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Targeting binge eating in bulimia nervosa and binge eating disorder using inhibitory control training and implementation intentions: A feasibility trial

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Abstract

Background. This trial examined the feasibility, acceptability, and effect sizes of clinical outcomes of an intervention that combines inhibitory control training (ICT) and implementation intentions (if-then planning) to target binge eating and eating disorder psychopathology.

Methods. Seventy-eight adult participants with bulimia nervosa or binge eating disorder were randomly allocated to receive food-specific, or general, ICT and if-then planning for four weeks.

Results. Recruitment and retention rates at four weeks (97.5% and 79.5%, respectively) met the pre-set cut-offs. The pre-set adherence to the intervention was met for the ICT sessions (84.6%), but not for if-then planning (53.4%). Binge eating frequency and eating disorder psychopathology decreased in both intervention groups at post-intervention (four weeks) and follow-up (eight weeks), with moderate to large effect sizes. There was a tendency for greater reductions in binge eating frequency and eating disorders psychopathology (i.e. larger effect sizes) in the food-specific intervention group. Across both groups, ICT and if-then planning were associated with small-to-moderate reductions in high energy-dense food valuation (post-intervention), food approach (post-intervention and follow-up), anxiety (follow-up), and depression (follow-up). Participants indicated that both interventions were acceptable.

Conclusions. The study findings reveal that combined ICT and if-then planning is associated with reductions in binge eating frequency and eating disorder psychopathology, and that the feasibility of ICT is promising, while improvements to if-then planning condition may be needed.

Key words: binge eating, eating disorders, feasibility, goal planning, if-then planning, inhibitory control training, trial.

Introduction

Eating disorders are complex medical and psychiatric conditions that are responsible for a significant increase in morbidity and mortality, and rank among the ten leading causes of disability among young women (Vos & Mathers, 2000). Bulimia nervosa (BN) and binge eating disorder (BED) are eating disorders characterised by episodes of loss of control over eating and intense perceived distress associated with those. Overeating is often compensated for by patients with BN, through practices such as dietary restraint, purging and over-exercise; whereas patients with BED do not typically use successful compensatory behaviours. While cognitive-behavioural therapy (CBT) is regarded as the treatment-of-choice for BN and BED (Wilson, Grilo, & Vitousek, 2007), it is only moderately effective, with fewer than 50% of patients with BN, and slightly over 50% of patients with BED, achieving abstinence at the end of treatment (Hay, 2013). It is possible that interventions targeting some of the mechanisms that underpin binge eating can provide a useful augmentation to standard treatment.

Binge eating behaviours are often exhibited among individuals with high levels of impulsivity (Schag *et al.*, 2013; Davis, 2013), a trait characterised by poor inhibitory control (i.e. weak control over impulsive responses) and heightened reward sensitivity (i.e. high degree to which individuals' behaviour is motivated by rewarding stimuli) (Dawe and Loxton, 2004). Based on this model, people with binge eating would experience greater motivation to approach palatable foods and would act impulsively on this motivation. A recent systematic review discussed findings from 20 studies investigating food-related impulsivity in BED and obesity and found that patients with BED experience increased reward for food stimuli and a greater tendency for rash-spontaneous behaviour (i.e. decreased inhibitory control) towards food and also in general, compared to normal weight individuals (Giel et al., 2017). Furthermore, studies using neurocognitive tasks indicate that individuals

with binge eating have deficits in executive functioning (Smith, Mason et al., 2018) and a meta-analysis of studies in binge-purge anorexia nervosa, BN and BED identified deficits in response inhibition using the go/no-go paradigm across clinical groups, compared to healthy individuals (Wu et al., 2013). The extent to which these deficits are specific to food stimuli, and/or rather generic, is less conclusive (e.g. Manasse et al., 2016 for evidence related to generic deficits; Svaldi et al., 2014 for evidence related to food-specific deficits), but there are some indications that they might be stronger for disorder-relevant stimuli, such as food (Giel et al., 2017; Svaldi et al., 2014; Wu et al., 2013).

Based on these findings, it is possible to argue that increased reward sensitivity and decreased inhibitory control are maintenance mechanisms of binge eating disorders. It follows that addressing these mechanisms might be associated with reduced eating disorder psychopathology. Indeed, there has been interest in developing treatments that strengthen inhibitory control and moderate reward sensitivity to food cues (van Koningsbruggen, Veling, Stroebe, & Aarts, 2017). 'Top-down' approaches aim to suppress impulsive processes by strengthening the influence of cognitive processes on behaviour (see Adriaanse et al., 2011). One example is goal planning through implementation intentions (i.e. if-then plans). Implementation intentions (also known as if-then plans) consist of specifying action plans to disrupt unhelpful habits, by predicting and counteracting possible triggers of these behaviours (Adriaanse *et al.*, 2011). Systematic reviews and meta-analyses have concluded that implementation intentions increase healthy food consumption, decrease the consumption of 'highly palatable' foods, and reduce fat intake in healthy populations (Adriaanse et al., 2011; Turton *et al.*, 2016) and overweight/obese individuals (Vilà, Carrero, & Redondo, 2017). Another approach to strengthening inhibitory control and reducing reward sensitivity to food cues is to use 'bottom-up' approaches to change 'seemingly' automatic reactions to stimuli (see Houben and Jansen, 2011; Lawrence *et al.*, 2015). Food-specific inhibitory

control training (ICT) is a bottom-up intervention that regulates automatic impulses towards palatable food cues by associating them with motor inhibition (Jones et al., 2016; Veling et al., 2017). Meta-analyses conducted among pre-clinical samples indicate that food-specific ICT, as opposed to general (non-food) ICT and food-go control is associated with greater reductions in high energy-dense food intake (Allom *et al.,* 2015; Jones *et al.,* 2016). Moreover, chocolate-specific ICT reduces desire to eat and chocolate intake (Houben & Jansen, 2015). Studies in clinical samples suggest that food-specific ICT is effective in reducing eating disorder pathology, body fat, weight, and energy-dense food consumption (Giel et al., 2017; Preuss et al., 2017; Stice et al., 2017; Turton et al., 2018). When food-specific inhibitory control training was compared to generic inhibitory control training, then no between-group significant differences were found in terms of food consumption, which might be due to the low dose of training completed (Turton et al., 2018; Aulbach et al., 2020). Several previous studies have shown that completing 4 sessions of food-related ICT over 1-4 weeks leads to reduced weight and reduced food intake (Camp & Lawrence, 2019; Lawrence et al., 2015; Veling et al., 2014). Possible ways to boost the effect of training are to repeat it over time and combine it with a complementary approach that targets top-down processes. One previous study examined whether combined food-specific ICT and implementation intentions would reduce self-serving of sweets among healthy students. While both interventions were effective, there was no additional benefit of combining them (van Koningsbruggen, Veling, Stroebe, & Aarts, 2017). To our knowledge, repeated training sessions and this combined approach remains untested among individuals with eating disorders.

