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Mental Imagery Training Increases Wanting of Rewards and Reward Sensitivity and Reduces Depressive Symptoms

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High reward sensitivity and wanting of rewarding stimuli help to identify and motivate repetition of pleasant activities. This behavioral activation is thought to increase positive emotions. Therefore, both mechanisms are highly relevant for resilience against depressive symptoms. Yet, these mechanisms have not been targeted by psychotherapeutic interventions. In the present study, we tested a mental imagery training comprising eight 10-minute sessions every second day and delivered via the Internet to healthy volunteers (N = 30, 21 female, mean age of 23.8 years, Caucasian) who were preselected for low reward sensitivity. Participants were paired according to age, sex, reward sensitivity, and mental imagery ability. Then, members of each pair were randomly assigned to either the intervention or wait condition. Ratings of wanting and response bias toward probabilistic reward cues (Probabilistic Reward Task) served as primary outcomes. We further tested whether training effects extended to approach behavior (Approach Avoidance Task) and depressive symptoms (Beck Depression Inventory). The intervention led to an increase in wanting ($p < .001$, $\eta^2_p = .45$) and reward sensitivity ($p = .004$, $\eta^2_p = .27$). Further, the training group displayed faster approach toward positive edibles and activities ($p = .025$, $\eta^2_p = .18$) and reductions in depressive symptoms ($p = .028$, $\eta^2_p = .16$). Results extend existing literature by showing that mental imagery training can increase wanting of rewarding stimuli and reward sensitivity. Further, the training appears to reduce depressive symptoms and thus may foster the successful implementation of exsiting treatments for depression such as behavioral activation and could also increase resilience against depressive symptoms.

Keywords: bias modification; wanting; reward sensitivity bias; depressive symptoms; mental imagery

In the past decade, the maintenance of mental health in the presence of severe psychological stressors, commonly referred to as resilience, has received increased attention (Kalisch, Muller, & Tuscher, 2014; Wu et al., 2013). Psychological factors that promote resilience include realistic optimism, which entails positive beliefs about the probability of future rewards (Stankevicius, Huys, Kalra, & Series, 2014), and positive risk-taking associated with reward anticipation (Knutson, Wimmer, Kuhnen, & Winkielman, 2008; Wu et al., 2013). In addition to the beneficial effects of positively biased reward anticipation, the experience of many daily rewards was shown to preserve mental health (Geschwind et al., 2010). Further, high reward sensitivity was associated with high levels of positive affects following stress, thereby increasing the likelihood of resilient outcomes (Corral-Frias, Nadel, Fellous, & Jacobs, 2016).

These reports correspond with clinical models stating that low reward sensitivity and low desire for future rewards reduce the motivation to engage in pleasurable activities and facilitate the development or aggravation of depressive symptoms (Admon & Pizzagalli, 2015; Lewinsohn, 1974). A large body of literature supports this hypothesis, showing low

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reward sensitivity in terms of a reduced response bias toward probabilistic reward cues in symptomatic (Huys, Pizzagalli, Bogdan, & Dayan, 2013) and fully remitted patients with major depression (Pechtel, Dutra, Goetz, & Pizzagalli, 2013) and in persons at high risk for depression (Foti, Kotov, Klein, & Hajcak, 2011). In some studies, reduced reward sensitivity even predicted persistence of depressive symptoms after treatment (Vrieze et al., 2013) and onset of major depression (Bress, Foti, Kotov, Klein, & Hajcak, 2013). Ample evidence also suggests reduced wanting of future rewards (Knutson, Bhanji, Cooney, Atlas, & Gotlib, 2008; Pizzagalli et al., 2009; Smoski et al., 2009; Ubl et al., 2015), accompanied by reduced willingness to exert effort to receive rewards (Clery-Melin et al., 2011; Treadway, Bossaller, Shelton, & Zald, 2012; Yang et al., 2014) in people with major depression. With regard to these studies, we assume that interventions that increase reward sensitivity and wanting might heighten motivation to engage in pleasurable activities hereby fostering the successful implementation of existing treatments for depression such as behavioral activation. In addition, such interventions might also increase resilience against depressive symptoms (Southwick & Charney, 2012).

