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Too Hot to Handle: Mood States Moderate Implicit Approach vs. Avoidance Tendencies Toward Food Cues in Patients with Obesity and Active Binge Eating Disorder

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Abstract

Patients with binge eating disorder (BED) display recurring episodes of eating large amounts of food in a short period of time, especially during negative mood states. However, the psychological processes linking negative mood to binge eating behavior have not been sufficiently explored. This study investigated the effects of experimentally inducing a negative (sad) mood state upon reaction times in a computerized Approach-Avoidance-Task (AAT) using images of foods and compared to a neutral control procedure in which negative mood was not induced. Differences in reaction times between "pulling" and "pushing away" food cues in the AAT were considered surrogates for fast, automatic (i.e., implicit) preferences ("bias") for either the approach or avoidance of foods. Obese patients with BED (n = 40), weight-matched (obese) individuals (n = 40), and norm-weight controls (n = 29) were asked to approach ("pull") or avoid ("push") images of high- and low-calorie foods following the induction of a negative mood state vs. the neutral control procedure. Sample size was within the common range of previous investigations of the kind. Similar to previous findings, obese patients with BED exhibited an avoidance bias (i.e., faster reaction times in "pushing" compared to "pulling") during the neutral control condition. However, a contrast analysis revealed that negative mood was associated with decreased avoidance bias in obese patients with BED, but not in obese and norm-weight controls. Mood status exerted no effect on BED patients' self-reported (i.e., explicit) ratings of the urge to consume foods. These findings may help to advance current understanding of how negative (sad) mood states may affect binge eating behaviors. Implications of these findings for developing novel treatment approaches are discussed.

Keywords: binge eating disorder, eating disorder, approach avoidance task, implicit bias, psychotherapy

Introduction

Binge eating disorder (BED) is characterized by recurrent episodes of eating large amounts of food in a short period of time, accompanied by marked distress, and without regular compensatory behaviors. BED was first included as a specific diagnosis in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (APA, 2013), and has since been identified as one of the most common eating disorders (EDs). An estimated 17.3 Mio. individuals suffer from BED worldwide (Santomauro et al., 2021), with lifetime prevalence averaging 1.53% (Qian et al., 2021). Although EDs are among the least common mental disorders (Rehm and Shield, 2019), they pose one of the highest mortality risks (Chesney et al., 2014), are associated with severe health impairments, and are generally considered a public health concern (Galmiche et al., 2019). BED currently ranks as the 126th of 295 level 4 causes of years lived with disability (YLD) according to the Global Burden of Disease 2019 estimates (Santomauro et al., 2021), and substantially increases the risk for developing comorbidities, including other psychiatric disorders, metabolic dysfunctions, and obesity (Hudson et al., 2007; McCuen-Wurst et al., 2018). Thus, it is important to develop novel treatment options and to illuminate the underlying psychological processes associated with BED (Paslakis et al., 2020). Here, we seek to advance current understanding of how negative mood states may affect binge eating behaviors.

Mood States and Binge Eating

Binge eating may be facilitated by a variety of factors, including impulsivity (Shope et al., 2020), emotion regulation deficits (Mikhail et al., 2020), and negative/aversive mood states (Keating et al., 2019). Specifically, Cardi et al. (2015) found in a meta-analysis of 33 studies with 2491 individuals, that experimentally-induced negative mood states increase food intake in obese (OB) BED patients compared to control conditions in which negative moods were not induced. Moreover, negative mood effects were stronger in OB-BED patients compared to OB and normal-weight controls without BED, suggesting a functional relation between negative mood states and binge eating behaviors (Hilbert and Tuschen-Caffier, 2007; Walsh et al., 1987).

But how does negative mood promote binge eating behavior? Although the link between negative mood and binge eating has been well-established, its underlying psychological processes have not been sufficiently explored. Goldschmidt et al. (2011) hypothesized that negative mood increases the perceived loss of control over eating behavior, but could not confirm this prediction in a study with OB-BED and OB children (n = 23). Similarly, Hilbert and Tuschen-Caffier (2007) investigated the possibility of mood restoration in OB-BED and OB adults (n = 20), but could not confirm that binge eating improves mood in OB-BED patients. Notwithstanding that these studies may have been underpowered (Califf et al., 2012), further research on the underlying processes of mood effects in BED patients is clearly warranted.

Building on the idea that food intake in EDs could be steered by processes outside of conscious (i.e., explicit) control (Paslakis et al., 2020), we hypothesized that negative mood states may alter implicit approach and avoidance biases to foods in BED patients. Implicit biases are believed to reflect fast and automatic motivational processes and are thought to circumvent higher cognitive control mechanisms (e.g., attention, concentration, memory) (Schultheiss, 2008). Usually, approach biases are found towards stimuli perceived as rewarding, while avoidance biases are directed away from stimuli perceived as aversive. One prominent example of measuring implicit approach and avoidance biases in laboratory settings is the Approach Avoidance Task (AAT, Rinck and Becker, 2007). In the AAT, participants are asked to pull towards or push away stimuli using a computer mouse or joystick based on an arbitrary feature (e.g., the picture format) (e.g., Rinck and Becker, 2007). Based on differences in reaction times, the AAT typically reveals that appetitive stimuli are pulled towards oneself faster than they are pushed away (i.e., revealing an approach bias), whereas aversive stimuli are pushed away faster than they are pulled (i.e., displaying an avoidance bias; Chen and Bargh, 1999; Förster and Strack, 1997).