Our primary objective was to assess the feasibility (recruitment, adherence, and retention rates) of combined go/no-go training and if-then planning among individuals with bulimia nervosa and binge eating disorder. Feasibility was defined as 1) recruitment of 75% of

the target number (N = 80), 2) adherence to ICT, with ≥ 75% of participants completing at least four training sessions within four weeks (a possible minimum effective dose based on previous research); 3) adherence to implementation intentions sessions, with ≥ 75% of the participants developing a plan with the mentor and implementing the plan, and 4) ≥ 80% retention in the study at four weeks. Furthermore, we described effect sizes for between-group (food-specific inhibitory control training vs. general inhibitory control training) and within-group (pre vs. post-training) differences in binge eating frequency and eating disorder psychopathology (primary outcomes) and weight, self-regulation of eating, food valuation, food approach, depression and anxiety (secondary outcomes). Feedback forms and focus groups were used to explore participants' views of the helpfulness, possible harms, practicality, and potential improvements to the intervention methodology. The evidence of feasibility and the effect size of changes in clinical outcomes will inform the procedures and sample size of a definitive trial (Eldridge et al., 2016).

Methods

Participants

Participants were recruited through eating disorder charity websites, social media, flyers, and eating disorder services (N = 6). Eligibility required that participants met full-threshold criteria for bulimia nervosa or binge eating disorder according to the *Structured Clinical Interview for DSM-5*, had a Body Mass Index (BMI) of at least 18.5, were between the ages of 18 and 60, were fluent in written/spoken English, and were willing to meet the research team on two occasions for face-to-face assessment. Participants were excluded if they were currently pregnant, had a visual impairment that could not be repaired with eyewear, a neurological impairment, alcohol or drug dependence, or psychosis.

Trial Design and Randomization

Seventy-eight participants with bulimia nervosa (N = 40) or binge eating disorder (N = 38) were recruited and randomly allocated into a food-specific (N = 40) or general (N = 38) intervention. A random number generator (https://www.randomizer.org) was used to assign consecutive participants to the intervention arms. See the Consort Diagram below (figure 1) for further details on the flow of participation.

----------Figure 1----------

Sample Size

Recommendations of sample sizes for feasibility studies indicate that it is appropriate to recruit between 24 and 50 participants per arm (Lancaster, Dodd, Williamson, 2004; Sim & Lewis, 2012; Julious, 2005). Moreover, previous research using identical versions of food-specific and general ICT in overweight adults (Lawrence et al., 2015), detected group differences in weight loss with a sample size of 40 participants per intervention group. Thus, our target sample size was 40 participants per intervention group.

Interventions

Inhibitory Control Training (go/no-go)

The ICT used in the present study was developed at the University of Exeter (Lawrence *et al.*, 2015). Participants were invited to complete the ICT training daily for four weeks. The completion of each session was recorded through the software and associated to a time stamp. The training involved go and no-go trials. Go trials and no-go trials were signified by a non-bold frame surrounding the picture and bold frame surrounding the picture, respectively (figure 2). Thirty-six pictures were individually presented on the left- or right-hand side of a computer screen for 1250ms, with a 1250ms inter-stimulus interval. During the go trials, participants were required to press ‘c’ or ‘m’ depending on the location

of the picture on the screen (‘c’ for left and ‘m ‘for right). During the no-go trials, participants had to withhold their response. Each of the 36 pictures was presented once per block, and participants completed six blocks per training session. They were encouraged to respond as quickly and accurately as possible and were given feedback regarding accuracy and speed (mean reaction time) between blocks.

In the food-specific ICT, the stimuli consisted of nine low-energy dense food pictures (e.g. fruits, vegetables, and rice cakes), nine high-energy dense foods food pictures (e.g. chocolate, cake, and crisps), and 18 filler pictures (i.e. clothing items). The high energy-dense food pictures were always paired with no-go signals, resulting in 54 high energy-dense food no go trials, while the ‘healthy’ food pictures were always paired with go signals, resulting in 54 healthy food go trials. The filler pictures were equally associated with go and no-go signals. The purpose of the filler items was to make the task more unpredictable and challenging, and to avoid making the aim too obvious to the participants (Lawrence *et al.*, 2015). In the general ICT, participants completed an almost identical task, apart from the 18 food pictures being replaced with pictures of tools and stationery (see Lawrence et al., 2015 for details). Food and non-food pictures were matched, as closely as possible, for size, colour, and visual complexity. Moreover, the rectangular frame always appeared against a white background. See figure 2 for an example of the stimuli used.

----------Figure 2----------

Implementation Intentions (if-then planning)

Participants were encouraged to identify an unhelpful habit, reflect on situations and motivations that are likely to precede the unhelpful behaviour, and then design an alternative behaviour. They were asked to write down their if-then plan and to indicate whether or not they had successfully implemented their planned alternative behaviour. Each participant was assigned one mentor, who followed up with them via email once per week for four weeks.

Mentors provided regular feedback to facilitate the development and implementation of the plan. In total, seven mentors were trained in delivering implementation intentions. Two mentors (GA and ML) were Psychology PhD candidates, three mentors had completed a BSc in Psychology (DW, NR, and SR), one mentor was a medical doctor completing a psychiatry residency (EC), and one mentor had completed a BSc in Nutrition and Dietetics (KB). All mentors were trained by the lead researcher (RC) and supervised by a clinical psychologist (VC). In the food-specific intervention group, participants were encouraged to select an unhelpful habit that relates to their eating behaviour (e.g. *If I am home alone and feeling anxious, then I will listen to a self-compassion meditation for 10 minutes*). In the general intervention group, participants were encouraged to select an unhelpful habit that is unrelated to their eating behaviour (e.g. *If I argue with a friend and feel upset, then I will ask them to meet to discuss what has upset me*.) The successful implementation of the plan was measured by ensuring that participants included both a situational and motivational cue in their plan and assessing whether they proposed an appropriate alternative behaviour (e.g. not simply a negation of the unhelpful habit).

Baseline assessment

Demographics. Participants completed a *demographic questionnaire*, which included questions relating to age, gender, weight, height, ethnicity, marital status, years spent in education, employment status, current/previous mental health support received, and use of psychiatric medication.