Other biases that are characteristic of depression, such as attentional bias toward negative stimuli and negative interpretation bias, have been successfully targeted by psychological interventions (Gotlib & Joormann, 2010). To the best of our knowledge, no intervention to alleviate blunted reward sensitivity and diminished wanting of future rewards is currently available. With regard to the development of such an intervention, mental imagery of pleasant scenes has been shown to be positively related to the activation of the brain's reward circuitry (Costa, Lang, Sabatinelli, Versace, & Bradley, 2010). Further, prefrontal brain activity while imagining pleasing activities or foods predicts individual preferences for these rewards (Gross et al., 2014) and correlates positively with the choice of larger, albeit delayed, rewards (Hakimi & Hare, 2015).

Considering these findings, we designed a mental imagery training focusing on positive emotions, affirmative thoughts, and pleasurable sensations associated with food stimuli and activities. The goal of the present study was to explore whether this training can increase wanting of these stimuli and elevate reward sensitivity. We chose these two primary outcome measures because increased wanting and heightened reward sensitivity foster approach toward desirable edibles and positive activities. This behavioral activation is thought to reduce depressive symptoms.

Methods

PARTICIPANTS

A priori power analyses using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) confirmed that a sample size of N = 28 would meet the following parameters: α = .05, β = .20, two groups (training and waitlist control), two measurements (before and after training), and a correlation among repeated measures of 0.6 (Pizzagalli, Jahn, & O'Shea, 2005). Foreseeing at least one dropout per group, we included N = 30 participants. This sample size can detect a medium-sized effect (f = .25), which was expected given existing literature (Blackwell et al., 2015).

We advertised the study through the home page of the university and Facebook. Within 1 week 263 volunteers (age: M = 23.3, range 19 – 30; 145 female) had followed the included link to the platform SoSci Survey (Leiner, 2014) and completed the German translation of the Reward Responsiveness Scale (RRS; Van den Berg, Franken, & Muris, 2010), which measures reward sensitivity, and the Spontaneous Use of Imagery Scale (Nelis, Holmes, Griffith, & Raes, 2014), which assesses mental imagery abilities.

In order to avoid ceiling effects, we performed a median split on the RRS data. Next, 70 persons with RRS scores $\leq$ 25 underwent the Structured Clinical Interview for DSM-IV Axis I (Wittchen, Zaudig, & Fydrich, 1997) administered via the phone by a trained clinical psychologist. In doing so, we ensured that only mentally healthy persons participated, meeting a demand of the Ethics Committee, which considered this study to be comparable to a phase I – II clinical trial (for participant flow, see Figure 1).

Given the small sample size, we created participant pairs that were matched according to reward sensitivity, age, sex, and mental imagery ability. We then randomly assigned one person of that pair to the training and the other to the wait condition.

The intervention and control groups consisted of Caucasian students and did not differ from the screening sample with regard to age and sex (screening sample vs. training: age: $t[261]$ = -1.17, p = .26, sex: χ^2 [262] = 0.86, p = .36; screening sample vs. control: age: $t[261]$ = -0.03, p = .97, sex: χ^2 [262] = 2.13, p = .14). Furthermore, study groups did not differ regarding age (intervention: M = 24.4, SD = 4.0; control: M = 23.3, SD = 3.5; $t[28]$ = 0.77; p = .45, 95% confidence interval [CI]: -1.77, 3.90), sex (intervention: 10 female; control: 11 female; $\chi^2[1]$ = 0.16; p = .69, 95% CI: .15, 3.49), the equivalent household disposable income based on the modified equivalence scale of the Organisation for Economic Co-operation and