The Effect of Emotion Regulation on Eating Behavior: An Experimental Intervention

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Abstract

While overweight and obesity rates are increasing steadily, effective treatments for weight loss are still lacking. A reason for this may be that most current interventions define these health conditions rather broadly: That is, they mainly attempt to modify individual's eating behavior by recommending them to decrease their energy intake (especially through dieting) in favor of increasing their energy expenditure. Thus, it may be promising to focus more on specific mechanisms that may play a role in eating behavior. Individuals' emotion regulation may be one such mechanisms and the present study aimed for exploring its role in an experimental intervention. A total of 88 participants participated in the study. The first hypothesis tested was whether the condition (suppression vs. reappraisal vs. control) had an effect on eating initiation. The second hypothesis tested was whether the condition had an effect on food intake. Before the laboratory experiment, more negative and less positive emotions were induced by evoking hunger through a 14 hr fast. Both hypotheses were rejected. However, the induction of hunger through fasting was successful and as expected, led to more negative and less positive emotions as compared to a previous measurement in a satiated state. To conclude, the study made one of the first attempts to investigate the role of emotion regulation in eating behavior. Future experiments with larger sample sizes might have sufficient statistical power to detect small to medium effects this study may have been unable to reveal.

Keywords: women, hunger, emotion, emotion regulation, eating behavior

The Effect of Emotion Regulation on Eating Behavior: An Experimental Intervention

Obesity is a widespread health issue and an exacerbating societal problem. The number of people in the world with overweight (OW) or obesity (OB) has increased so much in recent decades that obesity has officially been recognized as an epidemic by the World Health Organization (WHO; 2000) and by now is discussed even as a pandemic in the literature (e.g., Boutari & Mantzoros, 2022). According to the WHO (2022), 59% of the adults in the European Region currently live with OW (body mass index [BMI] $\geq$ 25 kg/m²) or OB (BMI $\geq$ 30 kg/m²). This prevalence is amongst the highest worldwide and it has risen "by 51% since 1975" (WHO, 2022, p. 8). The necessity to intervene in this development appears to be obvious for various reasons: First, it is a fact that OW/OB correlate with aberrant amounts of body fat bringing about increased health risks (WHO, 2021). Importantly, epidemiologists have identified several chronic diseases (e.g., Khan et al., 2018; Koopman et al., 2009) that are linked with OW/OB. Moreover, 14% of all-cause mortality cases in Europe were attributable to OW/OB as evidenced in a meta-analysis of 239 studies across four continents that even controlled for smoking and predating chronic diseases (Di Angelantonio, 2016). In addition, OB has a negative impact on the quality of life (Kolotkin et al., 2001; Nigatu et al., 2016) and bidirectionally correlates with major depressive disorder (Rajan & Menon, 2017). These major health issues have led to significant financial costs for health systems: For instance, a recent study estimated the financial costs of health care and productivity losses for an individual with OW/OB per year in the Netherlands (Hecker et al., 2022), which can be summed up to a total cost of €79 billion per year (Maastricht University, 2022). The epidemic proportions, the physical and mental health risks and, last but not least, the financial costs all taken together, make it clear that effective treatments for OW/OB are a crucial goal for research.

Unfortunately, the effectiveness of current treatments is deficient and indicates the urgent need for better treatments; for example, by capitalizing on new, potentially more promising mechanisms involved in eating behavior. Since one central issue in OW/OB is a positive energy balance with more energy intake (e.g., food consumption) than expenditure (e.g., physical exercise), most current recommendations for weight loss aid address this by emphasizing the reduction of the former and favoring the latter in order to shift the overall energy balance to negative (Blüher, 2019). However, the success rate for people wanting to lose weight and receiving even the best empirically supported non-surgical treatments currently available (i.e., *Behavioral Weight Loss*) is rather low (Boutelle et al., 2020; Wadden et al., 2011). Additionally revealing is a systematic review of high-quality studies (Nordmo et al., 2020) that reported an average weight loss of 7.4% that was completely irradicated 4.1 years after the intervention. The authors pointed to the necessity of more sustained interventions and alternative approaches addressing mechanisms responsible for the relative ineffectiveness of current approaches to OW/OB (Nordmo et al., 2020). Moreover, there is only limited evidence that large-scale strategies such as political reforms restructuring the obesogenic environment (e.g., the omnipresent availability of high-calorie food) would reduce OB prevalence through a simplistic mechanism of externally restricted energy intake (Bombak, 2014). Furthermore, important ethical consequences would have to be considered in such a strategy (Bombak, 2014). Thus, a potential reason for the ineffectiveness of current approaches may be their broad focus. Given the heterogeneity and complexity of OW/OB (Field et al., 2013), research into specific unexplored mechanisms may be a way to develop more effective interventions tailored to the individual.

