Born, 2004). After an intense practice phase in which each problem was only solvable by the repeated applications of two rules, participants worked on an apparently unrelated task which actually served to unobtrusively induce positive or negative affect. Directly afterwards, participants continued to work on the Number Reduction Task. Critically, the problems were now solvable either by the practiced strategy or by an obvious simple rule which allowed to cut short sequential responding. If affective state modulates whether a current mindset makes us blind for available simpler solutions, participants experiencing positive affect should be more likely to detect the simple rule than participants experiencing negative affect.

Method

Participants and Design

Eighty undergraduate students (67 females; mean age = 22.2 years, \(SD = 4.0\)) participated.\(^1\) Half of the participants were randomly assigned to a positive affect condition, the other half to a negative affect condition. All participants were tested individually and received course credit for participation. All participants were included in the data analysis, and all manipulations and measures are reported.

Materials and Procedure

To measure the effects of affect on the overcoming of a fixed mindset, a modified version of the Number Reduction Task (Thurstone & Thurstone, 1941) was used. Participants were always presented a string of eight digits and were required to enter a specific digit which represented the solution to the string. The solution could only be reached by sequentially processing the digits from left to right according to an instructed problem-solving strategy.
consisting of two rules (explained in Fig. 1A). Participants first practiced the problem-solving strategy until they had performed without any mistakes on ten consecutive strings in order to assure correct understanding of the two rules. To induce a strong mindset, participants then solved 60 additional problem strings, divided into two blocks of 30 problems each with a break of 15 sec in between.

After mindset induction, the affect induction phase followed. To unobtrusively induce affect, participants performed an apparently unrelated visual search task for three minutes in which they searched for happy or sad faces among neutral faces, depending on affect condition. The faces were taken from a published set of emotional faces (Ebner, Riediger, & Lindenberger, 2010); twenty persons were selected, each showing a neutral, positive, and negative expression. Participants in the positive condition were presented happy and neutral faces in random order, and they were asked to press the space bar when detecting happy faces. After each key press, they received feedback about correct and incorrect detections. Participants in the negative condition were presented sad and neutral faces in random order and were asked to detect sad faces. During search, participants listened to appropriate instrumental music (happy vs. sad). To assess the success of affect induction, participants rated their affective state experienced after the visual search task after the experiment on two 5-point scales (1 = not at all, 5 = extremely), labelled “I was happy” and “I was sad”.

Directly after finishing the visual search task, the critical test followed. The participants continued to work on the Number Reduction Task. However, unknown to participants, now the last digit of each given string always represented the solution which provided an additional simple way of reaching the solution, besides using the two practiced rules. To determine whether insight into the simple problem-solving strategy was gained, participants’ performance was monitored across 120 additional problems, divided into four blocks of 30 problems each with a
break of 15 sec in between.

Results

Affect Manipulation Check

Participants varied reliably in their affective ratings across affect conditions. As compared to the negative condition, participants in the positive condition rated significantly higher on the happiness scale ($M_{positive} = 2.60, SD = 1.24$ vs. $M_{negative} = 1.60, SD = 1.06$); $t(78) = -3.89, p < .001$), and significantly lower on the sadness scale ($M_{positive} = 1.08, SD = 0.27$ vs. $M_{negative} = 1.95, SD = 0.68$); $t(78) = 7.60, p < .001$).

Mindset-induction Phase

To examine performance in the mindset-induction phase, we compared performance across the two mindset-induction blocks. Incorrect responses (9.1%) and trials with solution times more than two standard deviations from each participant’s mean in each practice block (3.8%) were excluded. An analysis of variance with the factors of block (first vs. second block) and affect (positive vs. negative) revealed a significant main effect of block, $F(1, 78) = 78.20, p < .001, \eta^2_p = .50$, indicating that solution times strongly decreased from the first to the second block. There was no main effect of affect, $F(1, 78) = 0.21, p = .65$, and no interaction, $F(1, 78) = 0.05, p = .83$, indicating that solution times in the mindset-induction phase did not differ between affect conditions. Analyzing accuracy revealed a similar pattern. Accuracy slightly decreased from the first block ($M = .92, SD = .08$) to the second block ($M = .90, SD = .09$), $F(1, 78) = 6.62, p = .012, \eta^2_p = .08$, and there was no main effect of affect, $F(1, 78) = 3.11, p = .08$, and no interaction, $F(1, 78) = 0.93, p = .34$.

Critical Test

We first examined whether affect induction differentially weakened the application of the initially practiced problem-solving strategy. To this end, we compared solution times in the
second mindset-formation block with solution times after affect induction before any participant
gained insight into the alternative simple strategy. As most of the participants (96.3 %) did not
gain insight within the first eight problems, solution times for the first eight problems after affect
induction were analyzed (three participants were excluded from this analysis because they had
gained insight within the first eight problems). An analysis of variance with the factors of block
(second mindset-formation block vs. post-induction block) and affect (positive vs. negative)
revealed a significant main effect of block, \(F(1, 75) = 15.89, p < .001, \eta^2_p = .17\). Solution times
increased from the second mindset-formation block to the post-induction block, indicating that
working on an unrelated task generally weakened the application of the initially practiced
solution strategy. There was no main effect of affect, \(F(1, 75) = 0.14, p = .707\), and no
interaction between affect and block, \(F(1, 75) = 2.76, p = .101\), indicating that affect did not
influence the weakening of the initially practiced problem-solving strategy.