Consistent with the idea of altered implicit motivational processes in ED patients (Paslakis et al., 2020; Paslakis and De Zwaan, 2019), approach biases to food cues (e.g., food pictures) tend to be more pronounced in obese individuals (Kemps and Tiggemann, 2015), and weaker in individuals with anorexia nervosa (Paslakis et al., 2016). Moreover, our group recently conducted a first AAT study that investigated implicit biases to food cues in a sample of 24 OB-BED patients (Paslakis et al., 2017), but found no evidence for a pronounced approach bias compared to OB and normal-weight controls. If anything, preliminary evidence for an avoidance bias was obtained, likely reflecting OB-BED patients' ambivalent motivations and experiences regarding foods (Leehr et al., 2016). However, the sample was rather small, and mood states were not taken into consideration. Thus, whether mood states moderate implicit approach biases towards food cues in BED patients remains to be explored.

The Present Study

The present study investigated the effect of negative mood states on implicit biases to food cues in obese patients with BED. Specifically, OB-BED patients first completed an experimental negative mood induction or underwent a neutral control procedure during which negative mood was not induced (Velten, 1968). Subsequently, implicit approach and avoidance biases toward high- and low-calorie food cues were measured using an Approach Avoidance Task (AAT) (Paslakis et al., 2017). We predicted that negative mood induction would have an impact on implicit bias in the AAT, in that OB-BED patients would show increased approach and/or reduced avoidance biases after negative mood induction, when compared to the neutral mood condition. Given the strong associations of BED with obesity, weight-matched (i.e., OB) individuals without an eating disorder as well as normal-weight healthy individuals were recruited as controls. We expected attenuated, if any, mood effects for OB and normal-weight controls on AAT biases (Vrijsen et al., 2013).

Material and Methods

Participants

N = 40 obese patients with an active BED (OB-BED; Body mass index (BMI) > 30 kg/m²) were included in the present study at the Department of Psychosomatic Medicine and Psychotherapy of the University Hospital in Erlangen, Germany. For the diagnosis of BED, the DSM-V criteria for BED (e.g., recurrent episodes of binge eating, marked distress, absence of compensatory behaviors) had to be fulfilled (APA, 2013), and were assessed and confirmed both by means of reviewing pre-existing documentation as well as during a clinical interview carried out by a physician and long-time expert in the diagnosis and treatment of eating disorders. Given the strong association of BED with obesity, n = 40 individuals with BMI > 30 kg/m² (OB), and n = 29 normal-weight individuals with a BMI between 19.0 and 24.9 kg/m² (CO), both without any ED diagnosis, were recruited as controls among hospital employees and students (CO), and individuals considering bariatric surgery as an option for weight loss (OB).

Common inclusion criteria across groups were: 18 years or older, absence of acute severe psychiatric or somatic concomitant diseases, and no acute suicidal tendencies. ED diagnoses other than BED, or clinically relevant ED symptoms, served as exclusion criteria. This was verified prior to study inclusion in a clinical interview by the physician in charge. Given the experimental induction of sad mood as part of the study, ethical concerns warranted the exclusion of any individuals with clinically severe depressive symptoms. Thus, none of the participants fulfilled the ICD-10 criteria for a severe depressive episode based on an expert physician's clinical judgement. Depression scores for statistical analyses as co-variate were assessed by means of the Beck Depression Inventory (BDI-II; Hautzinger et al., 2009).

The study was carried out in accordance with the Declaration of Helsinki and was reviewed and approved by the local ethics committee. Sample size was based on previous similar investigations (Paslakis et al., 2017, 2016), and achieved a power of .73 for detecting medium- or larger-sized (i.e., $f \geq .25$) group x mood-induction interaction effects at $p \leq .05$ (Faul et al., 2007). All tests were conducted at the local hospital. Participants had no previous experience with the procedure, were randomly selected to participate, and -except for the case of ethical concerns- also randomly assigned to the mood induction conditions, thus minimizing the potential for hypothesis-relevant selection biases. To ensure comparability in terms of hunger and satiety, all participants had consumed a meal within the 4-hour period prior to testing.

Materials and Procedure

After explaining of the procedure, participants indicated their age, weight, height, previous diagnoses, current medication, the occurrence of (subjective or objective) binge eating episodes, and the use of compensatory measures for weight control (vomiting, laxatives, or diuretic abuse, etc.); the DSM-5 criteria for present and past BED and depressive symptoms (BDI-II) were assessed as described above. Suicidal thoughts resulted in the exclusion of the participant and termination of the procedure for participants randomly assigned to the sad mood induction condition.