Emotions as a Potential Mechanism in Eating Behavior

One potential mechanism that has been described in the literature is (over)eating in reaction to emotions (Evers et al., 2010). On a basic level, it can be differentiated between an

increased motivation to eat based on (a) negative or (b) positive emotions (Macht & Simons, 2000). Eating more in reaction to negative emotions was observed, for instance, in young adults (Moss et al., 2021), individuals with OW (Geliebter & Aversa, 2003), and individuals with OB who satisfied the criteria for a binge-eating condition (Chua et al., 2004), but also—even though less consistently—in individuals of normal weight (Macht, 2008). However, a meta-analysis that differentiated results by sub-groups only found evidence for negative emotion-induced eating in restrained eaters (i.e., individuals who voluntarily restrict their food intake for weight loss; Evers et al., 2013). An underlying mechanism adopted from learning theory may be that overeating in reaction to negative emotions is driven by negative reinforcement (i.e., reduction of negative emotions through eating). This is especially plausible for palatable foods (e.g., foods rich in sugar and fat) since they have been shown to rapidly diminish stress responses (Macht & Mueller, 2007).

Eating more in reaction to positive emotions, compared to eating more in reaction to negative emotions, is a less researched topic but has been observed as well in several studies, for example in female and mixed-gender university students (Bongers et al, 2013; Evers et al., 2013). Further, a recent meta-analysis of experimental studies found a small effect of positive emotion on eating behavior: positive emotion increased food intake (Evers et al., 2018). An underlying mechanism for this relationship may be that positive emotion directs attention to the immediate hedonic goal of eating (Evers et al., 2013), most plausible for highly palatable foods (Drewnowski et al., 1991). In sum, positive emotions are not well researched so far but appear to show robust results across studies and participants. The effect of negative emotions on eating behavior is more researched but may depend on individual factors and shows more inconsistent results. To solve the puzzle between emotions and eating behavior, a current approach may be more promising to explain the mixed findings and to potentially inform

more effective treatments for OW/OB: to assess the way emotions are regulated—rather than the emotion itself—as a predictor of eating behavior (Evers et al., 2010).

Emotion Regulation as a Potential Mechanism in Eating Behavior

Emotion regulation (ER) describes the process of trying to adjust the experience or expression of one's emotions (Gross, 2002). Thereby, individuals can enhance, maintain, and reduce negative as well as positive emotions. While ER strategies are manifold, two main types of ER may be contrasted in particular (Gross, 2002): (a) *expressive suppression* and (b) *cognitive reappraisal*. Expressive suppression, in the following only referred to as suppression, is a modulation of the emotional response. For example, intentionally inhibiting the expression of anger in a traffic jam. While suppression may reduce the expression of behavior, it hardly changes negative but reduces positive emotions (Gross, 2002). Because of these unfavorable emotional consequences and the fact that suppression has been associated with worse psychological (John & Gross, 2004) and physical health (Ellis et al., 2019), suppression can be considered a maladaptive ER strategy. Cognitive reappraisal, in the following only referred to as reappraisal, is a cognitive change: an emotional situation is interpreted in non-emotional ways. For instance, a fear-provoking situation like cliff jumping is reinterpreted as a potential for growth by self-overcoming. Contrary to suppression, reappraisal reduces the experience of negative emotion and increases positive emotion (Gross, 2002). It also has been associated with better psychological (John & Gross, 2004) and physical health (Ellis et al., 2019) and thus can be considered an adaptive ER strategy.

Both ER strategies, suppression and reappraisal, have been investigated as predictors of eating behavior in previous experimental studies (Evers et al., 2010; Taut et al., 2012). Specifically, based on the observation of suppression as a maladaptive and reappraisal as an adaptive ER strategy in general, it was theorized that this relationship may also hold for eating behavior (Evers et al., 2010). Namely, that suppression as a maladaptive ER strategy would

lead to an increase in food intake, whereas reappraisal as an adaptive ER strategy would lead to a decrease in food intake. Indeed, in an experiment with a fabricated taste test with female healthy participants by Evers et al. (2010) some evidence for this proposition was found: While emotions had no effect on eating behavior, suppression predicted higher food intake in comparison with reappraisal. However, the reappraisal condition did not differ significantly from the control condition.

This first study on the role of ER in eating behavior (Evers et al., 2010) was later extended by Taut et al. (2012) in that they reframed the focus of food intake after eating request (e.g., in a taste test) to eating in the first place when being free in the initiation to eat. Their proposition was that people with a maladaptive ER strategy like suppression would be more ineffective in ER and thus would have to rely more on eating as a secondary way of regulating their emotions. On the other hand, people using an adaptive ER strategy would be expected to initiate eating less frequently in the first place. The experiment showed that participants in the suppression condition initiated eating more frequently than in the reappraisal condition (three-quarters vs. one-third). However, participants in the control condition—in which emotions could simply be experienced and expressed—initiated eating as frequently as in the suppression condition. Accordingly, the total amount of food intake differed between the conditions, so that food intake was most in participants suppressing and expressing emotions (i.e., the control condition), while participants in the reappraisal condition ate significantly less (61%, and 68%, respectively) amounts of food. In summary, both studies (Evers et al., 2010; Taut et al., 2012) found evidence for the role of ER in eating behavior. Nonetheless, their generalizability remains limited as they both relied on short film excerpts as a negative emotion induction method, which may have been less impactful, as Evers et al. (2010) acknowledged themselves and also of limited practical relevance as compared to more fundamental negative experiences one may encounter in daily life.

