**Research Program**

**1. Scientific Background**

Eating disorders (EDs) are a group of psychiatric conditions in which disordered eating leads to severe impairments in psychological and physical functioning (American Psychiatric Association, 2013). EDs are associated with the highest mortality rate of all psychiatric disorders and their prevalence among young adolescents has increased over the years (Smink, Van Hoeken, & Hoek, 2012). Current evidence-based treatments for adolescents with EDs have had limited success with symptom remission occurring only in 30%-50% of the patients (Kass, Kolko, & Wilfley, 2013).

Disordered eating can take shape as severe restriction of food intake that results in dangerous weight loss as in the case of anorexia nervosa (AN) or episodes of disinhibited binge eating that can lead to compensatory behaviors (e.g., vomiting) as in the case of bulimia nervosa (BN). Disordered eating in AN and BN is usually motivated by a desire to control body weight due to a disturbance in body image (American Psychiatric Association, 2013). However, **the mechanisms underlying the ability of individuals with AN to endure long periods of starvation on the one hand and those responsible for disinhibited eating in BN are poorly understood**. Better understanding of these mechanisms is important in order to identify novel treatment targets.

When searching for potential mechanisms that contribute to disordered eating, it is important to consider if a common mental process can account for different types of disordered eating. Given that binge and restrictive eating represent two opposite extremes in the ability exert **control over behavior** (i.e., loss of control vs. excessive control over eating, respectively), one of the most relevant mental processes to examine is the ability to control and inhibit undesired actions and behaviors, namely, inhibitory control (IC).

**Inhibitory Control and Disordered Eating**

IC allows us to deliberately inhibit dominant, automatic, or prepotent actions when necessary (Miyake et al., 2000). Thus, researchers have suggested that deficient IC may lead to disinhibited eating in EDs that are characterized by recurrent binge eating or purging behaviors (Bartholdy, Dalton, O’Daly, Campbell, & Schmidt, 2016; Hirst et al., 2017; Wu, Hartmann, Skunde, Herzog, & Friederich, 2013). To test this hypothesis, studies have used behavioral tasks (e.g., stop-signal task, go/no-go task) that measure the ability to inhibit prepotent responses in patients with binge eating/purging EDs. A meta-analysis supported the notion that IC deficits exist in these patients, especially in tasks that include presentation of high-calorie food stimuli (compared to non-food stimuli; Wu et al., 2013). This suggests that triggering environmental cues like the presence of high-calorie foods lead to IC failures in binge eating/purging EDs and thus, may account for disinhibited eating episodes.

In contrast to poor IC in binge eating/purging EDs, excessive use of IC was suggested to subserve dietary restraint in restrictive EDs types that are characterized by severe food restriction in the absence of binge eating or purging behaviors, like the restrictive subtype of AN (AN-R; Bartholdy et al., 2016; Hill, Peck, Wierenga, & Kaye, 2016; Kaye, Fudge, & Paulus, 2009). Only a few studies assessed IC in AN, with two neuroimaging studies showing aberrant brain activation related to IC in the absence of conclusive behavioral effects (Lock, Garrett, Beenhakker, & Reiss, 2011; Wierenga et al., 2014). However, these studies did not expose participants to triggering stimuli such as high-calorie foods. Using the stop-signal task, we have recently demonstrated that adolescents with AN-R are better able to inhibit a response following exposure to high-calorie food images compared to healthy adolescents (Weinbach, Lock, & Bohon, 2019). We have also reported excessive IC in adolescents with AN using other IC tasks as well (Weinbach, Bohon, & Lock, 2019; Weinbach, Sher, Lock, & Henik, 2018). Overall, it seems that exposure to food stimuli is a critical situational factor that modulates IC in opposite ways in patients with binge eating/purging EDs and restrictive EDs. However, in order to achieve a more holistic understanding of how IC can contribute to disordered eating, it is important to assess if IC interacts with other situational factors that are well known to influence disordered eating.

**Emotion, Inhibitory Control and Disordered Eating**

In addition to the presence or absence of food stimuli, another situational factor that is extremely relevant in modulating disordered eating is the patients’ affective state. Patients with eating disorders suffer from elevated negative emotionality (Engel et al., 2013). In order to regulate negative emotions, one needs to have some level of control over which emotions are experienced and how intense are they (i.e., emotion regulation; Gross, 1998). Numerous studies report difficulties in emotion regulation among adults and adolescents with EDs (e.g., Lavender et al., 2015; Prefit, Cândea, & Szentagotai-Tătar, 2019; Segal & Golan, 2016; Weinbach, Sher, & Bohon, 2018). Difficulty regulating negative affect leads to experiencing intense emotions that can act as a trigger for disordered eating behaviors (Lavender et al., 2015). For example, using ecological momentary assessment (EMA), studies have shown that negative affect increases prior to binge eating episodes in patients with binge eating/purging EDs and that higher daily ratings of negative affect are associated with a greater likelihood of dietary restriction on subsequent days in patients with restrictive EDs (Engel et al., 2016, 2013). **An important question is how do negative emotions trigger disordered eating in patients with EDs?**

**There are reasons to believe that IC is the missing link between emotional experiences and disordered eating for three main reasons that will be examined in the current research.** First, triggering negative emotions experimentally can impair healthy participants’ performance in IC tasks (Kalanthroff, Cohen, & Henik, 2013; Okon-Singer, Hendler, Pessoa, & Shackman, 2015; Verbruggen & De Houwer, 2007), indicating that emotions modulate IC, irrespective of psychopathology. If negative emotional states impair the ability to exert efficient IC and IC is required for regulating eating behaviors, it makes sense that negative emotions may exacerbate abnormalities in the ability to exert control (i.e., deficient or excessive control) over eating behaviors. However, the EDs literature seriously lacks studies that attempt to link affective states and IC as indicated by a recent systematic review (Smith, Mason, Johnson, Lavender, & Wonderlich, 2018). Nevertheless, using EMA, we have recently shown that among adults with binge eating/purging EDs, the relationship between momentary negative affect and subsequent binge eating is stronger on days characterized by reduced IC to food stimuli (Smith et al., 2019). This finding implies that negative affect impairs the ability to control a response when being exposed to food stimuli in these patients, hence leading to binge eating. **However, in order to determine if a causal relationship exists between negative affect and deficient/excessive control in response to food, it is vital to manipulate affective states experimentally (as opposed to correlational designs) while assessing food-related IC in patients with EDs.**

