심리학석사 학위논문

Identifying shared and unique mechanisms of food addiction and binge eating based on dietary restraint and body image concern

음식 중독과 폭식 행동의 공통된 기제 및 고유한 기제 확인: 섭식 절제와 신체상에 대한 걱정을 중심으로

2021 년 8 월

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이 논문을 심리학석사 학위논문으로 제출함

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Abstract

Strong evidence indicates that dietary restraint and excessive body image concerns are ironically associated with pathological overeating. Overeating is present in both food addiction and binge eating disorder (BED) but the role of dietary restraint and body image concerns in food addiction and BED still remains unclear. Furthermore, decision-making processes associated with food addiction and BED are yet to be identified. To address this gap, I designed a longitudinal study to investigate whether improved body image concerns by liposuction surgery would play a different role in food addiction and BED. I also investigated their decision-making under uncertainty using novel weight-related decision-making paradigms and computational modeling. In Study 1 (N=93), I validated the novel weight-related decision-making tasks in the community samples and found that measures from weight-related decision-making tasks are more related to body image concerns than those from tasks involving monetary decisions. In Study 2, obese individuals who registered for liposuction surgery (N = 102, body mass index greater than 25) were analyzed, and data on food addiction behavior, binge eating behaviors, dietary restraint, body image concerns, and model parameters (e.g., loss aversion, risk-seeking, and ambiguity tolerance) before and after the surgery was collected. The results showed that 1) only binge eating behavior, but not food addiction behavior, was alleviated after the surgery, 2) changes in body image concerns are significantly associated with binge eating behavior but not with food addiction, and 3) food addiction displayed positive association with attentional impulsivity, while binge eating showed the opposite. While there was no difference in the weight-related model parameters, our results suggest the difference between food addiction and BED, providing novel insights into their constructs.

Keywords: food addiction, binge eating disorder, dietary restraint, body image concern, weight-related decision-making

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Table of Contents

List of figures

List of Tables

Chapter 1. Introduction

In recent years, a wealth of research has documented scientific evidence for the existence of food addiction, while others controvert its validity and necessity (Gearhardt & Hebebrand, 2021; Hebebrand & Gearhardt, 2021). The concept of food addiction proposes that certain foods, those containing high carbohydrates or fat, can trigger an addictive-like process in individuals with vulnerable characteristics of addiction. According to the advocates, food addiction is a disease demonstrated by the loss of self-control over eating certain highly palatable food items. As substance use disorders (SUDs) are a cluster of chemical dependencies on substances of addiction, food addiction has been suggested as a disease with chemical dependencies on certain highly processed (HP) foods, high in fat, sugar, and carbohydrate, which lead to physical craving for such foods (Gearhardt et al., 2009). However, the concept of food addiction has yet to reach a scientific consensus, and further examination of its validity is required to bring the food addiction controversy to an end. Most of the evidence for or against food addiction has been overlaps between food addiction and SUDs.

1.1. Advocates of food addiction

Advocates of food addiction postulate parallels between addictive disorders and problematic overeating, and suggest that such HP foods should be viewed as the substance of addiction, which could help reduce the prevalence of obesity and improve treatment strategies (Gearhardt & Hebebrand, 2021; Tobore, 2020). The most widely used “diagnostic tool” of food addiction is the Yale Food Addiction Scale (YFAS) 2.0 (Gearhardt et al., 2016), which applied the criteria for SUDs in the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (Association, 2013)(DSM-5, American Psychiatric Association, 2013). The food addiction framework posits an addictive potential of high-sugar, high-fat foods, applying an addiction framework to HP foods. Thus, advocates of food addiction have mainly presented evidence of commonalities between HP foods and addictive substances.

Addictive substances could be characterized by three factors. First, they are typically a complex mixture of ingredients combined to deliver unnaturally high levels of reward; cigarettes contain nicotine with hundreds of ingredients such as cocoa or menthol, and alcoholic beverages are alcohol combined with fruits, grains, or sugar to enhance flavor (Hebebrand & Gearhardt, 2021). Second, all the substances directly activate the reward system by the release of dopamine in the ventral striatum, particularly in the nucleus accumbens (Heinz et al., 2020). Third, due to this hedonically pleasurable nature of the substances, alterations in reward-related neural systems occur, which leads to compulsive uses for some individuals (Berridge & Robinson, 2016; Everitt & Robbins, 2005; Gearhardt & Hebebrand, 2021).

Numerous literature has suggested that HP foods, such as pizza, ice cream, cakes, cookies, share the characteristics of addictive substances. First of all, HP foods are also a mixture of refined carbohydrates and fat with other ingredients such as salt or glutamate as flavor enhancers just like tobacco, and refined carbohydrates are delivered in various types of sugary food items just like alcohol, which is consumed in various types of liquor such as wine, beer, and cocktails.

Second, while natural rewards such as food consumption and sexual intercourse lead to the release of dopamine, numerous animal studies have reported that sugar and other refined food items activate mesolimbic dopaminergic reward systems in a similar manner as the addictive substances (Bello et al., 2002; Gearhardt et al., 2011; Johnson & Kenny, 2010).

Third, refined carbohydrates like sugars are found to be 'wanted' in the absence of homeostatic need, as the addictive substances are wanted regardless of liking (Lowe & Butryn, 2007). Neurobiological mechanisms of 'wanting' are represented by mesocorticolimbic circuitry, the major dopamine pathway responsible for reward and motivation (Berridge, 1996; Morales & Berridge, 2020). 'Wanting' should be distinguished from 'liking', which is related to the pleasure and palatability of foods usually encoded in primary gustatory regions in the brain (Berridge, 1996; Morales & Berridge, 2020). Researchers have suggested that both SUD and binge eating could be framed as excessive 'wanting' caused by cue-induced sensitization in the brain mesolimbic systems, regardless of 'liking' (Morales & Berridge, 2020; Robinson & Berridge, 2008). Thus, according to the 'incentive-sensitization theory' (Berridge, 1996), sensitized reward systems to food-related cues push individuals toward habitual and compulsive eating, just as sensitization to substance-related cues induce compulsive drug use (Berridge, 2009; Morales & Berridge, 2020; Pelchat et al., 2004).

In addition, a sort of behavioral indicator triggered by excessive drug use has also been reported in the food domain. For example, diminished self-control over consumption is the main diagnostic criterion for eating disorders related to binge eating, and behavioral and neural evidence for food craving has been well documented (Meule & Kübler, 2012; Pelchat, 2002; Schulte et al., 2019). Also, continued use despite knowing the negative consequences on health and repeated failed attempts to cut down consumption are common behaviors toward HP foods in some individuals, which corresponds to that of individuals with SUD toward substances of abuse (Meule & Gearhardt, 2014).

1.2. Opponents of food addiction

Refutation toward using the concept "food addiction" points out the differences, or not-yet-proven commonalities, between HP foods and addictive substances. Also, the opponents cast doubt about the validity of food addiction in that the concept has not been dissociated from BED. Regarding the impact on society, they also worry that the concept of food addiction is placing the reason for the obesity pandemic to individuals consuming those HP foods, not to the environmental factors such as cheap and effectively marketed foods by tactics of the food industry to promote food consumption (Hebebrand & Gearhardt, 2021).