The Present Study: Hunger, Emotion Regulation, and Eating Behavior

A familiar experience of daily life is hunger and it is not only a sensational experience but may also be accompanied by a whole range of increased negative emotions (Ackermans et al., 2022). This makes it a better candidate for a negative emotion induction method since its effects can be considered more profound in that several types of negative emotions (e.g., tension, fatigue, and anger) are increased and this state also may be expected to remain for a longer period of time than it is the case for the negative emotions after short movie exceptions in previous experiments. Moreover, especially dieters may be affected since they may be expected to report being hungry more often; there is at least evidence for more food cravings in dieters (Massey & Hill, 2012). If hunger leads to negative emotions (Ackermans et al., 2022) and these emotions are maladaptively regulated (e.g., via suppression) it may be that overeating is the result, which then is afterward reacted to by means of food restriction, leading to hunger again and thereby to a closed loop of disordered eating (Ackermans et al., 2022).

The aim of the present study was thus to test the effect of three conditions (suppression, reappraisal, and control) on the outcome measures of both studies, food intake (Evers et al., 2010) as well as eating initiation (Taut et al., 2012) in an experiment with hunger as the emotion induction method. Furthermore, the participants were given a free choice to eat as it was done in the study by Taut et al. (2012). It was argued that this study's setup may contribute to a better understanding of eating behavior in the case of (mal)adaptive ER strategies when faced with hunger and (as a result) negative emotions. Moreover, as an exploratory analysis, the ER approach to eating behavior can be contrasted in this study with the earlier approach of taking into account emotions only. The first hypothesis (eating initiation) states that participants will begin to eat more frequently in the suppression as compared to the reappraisal condition. However, based on the study by Taut et al. (2012),

participants in the control condition are proposed to begin to eat as frequently as the participants in the suppression condition. The second hypothesis (food intake) states that participants will have an overall higher food intake in the suppression as compared to the reappraisal and control condition. However, based on the study by Evers et al. (2010), participants in the control condition are expected to eat as much as participants in the reappraisal condition. In addition, it will be explored whether there is evidence for emotions alone to predict food intake. Based on the meta-analysis by Evers et al. (2018), it can be expected that negative emotions would have no effect on food intake, while positive emotions would have a small positive effect on food intake.

Methods

Participants

Eligible participants were women who were not underweight (i.e., BMI ≥ 18.5 kg/m^2). These were recruited by invitation in two ways: The first way was to recruit first-year psychology students from the University of Groningen via the psychology department's SONA system. The second way was to recruit participants from the general public via the psychology department's paid participants pool. A total of 142 participants signed up for the study. Of these, 20 (13%) were excluded because they either stopped participating in the study (n = 15) or they had their laboratory session scheduled after the day on which the data for this study were extracted (n = 5). In the final sample (N = 122), 99 participants were between 17 and 21 years old (M = 19.4, SD = 1.1), and 23 participants were older than 21 years. Women recruited from the SONA system were compensated with course credits (n = 115) and women from the paid participants pool were compensated with money (€11, n = 7) after participation was successfully completed.

Measures

Body Mass Index

To ensure participants met the eligibility criteria, both height and weight were measured in the laboratory and BMI was calculated.

Hunger

Fasting Duration. To check whether participants complied with the fasting instructions, the item "How long has it been since you last ate?" was adopted from the Hunger Scale (Grand, 1968). The time elapsed since they had last eaten had to be indicated in hours and minutes.

Subjective Hunger. To check whether abstaining from eating for 14 hr induced higher scores of subjective hunger when compared to having eaten within 2 hr (i.e., being satiated), the item "How hungry do you feel right now?" was adopted from the Hunger Scale (Grand, 1968). The item was answered on a 7-point Likert scale from 1 (*not hungry at all*) to 7 (*extremely hungry*).

Emotions

To assess participants' current states of negative and positive emotions, the Profile of Mood States (POMS; Grove & Prapavessis, 1992) was used. The POMS includes 40 items representing different emotions. The participants could indicate how much these emotions currently applied to them ranging from 1 (*not at all*) to 5 (*extremely*). Moreover, the POMS is divided into seven subscales, of which the internal consistency in this study ranged from acceptable to excellent. The negative emotion subscales are Anger (6 items; e.g., "angry" and "bitter"; $\alpha = .78$), Confusion (5 items; e.g., "confused" and "forgetful"; $\alpha = .67$), Depression (7 items; e.g., "hopeless" and "worthless"; $\alpha = .91$), Fatigue (5 items; e.g., "fatigued" and "exhausted"; $\alpha = .87$), and Tension (6 items; e.g., "tense" and "restless"; $\alpha = .83$). The

positive emotion subscales are Esteem-Related Affect (6 items; e.g., “proud” and “satisfied”; $\alpha = .62$), and Vigor (5 items; e.g., “lively” and “vigorous”; $\alpha = .80$).