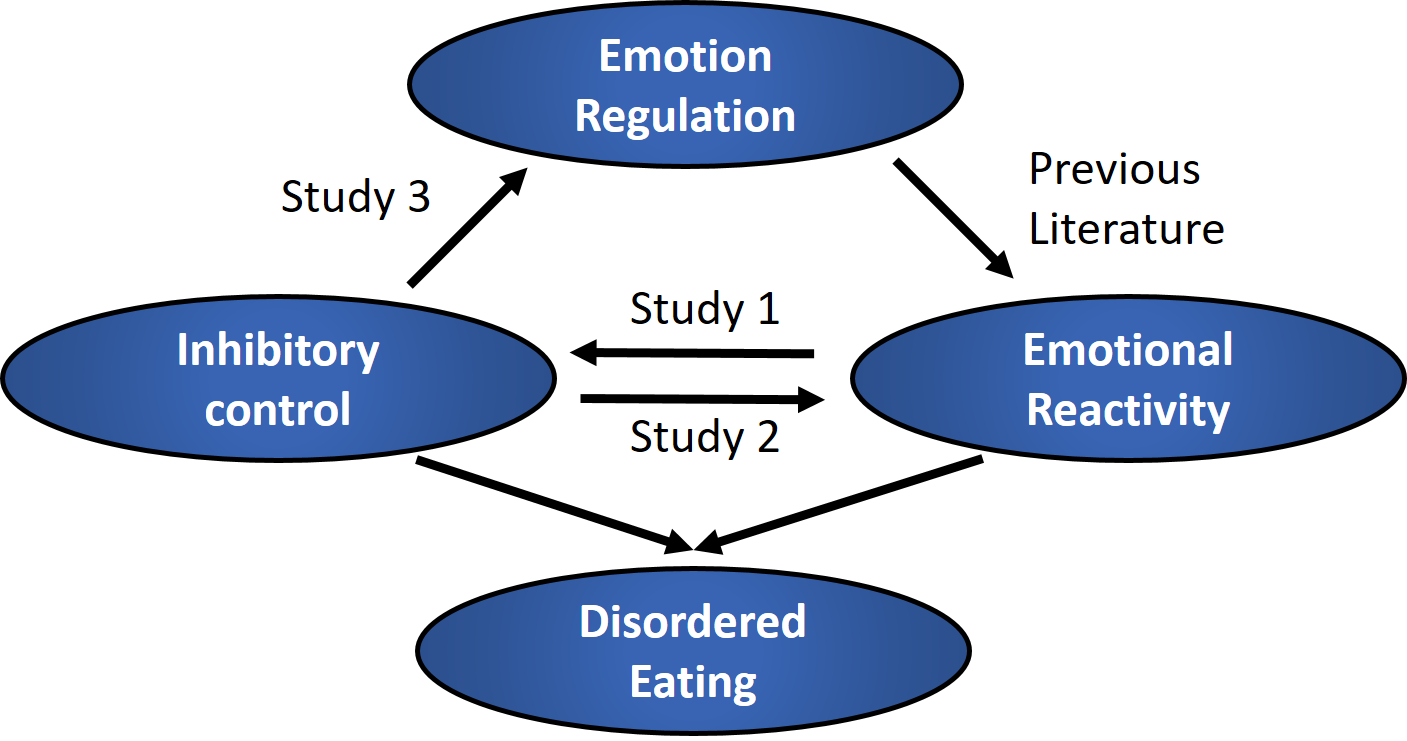
Second, while emotions may influence IC in a way that could lead to disordered eating (emotion 🡪 IC), IC may also influence emotional experiences (IC 🡪 emotion) in a way that would contribute to disordered eating. At the physiological level, emotions exert an increased sympathetic response of the autonomic nervous system (ANS). For example, pupil dilation is considered a proxy of emotional arousal because studies repeatedly show that the pupil’s diameter increases (a sympathetic response of the ANS) in response to emotional compared to neutral stimuli (e.g., Bradley, Miccoli, Escrig, & Lang, 2008; Bradley, Sapigao, & Lang, 2017; Cohen, Moyal, & Henik, 2015; Granholm & Steinhauer, 2004). Importantly, a study by Cohen and colleagues (2015) revealed that when IC is triggered experimentally (after trials that require IC resources to resolve a cognitive conflict), the increase in pupil diameter in response to negative emotional stimuli is attenuated. In other words, IC can suppress negative emotional reactivity (Cohen et al., 2015). In the context of EDs, food stimuli act as emotionally arousing stimuli as indicated by increased pupil dilation in response to high vs. low calorie food images in adults with AN (Godier, Scaife, Braeutigam, & Park, 2016). **It could be that a failure to use IC in order to suppress emotional reactivity in response to high-calorie foods may increase the risk for loss of control over eating in patients with binge eating/purging EDs. In contrast, excessive IC may suppress emotional responses to food stimuli, hence leading to a greater ability to control actions in the presence of food in patients with restrictive EDs.**

Lastly, difficulty using effective emotion regulation skills leads to increased negative affect, which in turn, exacerbates disordered eating (Lavender et al., 2015). For example, cognitive reappraisal is an effective emotion regulation strategy involving the ability to reinterpret a negative event to reduce its emotional impact (Gross, 1998). Limited use of cognitive reappraisal predicts higher levels of eating pathology in binge eating/purging EDs, but not in restrictive EDs (Danner, Evers, Stok, Van Elburg, & De Ridder, 2012). Interestingly, tight links exist between cognitive reappraisal and IC, as both are involved in regulating thoughts and behaviors. For example, one study showed correlations between performance in a cognitive reappraisal task and an IC task (e.g. stop-signal task) at the brain and behavioral level (Tabibnia et al., 2011). Another study demonstrated that transcranial direct current stimulation (tDSC) above the right dorsolateral prefrontal cortex (dLPF), an area highly implemented in IC, resulted in decreased emotional arousal rating in a reappraisal task (Feeser, Prehn, Kazzer, Mungee, & Bajbouj, 2014). Lastly, a recent study trained healthy adults to recruit IC (via the flanker task) while watching negative images. Participants in the training group showed higher propensity to reappraise a negative personal event after the training compared to those in a sham training group (Cohen & Mor, 2018). **Thus, it is important to extend research on healthy population to examine whether priming IC can improve cognitive reappraisal in clinical populations as well. Specifically, whether priming IC in patients with EDs may help improve cognitive reappraisal**, especially in binge eating/purging EDs wherein limited use of reappraisal predicts eating pathology (Danner et al., 2012).

**Research Objectives & Expected Significance**

The aim of the current research project is to **examine causal relationships between IC and emotion processing in adolescents with binge eating/purging EDs and restrictive EDs and to assess how these may contribute to disordered eating (see Figure 1).**

Figure 1. Hypothesized links between IC, emotion regulation, emotion reactivity, and disordered eating.



**In particular, the four measurable objectives and significance for each are as follows: Objective 1 is to examine if emotions (negative, positive, or neutral) can influence the ability to stop a response following exposure to food vs. non-food stimuli in adolescents with EDs (Study 1).** The study will shed light on a potential mechanism by which negative affect exacerbates different disordered eating patterns. **Objective 2 is to assess if experimentally triggering IC can modulate the physiological response (assessed via pupil dilation) to high- and low-calorie food stimuli among adolescents with EDs (Study 2).** This study will elucidate if the ability to exert control over an automatic emotional response to food differs as a function of the ED type. **Objective 3 is to determine if priming IC can improve reappraisal in adolescents with EDs (Study 3).** This study will clarify if activating IC in emotional contexts can improve the ability to reappraise negative emotional content in adolescents with EDs. We have collected promising preliminary results for Study 3 as will be detailed below. Lastly, **Objective 4 is to assess whether the primary measures from each of the three studies described above can prospectively predict disordered eating patterns.** This will be done by conducting a comprehensive assessment of disordered eating at baseline and 3-month follow-up.

**The proposed studies are expected to greatly advance basic and clinical understanding of EDs.** First and foremost, IC abnormalities have been suggested to be a mechanism contributing to disordered eating. In addition, negative affect is known to trigger disordered eating. **At present, the EDs literature seriously lacks studies that investigate the relationship between emotion and IC** (Smith et al., 2018). **Thus, the studies suggested will help better understand how interactions between IC and emotion can contribute to and maintain the primary clinical symptom in EDs, namely, disordered eating.**

Moreover, focusing on adolescents with EDs is important because EDs commonly onset during this developmental stage which happens to be a critical period for the development of both IC and emotion regulation (Ahmed, Bittencourt-Hewitt, & Sebastian, 2015; Silvers et al., 2012; Steinberg, 2005). As such, it is possible that abnormalities in cognitive and emotional systems during adolescence will have lasting effects into adulthood in EDs (Hirst et al., 2017). An additional advantage in studying adolescents with EDs is that this population is less subjected to potential effects of enduring illness or diagnostic crossovers, which mitigates the potential confounding influences of these variables.

The proposed project is also expected to have clinical implications. Exposing abnormalities in cognition-emotion interactions in EDs during adolescence may emphasize the need to target cognitive functioning and emotion regulation during therapy at early stages of the disorder. For example, various cognitive trainings are currently offered for patients with EDs. Much research has been conducted on Cognitive Remediation Therapy (CRT) for adolescents and adults with EDs (for review see Dahlgren & Rø, 2014; Tchanturia, Giombini, Leppanen, & Kinnaird, 2017). Although CRT leads to some improvements in cognitive functions, evidence regarding the ability of CRT to alleviate clinical symptoms is sparse (Smith et al., 2018). **A potential reason for that is poor understanding of the mechanisms by which neurocognitive processes contribute to clinical symptoms in EDs. In order to increase precision of such training procedures, it is important to know which neurocognitive processes to target, how to influence them, and what clinical outcome to expect.** Findings from the proposed studies may help to achieve this goal. For example, the proposed studies may shed light on how negative emotions contribute to abnormalities in food-related IC and how IC can be used to promote adaptive emotion regulation skills in adolescents with EDs. Such results may highlight the importance of prioritizing emotion focused treatments for EDs (Sala, Heard, & Black, 2016) that target better management and expression of emotion, instead of training neurocognitive processes per se.