Eating Disorder Diagnosis. The *Structured Clinical Interview for DSM-5 (SCID-5;* First, 2014) was used to confirm a diagnosis of bulimia nervosa or binge eating disorder.

Measures and cut-off of feasibility and acceptability

For go/no-go training task completion, the total number of completed trainings across 28 days was calculated. The adherence cut-off was evidenced by ≥ 75% of participants completing ≥ four training sessions. Whilst participants were encouraged to complete the ICT daily, there is no known minimum effective dose of food-ICT. Three real-world studies have demonstrated weight-loss or reduced food intake following four sessions of food go/no-go training completed over one week or one month (Camp and Lawrence, 2019; Lawrence et al., 2015; Veling et al., 2014). Therefore, the present study's adherence to ICT was set as the proportion of participants who completed at least this minimum dose of four training sessions at home (in addition to the two sessions completed in the lab).

For if-then planning, every mentor scored their participants' engagement on a 4-point Likert scale: 1) no engagement (scored 0), 2) engagement with no successful planning or implementation of goal (scored 1), 3) engagement with partially successful implementation of goal (scored 3), and 4) engagement with successful implementation of goal (scored 4). The scores were re-assessed by the lead researcher (RC). In cases where disagreement was evident, these were discussed and revised. The adherence cut-off was evidenced by ≥ 75% of participants receiving a score of 3 or 4. Acceptability was measured using feedback forms and focus groups (please refer to Supplementary Materials 3).

Clinical outcomes

Primary outcomes. Eating disorder psychopathology was assessed using the Eating Disorder Examination Questionnaire (EDE-Q; Fairburn, 2008), a 28-item self-report of eating behaviours in the previous 28 days. The questionnaire comprises four subscales: dietary restraint (DR), eating concern (EC), weight concern (WC), and shape concern (SC). In this study, we considered item 15 as a standalone outcome to assess binge eating frequency (*Over the last 28 days, on how many days have such episodes of overeating*

occurred (i.e. you have eaten an unusually large amount of food and have had a sense of loss of control at that time)?

Secondary outcomes. These included: (1) weight, (2) self-regulation of eating (Self-Regulation of Eating Behaviour Questionnaire; Kliemann, Beeken, Wardle, & Johnson, 2016), (3) food valuation (rating of liking for trained foods using a visual analogue scale ; Lawrence et al., 2015), (4) food approach (The Adult Eating Behaviour Questionnaire; Hunot et al., 2016), (5) depression (Patient Health Questionnaire-9; Kroenke et al., 2001) and anxiety (Generalised Anxiety Disorder-7; Spitzer et al., 2006). These questionnaires (including reliability indexes) are described further in Supplementary Materials 4.

Procedure

After consent, participants were sent the baseline battery of questionnaires via Qualtrics (i.e. online platform) and entered the lab for a baseline assessment. During the lab session, participants had their weight measured. They completed the food-rating test and completed a session of the food-specific and general go/no-go training during EEG recordings (EEG findings not reported in the present manuscript). After random allocation to one of the two intervention groups (food-specific vs. general), they were encouraged to complete the online ICT training on their computers daily and to work on if-then plans with their mentor weekly for four weeks. They were also encouraged to complete a daily food diary. The purpose of the daily food diary was to assess the relationship between potential predictors of binge eating (e.g. restriction, meal skipping, negative mood) on the probability of binge eating. Given that this involved ecological momentary assessment, analyses and results will be presented in a separate manuscript.

Between 28 and 32 days from baseline session, participants completed the post-intervention questionnaires and re-entered the lab for the post-intervention assessment. Four

weeks later, they completed a third battery of questionnaires. Figure 3 describes the measures collected at baseline, post-intervention and follow-up. All participants received £30 for taking part, as well as a copy of the self-help book 'Getting Better Bite by Bite' (Schmidt, Treasure, & Alexander, 2015). At the end of the study, participants were asked to complete a feedback form and were invited to participate in an online focus group.

----------Figure 3----------

Statistical analyses

Descriptive and frequency statistics were used to describe demographic and clinical characteristics. Clinical outcomes were analysed following a per-protocol framework; only data from participants who completed the post-intervention questionnaire was analysed. Clinical outcomes were presented using means, standard deviations, effect sizes and 95% confidence intervals. Within-group effect sizes were calculated comparing baseline scores with post-intervention and with follow-up scores, within each intervention group. Between-group effect sizes were calculated comparing change scores between the two groups at post-intervention and follow-up. Dependent and independent sample t-tests were performed and Cohen's d effect sizes were derived using means, standard deviations, sample sizes, and t-values based on the recommendations and syntax of Lakens (2013). Following the benchmarks suggested by Cohen (1988), effect sizes were interpreted as small (d = 0.2), moderate (d = 0.5) and large (d = 0.8). Confidence intervals (95%) were derived using syntaxes adopted from Smithson (2001).

Results

Recruitment and completion of measures

The CONSORT diagram (Thabane et al., 2016) that describes participants' recruitment and completion of assessments is shown in Figure 1. The pre-set recruitment

target was met over an 11-month period (December 2017-November 2018), with a recruitment of 97.5% of the targeted sample size. The pre-set retention rate of 80% at four weeks was almost met (79.5%). Of the 16 participants who did not complete the four-week assessment, 13 had not continued with the intervention and three had carried on with the intervention but failed to complete the assessment. Eleven participants did not complete the follow-up questionnaires (please refer to Supplementary Materials 1 for more details).

Demographic and Psychological Characteristics

Demographic and clinical characteristics are described in Table 1. A large majority of participants had a severe and enduring form of the illness, with a mean duration of illness of 15.5 years, and 80% reportedly experiencing disordered eating symptoms for over five years. Moreover, 78% had a comorbid anxiety and/or depressive disorder, 34% were currently taking psychiatric medication, and 41% had received psychiatric/psychological support within the previous 6 months. Participants' mean depression and anxiety severity scores indicated moderately severe depression (M = 11.92; SD = 6.32) and moderate anxiety (M = 9.55; SD = 6.05). The food-specific intervention (N = 40) and the general intervention (N = 38) groups were similar in their baseline demographic and clinical characteristics. See table 1 for summary.

----------Table 1----------

Adherence to interventions

At least four computerised training sessions were completed by 84.6% of participants, meeting the pre-set cut-off. Participants in the food-specific intervention group completed an average of 13.81 (SD = 6.95, range = 2- 30) training sessions and those in the general intervention group completed an average of 11.97 (SD = 7.57, range = 0 – 27). Manipulation checks of reaction times to go stimuli and commission errors to no-go stimuli indicated, as

expected, evidence of stimulus-response learning. There were significantly faster go reaction times to 100% go stimuli (e.g. low energy-dense food) vs. filler images and significantly lower no-go commission errors to 100% no-go stimuli (e.g. high-energy dense food) vs. filler images. Methods for calculating stimulus-response learning and results are presented in Supplementary Materials 2. With regards to if-then planning, 53.4% of participants completed it (65.6% in the food-specific group and 40% in the general group), which was below the pre-set adherence level.