Mood Induction

Next, participants underwent a process designed to put them in a negative mood or underwent a neutral control procedure in which negative mood was not induced. First, participants reported their current mood and arousal levels using two self-assessment manikins (SAM, Bradley and Lang, 1994). Then, after electronic randomization, either a sad or neutral video about 7 minutes in length was shown. The video showed the Velten (1968) mood statements for 20 seconds, and participants were asked to read them twice, silently and aloud. Participants were prompted to relate the sentences to own past experiences. This was accompanied by a corresponding visual color background (dark blue for the sad mood, white for the neutral condition) and a piece of music (i.e., excerpts from Adagio for Strings Op. 11 by Samuel Barber for sad mood, and The Planets, Op. 32 VII Neptune: the Mystic by Gustav Holst in the neutral condition; Marcusson-Clavertz et al., 2019). The video was shown in a darkened room and music was played via headphones, with the examiner staying outside of the participant's field of view. Afterwards, mood and arousal levels were measured again using SAM, to assess the impact of the mood induction procedure.

Approach-Avoidance-Task

After the mood induction, participants advanced to the AAT. Participants were first instructed how to use the PC mouse to either "pull" or "push" food images based on the picture format (portrait or landscape). The assignment of movement direction and picture orientation were counterbalanced across participants, such that participants were either asked to pull portrait pictures and push landscape pictures, or to pull landscape pictures and push portrait pictures. Movements in both directions caused the image size to change, such that images enlarged when pulled and shrank when pushed. Because reaction times (RT) served as the primary dependent variable, participants were instructed to react as quickly and precisely as possible. At the beginning of each trial, a fixation cross was shown in the middle of the screen; this served as a starting position. The appearance of a picture was initiated by the participant by clicking on the fixation cross with the computer mouse. Before the actual experiment, participants went through a practice run, in which they learned to "push" or "pull" 20 white rectangles (without food pictures); otherwise, they followed the same instructions as described above. If a mistake was made during the practice run, visual feedback was displayed.

Stimuli

Twenty standardized, previously used images showing high calorie foods (HC; e.g., hamburger, cake) and twenty images showing low calorie foods (LC; e.g., salad, apples) were selected from the food.pics database as food cues (Blechert et al., 2014; for additional details, see Paslakis et al., 2017). Thus, 50% of the images shown in the AAT contained HC foods and 50% contained LC foods. We varied calorie content to explore the specificity of altered approach biases in patients with BED (Paslakis et al., 2017, 2016). Each of the food cues was displayed in both landscape and portrait format, and all trials were presented in random order.

Explicit Ratings

Following the AAT, participants were asked to rate the presented food images on a scale between 0 and 100 regarding a) urge to eat (How much would you like to eat this food now?), b) regret (How much would you regret eating this food?), and c) healthiness (How healthy do you think this food is?).

Concluding the study, current mood and arousal levels were evaluated again, and participants in the sad mood condition were offered a consultation and viewing a comedy video (Mr. Bean meets the Queen), if desired.

Data Analysis

Analyses of variance (ANOVAs) were conducted to test for effects of group (OB-BED vs. OB vs. CO), and mood induction (neutral vs. negative) on AAT RT bias scores, AAT errors, and explicit ratings. Where appropriate, movement direction (push vs. pull), time of measurement (pre-induction vs. post-induction vs. study-end), and food type (HC vs. LC) were included as repeated-measures factors. Anthropometric variables (age, BMI, BDI) were compared between groups using one-way multivariate analysis of variance (MANOVA), and a Chi-squared test of independence (for sex ratio), with group as independent variable. In addition to the omnibus testing strategy (i.e., simultaneously testing for all possible effects), effects on AAT bias scores were also investigated using a more powerful and specific planned contrast analysis (Furr & Rosenthal, 2003) that evaluates the observed data against the theoretical predictions (i.e., that negative mood increases approach behavior *only* in patients with BED). The significance level for all analyses was set at $p \leq .05$. Effect sizes are reported as η_p^2. Post hoc pairwise comparisons report Bonferroni-adjusted *p*-values for multiple comparisons. Variable values are reported as mean ± standard deviation. Data were aggregated using MATLAB (The MathWorks, Inc., Natick, MA, USA) and analyzed with the Statistical Package for the Social Sciences (SPSS 25; Armonk, NY, USA: IBM Corp.).

Results

Participant Characteristics

Anthropometric variables are summarized in Table 1. Participant sexes were similarly distributed across participant groups, χ^2 (df = 2) = 0.36, $p = .83$. However, groups differed in BMI (post hoc: OB-BED > OB > CO), age (post hoc: OB > OB-BED > CO), and BDI (post hoc: OB-BED > OB > CO), $F(6, 208) = 40.30$, $p < .001$, $\eta^2 = .54$, Wilk's $\Lambda = .21$. To control for effects of these differences on any of the findings, analyses of co-variance (ANCOVAs) with either age, BMI, or BDI scores were conducted in addition to the planned analyses. However, as including these variables did not alter the core findings presented below, these analyses are not reported here (please refer to "Supplementary materials").