Although refined carbohydrates or fat are presented as addictive ingredients in HP foods, the food addiction concept lacks specificity and evidence about the chemical agents or compounds responsible for addiction (Hebebrand & Gearhardt, 2021). Evidence of glucose or sucrose addiction has been found in numerous animal studies but has not been verified in human studies yet (Hebebrand et al., 2014). Thus, in order to extend the findings in animal studies, biological and neurological evidence such as elimination of half-life (time required for the amount of drug in the body to decrease by half (Nnane, 2005)) of sugar should be presented. Indeed, YFAS 2.0 does not focus on a single item but lets the responders think of any food that 'they might have difficulty controlling': Simply presenting a list of FD foods without any specific criteria enables possibilities of respondents answering without specific foods in mind, which diverges from the diagnosis of SUD (Hebebrand & Gearhardt, 2021). Another critical issue is dissociation with similar pre-existing constructs; obesity and BED. Obesity means having a higher body mass index (BMI), which is a weight divided by the square of height, and BED is defined as an eating disorder in DSM-5, diagnosed with "recurrent episodes of eating abnormally large amounts of food while experiencing a loss of control, without compensatory behaviors observed in bulimia nervosa (American Psychiatric Association, 2013)". Obesity, BED, and food addiction not only share the main behavioral symptom, overeating with lack of self-control, but also have been reported to highly co-occur. Prevalence of food addiction increased as BMI gets higher (Flint et al., 2014), and co-occurrence of BED and food addiction is high, though it varies from 47.2% (Gearhardt et al., 2016) to 91% (Carter et al., 2019) and the sample size is small.

Lastly, the opponents also cast doubt about whether food addiction could explain obesity. 42.8% of adolescents (12 out of 28) with restricting-type anorexia nervosa have reported to met the food addiction threshold (Albayrak et al., 2017), and the prevalence rate of YFAS diagnosis in under/normal weight was 1.6% while 7.7% in overweight/obese individuals (Hebebrand et al., 2014). Due to these inconsistent findings with pre-existing diagnoses or diseases, the construct validity of food addiction has been accepted.

1.3. Main Issues on Food addiction & critical gap in understanding food addiction

Implementation of the food addiction concept has been highly controversial since it was first proposed. The following are the main reasons obstructing a scientific consensus, and the main issues of the recent controversy that need to be addressed in future research.

First, the most fundamental and critical obstacle is the inconsistent and ambiguous use of the word “food addiction”. According to the researchers who first advocated the concept, the core feature of food addiction is the addictive property of high-carbohydrate and high-fat foods (Gearhardt et al., 2008). However, the feature is sometimes obscured by misinterpretation or misuse of the concept. For example, in the Great Debates in Nutrition about the concept “food addiction” (Hebebrand & Gearhardt, 2021), Hebebrand described food addiction as a “definition for addictive-like overeating”. This makes the meaning of food addiction seem to be overeating any food and its behavior is addictive, blurring the core feature of food addiction. Also, food addiction has often been confused with ‘overweight’, while weight status is not included as core feature of the concept. For instance, one of the critics for using the term food addiction was the low prevalence of food addiction among obese people (Hebebrand et al., 2014) and occurrence in anorexia nervosa (Albayrak et al., 2017), which is characterized by underweight and excessive efforts for weight control (American Psychiatric Association, 2013). In fact, the low co-occurrence of obesity and food addiction, and the existence of food addiction in the population of anorexia nervosa rather support the validity of food addiction, by presenting that food addiction contains unique variability which cannot be explained by obesity. Therefore, in order to reach an agreement by the accumulation of research, correct understanding and consistent usage of the term “food addiction” is essential.

Second, as suggested by the opponents, the addictive potential of certain foods or certain ingredients (e.g. refined carbohydrates such as sugar, or refined fat) should be identified in human studies. While the images of foods high in carbohydrates and fat have been associated with higher activation of reward circuits compared to images with only fat or carbohydrate (DiFeliceantonio et al., 2018), neural mechanisms of consuming actual HP food have not been tested yet. Neuroimaging studies of food processing have mostly used visual or olfactory stimuli, and gustatory stimuli have been limited to liquid (Agarwal et al., 2021). Future studies might examine the addictive properties of certain foods or ingredients by applying the studies that have tested the mechanisms of addictive substances (Boileau et al., 2012; Volkow et al., 2004).

Third, shared and distinct mechanisms of food addiction, BED, and obesity should be clarified. Obesity is a complex condition affected by multiple biopsychosocial and environmental factors, and food addiction could be one of the factors that account for pathological overweight (Hebebrand & Gearhardt, 2021). Also, recent meta-analyses have shown that obesity is unrelated to food-related cravings (Hagan et al., 2020; Hardman et al., 2020), while food craving is one of the critical factors in the addiction framework (Schulte et al., 2016) and has been found in individuals with food addiction diagnosed with YFAS 1.0 (Meule & Kübler, 2012). While obesity and food addiction could be relatively well disentangled, dissociation of BED and food addiction requires further research. Although unique mechanisms of food addiction and BED have been suggested by Schulte et al. (2016), empirical evidence from human studies does not sufficiently support the use of "food addiction" in the presence of similar constructs.

1.4. Food addiction versus binge eating disorder

Schulte et al. (2016) has suggested unique mechanisms of BED and food addiction, and argued that the two concepts do not overlap completely. While reward dysfunction, craving, emotion dysregulation, and impulsivity have been suggested as shared mechanisms of BED and food addiction, unique mechanisms of each construct do exist; in food addition, the addictive properties of highly processed foods are the essence that causes withdrawal and tolerance, while dietary restraint and concern on body image play an important role in BED (Schulte et al., 2016)

As discussed in "1.2. Advocates of food addiction", similarities between addictive substances and HP foods have been well documented. In particular, addictive-like responses to sugary/fatty foods, but not to ordinary chow, have been reported in animal studies (Boggiano et al., 2007; Klump et al., 2013), and also in human studies, strong responses to actual or images of HP foods highly resembled responses toward addictive substances (Gearhardt et al., 2011; Pelchat et al., 2004; Stice et al., 2013b, 2013a).

Withdrawal, defined as physiological or psychological symptoms in response to abstinence of a substance (American Psychiatric Association, 2013), has been observed in animal studies, rats showing opioid-like withdrawal symptoms after sucrose consumption such as teeth chattering and aggressive behavior (Avena et al., 2008, 2009). Withdrawal-like symptoms to carbohydrates have been reported in human studies as well (Gearhardt et al., 2009; Pelchat, 2002). Similarly, tolerance, defined as a need to consume an increased amount of a substance to experience the desired hedonic effects, or diminished effect of a constant dose over time, has been reported for HP foods. Frequent consumption of ice cream led to reduced neural activation on reward circuitry toward milk-shake (Burger & Stice, 2012), and repeated administration of high-carbohydrates foods reduced its effect of reducing self-reported dysphoric mood in obese individuals (Spring et al., 2008). In general, extensive comparisons of food and addictive substances defined in DSM-5 indicate that most of the diagnostic criteria of SUDs, including withdrawal and tolerance, are empirically supported or plausible for HP foods (Goldstein & Volkow, 2011; Meule & Gearhardt, 2014). However, it needs to be further examined whether individuals diagnosed with food addiction using the YFAS develop greater withdrawal or tolerance to HP foods.

For the unique mechanisms of BED, dietary restraint and body image concern have been pointed out as core features of the disorder. Dietary restraint is defined in two ways: 1) an intentional attempt to cut caloric intake and 2) strict dietary rules induced by concerns about shape or weight. Since it has been reported that the link between the level of dietary restriction and the amount of caloric intake is low, dietary restraint has been conceptualized as cognitive rules about the caloric intake, rather than the actual cut-down on food consumption. It is well documented that dietary restraint, mainly represented as dieting, is one of the risk factors for binge eating (Grilo & Masheb, 2000; Hilbert et al., 2014; Stice et al., 2008). For instance, 65% of individuals with BED reported that dieting preceded binge eating (Grilo & Masheb, 2000), and in a 5-year prospective study fasting was one of the strongest risk factors of binge eating pathology in adolescents girls (Stice et al., 2008). Thus, while dieting could be a consequence of binge eating, dieting could also be a risk factor for binge eating in some individuals (Schulte et al., 2016). However, since individuals with food addiction are also prone to weight gain, dieting could be displayed in food addiction as well. Thus, in order to include dietary restraint as a unique feature of BED, it is necessary to examine that dietary restraint plays a causal role only in BED but not in food addiction.