Acceptability

Thirty-four participants completed the feedback form. Overall, there was a trend for participants in the food-specific intervention group to report greater understanding of the rationale, motivation, perceived benefit, perceived worthwhileness, and likelihood of recommending the intervention to others compared to the general intervention group. During the focus groups, participants expressed benefits of taking part, such as viewing the training as an enjoyable game and becoming more conscious of eating choices. They also brought unhelpful aspects to light, such as feeling dissatisfied with the delivery of implementation intentions via email (vs. face-to-face). Participants reported no harm as a result of taking part in the study, however some expressed practical concerns about the ease of accessing the computerised training on their pc/laptops. The methods, materials and results for the quantitative and qualitative feedback from participants are described in Supplementary Materials 3.

Primary clinical outcomes

Between-group. The means, standard deviations, and between group effect sizes (with confidence intervals) of change scores in primary clinical outcomes are presented in Table 2

(baseline to post-intervention and baseline to follow-up). The reduction in binge frequency was higher in the food-specific intervention group, compared to the general intervention group at post-intervention (d_s = 0.35, 95% CI [-0.16, 0.85]) and at follow-up (d_s = 0.41, 95% CI [-0.18, 0.93]. There was a slightly greater reduction in eating disorder psychopathology in the food-specific intervention group compared to the general intervention group at post-intervention (d_s = 0.22, 95% CI [-0.29, 0.72]). At follow-up, the size of the difference between groups was greater in the food-specific intervention group (d_s = 0.61, 95% CI [0.03, 1.17].

Within-group: Participants allocated to the food-specific intervention had small-to-moderate sized reductions in binge-eating frequency post-intervention (d_z = 0.44, 95% CI [0.07, 0.80]), whereas those allocated to the general intervention had negligible reductions in binge eating frequency (d_z = 0.10; 95% CI [-0.26, 0.46]). The change in binge frequency by follow-up was moderate-to-large in the food-specific intervention group (d_z = 0.75, 95% CI [0.31, 1.15]) and small-to-moderate in the general intervention group: d_z = 0.45, 95% CI [0.04, 0.80]). Participants in both groups achieved large-sized reductions in eating disorder psychopathology at post-intervention (food-specific: d_z= 1.04, 95% CI [0.60, 1.46]; general: d_z=0.74, 95% CI [0.31, 1.16], respectively). At follow-up, the food-specific intervention group showed large-sized reductions in eating disorder psychopathology (d_z = 1.41, 95% CI [0.84, 1.96]) while the general intervention group showed moderate reductions (d_z = 0.55, 95% CI [0.11, 0.97]).

----------Table 2----------

Moderator analyses

Supplementary moderator analyses were performed to examine whether training effects on binge eating frequency and eating disorder psychopathology were moderated by number of training tasks completed and engagement with if-then planning. These analyses were

conducted to get a preliminary indication as to how many sessions might be needed to obtain a clinical effect, considering that there is not conclusive evidence in the literature. Findings indicated that the general intervention group had smaller reductions in binge eating frequency than the food-specific intervention group when participants completed fewer than eight training sessions. Methods and results are presented in Supplementary Materials 5.

Secondary clinical outcomes

Supplementary Materials 4 shows the data for the secondary clinical outcomes. The between-group differences in secondary clinical outcome changes were small at post-intervention and follow up. From baseline to post-intervention, both intervention groups showed small-to-moderate reductions in high energy-dense food valuation and food approach and only small/negligible changes on the other outcomes. From baseline to follow-up, both intervention groups showed small-sized reductions in food approach, anxiety, and depression.

Discussion

This trial examined the feasibility of combining inhibitory control training (ICT) and implementation intentions (if-then planning) to target binge eating and eating disorder psychopathology in patients with bulimia nervosa or binge eating disorder. Food-specific ICT and if-then planning were compared against a non-food focused version of the same intervention (general ICT and if-then planning). The feasibility outcomes were promising, with recruitment and retention rates meeting the pre-set cut-offs. The adherence cut-off was met for ICT, but not for if-then planning. Binge eating frequency and eating disorder psychopathology decreased in both intervention groups at post-intervention (four weeks) and at follow-up (eight weeks). The reduction in binge eating frequency and eating disorder psychopathology was overall slightly greater in the food-specific than the general

intervention group over time. The small difference between the food-specific and general intervention groups in reducing binge eating and eating disorder symptoms can be interpreted in several ways. First, both arms of the intervention had received active ingredients for behaviour change (e.g. online guidance combined with monitoring of behaviour). Another possibility is that general inhibitory control training and if-then training had produced some benefits. These factors, along with the small sample size that was only powered for feasibility, may have challenged our ability to detect between group differences.

Small-to-moderate reductions in secondary outcomes including high energy-dense food valuation, food approach, anxiety, and depression were found post-intervention and/or at follow-up. The reduction in self-reported 'food approach' in the present trial mirrors previous research with pre-clinical samples, which indicates that ICT for appetite behaviour change is associated with reduced consumption of food compared to control conditions (Jones et al., 2016). The parallel reduction in valuation of high energy-dense food following training is also in line with previous research conducted in pre-clinical populations (Veling et al., 2013; Lawrence et al., 2015; Chen et al., 2016; Chen et al., 2018; Houben and Giesen, 2018). It may also be possible, that for some individuals, exposure to high-dense calorie foods (as opposed to neutral stimuli) trigger cravings that interfere with the inhibitory mechanisms of the training (Boswell & Kober, 2016), although we had no feedback to support this. Further research with a dismantling design is needed to explore the mechanisms involved.

With regards to acceptability, participants in the food-specific intervention group reported slightly greater understanding of rationale, motivation, perceived benefit, perceived worthwhileness, and likelihood of recommending the intervention to others, compared to the general intervention group. There was little difference between groups on the general feedback provided during the focus groups.