Explicit Ratings

Explicit ratings are summarized in Table 2.

Mood

To control for the effects of mood induction, mood ratings were submitted to a 3 (group) x 2 (mood induction) x 3 (time) ANOVA with time as repeated-measures factor. This analysis revealed a main effect for group, $F(2, 103) = 5.84$, $p = .004$, $\eta^2 = .10$. That is, OB-BED reported overall lower mood than CO participants, $p = .003$; mood ratings between OB-BED and OB, and between OB and CO did not differ, *p*s = .11 and .51. Second, and more importantly, the analysis revealed main effects for mood induction, $F(1, 103) = 6.09$, $p = .02$, $\eta^2 = .06$, and time, $F(2, 206) = 24.99$, $p < .001$, $\eta^2 = .20$, that were qualified by the predicted mood induction x time interaction, $F(2, 103) = 17.99$, $p < .001$, $\eta^2 = .15$. While mood ratings were comparable between neutral (6.12 ± 1.15) and negative (6.18 ± 1.48) conditions prior to induction, $p = .90$, participants assigned to the negative condition (4.56 ± 1.57) reported lower moods post-induction than participants assigned to the neutral condition (5.97 ± 1.31), $p < .001$. At study-end, ratings were again comparable ($M_{\text{negative}} = 6.04 \pm 1.07$ vs. $M_{\text{neutral}} = 6.00 \pm 1.30$), $p = .88$. The decrease in mood from pre- to post-induction, and recovery from post-induction to study-end in the negative induction condition, were significant as well, *p*s < .001, all other comparisons, *p*s = 1.00. No other effects were significant, all *F*s < 1.15, *p*s > .32.

Arousal

Possible effects of mood induction on arousal were similarly explored in a 3 (group) x 2 (mood induction) x 3 (time) mixed-measures ANOVA. However, only main effects for time, $F(2, 206) = 4.94$, $p = .008$, $\eta^2 = .05$, and group, $F(2, 103) = 4.25$, $p = .02$, $\eta^2 = .08$, were obtained, revealing, first, a decrease in arousal from post-induction to study-end, $p = .005$, other comparisons ps > .10, and, second, increased levels of arousal for OB-BED and OB compared to CO participants, ps = .04 and .02. Arousal levels remained comparable between OB-BED and OB, $p = 1.00$. No other effects were significant, all Fs < 2.42, ps > .09.

Urge, regret, and healthiness ratings of food pictures

Three separate 3 (group) x 2 (mood induction) x 2 (food type) ANOVAs with food as repeated-measures variable were conducted for ratings of urge to eat, regret, and healthiness ratings. For urge, the analysis revealed, first, a food x group interaction, $F(2, 103) = 6.26$, $p = .003$, $\eta^2 = .11$. OB-BED reported a higher urge to eat HC compared to LC foods, $p = .01$; no differences were observed for OB and CO, ps = .09 and .08. Group-based comparisons further revealed an increased urge in OB-BED vs. OB for HC foods, $p = .006$; no other differences were significant, ps > .15. Second, a group x mood interaction was obtained, $F(2, 103) = 4.54$, $p = .02$, $\eta^2 = .08$. Negative (vs. neutral) mood induction led to an increased urge in OB, $p = .03$, but not in OB-BED or CO, ps > .12. Group-based pairwise comparisons further showed that, under neutral induction conditions, OB reported lower urge than both OB-BED and CO, ps = .01 and .02, respectively. Other pairwise comparisons were not significant, ps > .87. No other effects were obtained, Fs < 1.1, ps > .33.

Regret was found to vary by group, $F(2, 103) = 10.61$, $p < .001$, $\eta^2 = .17$, food, $F(1, 103) = 1178$, $p < .001$, $\eta^2 = .92$, as well as their interaction, $F(2, 103) = 6.89$, $p = .002$, $\eta^2 = .12$; all other Fs < 1.4, ps > .24. Pairwise comparisons showed that all participants reported higher levels of regret for eating HC vs. LC foods, ps < .001. However, according to group-based pairwise comparisons, regret ratings for HC foods were elevated in OB-BED and OB compared to CO, ps < .002, with OB-BED and OB remaining at similar levels, $p = 1.00$. Similarly, although attenuated, regret ratings for LC foods were elevated in OB-BED and OB compared to CO, ps = .03 and .06, with OB-BED and OB remaining at similar levels, $p = 1.00$.