Body image concern refers to placing extreme value on one’s body image, shape, or weight. It has been thought to play a key role in inducing binge eating episodes, and is also reported as a significant predictor of severity of eating psychopathology (Fairburn et al., 2003; Sonneville et al., 2015). Similar to dietary restraint, extreme concerns on body image could precede binge eating for some individuals, while others may experience elevated concern due to negative outcomes of overeating, such as weight gain (Schulte et al., 2016). The consequential increase in body image concern also applies to food addiction, and previous studies have actually reported that individuals with food addiction were associated with higher body concerns (Gearhardt et al., 2013, 2014; Schebendach et al., 2013). However, concern on body image could not be incorporated with an addiction perspective of food addiction, but empirical evidence should be provided that body image concern is not a critical factor in food addiction but just a mere consequence, or side effect of addictive behaviors on highly processed foods.

In short, while it has been actively discussed whether each unique feature exists in the corresponding concepts, whether withdrawal and tolerance exist in food addiction and dietary restraint and body image concern are critical in BED, future research should also address and confirm that each unique feature of the concept is not associated with the other concept; the features of BED do not exist in food addiction, and the features of food addiction do not exist in BED.

1.5. Objectives

The fundamental question of this paper is whether food addiction is different from BED. Currently, unique mechanisms of each concept have been studied by examining the existence of the unique features in the corresponding concept respectively, but no studies so far have experimentally examined the difference in food addiction and binge eating disorder in the relationships with the unique features of each concept. Here, I focused on the unique mechanisms of BED, body image concern and dietary restraint, and investigated whether the difference between food addiction behavior and binge eating behavior exists in the relationships with the unique mechanisms of BED.

In this paper, data were collected from obese individuals who came to local obesity clinics for liposuction surgery. I recruited obese individuals since BED and food addiction have a high prevalence rate among obese individuals compared to individuals with normal weights, and three factors were considered when I decided to target individuals who registered for the liposuction surgery. First, the covariance between food addiction and BED is high. Second, body image concerns and dietary restraint are reported in individuals with food addiction as well as individuals with BED. Third, liposuction surgery could alleviate the negative outcome of problematic eating behavior, weight gain that is known to induce body image concern and dietary restraint in food addiction and BED, making the dissociation obscure. Thus, by tracking the changes before and after the weight-loss intervention, and examining the relationship between changes in food addiction behavior, binge eating behavior, body image concern, and dietary restraint, this paper aimed to examine whether food addiction and binge eating could be dissociated.

Additionally, in order to capture differences in weight-related decision-making associated with body image concern and dietary restraint, I developed weight-related decision-making tasks (Figure 2.2). Since body image concern and dietary restraint are measured by self-report surveys exclusively targeting each concept, it does not incorporate actual decision-making patterns related to weight. Note that weight-related decision-making is how the cognitive features, body image concern and dietary restraint, are expressed in real life. For instance, an individual with extreme concern on body image and strict cognitive rules on dietary restriction would display altered decision-making patterns related to weight, such as blindly pursuing weight loss. In order to capture the individual differences in the actual decision-making in the weight domain, I modified the original monetary versions of the decision-making tasks into the weight-related versions.

Decision-making tasks based on the prospect theory have been widely used in studies to capture individual differences in decision-making, and weight-related versions of the loss aversion task (LAT) measuring risk preference and loss aversion have been verified as a useful tool for measuring the decision-making process related to BMI (Lim & Bruce, 2015). By using the choice under risk and ambiguity (CRA) task for measuring weight-loss risk-seeking and ambiguity aversion parameter, and the LAT for weight-gain loss aversion, I examined whether food addiction and binge eating could be dissociated in terms of weight-related decision-making as well.
While the weight-related decision-making tasks based on the prospect theory (Kahneman & Tversky, 1979) has been already validated as a useful tool in explaining the decision-making process related to body mass (Lim & Bruce, 2015), since our tasks used slightly different models (Levy et al., 2010; Sokol-Hessner et al., 2009) and I developed the tasks using the adaptive design optimization (ADO) paradigm to enhance the rapid estimation of individual parameters (Ahn et al., 2020). Therefore, I examined whether the individual parameters estimated from the new tasks could explain weight-related measures better than the parameter estimated from the original monetary versions by conducting study 1. The aim of study 1 was to test the validity of the weight-related decision-making tasks in community samples; whether the tasks could be further utilized to measure individual differences in weight-related decision-making.

Lastly, I also examined whether food addiction and binge eating could be differentiated in terms of impulsivity and reward dysfunction, which are noted as the shared mechanisms between the two constructs (Schulte et al., 2016). While impulsivity and reward dysfunction were both suggested as risk factors of both food addiction and BED (Dawe & Loxton, 2004), whether there is a difference exist within the shared mechanisms has not been studied yet. Thus, I explored each relationship of food addiction behavior and binge eating behavior with the two risk factors, and investigated whether differences exist even in the common features.

The main goal of this study, differentiating food addiction and binge eating disorder, was addressed in study 2 by collecting data from obese individuals who

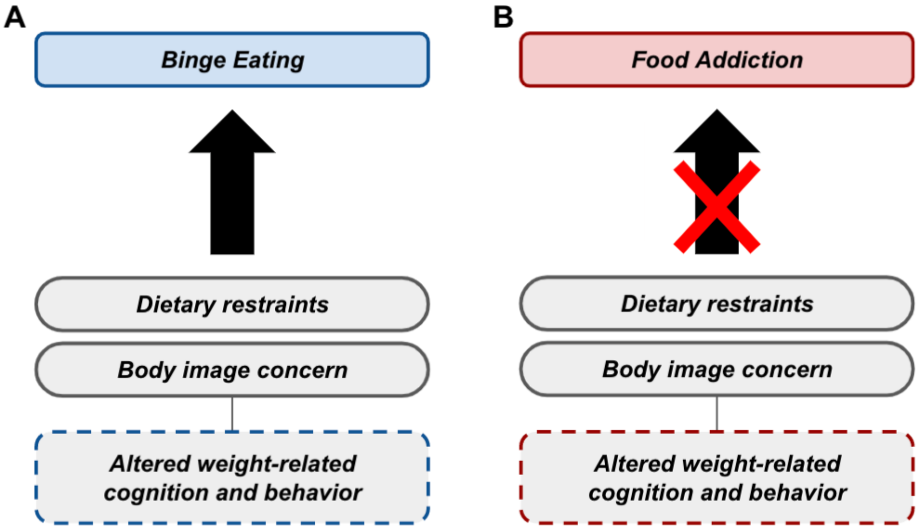

Figure 1.1: Schematics of research hypotheses

registered for liposuction weight-loss intervention and collecting data before and after the surgery (Figure 3.1). I hypothesized that food addiction and binge eating could be differentiated in terms of the relationship with body image concern and dietary restraint. By examining the relationships between the changes in food addiction behavior, binge eating behavior, body image concern, and dietary restraint before and after the surgery, I aimed to provide empirical support that body image concern and dietary restraint, the unique features of BED, are strongly associated with binge eating compared to food addiction. The second hypothesis was that food addiction and binge eating could also be dissociated based on the patterns of weight-related decision-making. Since there are few previous studies that have focused on decision-making specific to the weight domains, the difference in the patterns was explored using the weight-related decision-making tasks validated in study 1. Figure 1.1 shows the schematic of the two hypotheses.

Chapter 2. Study 1
– validation of weight-related decision-making tasks -

Study 1 aimed to validate the weight-related decision-making tasks in the community samples. Since the weight-related versions were developed in order to better capture individual differences in weight-related decision-making, I examined whether the parameters from the weight-related versions could better explain the individual differences in weight-related measures, compared to the original monetary versions of the decision-making tasks.