**Detailed Description of the Proposed Research**

Participants: The experimental tasks for all studies will be administered to 180 female adolescents (see power analysis below) aged 12-18. The study will include 60 adolescents with restrictive EDs (30 AN-R and 30 Atypical AN which includes all the symptoms of AN-R except for low body weight), 60 with binge eating/purging EDs (30 BN and 30 AN-binge eating/purging type; AN-BP which includes episodes of binge eating and purging behaviors but unlike BN are underweight) and 60 healthy controls (HC). In light of the potential variability in the developmental stages of IC, half of participants in each group will be between the ages 12-14 and half 15-18. This will increase the ability to assess the results while taking developmental stage in consideration. Inclusion criteria for the patient groups are: a) a diagnosis of AN-R, Atypical AN, AN-BP or BN, and b) body mass index (BMI) > 12 in the AN group. Inclusion criteria for HC include a) absence of a first-degree relative with a lifetime eating disorder, b) the absence of currently diagnosed major psychiatric disorder, and c) percentage of expected body weight > 85%. Exclusion criteria for both groups include the presence of a condition that may interfere with cognitive abilities such as acute psychosis, traumatic brain injury, epilepsy, or attention deficit disorder. Clinical details regarding illness duration, use of psychotropic medications, details on current/past treatments, and history of hospitalizations, if any, will be collected from the patients’ medical files. Demographic data regarding years of education, income (parents), marital status (parents), country of origin, and ethnicity will also be collected in order to better characterize the sample.

General procedure and recruitment strategy: Adolescents with EDs will be recruited via collaborations with three of the largest eating disorder clinics in Israel: Soroka Medical Center, Be’er Sheva; Sheba Academic Medical Hospital, Ramat Gan; and Rambam Health Care Campus, Haifa (see collaboration letters attached). Upon the identification of eligible participants, a research coordinator in each site will contact the patient and her parents to provide information regarding the study. Short eligibility phone screenings based on the inclusion and exclusion criteria will be carried out. Healthy adolescents will be recruited via advertisements in social networks and local schools. Consent and assent forms will be signed by the adolescents and their parents prior to inclusion in the study. After the consent process, an online link with the clinical questionnaires will be sent to the adolescent via Qualtrics. Following that, a research coordinator will schedule two in-person meetings (separated by at least one week but no more than a month) with the adolescent either at the PI’s lab in the University of Haifa or at the local EDs clinic. Participants will be asked to refrain from eating two hours before the session in order to control for effects of hunger. The first session will include administration of the SCID-5, a short IQ assessment, and the experimental task for Study 1. The second session will include the experimental tasks for Study 2 and 3. Following that, the adolescent will be debriefed. Three months following the last session, the adolescents will be contacted again to complete the follow-up assessment of disordered eating. Ethical approvals will be obtained prior to the study from the University of Haifa IRB committee and the Helsinki committee at each eating disorder clinic.

Measures:

*Structured Clinical Interview for DSM-5 (SCID-5;* First, Williams, Karg, & Spitzer, 2015)*:* Presence/absence of EDs, including specific subtype and comorbid diagnoses will be assessed using the SCID-5-Research Version by trained clinicians in each EDs center that will take part in the study and by clinical graduate students in the PI’s lab.

*Percentage of Expected Body Weight (%EBW):* Height and weight will be measured on the day of the assessment (either at the EDs clinics or in the lab visit). %EBW will be calculated based on the 50th percentile of body mass index (BMI) corrected for age and gender and obtained from the Centers for Disease Control and Prevention growth charts.

*Wechsler Adult Intelligence Scale and Wechsler Intelligence Scale for Children:* Potential differences in IQ between the groups will be assessed using the vocabulary and matrices subsets of the Wechsler Adult Intelligence Scale (WAIS; for participants aged 16 or above) and Wechsler Intelligence Scale for Children (WISC; for participants under the age of 16).

*Eating Disorder Examination Questionnaire (EDE-Q; Fairburn & Beglin, 1994):* The EDE-Q is a reliable and validated self-report questionnaire aimed to assess eating disorder severity and disordered eating patterns. The EDE-Q assesses the severity of the eating pathology based on four subscales: Restrained eating, Eating concerns, Shape concerns and Weight concerns. The EDE-Q also assesses the frequency of binge eating and purging behaviors (i.e., vomiting and use of laxatives to control weight) over the past month. The EDE-Q will be delivered at baseline (first assessment session) and three-month follow up.

*Other self-report questionnaires:* Symptoms of depression will be assessed using the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996), anxiety levels using the State-Trait Anxiety Questionnaire (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), and emotion regulation using the Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004) and the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003). These questionnaires will be used to validate that the sample characteristics are similar to those found in previous studies and assess associations between these measures and tasks’ results.

**Experimental Design - Study 1**

*Objective:* Study 1 will examine how emotions (negative, positive, or neutral) can impair or improve the ability to stop a response following exposure to food and non-food stimuli in adolescents with EDs.

*Working hypothesis:* It is hypothesized that emotional stimuli (negative, neutral, positive) will modulate the ability to stop an already initiated response while being exposed to high-calorie food stimuli. Specifically, it is expected that negative emotion will trigger greater disinhibition (i.e., difficulty stopping a response) in the presence of food stimuli in the binge eating/purging group and excessive inhibition (i.e., superior ability to stop a response) in the restrictive EDs group, compared to neutral emotion. In light of evidence suggesting that positive emotion can improve cognitive control (Xue et al., 2013), the EDs groups are expected to perform similar to HC under the positive emotion condition.

*Emotion-Food-Stop-Signal Task (E-F-SST):* The stop-signal task is considered by many a hallmark measure of response inhibition (Verbruggen & Logan, 2008). In a Food-SST (Ganor-Moscovitz, Weinbach, Canetti, & Kalanthroff, 2018; Weinbach, Lock, et al., 2019), participants will be presented with a fixation cross (1,000 ms) that will be replaced by a target image. Participants will decide as fast as they can if an image in the center of the screen is of food (e.g., by pressing the ‘z’ key) or non-food item (e.g., by pressing the ‘m’ key). In 25% of the trials, a stop signal (e.g., an auditory beep for 100 ms) will be delivered via headphones after the target (with an equal proportion after food and non-food images). The stop-signal instructs participants to withhold their response. The time between the target appearance and the stop signal (i.e., stop-signal delay; SSD) will be initially set at 250 ms and then adjusted in each trial based on performance. Specifically, following a successful stop, the SSD will increase by 50 ms in the next trial, increasing stopping difficulty. In case of a failure to stop, the SSD will decrease by 50 ms in the next stop signal trial, making it easier to stop. This procedure results in ~50% accuracy in stop signal trials. After the stop signal, a response window will appear for 1,500 ms and will disappear if a response was made. The stop-signal reaction time (SSRT) is the main measure of response inhibition with longer SSRT indicating greater difficulty to stop the already initiated response. SSRT is calculated as the mean reaction time (RT) in trials without a stop signal minus the mean SSD (for more details on this calculation see Verbruggen & Logan, 2009). In the current task, the SSD will be adjusted for food and non-food items separately, allowing us to calculate different SSRT for food and non-food items. Forty-eight high-calorie food images (with an equal proportion of sweet and savory foods) and 48 images of non-food items will be selected from a food picture database (Blechert, Meule, Busch, & Ohla, 2014). In order to manipulate emotional states, the task will include three emotional blocks. In each block, an emotional image (negative, positive, or neutral) will be presented prior to the target for 2,000 ms (see example of typical trials in Figure 2). The order of the blocks will be counterbalanced. Each block will include 48 images (144 emotional images overall). Negative, positive and neutral images that are appropriate for adolescents to view will be selected from the International Affective Picture System (IAPS) based on normative data (Lang, Bradley, & Cuthbert, 1997). Overall, the task will consist of 10 practice trials with feedback and three experimental blocks (in each 96 trials), resulting in 288 experimental trials (72 of which will include a stop-signal).