Next, we examined whether affect induction influenced the detection of the easy strategy.
As detection of the easy strategy allows to cut short sequential responding, gaining insight is
characterized by an abrupt, large, and sustained drop in solution times to a lower flat level curve
that is impossible to reach without knowledge of the simple solution (e.g., Darsaud et al., 2011;
Wagner et al., 2004; for a thorough discussion, see Haider & Rose, 2007; for examples see
Figure 1B, left panel). To determine whether insight into the easy strategy was gained, we
inspected each participant’s responses for such an abrupt and sustained qualitative shift in
responding. As suggested by Haider and Rose (2007), we used a moving median filter to identify
insight as clearly as possible. Similar to a moving average filter, a moving median filter
eliminates local noise. However, other than a moving average filter which smoothes large
solution times differences so that the time point of insight is attenuated, a moving median filter
emphasizes discontinuity so that the time point of insight is accentuated. With an odd number of
points in the median filter, the output of the filter will stay up until more than half of the solution times are on the lower level, whereupon it will drop to the lower level. Thus, median filtered data reflect a flat level curve which abruptly declines in case of insight to a lower flat level curve.

Because our goal was to identify insight as clearly as possible, we used a more conservative lag-9 median filter (i.e., the first median was computed over problem 1 through 9, the next median was computed over problem 2 through 10, and so on), which means that the output of the filter stayed up until at least more than five problems were solved faster than the previous problems. To assure that a decline in the median does not only reflect effects of random guessing, medians with less than eight correct responses were discarded. Insight was coded if an abrupt decline to a lower flat level curve was observed. Because a lag-9 median filter allows to identify insight as early as in problem 10, we additionally inspected solution times for the first 9 problems whether an abrupt and sustained drop in solution times occurred already within these trials.

Figure 1B (left panel) shows typical median-filtered solution time curves for participants with (upper panel) and without (lower panel) gaining insight into the easy strategy. In total, based on the behavioural change criterion, 54 out of 80 participants detected the easy strategy. Overall, in case of detection of the simple rule, the median-filtered solution times dropped abruptly from $M = 7.84$ ($SD = 2.40$) to 1.26 sec ($SD = 0.71$ sec). In addition, a post-experimental questionnaire was administered in which participants were asked whether they had noticed any alternative problem-solving strategies. Based on this measurement, three additional participants (one from the negative and three from the positive conditions) were identified as having gained insight into the easy strategy because they had explicit knowledge of it. Figure 1B (right panel) shows the probability of detecting the easy strategy as a function of induced affect. Positive affect increased the probability of gaining insight into the easy strategy as compared to negative
affect. In the positive condition, 35 out of 40 participants (87.5%) detected the easy strategy compared to only 23 out of 40 participants (57.5%) in the negative condition. A chi-square test of independence confirmed that the gaining of insight varied significantly depending on induced affect, $\chi^2(1, N = 80) = 9.03, p = .003$.

The used affect-induction technique did not allow including an affectively neutral condition without introducing serious confounds. In order to nevertheless get a hint as to whether the difference between the positive and negative conditions reflected a decreased mental set effect in positive states, an increased mental set effect in negative states, or both, we assigned those participants to a neutral affect group for whom induction of positive, respectively negative, affect was not effective. To assess the effectiveness of affect induction, we combined the two affective rating scores into a difference score (i.e., happiness score minus sadness score), with positive scores reflecting higher positive affect and negative scores reflecting higher negative affect. Affect induction was regarded as ineffective if the difference score was 0 or below in the positive condition ($N = 10$), and 0 or higher in the negative condition ($N = 17$). The percentage of participants gaining insight into the easy strategy increased across the negative (52.2%), the neutral (74.1%), and the positive (86.7%) affect groups ($\chi^2$ for linear trend = 7.53, $p = .006$), suggesting that mindset fixation varied continuously with affective valence from rigidity to flexibility.

Discussion

The present study demonstrates that the extent to which activated mindsets make us blind for more simple solutions depends on affective state. Participants experiencing positive affect were more likely to overcome intensely practiced complex problem-solving strategies in favour of readily available simple solutions, as compared to participants experiencing negative affect who were more likely to stick with their acquired problem-solving strategies. This pattern of
results is consistent with the broaden-and-build theory (Fredrickson, 1998) which posits that positive affect broadens and negative affect narrows thought-action repertoires. In particular, our results demonstrate that affect can modulate the breadth and flexibility of response tendencies even in situations where there is already a well-established way to successfully solve a problem.