Finally, healthiness ratings were found to vary by group, $F(2, 103) = 4.72$, $p = .01$, $\eta^2 = .08$, food, $F(1, 103) = 8953$, $p < .001$, $\eta^2 = .99$, and a group x food x mood induction interaction was found, $F(2, 103) = 4.27$, $p = .02$, $\eta^2 = .08$; all other *F*s < 1.2, *p*s > .33. All participants rated HC foods as less healthy than LC foods, *p*s < .001. However, mood-based pairwise comparisons showed that inducing a negative mood decreased healthiness ratings for LC foods in OB, $p = 02$; other *p*s > .07; group-based comparisons were not significant, *p*s > .08.

AAT Errors

The number of errors made in the AAT (i.e., initiating "pull" movements on "push" trials, and vice versa), summarized in Table 3, were submitted to a 3 (group) x 2 (mood induction) x 2 (food type) x 2 (movement direction) mixed-measures ANOVA. Although the analysis revealed a main effect of group due to an elevated number of errors in OB, $F(2, 103) = 3.19$, $p = .04$, $\eta^2 = .06$, error rates between individual groups were comparable according to pairwise comparisons, *p*s > .09. No other effects were obtained, *F*s < 2.1, *p*s > .13.

AAT Bias Scores

AAT bias scores were computed using median RT (in milliseconds) of push and pull movements (see Table 4). RT were defined as the sum of the onset of the first motor response in reaction to the stimulus and the length of the motor movement. AAT bias scores were calculated as the difference between push RT and pull RT. Thus, a negative score indicated an avoidance bias because pushing away was faster than pulling closer. Correspondingly, a positive score indicated an approach bias because pulling was faster than pushing. Median instead of mean RT were used due to their lower sensitivity to outliers (Leys et al., 2013; Ratcliff, 1993). Error trials were excluded. Furthermore, data from three participants with unusually high error rates (≥ 60 %), who were identified as multivariate outliers (using Mahalanobis distance with $p < .001$, Tabachnick and Fidell, 2007), were excluded from this analysis. The resultant AAT scores are depicted in Figure 1.

Submitting the AAT scores to a 3 (group) x 2 (mood induction:) x 2 (food type) mixed-measures ANOVA did not reveal any effect, including the predicted group x mood interaction, all *F*s

< 2.6, *p*s > .08. However, because omnibus tests such as ANOVA unselectively and hierarchically test for any interactions and main effects, rather than specifically and directly testing a theoretical prediction, absence of statistical significance may not reveal whether or not the observed pattern of data matches the hypothesis (Furr and Rosenthal, 2003). Based on our own and other previous findings (Leehr et al., 2016; Paslakis et al., 2017; Svaldi et al., 2016), we expected that, under neutral mood conditions, OB-BED would show an avoidance bias towards foods compared to OB and CO and that, under negative mood conditions, approach behavior was expected to increase in OB-BED only, leading to comparable biases among groups. Indeed, this theory-driven contrast (coded -5 1 1 1 1 1) significantly predicted the observed AAT scores, $t(100) = 2.74$, $p = .007$, $\eta^2 = .07$, revealing a mood-driven increase in bias for OB-BED ($M_{\text{neutral}} = -40.42 \pm 56.54$ vs. $M_{\text{negative}} = -5.15 \pm 56.12$) compared to OB ($M_{\text{neutral}} = 6.47 \pm 50.93$ vs. $M_{\text{negative}} = 11.89 \pm 101.99$) and CO ($M_{\text{neutral}} = -8.45 \pm 64.14$ vs. $M_{\text{negative}} = 3.63 \pm 31.71$).

Discussion

Patients with BED suffer from recurring episodes of eating large amounts of food, especially when in a negative mood (Cardi et al., 2015). Offering novel insight into this relation, we found that experimentally inducing a negative mood state was associated with decreased implicit avoidance biases to food cues in an Approach Avoidance Task (AAT) in obese patients with BED, but not in obese and normal-weight controls. In contrast, and consistent with the idea of separate behavior-regulating systems (Aulbach et al., 2019), BED patients' self-reported ratings on the urge to consume foods, regret related to consuming foods, or the perceived healthiness of foods remained unaffected by the experimental mood induction. To the best of our knowledge, these findings represent the first evidence for an effect of mood states on implicit biases specific to BED.

Previous research found that, counterintuitively, patients with BED show implicit food avoidance (Leehr et al., 2016; Paslakis et al., 2017), however, tested under neutral (not experimentally induced) mood conditions. At the same time, as research on biases in eating disorders continues to grow (for a systematic review, see Paslakis et al., 2020), more complex interactions between implicit processes and behaviors have started to emerge. Indeed, we found that implicit biases for BED patients changed under negative mood conditions. This could suggest that biases are not merely "hard-wired" behavioral associations, but represent adaptive behaviors sensitive to situational control (Cesario et al., 2010).