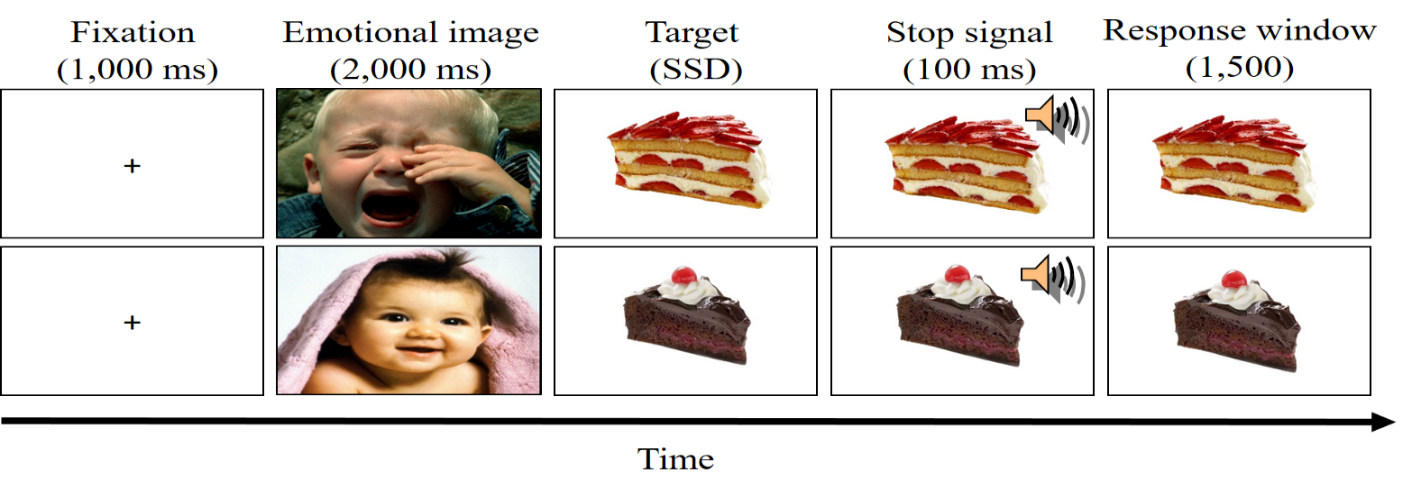


Figure 2. Example of two typical trials in which participants need to stop their response following exposure to high-calorie foods. The upper part is a trial in the negative emotional block and the lower part shows a trial in the positive emotional block.

*Mood and hunger assessment:* Before each experimental block and at the end of the experiment, mood will be assessed (using questions from the positive and negative affective schedule; Watson, Clark, & Tellegen, 1988) along with hunger level via a visual analogue scale in order to assess carry-over effects between the blocks in hunger and mood.

*Preliminary results:* We have recently shown that exposure to high-calorie food images leads to superior response inhibition in adolescents with AN-R compared to HC in the Food-SST (Weinbach, Lock, et al., 2019). As such, the proposed task should be sufficiently sensitive to detect changes in food-related IC in adolescents with EDs. Also, we have recently found that deficient food-related IC moderates the relationship between negative affect and binge eating in BN and AN-BP (Smith et al., 2019). Thus, it is likely that emotions will modulate food-related IC in the task proposed here.

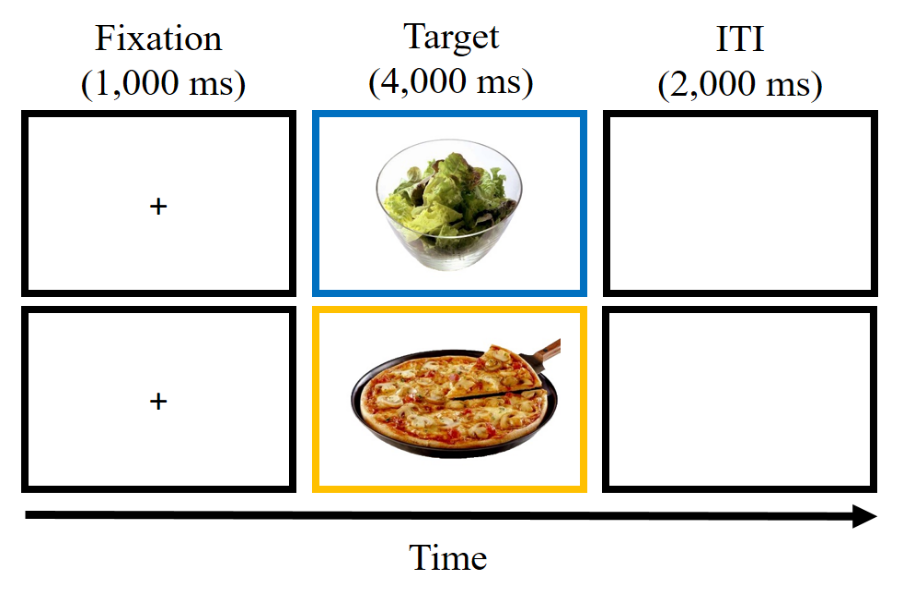
**Experimental Design - Study 2**

*Objective:* Study 2 will examine if experimentally triggering IC will modulate the physiological response (assessed via pupil dilation) to high- and low-calorie food stimuli among adolescents with EDs.

*Working hypothesis:* High-calorie food images elicit an emotional response in patients with EDs (Horndasch et al., 2018; Zhu et al., 2012) and increase pupil dilation (Godier et al., 2016), indicating increased sympathetic reaction of the ANS. We expect to replicate these findings and show increased pupil diameter for high vs. low calorie food images in adolescents with restrictive and binge eating/purging. **However**, when IC will be experimentally triggered (in trials wherein participants need to inhibit a response while being exposed to high-calorie food images), the effect of increased pupil diameter for high-calorie foods will be suppressed. The suppression effect is expected to occur in patients with restrictive EDs (who are characterized by excessive food-related IC), but not in those with binge eating purging EDs (who are characterized by deficient food-related IC). This pattern will confirm that patients with restrictive EDs can use IC resources to suppress an automatic physiological response to high-calorie foods.

*Food Go/No Go task (Food-GNG):* In a Food-GNG task, participants will be presented with a fixation cross (1,000 ms) that will be replaced by a colored frame. Participants will be asked to respond by pressing the space bar when a blue frame is presented (go-trials; 75% of the trials) and withhold their response when an orange frame is shown (no-go trials; 25% of the trials). Figure 3 shows an example of two typical trials. The colors for go and no-go trials will equal in luminance level and assignment of blue and orange to go vs. no-go signals will be counterbalanced across participants. Inside the frames, images of high- and low-calorie foods (64 of each and different from those in study 1) will be presented. Scrambled versions of the food images will also be included in order to control for luminance, color, and other visual characteristics that can influence pupil dilation. The target frame with the image inside will be presented for 4,000 ms and will not disappear upon response in order to make sure that the image remains visible for equal amount of time in all conditions to allow sufficient time for pupil dilation without changing luminance. The task will include 16 practice trials and 480 experimental trials (120 no-go trials) distributed equally in five blocks.

Figure 3. Example of two typical trials. In the upper part, participants respond (blue frame) and an image of low-calorie food is presented. In the lower part, participants withhold their response (orange frame) and a picture of high-calorie food is presented.



*Apparatus and procedure:* Pupillometry will be measured via a portable eye-tracker (EyeLink Portable Duo, SR Research) with a sampling rate of 1000 Hz (1 ms inter-sampling time). To ensure that the luminance level in the experimental room is similar between the sites, the room will be darkened and we will place the same lamps (with a 40v light bulb) in each site. Portable chin rests will also be purchased and placed in each site.

**Experimental Design - Study 3**

*Objective:* Study 3 will assess if priming IC can improve reappraisal in adolescents with EDs.

*Working hypothesis:* It is expected that priming IC will improve reappraisal of a negative emotional image on a trial-by-trial basis in adolescents with EDs. Because adolescents with binge eating/purging EDs have greater difficulties using reappraisal compared to those with restrictive EDs (Danner et al., 2012), it is expected that adolescents with binge eating/purging EDs will show the greatest benefit from priming their IC on their ability to reappraise negative emotional content.

*GNG-reappraisal task:* In a cognitive reappraisal task, participants will view negative images and be requested to rate how negative they feel after each image (on a scale from 1-5, 5 being most negative). Before the images appear, a cue will instruct participants to either “watch” the image without trying to change their emotional experience or “rethink”, that is, think about the picture differently in a way that would make it less negative (i.e., reappraisal condition), for example: “*This is just a scene from a movie...*”. Additional examples will be given to the participants before the task to ensure they understand the “rethink” condition. Lower negativity rating after “rethink” compared to “watch” cues represents successful reappraisal. Numerous behavioral and neuroimaging studies have used this task to assess reappraisal (for review see Buhle et al., 2014). In the current study, we will modify the original task so that participants perform a GNG task between the cue and the target (see Figure 4). In the GNG task, participants will see different letters and will be instructed to respond as fast as they can to each letter presented (go-trials; 75% of the trials) but withhold their response when seeing the letters ‘C’, ‘F’, or ‘T’ (no-go trials; 25% of the trials). Immediately after they respond or withhold a response, a negative image will appear and they will “watch” or “rethink” based on the cue that was presented before the GNG task. The task will include 240 trials (60 no-go trials and 180 go trials) spread over three blocks. In each no-go and go condition, the proportion of “watch” and “rethink” cues will be equal. The images will be taken from the IAPS (different from those in study 1) and will be different in the “watch” and “rethink” conditions but the mean valence and arousal ratings (based on norms) will be kept equal between the two conditions.