Eating Measures

Eating Initiation. The analyses from the food intake measure below were used to code every participant as either 0 (if no total kilocalories [kcal] were consumed) or 1 (if any total kcal were consumed).

Food Intake. At the end of each laboratory session, the content of each of two bowls (of chips and M&Ms) was measured and the difference to the initial standardized weights (i.e., 50 g of chips and 150 g of M&Ms; see procedure) was calculated. Each difference in weight was first transformed into kcal and then they were summed up to represent a measure of the total kcal of food intake per participant.

Procedure

The present study was part of a larger research project, which was first approved by the ethics committee of the University of Groningen (PSY-2122-S-0426) before the recruitment of participants began. During recruitment, participants were told that the study was about hunger, emotions, and personality, although the latter was not true, but necessary to blind them from the fact that eating initiation and food intake were measured at the end of each laboratory session. After registration, every participant was run through two sessions with a researcher: an online meeting and an experiment in the laboratory. A flowchart of this procedure is displayed in Figure 1 (see Appendix). Before the online meeting, all participants were instructed to have eaten within 2 hr before the start of the meeting in order to attend it satiated. In the online meeting, which lasted for 20 min, all participants first gave their informed consent. They then completed online questionnaires in Qualtrics about hunger, emotions, and others not relevant to the current study (but to the larger research project). Meanwhile, the researcher remained present in the online meeting room to foster more

mindful answers and to allow the participant to ask questions anytime. At the end of the online meeting, the researcher and the participant scheduled a time slot for the subsequent laboratory experiment. The time between both sessions ranged from 1 to 23 days (M = 6.6, SD = 3.6). Finally, participants were instructed to not eat any food within 14 hr and to not drink any alcohol within 24 hr before the laboratory experiment took place. Drinking water, tea, and black coffee were allowed at any time.

Before the laboratory experiment, which consisted of a first and a second part, each participant was randomly assigned to the suppression (n = 36), reappraisal (n = 49), or control condition (n = 37). Upon arrival in the laboratory, compliance with the 14 hr fasting instruction was first checked by requesting verbal confirmation. If compliance was unsuccessful, a new time slot was scheduled. If compliance was successful, the first part of the experiment started and the participant was seated at a desk with a computer to answer the same questionnaires from the online meeting on hunger and emotions again in Qualtrics. Next, and depending on the assigned condition, participants received a specific audio instruction (i.e., ER manipulation) via headphones which was embedded in the Qualtrics questionnaire. Participants in the suppression condition were asked to apply the behavioral strategy by pretending they had not fasted and by not expressing any negative emotions—especially in their faces—for the remainder of the study. Participants in the reappraisal condition were asked to apply the cognitive strategy by focusing on a positive interpretation of fasting (i.e., regulating blood sugar and giving the digestive system a break) for the remainder of the study. Participants in the control condition were simply asked to do a visualization exercise (i.e., imagining a nearby park and walking through it). Across all three conditions, participants were given 3 min to mentally practice the strategy (suppression and reappraisal condition) or do the visualization exercise (control condition) before they could continue with the questionnaire. Finally, participants were asked to fill in the questionnaire on

emotions—in order to measure any changes induced by the particular condition—and other questionnaires not relevant to this study.

In the second part of the experiment, participants were guided into a room next door. The participants were seated at a desk with a computer in front of which a bowl of chips and a bowl of M&Ms had been placed. Each of these bowls contained a standardized amount of food, that is, 50 g (254 kcal) of chips and 150 g (721.5 kcal) of M&Ms. The participants were asked to watch a video clip (i.e., a video of a nature scene) and fill out questionnaires (i.e., questions about the video clip and a personality questionnaire). Moreover, the participants were informed that fasting was no longer important for the second part of the experiment and that they were therefore allowed to eat as much as they wanted from the food provided. Further, if the participants were assigned to one of the two ER conditions, it was emphasized that it was important to remember the previous ER instructions while completing the subsequent tasks. However, if the participants were assigned to the control condition no such reminder was given. Finally, the participants were informed that the researcher would come back after 20 min to get the participant (this was to ensure all participants were exposed to the food bowls provided for the same amount of time). Actually, the tasks assigned in the second part of the laboratory experiment were only filler tasks with no relevance to the study but were used to give the participants the opportunity to eat to measure eating initiation and food intake.

At the end of the experiment, participants were lastly asked whether the researcher could measure their height and weight. After the participants had left the room, the researcher measured the food left in the bowls—unknown to the participants—to calculate the total kcal consumed, if any. At the end of the data collection of the larger research project, all participants will be debriefed from the blinding and given a full explanation of the true purpose of the study via e-mail.