Strengths and limitations

The present research has a number of limitations. First, it did not include a 'no treatment' comparison group. However, the use of an active control group which was matched to the experimental condition for all, except one variable (i.e. food-specific focus) can be argued to represent a more appropriate comparison group than a 'no treatment' group. Furthermore, it could be argued all the participants received one session of food no-go training during the assessment and thus, may have all received a small dose of active intervention. Some studies have indeed shown that one session of training can have some effect, reducing food intake in the short-term (Jones et al., 2016). Another limitation of this study is that the combined design (ICT + if-then plans) does not assess the differential impact of ICT and if-then planning on clinical outcomes. Adherence rates and participants' feedback indicated that the if-then planning sessions were less acceptable than ICT. In addition, while all eating disorder psychopathology sub-scales (including dietary restraint) reduced from baseline to post-intervention within the present sample, it is important to monitor the potential impact of the training on overall food restriction.

With regards to limitations of measures, participants' height was self-reported. Moreover, with the exception of psychiatric medication, the baseline assessment did not include a question regarding current treatment. As such, we were unable to control for possible confounding effects of existing treatments. Finally, the quantitative analyses were conducted following a per-protocol framework. This enabled us to assess the "as received" (as opposed to the "as assigned") effect of treatment and measure the effect of the experimental condition against the control condition when all participants adhered to the assigned condition (Ten Have et al., 2008).

Despite these limitations, this study has notable strengths in that (1) it established pre-set criteria against which to assess the feasibility of study methods (as described in the pre-

registered protocol on ClinicalTrials.gov; ID: NCT03126526), (2) it tested the target intervention outside the laboratory, in individuals' own settings and (3) it included assessment of parameters, such as the moderator effect of number of sessions completed on clinical outcomes and measurement of a range of secondary outcomes to establish the potential mechanisms and generalisability of the targeted intervention. New developments may help improving the accessibility of the intervention. For example, Lawrence and colleagues (2018) have designed an app-based version of the training, which allows individuals to complete it on their smartphones and to personalize the food stimuli used. Similarly, the use of goal setting strategies (e.g. if-then planning), might be enhanced through an interactive and engaging interface, which could also record the momentary implementation of the plans. The use of gamification could further strengthen participants' engagement in the training over time (Fernandez-Aranda et al., 2015; Johnson et al., 2016; Kakoschke et al., 2018).

Conclusion

The present trial provides preliminary evidence that combined ICT and implementation intentions may be a feasible and acceptable method of augmenting treatment for people which chronic forms of bulimia nervosa and binge eating disorder by producing clinically relevant changes in binge-eating frequency and eating disorder psychopathology. Further research would be needed to test the efficacy of the intervention and examine and optimise the specific mechanisms of change. Based on the feasibility testing that we conducted, a randomised controlled trial to test the efficacy of food-specific ICT combined with a refined version of implementation intentions (delivered for example over the phone to increase patient's engagement) to enhance treatment as usual and compared against treatment as usual only, would be warranted.

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Conflict of Interest

The authors declare that they have no conflicts of interest.

Ethical Standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. The London Westminster Research

Ethics Committee and the Health Research Authority approved all the procedures involved in this study (IRAS Project ID: 209609). The present study adheres to open science principles. It was pre-registered on ClinicalTrials.gov (ID: NCT03126526). The data were analysed in line with pre-registered aims, and both null and significant findings are reported.

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Tables

Table 1 Baseline demographic and clinical characteristics of the groups.

Data presented as means, standard deviations (SD) and frequencies (N, %).

	Food-specific intervention group (N=40) Mean (SD) or N (%)	General intervention group (N=38) Mean (SD) or N (%)	*p-value*
Demographic Characteristics			
Age	33.38 (12.58)	33.50 (12.52)	0.98
Weight (kg)	84.72 (27.02)	79.23 (26.97)	0.87
Body mass index	30.10 (8.17)	28.36 (9.44)	0.42
Years of education	16.63 (2.67)	16.81 (3.88)	0.24
Duration of illness (years)	16.26 (12.93)	14.75 (9.95)	0.21
Gender	Female = 36 (90%) Male = 4 (10%)	Female = 36 (94.7%) Male = 2 (5.3%)	0.68
Ethnicity	White = 32 (80%) Asian = 2 (5%) Black = 1 (2.5%) Middle Eastern = 3 (7.5%) Latin American = 2 (5%)	White = 28 (73.7%) Mixed (White/Black) = 2 (5.3%) Asian = 3 (7.9%) Black = 4 (10.5%) Latin American = 1 (2.6%)	0.20
Relationship Status	Relationship = 19 (47.5%) No Relationship= 21 (52.5%)	Relationship = 20 (52.6%) No Relationship= 18 (47.4%)	0.65
Clinical characteristics			
Diagnosis	Binge Eating Disorder = 22 (55%) Bulimia Nervosa = 18 (45%)	Binge Eating Disorder = 16 (42.1%) Bulimia Nervosa = 22 (57.9%)	0.26

Use of psychiatric medication	Yes = 12 (30%)	Yes = 15 (39.5%)	0.38
Treatment received in past six months	Yes = 17 (42.5%)	Yes = 15 (39.5%)	0.79
Comorbid mood and/or anxiety disorder	Yes = 29 (72.5%)	Yes = 32 (84.2%)	0.21
Binge Eating Frequency	12.60 (7.42)	13.97 (7.93)	0.43
Purging	Yes= 9 (22.5%)	Yes = 14 (36.8%)	0.44
Laxative/Diuretic	Yes = 8 (20%)	Yes= 9 (22.5%)	.22
Compulsive Exercise Frequency	Yes = 15 (37.5%)	Yes = 19 (50%)	.49
Eating Disorder Examination Global Score	3.65 (0.90)	3.81 (1.20)	0.51
Self-regulation of Eating Behaviour Questionnaire	2.61 (0.63)	2.60 (0.54)	0.94
Adult Eating Behavior Questionnaire			
Enjoyment of Food	4.08 (1.02)	3.99 (0.98)	0.69
Emotional Overeating	4.05 (0.74)	3.95 (0.90)	0.60
Fussiness	2.26 (0.91)	2.23 (0.97)	0.88
Emotional Under-eating	2.11 (0.74)	2.34 (0.96)	0.43
Food responsiveness	3.98 (0.77)	3.88 (0.66)	0.54
Slowness in Eating	2.05 (0.93)	2.2 (0.84)	0.37
Hunger	3.21 (0.67)	2.99 (0.84)	0.76
Satiety	2.25 (0.72)	2.22 (0.62)	0.69
Generalised Anxiety Disorder-7	9.25 (5.49)	9.87 (6.66)	0.66
Patient Health Questionnaire-9	11.05 (5.97)	12.84 (6.62)	0.21

*P-values for Age, Weight, BMI, Years of Education, Duration of Illness, EDEQ-Q Global Score, AEBQ, GAD-7 and PHQ-9 were obtained using independent samples t-tests

P-values for Gender, Ethnicity, Diagnosis, Relationship Status, Use of Psychiatric Medication, Psychological/Psychiatric Treatment received in past 6 months, Comorbid Mood and/or Anxiety Disorder, Purging, Laxative/Diuretic Use, and Compulsive Exercise were obtained using Pearson's Chi-Square

Table 2. Change scores in primary outcomes from baseline to post-intervention (four weeks) and from baseline to follow-up (eight weeks). Data presented as means (M), standard deviations (SD) and effect sizes (d_s ES) and 95% confidence intervals (CI).