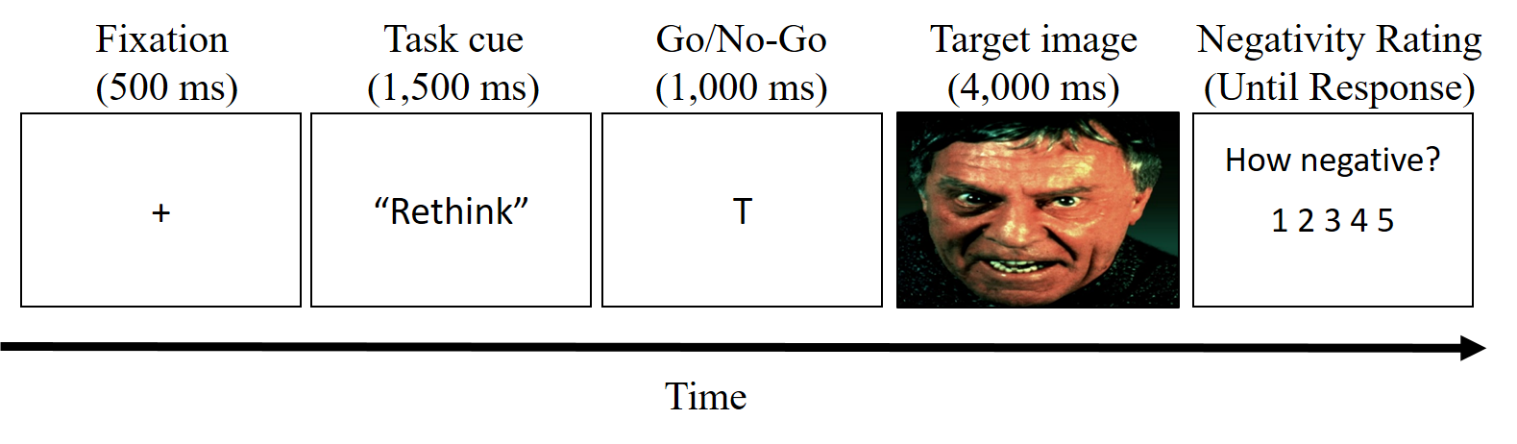


Figure 4. Example of a typical trial in the GNG Reappraisal task. In this example, participants see a “Rethink” cue (meaning they will need to reappraise the upcoming picture). However, before the image appears, they will need to withhold their response (because the letter ‘T’ is a no-go signal). After the image, participants rate how negative they currently feel. The task will allow comparing the ability to reappraise negative images following go vs. no-go trials.

*Preliminary results:* We have obtained promising preliminary results in an identical version of this task with the only difference that an interference control task (the flanker task) was used to prime IC (instead of a GNG task). The task was administered to 14 adolescents with binge eating/purging EDs (10 with BN and 4 with AN-BP). In the flanker task we used, participants indicated whether an arrow in the center of the screen pointed left or right. Flanking arrows next to the target could be congruent (i.e., pointing in the same direction; 🡪🡪🡪🡪🡪) or incongruent (i.e., pointing in a different direction; 🡪🡪🡨🡪🡪), thus creating a conflict that requires IC resources to resolve. **The results showed that following “rethink” cues, participants had lower negativity ratings when incongruent flankers preceded the image compared to congruent flankers**, indicating that participants reappraised better after IC was primed. This effect did not reach a significant level with 14 participants (*F*(1,13) = 2.67, *p* = .12) but had a robust effect size of η2 = .17 and thus will likely reach significance level with 60 participants in each group. Because the current proposal focuses on behavioral inhibition (using GNG and SST) and not interference control, we would like to pilot a version of this task using the GNG task. However, if the results will not be as promising as those with the flanker task, we will carry on using the flanker task to prime IC in the current study as well.

Pilot testing using an analogue sample: In order to assess the feasibility of the procedure and the sensitivity of the tasks, we will run all the tasks described in the three studies using an analogue sample of healthy students who are high (N=35) or low (N=35) on a restricted eating scale (assessed via the restricted eating subscale from the Dutch Eating Behavior Questionnaire; DEBQ; van Strien, Frijters, Bergers, & Defares, 1986). This sample is best suited to assess the tasks because a recent meta-analysis revealed converging evidence indicating that people who are high on restricted eating eat more in response to negative emotions (Evers, Dingemans, Junghans, & Boevé, 2018). We have also previously shown aberrant food-related IC in restricted eaters (Ganor-Moscovitz et al., 2018). These findings suggest that abnormal interactions between IC and emotion are present in restricted eaters. Administering the tasks to a sample of restricted eaters before running clinical samples will allow assessing potential carry-over effects between the tasks and conditions and help us decide on the ideal approach for collecting data when running the study with the clinical samples. Although defined here as pilot tests, note that the tasks’ results using this analogue sample may lead to three stand-alone publications on IC and emotion processing among restricted eaters and provide more deliverables from the current project.

**Statistical Analyses and Expected Results:**

**Study 1**

*Approach:* A mixed-model analysis of variance (ANOVA) with SSRT as the dependent measure, group (restrictive EDs / binge eating/purging EDs / HC) as the between-subject independent variable, emotional block (positive / negative / neutral) and target type (food / non-food image) as the within-subject independent variables will be carried out.

*Within-group effects:* In the restrictive EDs group, SSRT is expected to be **shorter** for food vs. non-food items (indicating better inhibition following exposure of food images). Importantly, this effect is predicted to be larger in the negative emotional block compared to the neutral and positive emotional blocks. It is further expected the in the positive emotional block, there will be no difference in SSRT between food and non-food images. In the binge eating/purging EDs group, we expect SSRT to be **longer** for food vs. non-food items (indicating poorer ability to stop a response following exposure to food). Importantly, this effect is expected to be larger in the negative emotional block compared to the other two blocks. In addition, no difference between food and non-food SSRT is expected in the positive emotional block. In the HC group, no interaction between emotional block and target type is expected.

*Between-group effects:* We expect that food SSRT will be larger in the binge eating/purging group compared to the restrictive EDs group and HC. We also expect that the food SSRT will be shorter in the restrictive EDs group compared to HC. Furthermore, these differences between the groups are expected to be largest in the negative emotional block and absent in the positive emotional block.

**Study 2**

*Data processing:* Pupillometry will be processed and analyzed using CHAP, an open source software for processing pupillometry (Hershman, Henik, & Cohen, 2019). Eye-blinks will be detected and replaced using linear interpolation. In each trial, the mean pupil size will be calculated during the 200 ms prior to the target and will be used as baseline. For each participant, the pupil size within the target’s time window will be subtracted from the baseline measurement in order to account for individual differences in pupil size.

*Approach:* A mixed-model ANOVA will use the mean pupil diameter for the target (after baseline correction) as the dependent variable, group (restrictive EDs / binge eating/purging EDs / HC) as the between-subject independent variable and food type (high / low-calorie food) and trial type (go / no-go trial) will be included as within-subject variables. Only accurate responses will be used. Pupillometry for erroneous responses (commission and omission errors) will be performed if there will be enough trials to perform such analysis.

*Within-group effects:* In the restrictive EDs group, larger pupil dilation is expected in go trials following presentation of high vs. low calorie food images. However, we expect that this effect will be attenuated in the no-go condition due to a reduction in pupil size in the high-calorie foods condition. In the binge eating/purging EDs group, we expect to show increased pupil diameter for high vs. low-calorie foods in both go and no-go conditions.

*Between-group effects:* We predict that the pupil diameter will be larger for high-calorie foods in the binge eating/purging group compared to the restrictive EDs group, but only in the no-go condition. In go trials (i.e., when IC is not triggered), we expect to see similar increase in both groups in response to high-calorie foods and that this increase will be larger than that in the HC group.

**Study 3**

*Approach:* A mixed-model ANOVA with mean negativity rating as the dependent variable, group (binge eating/purging EDs / restrictive EDs / HC) as between-subject independent variable, cue type (“watch” / “rethink”) and trial type (go / no-go trial) will be included as within-subject independent variables.