Of course, interpreting these findings is subject to several limitations. First, the current study investigated only effects of negative mood states on approach-avoidance behavior, without including a positive mood control. Thus, whether or not inducing a positive mood could benefit patients with BED by counteracting approach behavior (Cardi et al., 2015) still needs to be explored. Second, patients with BED at various treatment stages were included in the study, limiting any interpretation as to whether the observed overall biases, or the size of mood effects, are a characteristic for patients with BED in general, and/or sensitive to change. Relatedly, it must be noted that control participants were primarily recruited among individuals considering bariatric surgery as an option for weight loss (OB group), as well hospital staff and among medical students (normal-weight controls). Although control participants were altogether oblivious to the hypothesis and randomly assigned to the mood induction conditions, we cannot exclude that overall levels of approach bias, or its sensitivity to mood-based changes, were subjected to selection biases; at the same time, mood induction did not significantly alter the AAT bias in controls, similar also to Vrijsen et al., 2013). Third, and most importantly, as only pictures of foods were used, the significance of mood-induced implicit approach biases for actual eating behavior and BED-related outcomes still needs to be explored. The question of whether or not similar mood effects on implicit biases towards food may be observed for binge eating in patients with other eating disorder diagnoses (e.g., bulimia nervosa or even anorexia nervosa), cannot be answered based on our results and also requires further confirmation.

Nevertheless, since established therapeutic approaches for BED, such as cognitive behavioral therapy (CBT), are considered only moderately effective (Hilbert et al., 2012; Iacovino et al., 2012; Wilson and Shafran, 2005), the present findings may ultimately help to inspire more effective intervention procedures. Indeed, the AAT has also been used as a training tool, for example, to reduce food craving (Brockmeyer et al., 2015), chocolate consumption (Schumacher et al., 2016), and for creating an avoidance bias for alcohol-related cues (Eberl et al., 2013), which positively affected relapse rates at a 1-year follow-up in patients with alcohol dependency. Despite these so-called implicit processes interventions gaining in popularity (Aulbach et al., 2019), AAT-based trainings are not always successful (Becker et al., 2015). However, existing procedures have not yet taken triggering conditions of disordered eating into consideration. Based on our findings, we would therefore suggest that future studies should induce negative mood prior to training, as to create an intervention opportunity for tackling implicit biases related to binge eating behavior. In addition, our study attests to the importance of targeting triggering conditions themselves, such as negative mood states (Cardi et al., 2015), in order to reduce the occurrence of binge eating behavior.

Author Contributions

G.P. conceived, designed, and supervised the study; J.K. recruited participants and performed the experiments; S.K. and G.H. analyzed the data. G.P., J.K., G.H., and E.Y. wrote the paper which was critically discussed, corrected, and accepted by all authors.

Conflict of interest

The authors declared no conflicts of interest with respect to the authorship or the publication of this article.

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References

APA, 2013. Diagnostic and Statistical Manual of Mental Disorders: DSM-5. American Psychiatric Association, Washington, DC.

Aulbach, M.B., Knittle, K., Haukkala, A., 2019. Implicit process interventions in eating behaviour: a meta-analysis examining mediators and moderators. Health Psychol. Rev. 13, 179–208. https://doi.org/10.1080/17437199.2019.1571933

Becker, D., Jostmann, N.B., Wiers, R.W., Holland, R.W., 2015. Approach avoidance training in the eating domain: Testing the effectiveness across three single session studies. Appetite 85, 58–65. https://doi.org/10.1016/j.appet.2014.11.017

Blechert, J., Meule, A., Busch, N.A., Ohla, K., 2014. Food-pics: An image database for experimental research on eating and appetite. Front. Psychol. 5, 1–10. https://doi.org/10.3389/fpsyg.2014.00617

Bradley, M.M., Lang, P.J., 1994. Measuring emotion: The self-assessment manikin and the semantic differential. J. Behav. Ther. Exp. Psychiatry 25, 49–59. https://doi.org/10.1016/0005-7916(94)90063-9

Brockmeyer, T., Hahn, C., Reetz, C., Schmidt, U., Friederich, H.-C., 2015. Approach Bias Modification in Food Craving-A Proof-of-Concept Study. Eur. Eat. Disord. Rev. 23, 352–360. https://doi.org/10.1002/erv.2382

Califf, R.M., Zarin, D.A., Kramer, J.M., Sherman, R.E., Aberle, L.H., Tasneem, A., 2012. Characteristics of clinical trials registered in ClinicalTrials.gov, 2007-2010. JAMA - J. Am. Med. Assoc. 307, 1838–1847. https://doi.org/10.1001/jama.2012.3424

Cardi, V., Leppanen, J., Treasure, J., 2015. The effects of negative and positive mood induction on eating behaviour: A meta-analysis of laboratory studies in the healthy population and eating and weight disorders. Neurosci. Biobehav. Rev. 57, 299–309. https://doi.org/10.1016/j.neubiorev.2015.08.011

Cesario, J., Plaks, J.E., Hagiwara, N., Navarrete, C.D., Higgins, E.T., 2010. The ecology of automaticity. How situational contingencies shape action semantics and social behavior. Psychol. Sci. 21, 1311–7. https://doi.org/10.1177/0956797610378685