2.1. Method

2.1.1. Participants and procedure

Ninety-five healthy women (age range 19-36 years; mean 23.43, SD 3.48) were recruited through online communities and visited the laboratory for participation. Participants provided written informed consent and were paid for their participation. All study protocols in this work were approved by the Institutional Review Board (IRB) at Seoul National University (IRB No. 2004/001-010). For all studies reported in this work, I used the following criteria: a participant is excluded from further analysis 1) if the participant has any missing data on tasks, surveys, and body measurements, and 2) if the participant failed to respond correctly on dummy questions (i.e. "Please answer 'yes' to this question ('yes' required)", "I cannot carry a 1,000kg dumbbell ('yes' required)", "I can stay up for three years without sleeping ('no' required)"). In other words, I excluded participants with missing data and who seemingly answered randomly to the surveys. In study 1, 2 participants answered incorrectly to the dummy questions, so a total of 93 participants were included in the analyses.

At a visit, participants completed five decision-making tasks, and answered surveys measuring weight-related indexes, which will be explained in the following sections. Surveys included self-reported body weight and height, which were used to calculate body mass index. Mean body mass index was 20.6 kg/m^2 (SD = 2.68, range 16.8-35.46 kg/m^2) (Figure 2.1). See Table 2.1 for participants' demographic characteristics.

2.1.2. Decision-making tasks

Participants completed decision-making tasks using a smartphone application "cocomo" (Figure 2.2). Each task requires participants to choose between two options multiple times based on their preferences, following instructions about each

Table 2.1: Demographic data, body measurements and survey data of participants (Study 1)

Variable	Number	%
gender (female)	93	100%
currently on diet		
yes	47	50.54%
no	46	49.46%
last education		
high school	69	74.19%
college	16	17.20%
> college	8	8.60%

Variable	Mean(SD)	95% CI	range
age	23.42 (3.53)	22.69 - 24.15	19 - 36
BMI	20.57 (2.71)	20.01 - 21.12	16.8 - 35.46
weight gap	3.85 (4.29)	2.97 - 4.74	-4 - 23
binge eating behavior	11.76 (6.41)	10.44 - 13.08	2 - 35
food addiction behavior	4.99 (2.25)	4.53 - 5.45	0 - 11
body image concern	101.87 (32.39)	95.2 - 108.54	35 - 174
body image gap	1.3 (1.23)	1.05 - 1.55	-1 - 5
DEBQ			
restrained eating	32.09 (8.49)	30.34 - 33.83	12 - 47
external eating	33.75 (5.01)	32.72 - 34.79	21 - 45
emotional eating	32.74 (11.66)	30.34 - 35.14	13 - 61
BIS-11	64.84 (8.7)	63.05 - 66.63	43 - 92
attentional impulsivity	17.66 (3.52)	16.93 - 18.38	11 - 28
non-planning impulsivity	25.45 (4.77)	24.47 - 26.43	12 - 37
motor impulsivity	21.73 (3.42)	21.03 - 22.44	15 - 32

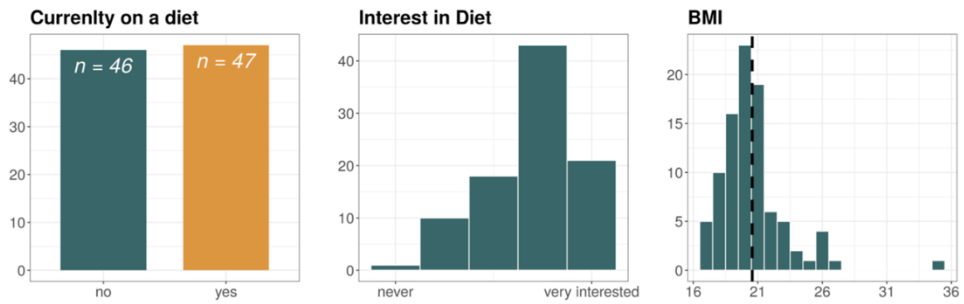

Figure 2.1: Histograms of diet status, interest in diet, and body mass index (BMI)

scenario. Tasks include the CRA Task (Levy et al., 2010), the LAT (Sokol-Hessner et al., 2009), and the Delay Discounting Task (DDT) (Mazur, 1987). In addition to the original monetary version of the three tasks that present options with monetary gain or monetary loss, I developed a weight-related version of the CRA and the LAT task that displays options of weight gain or weight loss. Participants conducted the five tasks (monetary CRA, monetary LAT, monetary DDT, weight-related CRA, and weight-related LAT) in a randomized order to prevent order effects.

All tasks were designed using the ADO framework, which is a statistical method that aims to find the most informative experimental design for estimating model parameters in the middle of an experiment (Cavagnaro et al., 2010; Myung et al., 2013; Yang, 2020). Using the ADO framework, I could conduct adaptive experiments that lead to the rapid accumulation of information of each participant with the fewest number of trials. The framework requires a quantitative model that predicts experimental outcomes based on the model's parameters and experimental parameters. For more details about the ADO framework, see Yang (2020), Cavagnaro et al., (2010), Myung et al., (2013), and for the validation of the reliability of ADO framework, see Ahn et al., (2020). See Appendix A for more information about each task, models, and parameter.

2.1.3. Measures

Body measurements and eating habits. Body measurements were collected by self-report. Participants reported their current weight and height, which were then used to calculate body mass index (BMI; weight (kg) / [height (m)]^2. Also, since preference and frequency of eating junk foods could be critical in weight gain, I collected the preference of junk foods and frequency of consuming junk foods in a 5-point Likert scale.

Yale Food Addiction Scale 2.0. The Yale Food Addiction Scale Version 2.0 (YFAS) is a tool to measure food addiction behavior. YFAS Version 2.0 aims to maintain

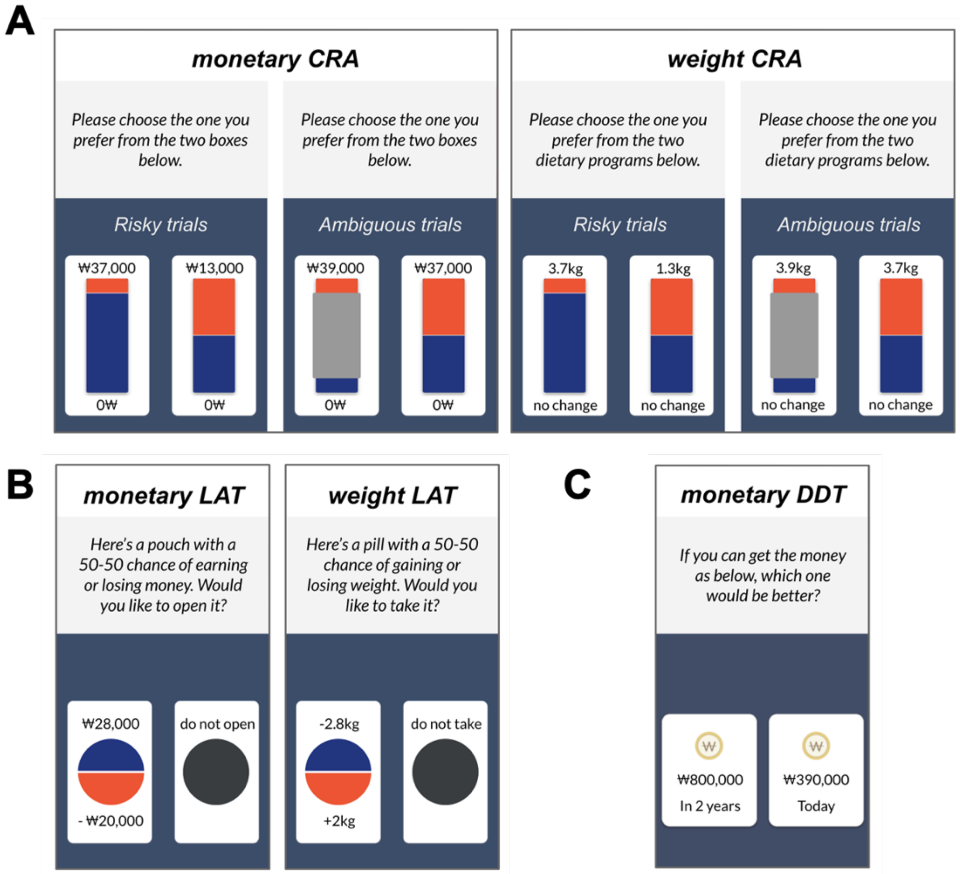

Figure 2.2: A schematic of the decision-making tasks (CRA, choice under risk and ambiguity task; LAT, Loss aversion task; DDT, delay discounting task)