The blinding effects of activated mindsets are typically explained by the assumption that people with an activated mindset focus on thoughts and actions associated with the mindset, which interfere with thoughts and actions associated with alternative problem-solving ways (e.g., Lovett & Anderson, 1996). Accordingly, there are two possible ways to overcome a fixed mindset. One can weaken thoughts and actions associated with the mindset, or one can strengthen thoughts and actions associated with alternative ways to solve the problem. In the present study, although the probability of detecting the simple solution was increased in the positive affect condition, solution times before gaining insight were not influenced by affect, suggesting that experiencing positive affect strengthened alternative ways of thinking and acting without weakening responses associated with the activated mindset. Accordingly, in terms of costs and benefits, positive affect seems to be an optimal tool to overcome a fixed mindset because the detection of new ways of thinking is promoted without losing the benefits of activated mindsets.

There is one potential alternative explanation for why participants experiencing positive affect were more likely to overcome the practiced complex problem-solving strategy in favour of the available simple solution. Rather than increasing the detection of the simple solution, positive affect may have increased the readiness to disregard instructions. That is, it may have been the case that although more of the participants in the negative condition gained insight into the simple solution, this was not evident in their behavioural patterns because they more rigidly followed the initially instructed rules. However, this seems unlikely for at least two reasons.
First, the benefit from using the simple solution was extremely high (i.e., a benefit of an 84%-decrease in solution times), implying that it is unlikely that anyone continued to use the much more time consuming solution strategy, at least over many trials, after insight into the simple solution was gained. Second, quite the opposite was evident according to the statements in the post-experimental questionnaire, because only one participant from the negative condition but three participants from the positive condition reported explicit knowledge about the hidden simple rule without any changes in their behavioral response patterns (see also Footnote 2).

One strength of the present study is that affect was unobtrusively induced, using an affect-induction technique which was not confounded by additional variables that hamper many established affect-induction techniques, such as priming effects introduced by affect-unrelated differences in the contents of affective films or emotional autobiographical memories. Accordingly, our results seem to reflect real effects of authentic affect, and not just effects of people’s everyday knowledge about what they would do if they were experiencing a particular affect (e.g., Perrig & Perrig, 1988), or effects of arbitrary differences between affect-induction conditions. In particular, in terms of practical relevance, given that relatively subtle changes in affect can counteract the detrimental effects of an activated mindset without impairing its beneficial effects, methods that bring about changes in affective state seem to be promising techniques to improve performance in situations where both automaticity and flexibility are required for optimal functioning.
Footnotes

1 Sample size was not determined before data collection. We did a first data analysis after data from 50 participants had been collected, showing that happy participants experiencing positive affect were more likely to detect the simple solution than participants experiencing negative affect, $\chi^2(1, N = 50) = 4.67, p = .031$. We then decided to check the robustness of this finding by collecting data from 30 additional participants. The results for the additional 30 participants fully replicated the results for the first 50 participants, $\chi^2(1, N = 30) = 4.66, p = .031$.

2 Two independent raters coded the gaining of insight based on the median filtered solution times. The inter-rater reliability showed complete agreement (Cohen’s kappa = 1.0).

3 One possibility why insight was not evident in solution times of these participants may have been that they continued to use the instructed rules although they had gained insight into the easy strategy. However, given that the benefit from using the easy strategy was extremely large (i.e., a benefit of an 84%-decrease in solution times), it seems unlikely that this was the case. More likely, insight was not evident in solution times of these participants because they had gained insight into the easy strategy so late that a sustained decrease of solution times was not detectable.

4 Analyzing the gaining of insight based only on the behavioural change criterion revealed a similar pattern, with a higher insight rate in the positive than the negative condition, $\chi^2(1, N = 80) = 5.70, p = .017$. 
References


Figure Caption

Figure 1. Procedure and results of the experiment. (A) Experimental procedure: Overall, participants solved 180 problems of the Number Reduction Task. In each trial, a string of eight digits (consisting of the numbers ‘1’, ‘4’, and ‘9’) was presented (e.g., 14494194), and participants were asked to determine a digit defined as the ‘solution’ of the problem. During mindset-formation, the solution could only be achieved by generating a new seven-digit string based on a sequential processing of the digits from left to right, as defined in the following way. The first digit of the new string is based on a comparison of the first two digits of the given string. For the subsequent new digits, the next digit of the given string is compared with the last newly created digit. The comparison is based on two rules: (i) the ‘different rule’--- if the two digits to be used for creating the next new digit differ, the next new digit is the third digit (e.g., if the two existing digits are 4 and 9, the next new digit is 1), and (ii) the ‘same rule’--- if the two existing digits are the same, the next new digit is the same as well (e.g., if the existing digits are 4 and 4, the next new digit also is 4). The last digit of the new string is considered as the solution of the task. After affect induction, participants continued to work on the Number Reduction Task. However, unknown to the participants, there now was an additional ‘simple rule’ because the last digit of each given string always represented the solution. (B) Left panel: Sample median-filtered solution time curves for participants with (upper panel) and without (lower panel) gaining insight into the simple rule. Insight gaining is accompanied by an abrupt, large, and sustained decrease in solution times to a lower flat level curve. Right panel: Percentage of participants gaining insight into the simple rule as a function of affect.
Figure 1
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