	Food-Specific Intervention M (SD)			General Intervention M (SD)			Mean Difference M (95% CI)	Between-group Cohen's d_s ES (95% CI)
	Baseline	Post-Intervention	Difference Score	Baseline	Post-Intervention	Difference Score		
Binge-Eating Frequency N = 32 | N = 30	12.97 (7.86)	9.66 (7.15)	3.31 (7.51)	13.90 (8.59)	13.17 (8.43)	0.73 (7.29)	2.58 (-1.18, 6.34)	0.35 (-0.16, 0.85)
	Baseline	Follow-up	Difference Score	Baseline	Follow-up	Difference Score		
Binge-Eating Frequency N = 26 | N = 25	13.19 (8.57)	6.62 (6.22)	6.58 (8.83)	13.68 (8.49)	10.24 (10.15)	3.44 (7.70)	3.14 (2.32, -1.53)	0.41 (-0.18, 0.93)

Figures

Figure 1. Consort diagram of participation in the study

The flow-chart describes participants' recruitment and completion of the assessment measures at baseline, post-intervention and follow-up.

Note: Forty-two individuals did not meet criteria to participate because they were not able to commute to London for electroencephalography testing (N = 17), did not experience ≥ 1 binge eating episode per week (N = 12), had a body mass index < 18.5 (N = 5), had a diagnosis of anorexia nervosa (N = 4), were below the age of 18 (N = 2), or had epilepsy (N = 2).

Figure 2. Example of 'go' and 'no-go' trials in the inhibitory control training task

The 'go' trial includes the presentation of a low-energy dense food; in this condition participants are instructed to press the letter 'M' as quickly as possible on the keyboard. The 'no-go' trial includes the presentation of a high-energy dense food; in this condition participants are instructed to avoid a motor response.

Figure 3. Timeline of the study's procedure

Participants completed online questionnaires at three time points (baseline, post-intervention and follow-up). At baseline and post-intervention they also attended a face-to-face session.

EDE-Q: Eating Disorder Examination Questionnaire; AEBQ: Adult Eating Behaviour Questionnaire (AEBQ); SREBQ: Self-Regulation of Eating Behaviour Questionnaire (SREBQ); GAD-7: Generalised Anxiety Disorder; PHQ-9: Patient Health Questionnaire.

Supplementary Materials

Targeting binge eating in bulimia nervosa and binge eating disorder using inhibitory control training and implementation intentions: A feasibility trial

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Supplementary Materials 1: Reasons for drop out

Of the 16 participants who did not complete the post-intervention assessment, 13 had dropped out of the trial. Of these, eight participants stopped responding to emails and five reported personal struggles interfering with research engagement. The 11 participants who did not complete the follow-up questionnaire stopped responding to emails and did not provide a reason for the drop-out.

Supplementary Materials 2: Go/no-go task performance and reaction time

Methods

To ensure that stimulus-response learning had taken place during the training task (manipulation check), differences in reaction times and commission errors between 100% predictive (food) and 50% predictive (clothing filler) stimuli were assessed using two repeated measures ANOVAs. Evidence of stimulus-response learning would require that participants exhibited quicker reaction times and made a lower number of errors to 100% predictive versus 50% predictive stimuli (as observed in Lawrence et al., 2015).

Independent samples t-tests were conducted to compare reaction time and task performance (i.e. commission and omission errors) among participants taking psychiatric medication and participants not taking psychiatric medication.

Results

A main effect of stimulus type was observed for the reaction times of "go" stimuli [$F(1,59) = 131.14$, $p = .000$], with faster reactions to predictive versus non-predictive go stimuli (see supplementary table S1). A stimulus type x intervention group interaction was also found [$F(1,59) = 4.76$, $p = 0.03$], indicating that the difference between 100% and 50% predictive stimuli was greater in the food-specific intervention group compared to the general intervention group. No main effect of intervention group was found ($p > .05$). A main effect of stimulus type was found for commission errors on "no-go" trials [$F(1,59) = 7.75$, $p = .007$]. Both groups made fewer errors to 100% predictive than 50% predictive stimuli. Consistent with previous studies, (Lawrence et al., 2015; Stice et al., 2017), no main effect of intervention group or stimulus type x intervention group interactions were found ($p > .05$). See supplementary table S1.

There was no significant difference in task performance [t (59) = -.409, p = .684] or reaction time [t (59) = .074, p = .743] between participants taking psychiatric medication and participants not taking psychiatric medication.

Table S1. Manipulation Check

Descriptive statistics of commission errors and reaction times in response to 50% predictive and 100% predictive stimuli.

	50% Predictive Stimuli M (SD)	100% Predictive Stimuli M (SD)
Commission Errors (number/out of 36)		
Food-Specific Intervention	3.2(2.1)	1.8(1.5)
General Intervention	3.4(2.0)	2.3(4.7)
Reaction Time (ms)		
Food-Specific Intervention	552(91)	523(85)
General Intervention	530(90)	510(79)

Supplementary Materials 3: Analysis of acceptability

Methods

Feedback form. The feedback form included questions relating to the two sections of the intervention (go/no-go training and if-then planning). For each section, participants rated the extent to which they: 1) understood the rationale, 2) felt motivation, 3) found it effortful to complete, 4) perceived benefit, 5) perceived worthwhileness, and 6) would recommend to others. Responses were given on a visual analogue scale from 0-100, with 0 indicating "not at all" and 100 indicating "very much so". Acceptability of the combined intervention across the two intervention groups was assessed using independent samples t-tests (and related effect sizes).

Focus Groups. The focus groups included six open-ended questions, including:

1) "Which aspect of the computerized training and goal setting guidance was the most/least helpful?", 2) "Can you please tell us about any practical problems receiving the computerized training and/or goal setting guidance?", 3) "What changes to the protocol do you believe would have made your involvement more simple or less effortful?", 4) "In what ways could the research team have facilitated your engagement, offered more support, or made the intervention more accessible?", 5) "Did you like the one-to-one format, or do you feel like some elements could have been delivered as a group intervention?", and 6) "Can you tell us in what ways the intervention met or did not meet your expectations?".