*Within-group effects:* In the “rethink” condition, the negativity rating is expected to be smaller when a no-go trial precedes the image compared to a go trial (in all groups). Negativity rating after a “watch” condition is not expected to be different as a function of go vs. no-go condition.

*Between-group effects:* We will compare the IC benefit in the “rethink” condition (i.e., the gap in negativity rating between “rethink”-go and “rethink no-go” conditions between the groups. It is expected that this benefit will be larger in the binge eating/purging EDs group compared to the restrictive EDs and HC groups.

**Power analysis:**

A previous meta-analysis showed a medium-large effect size for deficits in food-related IC in binge eating/purging EDs (Hedge’s g = -0.67; Wu et al., 2013) and in our previous study we showed medium-large effect size for superior food-related IC in AN-R (η2 = 0.11; Weinbach, Lock, et al., 2019). A previous study reported a large effect size (η2 = .19) for IC suppression on pupil dilation to emotional stimuli in healthy participants (Cohen et al., 2015). Lastly, our preliminary results revealed a large effect size (η2 = 0.17) for the benefit of IC on reappraisal in adolescents with binge eating/purging EDs. Thus, for the power analysis, we used a medium-large effect size estimate of η2 = .09. A power analysis using G\*power (Faul, Erdfelder, Lang, & Buchner, 2007) showed that for a power > 80% with a priori alpha set at 0.05 to study within-between variables interactions in the ANOVAs, 30 participants are needed in each diagnostic group. We decided to recruit 60 participants in each group so that our specific EDs subtype analysis (see above) will be sufficiently powered.

**Additional Analyses:**

*Contribution of IC-emotion interactions to disordered eating:* The contribution of the primary measures in each task to disordered eating will be assessed. Primary measures refer to the difference in SSRT to food vs. non-food stimuli in a negative emotional block in Study 1, averaged difference in pupil diameter in response to high vs. low calorie foods in the no-go condition in Study 2, and the difference in negativity ratings following a “rethink” cue in a go vs. no-go condition in Study 3. Three main measures of disordered eating will be taken from the EDE-Q: the restricted eating subscale, frequency of binge eating episodes over the past month, and the number of purging behaviors engaged in order to control weight (vomiting + use of laxatives) over the past month. In each study, a multilevel regression analysis will include the primary measure relevant for that study, group, and the primary measure\*group interaction as predictors of the three disordered eating measures. To analyze the follow up data, the three measures of disordered eating at baseline will be added as predictors and follow-up disordered eating measures as dependent variables. It is expected that the primary measures will prospectively predict follow-up clinical measures of disordered eating over and above baseline measurements of these variables.

*Analyses of specific EDs subtypes:*In the primary analyses, we will separate the groups based on disordered eating type (i.e., restrictive vs. binge eating/purging). However, we also plan to assess differences between the specific diagnoses. This is important because if the results of AN-R and Atypical AN are similar, but different from AN-BP and BN, this will provide strong evidence that any abnormalities found in the interaction between IC and emotion cannot be attributed to weight status. This is because AN-R and Atypical AN share similar disordered eating pattern but differ in weight (Atypical AN are not underweight). In addition, AN-R and AN-BP do not share the same disordered eating patterns, but both are characterized by low weight.

*Exploratory correlational analyses:*Exploratory correlational analysis will examine associations between the primary measures in each task and clinical/demographic variables including age, %EBW, illness duration (only in the patient group), emotion regulation difficulties (DERS) and propensity for using reappraisal (assessed via the ERQ). This will allow assessing the contribution all these variables to IC-emotion interactions.

*Dealing with comorbid symptoms and diagnoses:*In order to assess potential confounds such as comorbid symptoms of depression and anxiety which are common in patients with EDs (Bulik, 2002), we will assess if the results differ when entering BDI and STAI as covariates. In addition, the proportion of patients with a comorbid DSM psychiatric diagnosis (e.g., major depression, obsessive-compulsive disorder, post-traumatic stress disorder, etc.) will be assessed using the SCID-5. We will assess if the primary effects remain unchanged when excluding patients with comorbid diagnoses in a similar approach to that we have taken in a previous study assessing emotion regulation in adolescents with restrictive vs. binge eating/purging EDs (Weinbach, Sher, & Bohon, 2018).

**Potential Pitfalls, Limitations, and Contingency Plans**

A recruitment rate of 3-4 patients per month is expected based on recruitment rates in previous studies conducted by the PI involving adolescents with EDs in Israel (Weinbach, Perry, Sher, Lock, & Henik, 2017; Weinbach, Sher, & Bohon, 2018; Weinbach, Sher, Lock, et al., 2018). To mitigate the risk of not reaching the target sample according to schedule, the study will be carried out in three independent EDs clinics (see collaboration letters attached). If the recruitment rate will not be satisfactory, the PI will approach additional EDs centers across the country to offer collaboration on this project.

Limitations of the proposed study include inability to determine if specific emotions (e.g., disgust, sadness, or anger) have specific influences on food-related IC. However, in light of previous research indicating difficulties in labeling and differentiating specific emotions among individuals with EDs (Nowakowski, McFarlane, & Cassin, 2013), it was decided that this research will treat negative emotions broadly. In addition, the study does not include a pure binge eating disorder group which limits its ability to generalize conclusions to all EDs types characterized by binge eating. However, we have recently found that the association between negative affect and food-related inhibition is associated more strongly with binge eating in EDs with compensatory behaviors (e.g., BN, AN-BP) compared to binge eating without compensatory behaviors (Smith et al., 2019). In addition, diagnostic crossovers from restrictive EDs to binge eating/purging EDs may take place over time (Eddy et al., 2008). Cognition-emotion interactions may differ in patients who crossover compared to those who do not and the current studies have limited ability to detect such differences. However, in adolescents, such crossovers are less frequent due to their short illness duration. In addition, we have recently suggested that deterioration of IC over time may make patients with restrictive EDs more susceptible for impulsive binge eating and/or purging behaviors (Weinbach, Lock, et al., 2019). If so, longer illness duration should be associated with reduced ability to inhibit a response to food stimuli in the restricted EDs group and we will be able to test this prediction. Lastly, to mitigate the risk of failed hypotheses, the three studies were designed to answer independent questions and Bayesian statistics will be used to assess null results which can also be interesting in light of the unique research questions and population examined.

**Resources Available for the Proposed Study**

Dr. Noam Weinbach is starting his second year as a senior lecturer (assistant professor) in the Department of Psychology in the University of Haifa. Dr. Weinbach has extensive experience in studying IC and emotion regulation in healthy and clinical populations (particularly in adolescents with EDs). Dr. Weinbach is a certified clinical psychologist with over 8-years of clinical experience working in inpatient and outpatient eating disorder clinics. Dr. Weinbach completed a Fulbright post-doctoral fellowship at the world-leading center for eating disorder research and treatment at Stanford University led by Prof. James lock, where he gained hands-on training in integrating basic and clinical research on child and adolescent EDs. At the University of Haifa, Dr. Weinbach has established the Experimental Psychopathology Laboratory and is currently mentoring five graduate students, all of which are engaged in research on how cognitive and emotional functioning impacts eating behaviors and body image. Dr. Weinbach’s laboratory includes three experimental rooms with state-of-the-art equipment and facilities for conducting behavioral experiments in healthy and clinical populations. For the eye-tracking experiment in Study 2, two portable eye-tracking devices will be purchased using the ISF young faculty equipment grant. These will be used for running participants in Haifa and Tel-Aviv sites. Another eye-tracking device will be used in the southern site (Beer-Sheva) through a collaboration with the Cognitive Neuropsychology Laboratory at Ben-Gurion University, led by Prof. Avishai Henik (Dr. Weinbach’s PhD mentor). We will make sure that the equipment is similar in all sites and that the experiments are being carried-out in similar conditions. Dr. Noga Cohen, who is also a faculty at the University of Haifa, will collaborate and consult on all technical aspects regarding the design, data collection, and analysis of the eye-tracking study (see collaboration letter attached). Dr. Cohen is an expert in studying pupil dilation. She was the first to show how IC suppresses pupillary responses to emotional stimuli (Cohen et al., 2015) and is one of the developers of CHAP, a software for the processing and analysis of pupillary data (Hershman et al., 2019).