Statistical Analyses

The statistical analyses were all performed with SPSS (version 28). To first check compliance with the eating instruction for the online meeting, it was analyzed when participants had last eaten and participants above the cut-off score of 2 hr were deleted from the data set. To check compliance with the fasting instruction for the laboratory experiment, the participants' fasting duration was analyzed and participants below the cut-off score of 14 hr were deleted from the data set. To check compliance with the selection criterium of not being underweight, participants' BMI was analyzed and participants below the cut-off score of BMI = 18.5 were deleted from the data set. After the exclusion of the participants who did not comply or had missing data, a sensitivity analysis for the remaining data set was conducted.

To check whether the duration the participants had not eaten (fasted) was indeed longer before the laboratory compared to the online session a pairwise *t*-test was conducted. To check whether the manipulation of hunger was successful, a pairwise *t*-test was used to assess the significance of the difference between subjective hunger in the online compared to the laboratory session. For both tests, Cohen's *d* was used as a measure of effect size. To check whether the intensity of negative and positive emotions was indeed changed by the induction of hunger through fasting, two separate one-way repeated measures multivariate analysis of variance (MANOVA) were performed with timepoint (online vs. laboratory session [pre-ER manipulation]) as the independent variable and negative emotions (anger, confusion, depression, fatigue, and tension), and positive emotions (esteem-related affect, vigor), respectively, as the dependent variables. As a measure of effect size, partial eta squared was analyzed for both MANOVAs. If significant, the MANOVA was followed up with a one-way analysis of variance (ANOVA) for each emotion.

To check whether the ER manipulation had an effect on the intensity of negative as well as positive emotions and whether there was an interaction effect between condition and timepoint present, two separate mixed repeated measures MANOVA were performed with the condition (suppression vs. reappraisal vs. control) as the between-subjects and timepoint (laboratory session pre-ER vs. post-ER manipulation) as the within-subjects factor on the dependent variables negative, and positive emotions, respectively. As a measure of effect size, partial eta squared was analyzed for both MANOVAs.

The first hypothesis (eating initiation) was investigated by conducting an independent 3x2 chi-square test with the predictor variable condition (reappraisal vs. suppression vs. control) on the outcome variable eating initiation (yes vs. no). Cramer's *V* was used as a measure of effect size. If the 3x2 chi-square test was significant, chi-square tests for all pairs were conducted. The power analysis using G*Power (version 3.1; Faul et al., 2009) indicated that to achieve 80% power for a medium effect at $\alpha = .05$, a minimum sample size of $N = 108$ is required.

The second hypothesis (food intake) was investigated by conducting a one-way ANOVA with the predictor variable condition on total food intake (kcal). If the ANOVA was significant, independent *t*-tests for all pairs were conducted. Eta squared was used as a measure of effect size. The power analysis using G*Power (version 3.1; Faul et al., 2009) indicated that to achieve 80% power for a total medium effect at $\alpha = .05$, a minimum sample size of $N = 159$ is required.

Additionally, one exploratory analysis was performed: To test whether the intensity of negative or positive emotions measured in the laboratory post-ER had an effect on total food intake, two multiple regression analyses were performed with negative and positive emotions post-ER as the independent, and total food intake (kcal) as the dependent variable. For both regression analyses, R-squared was used as a measure of effect size.

Results

Compliance

Most participants (*n* = 100, 83%) had eaten within the last 2 hr before the start of the online meeting as instructed. Nine-teen participants had eaten lastly between 135 and 870 min (i.e., > 2 hr) and three participants did not fill out the question on fasting duration. Thus, these 22 participants were removed from the data set. Most participants (*n* = 111, 91%) came to the laboratory after having fasted for at least 14 hr as instructed. The remaining 11 participants did not comply with the fasting instructions as they indicated a fast below 14 hr ranging from 0 to 13 hr and were thus excluded from the analyses. In four cases, participants' BMI was below 18.5 kg/m². These participants were therefore excluded from the analyses. Furthermore, one participant did not want to be weighed, hence the BMI could not be computed and the participant was excluded from the analysis.

After the exclusion of the mentioned participants, a total of 88 cases with 23 participants in the suppression, 35 in the reappraisal, and 30 in the control condition remained for the analyses. Accordingly, the sensitivity analysis yielded that an effect size greater than 0.33 (i.e., medium effect or larger) could reliably be found with $\alpha = .05$ and 80% power for the first hypothesis (eating initiation). The final sample size of 88 participants also established that an effect size greater than 0.34 (i.e., medium effect or larger) could reliably be found with $\alpha = .05$ and 80% power for the second hypothesis (food intake).

Descriptive Statistics

Table 1 contains descriptive statistics for this study's sample: BMI, the fasting duration and subjective hunger both in the online and the laboratory session, and the total kcal consumed in the laboratory session.