consistency with the current diagnostic criteria of SUDs, and has been reported to be associated with elevated BMI, binge eating, and weight cycling (Gearhardt et al., 2016). To measure food addiction behavior, I used the Korean version of YFAS (Shin et al., 2018), which was validated with the internal consistency (Cronbach's α) of .977, and high correlation with BMI, binge eating scale, and food craving scale. According to Gearhardt et al. (2016), the YFAS has two scoring options: 1) a continuous symptom count by counting the number of diagnostic criteria met by the participant and 2) a diagnosis of food addiction based on the number of symptoms and the existence of clinically significant impairments or distress ("mild" in 2-3 symptoms, "moderate" in 4-5 symptoms, "severe" in more than 6 symptoms, only in the cases where significant impairment or distress is reported). Here, I used the first scoring option and the number of food addiction behavior was used as an individual index for food addiction.

Binge Eating Scale. The Binge Eating Scale (BES) assesses the severity of binge eating behavior (Gormally et al., 1982). It consists of 16 questions that measure the presence of overeating behavior, attitude and emotion toward the behavior such as guilt or fear. Participants are asked to respond among the three or four response options, codes zero to two or three, respectively. The total BES score is summed (range 0-46), and the clinical cutoff was none-to-minimal (<17), moderate (18-26), and severe (>27) (Marcus et al., 1988). I used the Korean version of the BES with internal consistency (Cronbach's α) .84 (S. H. Lee & Hyun, 2001). Here, I used the continuous scores of the total BES score as an index for binge eating behavior.

Body Shape Questionnaire. The Body Shape Questionnaire (BSQ) measures concerns about body shape and weight, which constitute a central feature of eating disorders anorexia nervosa, bulimia nervosa, and also binge eating disorder (Cooper et al., 1987). There are 34 questions and 6-point Likert scales are used. I used the Korean version of the BSQ, which was translated and validated by (Chee, 2012). The internal consistency (Cronbach's α) was .96, and test-retest reliability was high with a correlation coefficient of .93 (Chee, 2012). The total score of BSQ was used as an index for body image concerns.

Dutch Eating Behavior Questionnaire. The Dutch Eating Behavior Questionnaire (DEBQ) was developed to examine the three theories of overeating; the psychosomatic theory suggesting that overeating derives from misperception of one's status before eating such as negative emotional states (emotional eating), the externality theory suggesting the importance of external food-related stimuli in food intake (external eating), and the restraint theory which suggests that dietary restraint requires cognitive efforts of self-control, and disinhibitors of such control break the control and then overeating occurs (restrained eating) (Strien et al., 1986). Among 33 questions with a 5-point Likert scale, 10 items measure external eating, 13 items ask about emotional eating, and 10 items ask about restrained eating. The Korean version was translated and validated by Kim et al. (1996). Each of the three constructs' internal consistency (Cronbach's α) was .93, .79, .90 (H. J. Kim et al., 1996). The total score of restrained eating was used as an index for dietary restraint.

Body perception scale. Body perception scale assesses the difference between perceived body image and the desired body image of an individual, by having participants choose how their current body image and desired body image among 9 different body images. I calculated a single score for the discrepancy between the desired body image and the current body image by subtracting the point of the current body image from the point of desired body image. Therefore, the higher discrepancy score indicates the higher desire to lose weight.

Barratt Impulsivity Scale-11. To measure impulsivity, I used the Barratt Impulsivity Scale-11 (BIS-11) (Patton et al., 1995) which consists of 30 items and uses a 4-point Likert scale. The subscales include attentional impulsivity (inability to focus attention or concentrate), motor impulsivity (acting without thinking), and non-planning impulsivity (lack of future orientation of forethought). I used the Korean version of BIS-11, which was translated and validated by Heo et al. (2012). The internal consistency of the Korean version of BIS-11 was .58 to .80 (Heo et al., 2012).

2.1.4. Data analysis

To check the relationship between monetary decision-making tasks' parameters and the weight-related decision-making tasks' parameters, I first conducted a correlation analysis between monetary and weight-related parameters. Then, to examine the relationship of each parameter and the weight-related measures, and verify whether the weight-related parameters could better explain the weight-related features of individuals, I compared the correlation coefficients of monetary and weight-related parameters with each weight-related measure. Lastly, I conducted an elastic net to identify significant variables that can classify individuals who are currently on a diet from those who are not. The elastic net is a penalized least squares method that performs automatic variable selection by shrinking coefficients of unimportant variables to zero (Tibshirani, 1996, 2011). The dependent variable was diet status, dieters coded as "1" and non-dieters coded as "0", and all the measures obtained from the tasks and surveys were independent variables: seven model parameters (monetary loss aversion parameter, weight-gain aversion parameter, monetary risk-seeking parameter, monetary ambiguity aversion parameter, weight-related risk-seeking parameter, weight-related ambiguity aversion parameter, delay discounting rate), demographic variables (age and BMI), and sixteen survey indices (interest in diet, fast food preference, fast food frequency, weight gap, BIS-11 total score and three subscores, body image gap, shape and body image concern, and three subscales of DEBQ including restrained eating (dietary restraint), emotional eating, and external eating).

I used an R package called "easyml", a toolkit for easily building and evaluating machine learning models using the glmnet package (Friedman et al., 2010) for the elastic net (https://github.com/CCS-Lab/easyml) (Ahn et al., 2017). The mixing parameter *alpha* was set to 0.5 to conduct an elastic net. I trained the model using 10-fold cross-validation within the training set, and this generated an estimated coefficient 100 times for a particular train-test split, whereby I calculated the mean and standard deviation of the estimated coefficients. By replicating predictions multiple times for a particular train-test split, averaging the predictions across 10 iterations and using 1000 divisions of the train-test splits, I could avoid intrinsic random errors (see Ahn et al. (2017), (Kwon et al., 2021) for more details).

2.2. Results

2.2.1. Correlation between task parameters

Correlation between estimated parameter from monetary and weight-related versions of the decision-making tasks were all significant (α_{weight} and $\alpha_{monetary}$, $r = .25$, $p < .001$, $\rho = .31$, $p < 0.05$; β_{weight} and $\beta_{monetary}$, $r = .43$, $p < 0.001$, $\rho = .38$, $p < 0.001$; λ_{weight} and $\lambda_{monetary}$, $r = .36$, $p < 0.001$, $\rho = .37$, $p < 0.001$; r, pearson's correlation; ρ, robust correlation), suggesting that the weight-related versions of the decision-making tasks could capture individual differences similarly as the original monetary versions (Figure 2.3). In addition, note that the results imply that the monetary and the weight-related version of the decision-making tasks could be distinguished in terms of domain specificity; weight-related versions explaining weight-related measures better than the monetary version.