Statistical analyses

The quantitative data of the feedback form were analysed using independent samples t-tests,for each of the six outcomes, and Cohen's d effect sizes were derived using the recommendations of Lakens (2013). For qualitative analysis of focus groups responses, a thematic analysis was carried out. Two independent researchers (PM and JK) coded the responses and then discussed discrepancies. Initial codes were then generated and incorporated into meaningful clusters of data and entered into Nvivo (Nvivo Computer Software).

Results

Feedback form

The quantitative data of the feedback form are described in supplementary table S2 and presented as means, standard deviations and effect sizes for the go/no-go training and implementation intentions separately.

Table S2. Quantitative feedback on the intervention.

Data are provided separately for the go/no-go training and if-then planning, for each intervention group, and are expressed as means (M), standard deviations (SD) and between-group effect sizes (Cohen's d_s and 95% confidence intervals – CI).

	Food-Specific Intervention (N = 18) M (SD)	General Intervention (N = 16) M (SD)	Cohen's d_s Effect Size (95% CI)
Go/no-go training			
Understanding Rationale	71.1 (18.8)	63.7 (26.9)	0.33 (-0.36, 0.99)
Motivation to Complete	76.7 (19.4)	64.4 (28.5)	0.51 (-0.19, 1.18)
Effort	55.6 (21.5)	55.6 (22.2)	0.00 (-0.67, 0.67)
Perceived Benefit	50.6 (27.3)	46.0 (25.0)	0.17 (-0.50, 0.85)
Perceived Worthwhileness	66.1 (21.2)	53.1 (24.7)	0.57 (-0.13, 1.24)
Likelihood of Recommending to Others	63.9 (25.0)	51.3 (29.0)	0.47 (-0.23, 1.14)
Implementation intentions (If-then planning)			
Understanding Rationale	77.6 (22.2)	63.3 (22.3)	0.64 (-0.06, 1.32)
Motivation to Complete	67.2 (22.2)	61.1 (23.9)	0.26 (-0.42, 0.94)
Effort	53.3 (21.4)	57.3 (18.3)	0.20 (-0.48, 0.87)
Perceived Benefit	56.7 (28.3)	47.3 (24.0)	0.35 (-0.33, 1.03)
Perceived Worthwhileness	60.0 (26.1)	54.0 (23.8)	0.24 (-0.44, 0.91)
Likelihood of Recommending to Others	61.1 (23.0)	53.6 (29.2)	0.29 (-0.40, 0.96)

Focus groups

Ten participants were included in the focus groups, including six participants who had taken part in the food-specific intervention and four participants who had taken part in the general intervention. Intervention-related acceptability, difficulties and suggestions for improvement were evaluated in the focus groups.

- **Acceptability:** included all aspects of the intervention that participants deemed acceptable and helpful. Five of ten participants (three from food-specific and two from general intervention group) mentioned acceptable aspects related to the study (e.g. "*I viewed it as a game with a score I was trying to beat so enjoyed it*"; "*I think that I'm more conscious of the choices I am making and now I reward my self with more caring behaviour*").
- **Difficulties:** included any aspects of the intervention that were deemed unhelpful and/or problematic in the participant's experience. Seven of ten participants (four from the food-specific and three from the general intervention group) discussed problematic or unhelpful features of the intervention (e.g. *"I personally did not find the mentoring that helpful*"; *"I sometimes found the computerised training a challenge as I didn't always have easy access to a laptop, and my routine is a bit topsy-turvy"; "I found the mentoring to be a lot of back and forth emails and before I knew it the time was up before I think I fully grasped how it was helpful. I think emails made it morelong winded").*
- **Intervention development:** included proposals for potential improvements to the intervention in future research. Four of ten participants (all from food-specific intervention group) described how they believed the intervention could be improved (e.g. *"It would have been nice to have a longer term point of contact with the mentor"; "Being able to do the training on your phone would be extremely helpful!"*).

Supplementary Materials 4: Changes in secondary clinical outcomes

Methods

The following secondary clinical outcomes were assessed:

- Weight. This was measured using a digital scale
- Self-regulation of eating behaviour. The *Self-Regulation of Eating Behaviour Questionnaire* (SREBQ; Kliemann, Beeken, Wardle, & Johnson, 2016) is a 5-item questionnaire of self-regulatory capacity. In this study, the reliability of the SREBQ was moderate ($\alpha = 0.62$).

- Food valuation. The *Food Rating Test* (Lawrence *et al*., 2015) is a computerized measure that requires rating liking of different food images on a 100mm visual analogue scale ranging from 0-100. Participants rated 27 pictures of foods in a random order, including nine low energy-dense 'go' foods from the training task, nine high-energy dense 'no-go' foods from the training task, and nine novel foods that were not included in the training.
- Food approach behaviour. The *Adult Eating Behaviour Questionnaire (*AEBQ; Hunot et al., 2016*)* is a 35-item questionnaire that measures two dimensions of eating behaviour: Food Approach and Food Avoidance. The present study has examined the Food Approach Subscale, which includes hunger, food responsiveness, emotional over-eating, and enjoyment of food. In this study, the reliability of the Food Approach Subscale was high ($\alpha = 0.82$).
- Depressive symptoms. The PHQ-9 (Kroenke *et al*., 2001) is a nine-item measure of depressive symptoms over the two weeks prior to completion. Responses are given on a 4-point Likert scale ranging from 'not at all' to 'nearly every day'. In this study, the reliability of the PHQ-9 was high ($\alpha = 0.91$).
- Anxiety symptoms. The GAD-7 (Spitzer *et al*., 2006) is a seven-item measure of anxiety symptoms over the two weeks prior to completion. Responses are given on a four-point Likert scale ranging from 'not at all' to 'nearly every day'. In this study, the reliability of the GAD-7 was high ($\alpha = 0.88$).