Table 1

Descriptive Statistics of the Study Sample

Variable	Online		Laboratory		Between sessions		
	M	*SD*	*M*	*SD*	*t*	*p*	*d*
BMI	–	–	22.9	3.0	–	–	–
Fasting duration	0.4	0.5	15.0	1.7	-79.47	< .001	8.472
Subjective hunger	1.8	1.1	4.8	1.4	-17.38	< .001	1.853
Total kcal	–	–	141.9	163.0	–	–	–

Note. $N = 88$. All statistics displayed are derived from the sample as a whole (i.e., all conditions taken together) after participants who met the exclusion criteria were removed from the data set.

Manipulation Checks

The difference in hours between the participants' fasting duration in the online session and in the laboratory session was large: The participants had fasted for a longer time when attending the laboratory as compared to the online session (Table 1). Moreover, the difference in participants' subjective hunger between the online session and the laboratory session was large: The participants reported on having much more hunger when attending the laboratory as compared to the online session.

When the participants were in the laboratory and the ER manipulation had not yet been applied, their negative emotions ($M = 1.8$, $SD = 0.7$) were more negative in comparison to the previous online session ($M = 1.6$, $SD = 0.7$); this effect was large, Pillai's Trace = .388, $F(5, 83) = 10.54$, $p < .001$, $\eta p^2 = .388$. In detail, there were differences in anger, $F(1, 87) = 35.06$, $p < .001$, $\eta p^2 = .287$, confusion, $F(1, 87) = 8.36$, $p = .005$, $\eta p^2 = .088$, depression, $F(1, 87) = 4.36$, $p = .040$, $\eta p^2 = .048$, and fatigue, $F(1, 87) = 15.82$, $p < .001$, $\eta p^2 = .154$, but not in tension, $F(1, 87) = 1.55$, $p = .217$, $\eta p^2 = .017$. On the contrary, participants' positive emotions were less positive between the online ($M = 2.8$, $SD = 0.8$) and the laboratory session ($M = 2.5$,

SD = 0.9); this effect was large, Pillai's Trace = .300, $F(2, 86) = 18.45$, $p < .001$, $\eta p^2 = .300$. In detail, there were differences in esteem-related affect, $F(1, 87) = 22.60$, $p < .001$, $\eta p^2 = .206$, and vigor, $F(1, 87) = 30.02$, $p < .001$, $\eta p^2 = .257$.

When participants' emotions were measured in the laboratory post-ER manipulation, their negative emotions (*M* = 1.5, *SD* = 0.6) were less negative in comparison to the pre-ER manipulation measurement (*M* = 1.8, *SD* = 0.7), thus, timepoint (pre- vs. post-ER manipulation) had a main effect on negative emotions. This effect was large, Pillai's Trace = .400, $F(5, 81) = 10.82$, $p < .001$, $\eta p^2 = .400$. In detail, there were differences in anger, $F(1, 85) = 30.30$, $p < .001$, $\eta p^2 = .263$, confusion, $F(1, 85) = 20.17$, $p < .001$, $\eta p^2 = .192$, depression, $F(1, 85) = 28.17$, $p < .001$, $\eta p^2 = .249$, fatigue, $F(1, 85) = 50.55$, $p < .001$, $\eta p^2 = .373$, and tension, $F(1, 85) = 17.96$, $p < .001$, $\eta p^2 = .174$. On the contrary, participants' positive emotions were more positive between the pre- (*M* = 2.5, *SD* = 0.9) and post-ER manipulation measurements (*M* = 2.6, *SD* = 0.9), thus, timepoint (pre- vs. post-ER manipulation) had a main effect on positive emotions. This effect was medium, Pillai's Trace = .092, $F(2, 84) = 4.27$, $p = .017$, $\eta p^2 = .092$. In detail, there were differences in esteem-related affect, $F(1, 85) = 7.07$, $p = .009$, $\eta p^2 = .077$, and vigor, $F(1, 85) = 6.35$, $p = .014$, $\eta p^2 = .070$. The interaction between timepoint (pre- vs. post-ER manipulation) and condition (suppression vs. reappraisal vs. control) on negative emotions was not significant, Pillai's Trace = .168, $F(10, 164) = 1.50$, $p = .144$, $\eta p^2 = .084$. Thus, the condition a participant was assigned to did not make a significant difference in the degree to which negative emotions were decreased between both timepoints. The interaction between timepoint and condition on positive emotions was also not significant, Pillai's Trace = .085, $F(4, 170) = 1.89$, $p = .114$, $\eta p^2 = .043$. Thus, the condition did not make a significant difference in the degree to which positive emotions increased between both timepoints.

Main Results

Hypothesis 1: Eating Initiation

There was no effect of the condition on eating initiation, $\chi^2(2, 88) = 0.78$, $p = .677$, Cramer's $V = .094$. Thus, there were no significant differences in eating initiation (yes vs. no) between the different conditions (suppression vs. reappraisal vs. control) and the first hypothesis was rejected. See Table 2 for further statistics for each condition.