2.2.2. Correlation between parameters of each version and weight-related measures

As expected, most of the weight-related measures were better explained by the weight-related parameters compared to the monetary parameters (Figure. 2.4). In particular, the weight-related risk-seeking parameter α_{weight} showed significant positive correlation with all the weight-related measures except for interest in diet and food addiction behavior (BMI, $r = .25$, $p < .05$, $\rho = .24$, $p < .05$; weight gap, $r = .33$, $p < .01$, $\rho = .38$, $p < .001$; body image gap $r = .28$, $p < .01$, $\rho = .31$, $p < .01$; interest in diet, $r = .22$, $p < .05$, $\rho = .19$, $p = .06$; binge eating behavior, $r = .17$, $p = .11$, $\rho = .27$, $p < .01$; food addiction behavior, $r = -.18$, $p = .09$, $\rho = .19$, $p = .07$; body image concern, $r = .25$, $p < .05$, $\rho = .26$, $p < .05$; dietary restraint, $r = .33$, $p < .01$, $\rho = .3$, $p < .01$), while the monetary risk-seeking parameter $\alpha_{monetary}$ was correlated with non of the measures. Individuals with higher BMI, larger gap between desired and current body weight/image, higher binge eating behavior, higher body image concern, and higher dietary restraints are more likely to prefer risky options over safer options when the prior provides greater weight loss.

The weight-related ambiguity aversion parameter β_{weight} was significantly correlated with BMI and weight gap (BMI, $r = -0.27$, $p < .01$, $\rho = -0.26$, $p < .05$; weight gap, $r = -0.24$, $p < .05$, $\rho = -0.29$, $p < .01$), while $\beta_{monetary}$ showed no significant

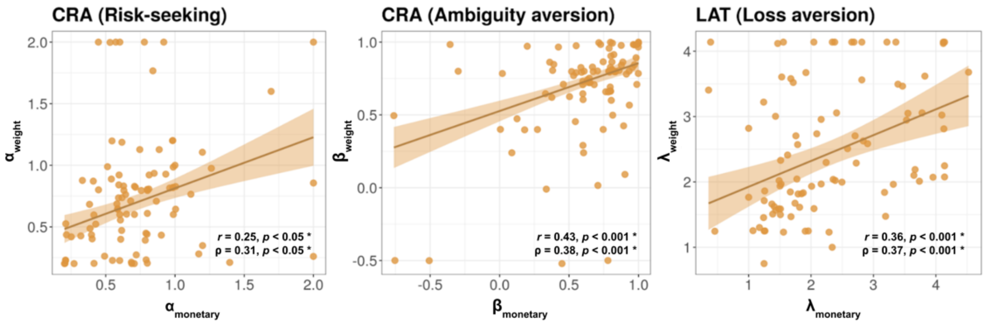

Figure 2.3: Correlations between parameters between monetary and weight-related decision-making tasks. The x axis is estimated parameter value of the monetary version of each task, and the y axis is from the weight-related version ($\alpha_{monetary}$, monetary-gain risk-seeking parameter; α_{weight}, weight-loss risk-seeking parameter; $\beta_{monetary}$, monetary-gain ambiguity aversion parameter; β_{weight}, weight-loss ambiguity aversion parameter; $\lambda_{monetary}$, monetary-loss aversion parameter; λ_{weight}, weight-gain aversion parameter). The regression line is a robust regression, r stands for pearson's correlation and ρ stands for a robust correlation coefficient. abbreviations: CRA, Choice under Risk and Ambiguity; LAT, Loss Aversion Task.

correlation. Individuals with higher BMI and those with a higher discrepancy between desired and current body weight were more likely to prefer ambiguous options over safer options when the ambiguous option provides greater weight loss.

Lastly, the weight-gain aversion parameter λ_{weight} was negatively correlated with BMI ($r = -0.22$, $p < .05$, $\rho = -0.24$, $p < .05$), weight gap ($r = -0.29$, $p < .01$, $\rho = -0.31$, $p < .01$), body image gap ($r = -0.36$, $p < .001$, $\rho = -0.34$, $p < .01$), and body image concern ($r = -0.3$, $p < .01$, $\rho = -0.3$, $p < 0.01$), while monetary loss aversion parameter $\lambda_{monetary}$ was negatively correlated only with body image gap ($r = -0.22$, $p < .05$, $\rho = -0.23$, $p < .05$). Individuals with higher BMI and greater dissatisfaction in their body weight or body image were more likely to choose to gamble in losing weight even if it could lead to weight gain.

In short, all the three weight-related parameters showed significant correlation with multiple weight-related measures, while only one significant correlation was found between the monetary parameters and the weight-related measures. Thus, the results suggest that weight-related parameters could better explain the weight-related measures than the original monetary version of the task, and that individuals with higher BMI and higher dissatisfaction in their body have a tendency of pursuing weight loss, even if it could lead to weight gain in the LAT, or failure of losing weight in the CRA task.

2.2.3. Elastic net

As in Figure 2.4, significant positive correlations were found between all the weight-related measures including BMI, gap between desired and current weight/image, interest in diet, binge eating behavior, food addiction behavior, body image concern, body image concern, and dietary restraint, except for the correlation between food addiction and BMI (r = .04, p = .722; ρ = .05, p = .627). As in line with previous literature, binge eating behavior and food addiction behavior were highly correlated (r = .64, p < .001, ρ = .58, p < .001), as well as body image concern and dietary restraint (r = .60, p < .001; ρ = .61, p < .001). Also, both food addiction behavior and binge eating behavior were significantly correlated with body image concern (food addiction behavior, r = .55, p < .001; ρ = .48, p < 0.001; binge eating behavior, r = .71, p <0.001; ρ = .69, p < 0.001), and dietary restraint (food addiction behavior, r = .31, p < 0.01; ρ = .28, p < 0.01; binge eating behavior, r = .33, p <0.01; ρ = .33, p < 0.01).

Note that the variables used are highly correlated with each other, I conducted the elastic net to examine the multivariate patterns of the multiple variables. Twenty-five predictors were independent variables, and the dependent variable was whether the individual is currently on a diet or not. As in Figure 2.6, greater dietary restraint measured by DEBQ and greater body image concern measured by BSQ were most predictive of classifying dieters. Also, greater interest in diet, the bigger gap between desired and current body weight, lower frequency of fast food consumption predicted the dieters. While the measures mentioned so far are conceptually linked to 'not eating' or 'doing a diet', measures that are contradictory to weight loss, greater preference of fast food and higher binge eating behavior, were also significant predictors of dieters. Also, while higher attentional impulsivity measured by BIS-11 was associated with doing a diet, a lower delay discounting rate indicating lower reward-related impulsivity was also predictive of dieters. Every parameter of the decision-making tasks was turned out to be nonsignificant predictors in classifying dieters from non-dieters, when all the other weight-related variables are included. Figure 2.7 shows the predictive power of the elastic net model.

2.3. Discussion

In study 1, I aimed to validate the weight-related decision-making tasks, and examine whether the parameters from the weight-related decision-making tasks better explain individual differences in weight-related measures, such as BMI, body dissatisfaction, dietary restraint, and body image concern, in a community sample. Our results suggest that the parameters of the weight-related decision-making tasks were more