Results

Changes in secondary outcomes are shown in Table S3. Overall, the changes in high energy-dense food valuation, self-regulation of eating behaviour, and depression were greater in the food-specific intervention group compared to the general group at four weeks. Participants in the food-specific intervention group had moderate-to-large-sized reductions in high energy-dense food valuation (d_z = 0.69, 95% CI [0.27, 1.10]), while those allocated to the general intervention group showed small-moderate size reductions in this outcome (d_z = 0.41, 95% CI [0.01, 0.81]). Participants in the food-specific intervention group showed small-to-moderate size improvements in self-regulation of eating behaviour (d_z = 0.38, 95% CI [0.00, 0.73]), while the general group showed negligible/no change in this outcome (d_z = 0.01, 95% CI [-0.35, 0.38]). Participants in the food-specific intervention group showed small reductions in depression (d_z = 0.21, 95% CI [-0.14, 0.56]), while participants in the general group only showed negligible changes in depression (d_z = 0.04, 95% CI [0.00, 0.26]). Both groups showed small-to-moderate reductions in food approach (food group: d_z = 0.39, 95% CI [0.34, 1.13]; general group: d_z = 0.60, 95% CI [-0.34, 1.17]), weight (food group: d_z = 0.25, 95% CI [-0.12,

0.61]; general group: d_z = 0.17, 95% CI [-0.22, 0.55]), low energy-dense food valuation (food group: d_z = 0.03, 95% CI [-0.00, 0.18]; general group: d_z = 0.02 95% CI [0.00, 0.12]), and anxiety (food group: d_z = 0.03, 95% CI [0.00, 0.17]; general group: d_z = 0.11, 95% CI [-0.26, 0.47]).

From baseline to follow-up (eight weeks), the food specific intervention group showed small-to-moderate greater changes in self-regulation of eating behaviour (food group: d_z = 0.32, 95% CI [0.00, 0.70]; general group: d_z = 0.13, 95% CI [0.00, 0.51]) and depression (food group: d_z = 0.70, 95% CI [0.21, 1.17]; general group: d_z = 0.38, 95% CI [-0.10, 0.86]). Both groups showed small sized reductions in food approach (food group: d_z = 0.35, 95% CI [-0.04, 0.75]; general group: d_z = 0.23, 95% CI [-0.17, 0.63]) and anxiety (food group: d_z = 0.35, 95% CI [-0.04, 0.75]; general group: d_z = 0.24, 95% CI [-0.22, 0.71]).

Table S3. Changes in secondary outcomes from baseline to post-intervention (four weeks) and from baseline to follow-up (eight weeks) in the two study groups. Data is expressed as means (M), standard deviations (SD), mean differences and between-group effect sizes (d_s and 95% confidence intervals-CI).

	Food-Specific Intervention M (SD)			General Intervention M (SD)			Mean Difference (95% CI)	Between-group Cohen's d_s ES (95% CI)
	Baseline	Post-Intervention	Difference Score	Baseline	Post-Intervention	Difference Score		
Weight (Kg) N = 30 | N = 28	84.17 (28.54)	84.17 (28.54)	0.64 (2.58)	84.54 (28.96)	84.10 (28.45)	0.44 (2.60)	0.20 (-1.19, 1.59)	0.08 (-0.44, 0.59)
High Energy-Dense Food Valuation N = 28 | N = 26	67.48 (13.55)	58.81 (17.17)	8.67 (12.53)	74.24 (14.84)	69.82 (15.69)	4.42 (10.77)	4.25 (-2.15, 10.65)	0.36 (-0.18, 0.90)
Low Energy-Dense Food Valuation N = 28 | N = 26	62.78 (17.75)	63.03 (17.62)	-0.25 (8.88)	63.41 (11.90)	63.59 (12.73)	-0.18 (9.94)	-0.07 (-5.21, 5.07)	0.00 (-0.54, 0.53)
Self-Regulation of Eating Behaviour N = 32 | N = 29	2.62 (0.65)	2.83 (0.52)	-0.21(0.57)	2.67 (0.56)	2.66 (0.45)	0.01 (0.54)	-0.22 (-0.50, 0.06)	0.40 (-0.12, 0.90)
Food Approach N = 32 | N = 29	3.82 (0.54)	3.69 (0.45)	0.14 (0.35)	3.74 (0.60)	3.60 (0.52)	0.14 (0.24)	-0.00 (-0.16, 0.15)	0.01 (-0.50, 0.50)

Depression N = 32 | N = 29	10.68 (5.85)	9.53 (6.61)	1.16 (5.38)	12.59 (6.27)	12.76 (6.69)	-0.17 (4.42)	1.33 (-1.21, 3.87)	0.27 (-0.24, 0.77)
Anxiety N = 32 | N = 29	8.94 (5.50)	9.03 (6.36)	-0.09 (3.66)	9.69 (6.52)	9.34 (6.34)	0.34 (3.24)	-0.44 (-2.22, 1.34)	0.13 (-0.38, 0.63)
	Baseline	Follow-up	Difference Score	Baseline	Follow-up	Difference Score		
Self-Regulation of Eating Behaviour N = 26 | N = 25	2.62 (0.68)	2.82 (0.45)	-0.20 (0.63)	2.71 (0.58)	2.79 (0.46)	-0.08 (0.60)	-0.12 (-0.47, 0.23)	0.19 (-0.36, 0.74)
Food Approach N = 26 | N = 25	3.89 (0.49)	3.70 (0.47)	0.19 (0.36)	3.71 (0.60)	3.50 (0.70)	0.20 (0.32)	-0.02 (-0.21, 0.17)	0.05 (-0.52, 0.58)
Depression N = 21 | N = 18	12.10 (5.21)	9.05 (5.21)	3.05 (4.36)	11.17 (5.23)	10.06 (5.55)	1.11 (2.91)	1.94 (-0.51, 4.39)	0.51 (-0.13, 1.14)
Anxiety N = 21 | N = 18	10.67 (5.23)	8.86 (5.11)	1.81 (5.14)	9.33 (5.86)	8.61 (5.39)	0.72 (2.97)	1.09 (-1.70, 3.88)	0.26 (-0.38, 0.88)

Supplementary Materials 5: Moderator Analysis

Methods

The PROCESS V3.3 SPSS macro Hayes (2012) was used to perform moderated regression analyses and examine whether training effects on binge eating frequency and eating disorder psychopathology were moderated by number of training tasks completed and engagement with if-then planning. The Johnson-Neyman procedure (Johnson & Fay, 1950) was performed to explore the significance level of interactions (intervention group x adherence) across different levels of intervention adherence in cases of moderator significance (p-value) $\leq .1$.

Results

There was no significant interaction between intervention group and number of trainings predicting binge-eating frequency at four weeks [$F (3, 58) = 2.38$, $p = .079$, $R^2 = .11$]. The Johnson-Neyman analysis revealed that the general intervention group had smaller reductions in binge eating frequency than the food-specific intervention group when participants completed fewer than 8 training sessions. There was no significant interaction between intervention group and number of trainings completed in relation to eating psychopathology [$F (3, 56) = 1.34$, $p = .27$, $R^2 = 0.07$]. No significant interactions between intervention group and if-then engagement were found for binge-eating frequency [$F (3, 58) = 1.61$, $p = .22$, $R^2 = .07$] or eating disorder psychopathology [$F (3, 56) = 1.51$, $p = .22$, $R^2 = .07$].