Hypothesis 2: Food Intake

There was no effect of the condition on food intake, $F(2, 84) = 0.48$, $p = .619$, $\eta^2 = .011$. Thus, there were no significant differences in food intake (kcal) between the three conditions and the second hypothesis was rejected. See Table 2 for further statistics for each condition.

Table 2

Eating Initiation and Food Intake in and Between the Three Conditions

	Suppression		Reappraisal		Control		Between-condition test	
	M	*SD*	*M*	*SD*	*M*	*SD*	*p*	Effect size
Eating initiation (% "yes")	78.3	–	74.3	–	83.3	–	.677	.094 (*V*)
Food intake (total kcal)	157.0	175.2	120.4	140.8	154.8	179.1	.619	.011 (η^2)

Note. $N = 88$ ($n = 23$ for suppression, $n = 35$ for reappraisal, and $n = 30$ for control).

Additionally, the intensity of negative emotions after the emotion manipulation had no effect on food intake, as the overall regression was not significant, $F(5, 81) = 0.87$, $p = .507$, $R^2 = .051$. The intensity of positive emotions after the emotion manipulation also had no effect on food intake, as the overall regression was not significant, $F(2, 84) = 0.10$, $p = .907$, $R^2 = .002$.

Discussion

The purpose of this study was to gain a better understanding of the role of ER in eating behavior by conducting an experiment with ER as an intervention. Against the background of the ineffectiveness of most current weight loss interventions (e.g., Wadden et al., 2011), the experiment was also aimed at informing the development of more effective interventions, with ER as an important mechanism to understanding eating behavior at its core. Focusing on the role of ER in eating behavior differed from most previous approaches reported in the literature that targeted the role of emotions (Evers et al., 2018). What is more, these previous approaches often exclusively explored negative emotions (e.g., Chua et al., 2004), overlooking the role of positive emotions. To investigate the ER approach, the experiment was designed with three conditions (suppression, reappraisal, and control) and tested two central hypotheses. The first hypothesis (eating initiation) stated that participants would begin to eat more frequently in the suppression as compared to the reappraisal condition. Participants in the control condition were proposed to begin to eat as frequently as the participants in the suppression condition. The second hypothesis (food intake) stated that participants would have an overall higher food intake in the suppression as compared to the reappraisal and the control condition. Participants in the control condition were expected to eat as much as participants in the reappraisal condition. In addition, it was argued that an additional analysis of the value of emotions alone (i.e., not ER) in predicting food intake would be a useful replication of the approach most commonly found in the existing literature (Evers et al., 2018).

The present study did not find evidence for the first hypothesis (eating initiation). Consequently, it seemed that it did not make a difference whether participants began to eat if they had been practicing to suppress their emotions or reappraise their emotions, or if they were not practicing at all. This study also did not find evidence for the second hypothesis

(food intake). Thus, there were no significant differences in food intake between the three conditions (suppression vs. reappraisal vs. control). Interestingly, there was no evidence neither for negative nor positive emotions to predict food intake (additional analysis). Besides the two central hypotheses, there was evidence, however, that the hunger manipulation was effective. There was a large effect in the difference in participants' subjective hunger between the online and the laboratory session: As expected, participants reported on feeling more hungry in the laboratory session. Furthermore, there was a large effect in both participants' negative and positive emotions between the online and the laboratory session: Participants reported on having more negative and less positive emotions in the laboratory session. While participants' negative emotions decreased (large effect) and positive emotions increased (medium effect) between the laboratory session pre-ER and post-ER manipulation measurements, the condition had no effect on this change. Thus, there were no differences between conditions in the degree to which the intensity of negative and positive emotions changed through the ER manipulation.

Implications

The rejection of the first hypothesis (eating initiation) is partly not in line with the results of the study by Taut et al. (2012) because in their study participants in the suppression condition initiated eating more frequently than in the reappraisal condition. Nonetheless, in their study participants in the control condition initiated eating as frequently as participants in the suppression condition which is in line with the present study. The rejection of the second hypothesis (food intake) is partly not in line with the results of the study by Evers et al. (2010) because in their study participants in the suppression condition had a higher food intake as participants in the reappraisal condition. Nonetheless, in their study participants in the control condition had the same food intake as participants in the reappraisal condition which is in line with the present study. However, on a merely descriptive level, the present study pointed

toward a lower food intake in the reappraisal condition as compared to both the suppression and the control condition. After the end of the data collection of the larger project, it might be worth testing whether this descriptive observation has also become statistically significant.