Additionally, Dr. Weinbach is currently engaged in international collaborations on behavioral, neuroimaging, and EMA studies on emotion and IC in EDs with Prof. James Lock and Dr. Cara Bohon from Stanford University and Prof. Ross Crosby from the University of North Dakota, Fargo. Prof. Eric Stice from Stanford University will collaborate on the current research project (see letter attached). These world-leading experts will be able to advice on theoretical and practical aspects of the research project when needed.

References

Ahmed, S. P., Bittencourt-Hewitt, A., & Sebastian, C. L. (2015). Neurocognitive bases of emotion regulation development in adolescence. *Developmental Cognitive Neuroscience*, *15*, 11–25. https://doi.org/10.1016/j.dcn.2015.07.006

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (5th ed.)*. Washington, DC: Author. https://doi.org/10.1176/appi.books.9780890425596.dsm10

Bartholdy, S., Dalton, B., O’Daly, O. G., Campbell, I. C., & Schmidt, U. (2016). A systematic review of the relationship between eating, weight and inhibitory control using the stop signal task. *Neuroscience and Biobehavioral Reviews*, *64*, 35–62. https://doi.org/10.1016/j.neubiorev.2016.02.010

Beck, A., Steer, R., & Brown, G. (1996). *Beck depression inventory-II*. San Antonio, TX: The Psychological Corporation. https://doi.org/10.1037/t00742-000

Blechert, J., Meule, A., Busch, N. A., & Ohla, K. (2014). Food-pics: an image database for experimental research on eating and appetite. *Frontiers in Psychology*, *5*, 617. https://doi.org/10.3389/fpsyg.2014.00617

Bradley, M. M., Miccoli, L., Escrig, M. A., & Lang, P. J. (2008). The pupil as a measure of emotional arousal and autonomic activation. *Psychophysiology*, *45*(4), 602–607. https://doi.org/10.1111/j.1469-8986.2008.00654.x

Bradley, M. M., Sapigao, R. G., & Lang, P. J. (2017). Sympathetic ANS modulation of pupil diameter in emotional scene perception: Effects of hedonic content, brightness, and contrast. *Psychophysiology*, *54*(10), 1419–1435. https://doi.org/10.1111/psyp.12890

Buhle, J. T., Silvers, J. A., Wage, T. D., Lopez, R., Onyemekwu, C., Kober, H., … Ochsner, K. N. (2014). Cognitive reappraisal of emotion: A meta-analysis of human neuroimaging studies. *Cerebral Cortex*, *24*(11), 2981–2990. https://doi.org/10.1093/cercor/bht154

Bulik, C. M. (2002). Anxiety, depression, and eating disorders. *Eating Disorders and Obesity: A Comprehensive Handbook*, *2*, 193–198. https://doi.org/10.1080/10447318.2017.1393974

Cohen, N., & Mor, N. (2018). Enhancing reappraisal by linking cognitive control and emotion. *Clinical Psychological Science*, *6*(1), 155–163. https://doi.org/10.1177/2167702617731379

Cohen, N., Moyal, N., & Henik, A. (2015). Executive control suppresses pupillary responses to aversive stimuli. *Biological Psychology*, *112*, 1–11. https://doi.org/10.1016/j.biopsycho.2015.09.006

Dahlgren, C. L., & Rø, Ø. (2014). A systematic review of cognitive remediation therapy for anorexia nervosa - development, current state and implications for future research and clinical practice. *Journal of Eating Disorders*, *2*, 1–11. https://doi.org/doi: 10.1186/s40337-014-0026-y

Danner, U. N., Evers, C., Stok, F. M., Van Elburg, A. A., & De Ridder, D. T. D. (2012). A double burden: Emotional eating and lack of cognitive reappraisal in eating disordered women. *European Eating Disorders Review*, *20*, 490–495. https://doi.org/10.1002/erv.2184

Engel, S. G., Crosby, R. D., Thomas, G., Bond, D., Lavender, J. M., Mason, T., … Wonderlich, S. A. (2016). Ecological momentary assessment in eating disorder and obesity research: a review of the recent literature. *Current Psychiatry Reports*, *18*(4), 1–9. https://doi.org/10.1007/s11920-016-0672-7

Engel, S. G., Wonderlich, S. a, Crosby, R. D., Mitchell, J. E., Crow, S., Peterson, C. B., … Gordon, K. H. (2013). The role of affect in the maintenance of anorexia nervosa: evidence from a naturalistic assessment of momentary behaviors and emotion. *Journal of Abnormal Psychology*, *122*, 709–719. https://doi.org/10.1037/a0034010

Evers, C., Dingemans, A., Junghans, A. F., & Boevé, A. (2018). Feeling bad or feeling good, does emotion affect your consumption of food? A meta-analysis of the experimental evidence. *Neuroscience and Biobehavioral Reviews*, *92*, 195–208. https://doi.org/10.1016/j.neubiorev.2018.05.028

Fairburn, C. G., & Beglin, S. J. (1994). Assessment of eating disorders: Interview or self‐report questionnaire? *International Journal of Eating Disorders*, *16*(4), 363–370. https://doi.org/10.1002/1098-108X(199412)16:4<363::AID-EAT2260160405>3.0.CO;2-#

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G\*Power: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*, 175–191.

Feeser, M., Prehn, K., Kazzer, P., Mungee, A., & Bajbouj, M. (2014). Transcranial direct current stimulation enhances cognitive control during emotion regulation. *Brain Stimulation*, *7*(1), 105–112. https://doi.org/10.1016/j.brs.2013.08.006

First, M. B., Williams, J. B. W., Karg, R. S., & Spitzer, R. L. (2015). *Structured clinical interview for DSM-5—Research version (SCID-5 for DSM-5, research version; SCID-5-RV)*. Arlington, VA: American Psychiatric Association.

Ganor-Moscovitz, N., Weinbach, N., Canetti, L., & Kalanthroff, E. (2018). The effect of food-related stimuli on inhibition in high vs. low restrained eaters. *Appetite*, *131*, 53–58. https://doi.org/10.1016/j.appet.2018.08.037

Godier, L. R., Scaife, J. C., Braeutigam, S., & Park, R. J. (2016). Enhanced early neuronal processing of food pictures in anorexia Nervosa: A magnetoencephalography study. *Psychiatry Journal*, *2016*, 1–13. https://doi.org/10.1155/2016/1795901

Granholm, E., & Steinhauer, S. R. (2004). Pupillometric measures of cognitive and emotional processes. *International Journal of Psychophysiology*, *52*(1), 1–6. https://doi.org/10.1016/J.IJPSYCHO.2003.12.001

Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the difficulties in emotion regulation scale. *Journal of Psychopathology and Behavioral Assessment*, *26*, 41–54. https://doi.org/10.1023/B:JOBA.0000007455.08539.94

Gross, J. J. (1998). The Emerging Field of Emotion Regulation: An Integrative Review. *Review of General Psychology*, *2*(3), 271–299. https://doi.org/10.1037/1089-2680.2.3.271

Gross, J. J., & John, O. P. (2003). Individual Differences in Two Emotion Regulation Processes: Implications for Affect, Relationships, and Well-Being. *Journal of Personality and Social Psychology*, *85*(2), 348–362. https://doi.org/10.1037/0022-3514.85.2.348

Hershman, R., Henik, A., & Cohen, N. (2019). CHAP: Open-source software for processing and analyzing pupillometry data. *Behavior Research Methods*, *51*(3), 1059–1074. https://doi.org/10.3758/s13428-018-01190-1

Hill, L., Peck, S. K., Wierenga, C. E., & Kaye, W. H. (2016). Applying neurobiology to the treatment of adults with anorexia nervosa. *Journal of Eating Disorders*, *4*(1), 31. https://doi.org/10.1186/s40337-016-0119-x

Hirst, R. B., Beard, C. L., Colby, K. A., Quittner, Z., Mills, B. M., & Lavender, J. M. (2017). Anorexia nervosa and bulimia nervosa: A meta-analysis of executive functioning. *Neuroscience and Biobehavioral Reviews*, *83*(May), 678–690. https://doi.org/10.1016/j.neubiorev.2017.08.011

Horndasch, S., Roesch, J., Forster, C., Dörfler, A., Lindsiepe, S., Heinrich, H., … Kratz, O. (2018). Neural processing of food and emotional stimuli in adolescent and adult anorexia nervosa patients. *PloS One*, *13*(3), e0191059. https://doi.org/10.1371/journal.pone.0191059