Chen, M., Bargh, J.A., 1999. Consequences of Automatic Evaluation: Immediate Behavioral Predispositions to Approach or Avoid the Stimulus. Personal. Soc. Psychol. Bull. 25, 215–224. https://doi.org/10.1177/0146167299025002007

Chesney, E., Goodwin, G.M., Fazel, S., 2014. Risks of all-cause and suicide mortality in mental disorders: A meta-review. World Psychiatry 13, 153–160. https://doi.org/10.1002/wps.20128

Eberl, C., Wiers, R.W., Pawelczack, S., Rinck, M., Becker, E.S., Lindenmeyer, J., 2013. Approach bias modification in alcohol dependence: Do clinical effects replicate and for whom does it work best? Dev. Cogn. Neurosci. 4, 38–51. https://doi.org/10.1016/j.dcn.2012.11.002

Faul, F., Erdfelder, E., Lang, A.G., Buchner, A., 2007. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences, in: Behavior Research Methods. Psychonomic Society Inc., pp. 175–191. https://doi.org/10.3758/BF03193146

Förster, J., Strack, F., 1997. Motor Actions in Retrieval of Valenced Information: A Motor Congruence Effect. Percept. Mot. Skills 85, 1419–1427. https://doi.org/10.2466/pms.1997.85.3f.1419

Furr, R.M., Rosenthal, R., 2003. Evaluating Theories Efficiently: The Nuts and Bolts of Contrast Analysis. Underst. Stat. 2, 33–67. https://doi.org/10.1207/s15328031us0201_03

Galmiche, M., Déchelotte, P., Lambert, G., Tavolacci, M.P., 2019. Prevalence of eating disorders over the 2000-2018 period: A systematic literature review. Am. J. Clin. Nutr. https://doi.org/10.1093/ajcn/nqy342

Goldschmidt, A.B., Tanofsky-Kraff, M., Wilfley, D.E., 2011. A laboratory-based study of mood and binge eating behavior in overweight children. Eat. Behav. 12, 37–43. https://doi.org/10.1016/j.eatbeh.2010.11.001

Hautzinger, M., Keller, F., Kühner, C., 2009. BDI-II. Beck-Depressions-Inventar. Revision. 2, Auflage.

Hilbert, A., Bishop, M.E., Stein, R.I., Tanofsky-Kraff, M., Swenson, A.K., Welch, R.R., Wilfley, D.E., 2012. Long-term efficacy of psychological treatments for binge eating disorder. Br. J. Psychiatry 200, 232–237. https://doi.org/10.1192/bjp.bp.110.089664

Hilbert, A., Tuschen-Caffier, B., 2007. Maintenance of binge eating through negative mood: A naturalistic comparison of binge eating disorder and bulimia nervosa. Int. J. Eat. Disord. 40, 521–530. https://doi.org/10.1002/eat.20401

Hudson, J.I., Hiripi, E., Pope, H.G., Kessler, R.C., 2007. The Prevalence and Correlates of Eating Disorders in the National Comorbidity Survey Replication. Biol. Psychiatry 61, 348–358. https://doi.org/10.1016/j.biopsych.2006.03.040

Iacovino, J.M., Gredysa, D.M., Altman, M., Wilfley, D.E., 2012. Psychological Treatments for Binge Eating Disorder. Curr. Psychiatry Rep. 14, 432–446. https://doi.org/10.1007/s11920-012-0277-8

Keating, L., Mills, J.S., Rawana, J.S., 2019. Momentary predictors of binge eating: An attachment perspective. Eat. Behav. 32, 44–52. https://doi.org/10.1016/j.eatbeh.2018.12.003

Kemps, E., Tiggemann, M., 2015. Approach bias for food cues in obese individuals. Psychol. Heal. 30, 370–380. https://doi.org/10.1080/08870446.2014.974605

Leehr, E.J., Schag, K., Brinkmann, A., Ehlis, A.C., Fallgatter, A.J., Zipfel, S., Giel, K.E., Dresler, T., 2016. Alleged approach-avoidance conflict for food stimuli in binge eating disorder. PLoS One 11, 1–15. https://doi.org/10.1371/journal.pone.0152271

Leys, C., Ley, C., Klein, O., Bernard, P., Licata, L., 2013. Detecting outliers: Do not use standard deviation around the mean, use absolute deviation around the median. J. Exp. Soc. Psychol. 49, 764–766. https://doi.org/10.1016/j.jesp.2013.03.013

Marcusson-Clavertz, D., Kjell, O.N.E., Persson, S.D., Cardeña, E., 2019. Online validation of combined mood induction procedures. PLoS One 14, e0217848. https://doi.org/10.1371/journal.pone.0217848

McCuen-Wurst, C., Ruggieri, M., Allison, K.C., 2018. Disordered eating and obesity: associations between binge-eating disorder, night-eating syndrome, and weight-related comorbidities. Ann. N. Y. Acad. Sci. https://doi.org/10.1111/nyas.13467