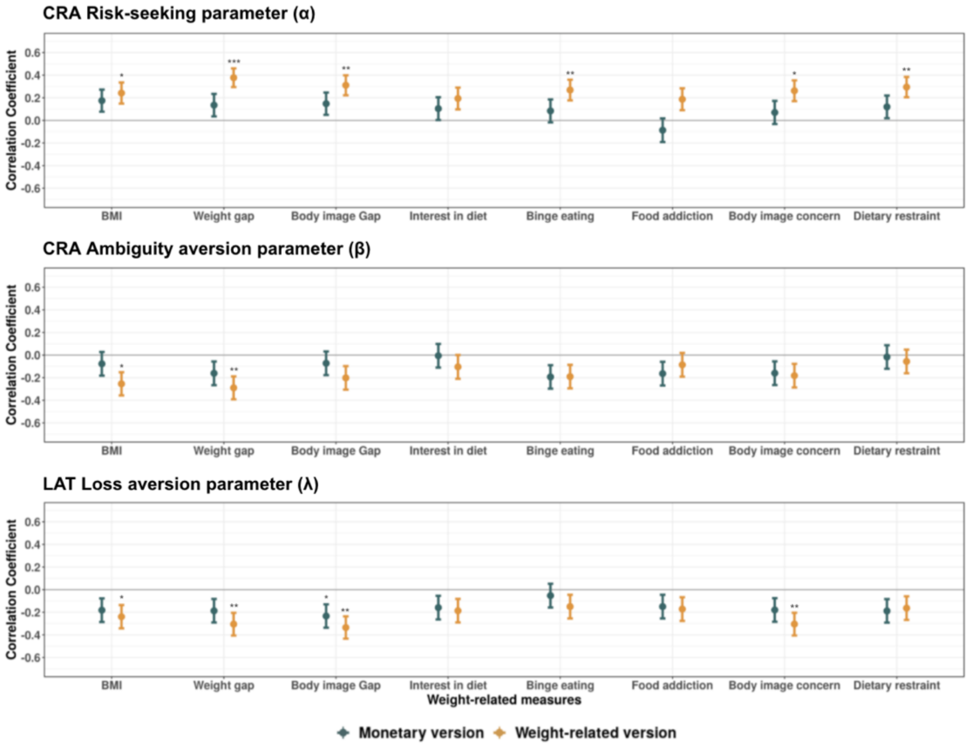

Figure 2.4: Comparison of correlations between task parameters and weight-related measures. The y axis is a robust correlation coefficient between each task parameter and the measure in the x axis. For instance, the first green point in the top left figure indicates a robust correlation coefficient between the $\alpha_{monetary}$ from the CRA task and the BMI, and the yellow point indicates a robust correlation coefficient between the α_{weight} from the CRA task and the BMI. Each error bar represents the standard error of each correlation coefficient. The asteroid above each point indicates significance of the correlation coefficient. (*: $p < .05$, **: $p < .01$; ***: $p < .001$)

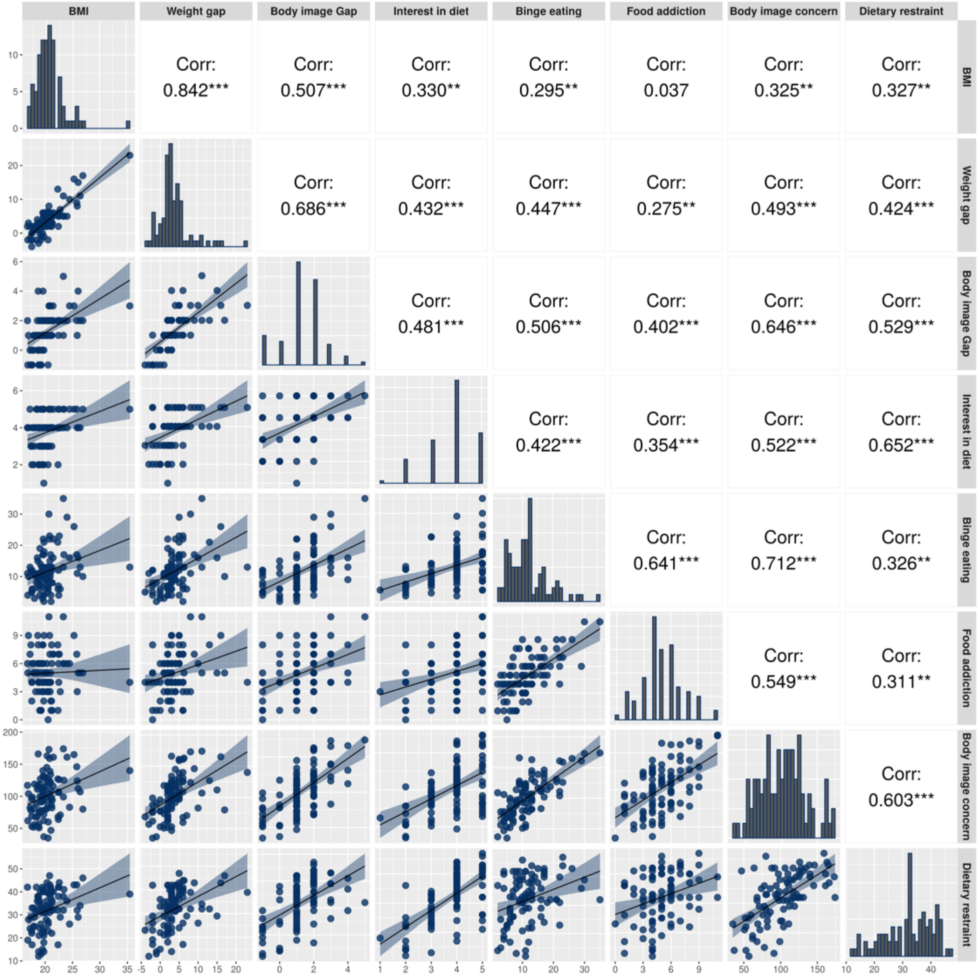

Figure 2.5: Correlations between weight-related measures

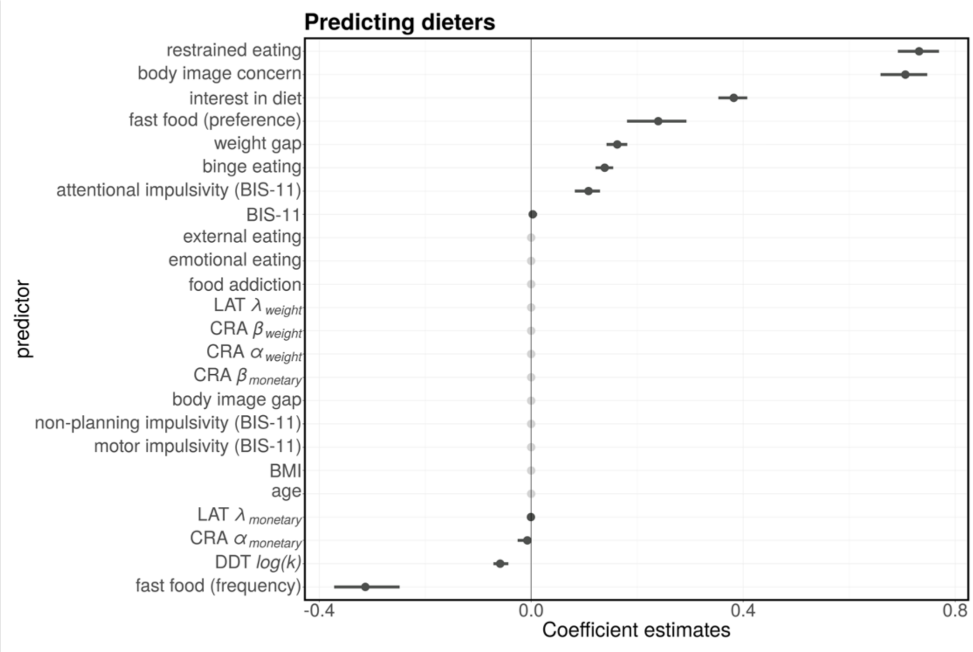

Figure 2.6: Multivariate patterns of weight-related measures and task parameters classifying dieters. Variables with black point (mean) with error bar (95% confidence interval) are significant predictors for the classification, and variables with gray color are those whose effects are shrunk to 0 by the elastic net. Among the significant predictors, only those who are not containing zero in the 95% confidence interval are finally selected as significant predictors: dietary restraint, body image concern, interest in diet, fast food (preference), weight gap, binge eating behavior, BIS-11 (attentional impulsivity), dd (k), fast food (frequency).