Besides the two central hypotheses, the non-significance of the additional analysis of negative emotions as a predictor of food intake was in line with the meta-analysis by Evers et al. (2018). That is, the meta-analysis also reported no significant effect of negative emotions on food intake (except for the sub-group of restricted dieters). However, the non-significance of the additional analysis of positive emotions as a predictor of food intake was not in line with the meta-analysis by Evers et al. (2018). That is, the meta-analysis did find that positive emotions predicted food intake, even though this effect was small. As reported in the sensitivity analysis of the present study, there was not enough power to reliably detect a small effect. Thus, a potential effect of positive emotions on food intake may have remained undetected. Moreover, the successful manipulation of hunger and thereby induction of more negative and less positive emotions in the laboratory session was a successful replication of the results of a previous study on hunger and emotions (Ackermans et al., 2022). While the ER manipulation induced a change in emotions, it can only be seen as partly successful since the change was indifferent to the conditions (see limitations for a further interpretation).

Strengths and Limitations

The present study had several strengths: some related to the procedure and others related to the design of the experiment. With regard to the procedure, a first strength was that participants completed the online session with a researcher present which may have fostered more mindful answers to the questionnaires. Second, participants were instructed to fast for 14 hr prior to participating in the laboratory session, which was an extensive fast, reflected in the successful manipulation of subjective hunger. Third, although different researchers guided the participants through the experiment, all researchers did so according to a standardized

protocol to ensure equality of circumstances in the laboratory. Further, depending on the condition, ER instructions were given via recorded audio rather than by the researcher in person for standardization purposes. Fourth, when participants were given the opportunity to eat in the second part of the laboratory experiment (see Appendix), they were unobserved in a second room to ensure that the mere presence of the researcher could not influence their eating behavior (e.g., by an evocation of shame).

With regard to the design of the experiment, a first strength was that a fasting instruction was used to induce hunger and thereby negative emotions of a broad spectrum were increased, presumably, over a long period of time. In previous experiments on ER and eating behavior (Evers et al., 2010; Taut et al., 2012) less impactful emotion induction procedures such as fear-evoking movie excerpts were used. Moreover, the experience of hunger may be expected especially in dieters and thus hunger is more relevant to the context of eating behavior. Second, the laboratory experiment included a control group which ensured the internal validity of the study. Third, negative emotions were measured extensively: five different negative emotions were measured over three time points. This made it possible to test the effect of hunger on a broad array of negative emotions and also to test whether the ER manipulation indeed changed also the intensity of emotions. Moreover, positive emotions were measured as well, which had previously been somewhat neglected in the literature (Evers et al., 2013). Fourth, not only food intake but also eating initiation were measured, which replicated the outcome measures of both previous studies on ER and eating behavior (Evers et al., 2010; Taut et al., 2012).

Nonetheless, the present study had also several limitations. Some of these limitations were related to the study sample and others were related to the design of the experiment. With regard to the sample, a first limitation was that the final sample of $N = 88$ was lower than the required sample size as established a priori in the power analysis. Thus, a larger sample size

could possibly still find evidence for the hypotheses on eating initiation and food intake. Importantly, the data collection of the larger research project is still ongoing and the hypotheses thus could be checked again in the future. Second, the sample consisted only of female participants with a university education level and mostly a healthy BMI (M = 22.9, SD = 3.0). Thus, it remains unclear to what extent the results generalize to other populations. Future research may address this by including samples of participants with eating disorders.

With regard to the design of the experiment, a first limitation was that the ER manipulation did not affect emotions differently according to condition. Based on the research of Gross (2002) it would have been expected that a maladaptive ER strategy like suppression would not change negative emotions but reduce positive emotions. On the other hand, the reappraisal would have been expected to reduce negative emotions and increase positive emotions (Gross, 2002). The control condition would have been expected to have no significant effect on emotions. However, in part, the ER manipulation may have not changed emotions according to the condition differently because the control condition involved a visualization exercise. It may be the case that visualizing oneself going through a nearby park had a calming effect on the participants which also reduced negative emotions and increased positive emotions. Future research may address this potential issue by including a more neutral control condition. For instance, a visualization of going through the academy building may be a more neutral environment (i.e., less calming than going through a green park). Second, it is unclear to what extent the ER manipulation at the end of the first part of the laboratory experiment (see Appendix) carried over to the second part when the participants had to apply the ER strategies when completing the filler tasks. Future research may address this by increasing the practice time for the ER strategies (present study: 3 min). A future experiment may also demand participants to more actively practice the ER strategies: Instead

of mere rehearsal, participants may be asked to come up with an example of how they would apply the ER strategy they were assigned to in a specific example of daily life.

Conclusion

In conclusion, this study is one of few exploring the role of ER in eating behavior by considering both individuals' initiation to eat and their food intake in an experimental intervention study. To do so, the present study successfully induced more intense negative and less intense positive emotions in individuals by instructing them to fast for at least 14 hrs. Since the two central hypotheses were rejected but the sample size was not large enough to detect small to medium effect sizes, future studies may replicate the present study with a larger sample size and try to overcome the reported limitations of the present study (e.g., by including participants with eating disorders in the sample). Thereby, the understanding of the role of ER in eating behavior may be extended with the potential of informing more effective interventions for OW/OB in the future.

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Appendix

Figure 1

Flowchart of the Online and Laboratory Sessions