Kass, A. E., Kolko, R. P., & Wilfley, D. E. (2013). Psychological treatments for eating disorders. *Current Opinion in Psychiatry*, *26*(6), 549–555. https://doi.org/10.1097/YCO.0b013e328365a30e.Psychological

Kaye, W. H., Fudge, J. L., & Paulus, M. (2009). New insights into symptoms and neurocircuit function of anorexia nervosa. *Nature Reviews Neuroscience*, *10*(8), 573–584. https://doi.org/10.1038/nrn2682

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). International Affective Picture System (IAPS): Technical manual and affective ratings. *NIMH Center for the Study of Emotion and Attention*, 39–58. https://doi.org/10.1027/0269-8803/a000147

Lavender, J. M., Wonderlich, S. A., Engel, S. G., Gordon, K. H., Kaye, W. H., & Mitchell, J. E. (2015). Dimensions of emotion dysregulation in anorexia nervosa and bulimia nervosa: A conceptual review of the empirical literature. *Clinical Psychology Review*, *40*, 111–122. https://doi.org/10.1016/j.cpr.2015.05.010

Lock, J., Garrett, A., Beenhakker, J., & Reiss, A. L. (2011). Aberrant brain activation during a response inhibition task in adolescent eating disorder subtypes. *American Journal of Psychiatry*, *168*(1), 55–64. https://doi.org/10.1176/appi.ajp.2010.10010056

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, a H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex “Frontal Lobe” tasks: a latent variable analysis. *Cognitive Psychology*, *41*(1), 49–100. https://doi.org/10.1006/cogp.1999.0734

Nowakowski, M. E., McFarlane, T., & Cassin, S. (2013). Alexithymia and eating disorders: a critical review of the literature. *Journal of Eating Disorders*, *1*, 21. https://doi.org/10.1186/2050-2974-1-21

Prefit, A.-B., Cândea, D. M., & Szentagotai-Tătar, A. (2019). Emotion regulation across eating pathology: A meta-analysis. *Appetite*, *143*, 104438. https://doi.org/10.1016/j.appet.2019.104438

Sala, M., Heard, A., & Black, E. A. (2016). Emotion-focused treatments for anorexia nervosa: a systematic review of the literature. *Eating and Weight Disorders - Studies on Anorexia, Bulimia and Obesity*, *21*(2), 147–164. https://doi.org/10.1007/s40519-016-0257-9

Segal, A., & Golan, M. (2016). Differences in emotion regulation along the eating disorder spectrum: Cross sectional study in adolescents out patient care. *Journal of Psychology & Clinical Psychiatry*, *6*(1). https://doi.org/10.15406/jpcpy.2016.06.00314

Silvers, J. a, McRae, K., Gabrieli, J. D. E., Gross, J. J., Remy, K. a, & Ochsner, K. N. (2012). Age-related differences in emotional reactivity, regulation, and rejection sensitivity in adolescence. *Emotion*, *12*(6), 1235–1247. https://doi.org/10.1037/a0028297

Smink, F. R. E., Van Hoeken, D., & Hoek, H. W. (2012). Epidemiology of eating disorders: Incidence, prevalence and mortality rates. *Current Psychiatry Reports*, *14*(4), 406–414. https://doi.org/10.1007/s11920-012-0282-y

Smith, K. E., Mason, T. B., Johnson, J. S., Lavender, J. M., & Wonderlich, S. A. (2018). A systematic review of reviews of neurocognitive functioning in eating disorders: The state-of-the-literature and future directions. *International Journal of Eating Disorders*. https://doi.org/10.1002/eat.22929

Smith, K. E., Mason, T. B., Schaefer, L. M., Juarascio, A., Dvorak, R., Weinbach, N., … Wonderlich, S. A. (2019). Examining intra-individual variability in food-related inhibitory control and negative affect as predictors of binge eating using ecological momentary assessment. *Journal of Psychiatric Research*. https://doi.org/10.1016/j.jpsychires.2019.10.017

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the state-trait anxiety inventory.* Palo Alto, CA: Consulting Psychologists Press.

Steinberg, L. (2005). Cognitive and affective development in adolescence. *Trends in Cognitive Sciences*, *9*(2), 69–74. https://doi.org/10.1016/j.tics.2004.12.005

Tabibnia, G., Monterosso, J. R., Baicy, K., Aron, A. R., Poldrack, R. A., Chakrapani, S., … London, E. D. (2011). Different forms of self-control share a neurocognitive substrate. *Journal of Neuroscience*, *31*(13), 4805–4810. https://doi.org/10.1523/JNEUROSCI.2859-10.2011

Tchanturia, K., Giombini, L., Leppanen, J., & Kinnaird, E. (2017). Evidence for cognitive remediation therapy in young people with anorexia nervosa: systematic review and meta-analysis of the literature. *European Eating Disorders Review*, *25*, 227–236. https://doi.org/10.1002/erv.2522

van Strien, T., Frijters, J. E. R., Bergers, G. P. A., & Defares, P. B. (1986). The Dutch Eating Behavior Questionnaire (DEBQ) for assessment of restrained, emotional, and external eating behavior. *International Journal of Eating Disorders*, *5*(2), 295–315. https://doi.org/10.1002/1098-108X(198602)5:2<295::AID-EAT2260050209>3.0.CO;2-T

Verbruggen, F., & Logan, G. D. (2008). Response inhibition in the stop-signal paradigm. *Trends in Cognitive Sciences*, *12*(11), 418–424. https://doi.org/10.1016/j.tics.2008.07.005

Verbruggen, F., & Logan, G. D. (2009). Models of response inhibition in the stop-signal and stop-change paradigms. *Neuroscience and Biobehavioral Reviews*, *33*(5), 647–661. https://doi.org/10.1016/j.neubiorev.2008.08.014

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063–1070. https://doi.org/10.1037/0022-3514.54.6.1063

Weinbach, N., Bohon, C., & Lock, J. (2019). Set-shifting in adolescents with weight-restored anorexia nervosa and their unaffected family members. *Journal of Psychiatric Research*, *112*, 71–76. https://doi.org/10.1016/j.jpsychires.2019.02.022

Weinbach, N., Lock, J., & Bohon, C. (2019). Superior response inhibition to high-calorie foods in adolescents with anorexia nervosa. *Behaviour Research and Therapy*, 103441. https://doi.org/10.1016/J.BRAT.2019.103441

Weinbach, N., Perry, A., Sher, H., Lock, J. D., & Henik, A. (2017). Weak central coherence in weight-restored adolescent anorexia nervosa: Characteristics and remediation. *International Journal of Eating Disorders*, *50*(8), 924–932. https://doi.org/10.1002/eat.22711

Weinbach, N., Sher, H., & Bohon, C. (2018). Differences in emotion regulation difficulties across types of eating disorders during adolescence. *Journal of Abnormal Child Psychology*, *46*(6), 1351–1358. https://doi.org/10.1007/s10802-017-0365-7

Weinbach, N., Sher, H., Lock, J. D., & Henik, A. (2018). Attention networks in adolescent anorexia nervosa. *European Child and Adolescent Psychiatry*, *27*(3), 343–351. https://doi.org/10.1007/s00787-017-1057-0

Wierenga, C., Bischoff-Grethe, A., Melrose, A. J., Grenesko-Stevens, E., Irvine, Z., Wagner, A., … Kaye, W. H. (2014). Altered BOLD response during inhibitory and error processing in adolescents with anorexia nervosa. *PloS One*, *9*, e92017. https://doi.org/doi:10.1371/journal.pone.0092017

Wu, M., Hartmann, M., Skunde, M., Herzog, W., & Friederich, H. C. (2013). Inhibitory control in bulimic-type eating disorders: A systematic review and meta-analysis. *PLoS ONE*, *8*(12), e83412. https://doi.org/10.1371/journal.pone.0083412

Xue, S., Cui, J., Wang, K., Zhang, S., Qiu, J., & Luo, Y. (2013). Positive emotion modulates cognitive control: An event-related potentials study. *Scandinavian Journal of Psychology*, *54*(2), 82–88. https://doi.org/10.1111/sjop.12031

Zhu, Y., Hu, X., Wang, J., Chen, J., Guo, Q., Li, C., & Enck, P. (2012). Processing of food, body and emotional stimuli in anorexia nervosa: a systematic review and meta-analysis of functional magnetic resonance imaging studies. *European Eating Disorders Review : The Journal of the Eating Disorders Association*, *20*(6), 439–450. https://doi.org/10.1002/erv.2197