Mikhail, M.E., Keel, P.K., Burt, S.A., Neale, M., Boker, S., Klump, K.L., 2020. Low emotion differentiation: An affective correlate of binge eating? Int. J. Eat. Disord. 53, 412–421. https://doi.org/10.1002/eat.23207

Paslakis, G., De Zwaan, M., 2019. Implicit Self-Regulation of Food-Intake: Consequences for Psychotherapy. PPmP Psychother. Psychosom. Medizinische Psychol. 69, 453–461. https://doi.org/10.1055/a-0845-9439

Paslakis, G., Kühn, S., Grunert, S., Erim, Y., 2017. Explicit and Implicit Approach vs. Avoidance Tendencies towards High vs. Low Calorie Food Cues in Patients with Obesity and Active Binge Eating Disorder. Nutrients 9, 1068. https://doi.org/10.3390/nu9101068

Paslakis, G., Kühn, S., Schaubschläger, A., Schieber, K., Röder, K., Rauh, E., Erim, Y., 2016. Explicit and implicit approach vs. avoidance tendencies towards high vs. low calorie food cues in patients with anorexia nervosa and healthy controls. Appetite 107, 171–179. https://doi.org/10.1016/j.appet.2016.08.001

Paslakis, G., Scholz-Hehn, A.D., Sommer, L.M., Kühn, S., 2020. Implicit bias to food and body cues in eating disorders: a systematic review. Eat. Weight Disord. https://doi.org/10.1007/s40519-020-00974-9

Qian, J., Wu, Y., Liu, F., Zhu, Y., Jin, H., Zhang, H., Wan, Y., Li, C., Yu, D., 2021. An update on the prevalence of eating disorders in the general population: a systematic review and meta-analysis. Eat. Weight Disord. https://doi.org/10.1007/s40519-021-01162-z

Ratcliff, R., 1993. Methods for Dealing With Reaction Time Outliers. Psychol. Bull. 114, 510–532. https://doi.org/10.1037/0033-2909.114.3.510

Rehm, J., Shield, K.D., 2019. Global Burden of Disease and the Impact of Mental and Addictive Disorders. Curr. Psychiatry Rep. https://doi.org/10.1007/s11920-019-0997-0

Rinck, M., Becker, E.S., 2007. Approach and avoidance in fear of spiders. J. Behav. Ther. Exp.

Psychiatry 38, 105–120. https://doi.org/10.1016/j.jbtep.2006.10.001

Santomauro, D.F., Melen, S., Mitchison, D., Vos, T., Whiteford, H., Ferrari, A.J., 2021. The hidden burden of eating disorders: an extension of estimates from the Global Burden of Disease Study 2019. The Lancet Psychiatry 8, 320–328. https://doi.org/10.1016/S2215-0366(21)00040-7

Schultheiss, O.C., 2008. Chapter "Implicit motives" from the book "Handbook of Personality: Theory and Research," third. ed. The Guilford Press, New York.

Schumacher, S.E., Kemps, E., Tiggemann, M., 2016. Bias modification training can alter approach bias and chocolate consumption. Appetite 96, 219–224. https://doi.org/10.1016/j.appet.2015.09.014

Shope, M.M., Prows, S.D., Racine, S.E., Culbert, K.M., 2020. Examining associations between emotion-based rash action and dysregulated eating symptoms in men and women. Eat. Behav. 37, 101379. https://doi.org/10.1016/j.eatbeh.2020.101379

Svaldi, J., Bender, C., Caffier, D., Ivanova, V., Mies, N., Fleischhaker, C., Tuschen-Caffier, B., 2016. Negative Mood Increases Selective Attention to Negatively Valenced Body Parts in Female Adolescents with Anorexia Nervosa. PLoS One 11, e0154462. https://doi.org/10.1371/journal.pone.0154462

Tabachnick, B.G., Fidell, L.S., 2007. Using Multivariate Statistics 5, Boston: Pearson Allyn and Bacon.

Velten, E., 1968. A laboratory task for induction of mood states. Behav. Res. Ther. 6, 473–482. https://doi.org/10.1016/0005-7967(68)90028-4

Vrijsen, J.N., Van Oostrom, I., Speckens, A., Becker, E.S., Rinck, M., 2013. Approach and avoidance of emotional faces in happy and sad mood. Cognit. Ther. Res. 37, 1–6. https://doi.org/10.1007/s10608-012-9436-9

Walsh, B.T., Gladis, M., Roose, S.P., 1987. Food Intake and Mood in Anorexia Nervosa and Bulimia. Ann. N. Y. Acad. Sci. 499, 231–238. https://doi.org/10.1111/j.1749-6632.1987.tb36214.x

Wilson, G.T., Shafran, R., 2005. Eating disorders guidelines from NICE. Lancet 365, 79–81. https://doi.org/10.1016/S0140-6736(04)17669-1