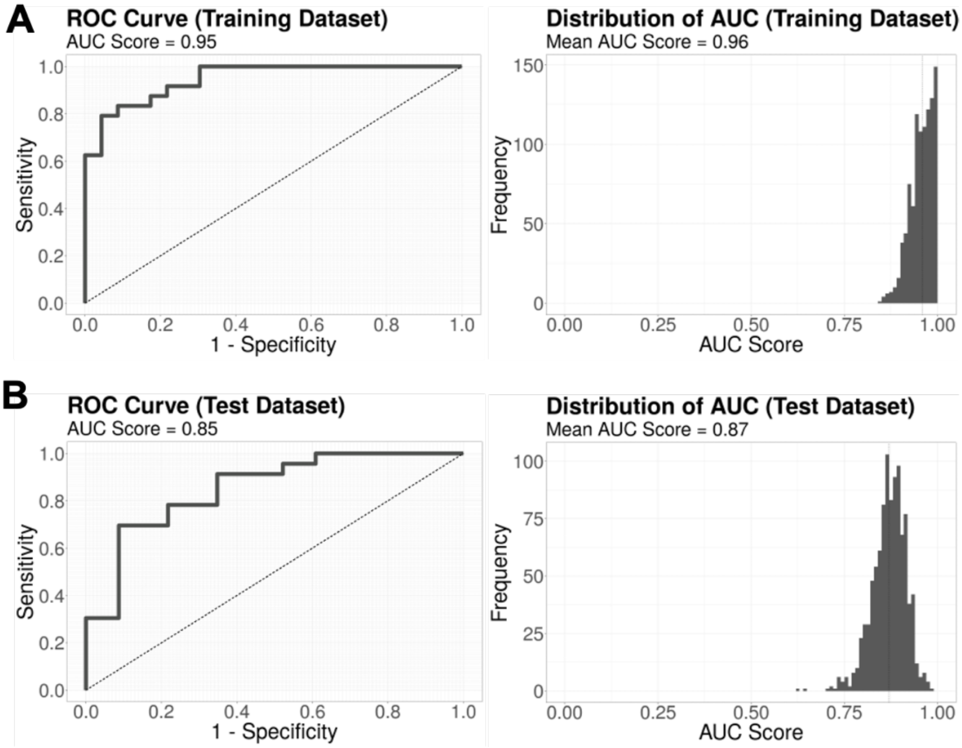

Figure 2.7: Multivariate patterns of weight-related measures and task parameters classifying dieters. The left figures are representative ROC curves (receiver operating characteristic curves) for training and test datasets. The x axis is false positive rate (1- specificity), and the y axis is true positive rate (sensitivity). The right figures are the distribution of the AUC (area under the ROC curve) values on the training and test sets over 1,000 random divisions of training/test datasets (see 2.1.4. Data analysis).

associated with the weight-related measures, compared to the parameters of the monetary versions. The weight-related risk-seeking parameter in the CRA task was positively correlated with six weight-related measures out of eight, while the monetary risk-seeking parameter did not show any correlation. The weight-related ambiguity aversion parameter and the weight-gain aversion parameter also displayed significant correlations with BMI and dissatisfaction with body weight/image. Thus, while the parameters from the monetary and the weight-related versions showed positive correlations, our results suggest that the weight-related versions of the LAT and the CRA task could be better tools for measuring weight-related decision-making. In other words, even though everything except for the scenario is identical and the estimated parameters of each version are significantly correlated, domain specificity exists in the decision-making tasks and using the corresponding choice scenario could enhance the explanatory power of the parameters.

I also conducted the elastic net to capture the multivariate patterns of variables classifying whether individuals are currently on a diet. The most predictive measures were dietary restraint and body image concern, which were more predictive than the subjective response of interest in diet, the discrepancy between desired and current body weight (weight gap), and the frequency of having fast food. Also, the objective status of BMI, which determines whether the individual is obese or not, turned out to be a nonsignificant predictor of diet. Interestingly, while most of the significant predictors were conceptually in line with weight loss, including higher dietary restraint, concern on body image, interest in diet, dissatisfaction in current weight, and lower fast food consumption, two predictors conflicted with weight loss: greater preference of fast food and higher binge eating behavior. However, since our analysis does not imply a causal relationship between the predictors and being on a diet, one possible explanation could be that individuals who prefer fast food and who experience binge eating episodes frequently are more likely to be on a diet due to weight gain induced by such eating habits. Another contradictory finding at first glance was that two types of impulsivity, attentional impulsivity measured by BIS-11 and reward-related impulsivity measured by delay discounting rate of the DDT, displayed different directions of prediction; higher attentional impulsivity and lower reward-related impulsivity predicting being on a diet. Note that attentional impulsivity refers to an inability to concentrate while the impulsivity measured by high delay discounting rate implies a preference for immediate gratification, and previous studies have also reported inconsistent results between the DDT and other self-reported measures of impulsivity (Jauregi et al., 2018). Thus, the findings could be interpreted as different aspects of impulsivity having predictive power on classifying dieters; individuals who have difficulties in paying attention and who are better at delaying monetary reward are more likely to be on a diet.

This study has two novelties. First, by modifying the monetary versions of the CRA and the LAT, I could replicate the findings of Lim & Bruce (2015) that weight-related decision-making tasks could help explain decision-making processes related to BMI. In addition, since the tasks and models in this study are different from Lim & Bruce (2015), our results provided evidence that weight-related decision-making tasks are a valid tool for measuring weight-related decision-making even when using different tasks and models. Second, I applied the ADO framework in the decision-making tasks to enable rapid estimation of individual parameters. Note that the original decision-making tasks require hundreds of trials, which makes it hard to utilize the task in a real clinical setting due to time constraints. Using the ADO implemented tasks used in our study, I could accurately and rapidly measure individual differences in weight-related decision-making.

Chapter 3. Study 2
- Examination of shared and unique mechanisms of food addiction and binge eating behavior -

The aim of study 2 was to investigate whether food addiction and binge eating could be dissociated in terms of 1) the unique mechanisms of BED (body image concern and dietary restraint), 2) weight-related decision-making measured by the tasks validated in study1 (weight-loss related risk-seeking, weight-loss related ambiguity aversion, weight-gain aversion), and 3) the shared mechanisms of food addiction and BED (impulsivity and reward dysfunction).

3.1. Method

3.1.1. Participants and procedure

In local obesity clinics in South Korea, 238 participants were recruited across 15 branches in an ongoing study with a target of recruiting 1,000 participants. Participants are obese individuals (BMI $\geq$ 25) who registered for a liposuction weight-loss surgery. As in Figure 3.1, data will be collected three times; 1~2 weeks before the surgery, 1~2 weeks after the surgery, and 3~4 weeks after the surgery. Demographic characteristics of the participants appear in Table. 3.1. Following the data exclusion criteria in "5.1.1. Participants and procedure", 1) participants who dropped out during the procedure or who failed to perform any surveys or tasks on time (the tasks and surveys before the surgery should be completed before getting the surgery, while the surveys or tasks after the surgery have less strict submission deadline; N = 25), and 2) participants who failed to respond correctly on any dummy question (N = 43) were excluded from the further analyses. Additionally, two more criteria were applied in study 2: 1) participants with parameter value estimated at the upper boundary of the parameter range (N = 106), 2) participants whose mean response time in the decision-making tasks exceeds 10 seconds (N = 19). Therefore, in study 2, a total of 102 participants were analyzed.

3.1.2. Decision-making tasks

The same decision-making tasks used in Study 1 (Monetary LAT, weight LAT, monetary CRA, weight CRA, DD) were used (See Appendix A for more details). All five tasks were conducted twice, before and after the liposuction surgery. The weight LAT and the weight CRA were conducted once again, 3~4 weeks after the liposuction surgery. In short, the monetary LAT and the monetary CRA have been conducted three times, while other tasks have been conducted twice.

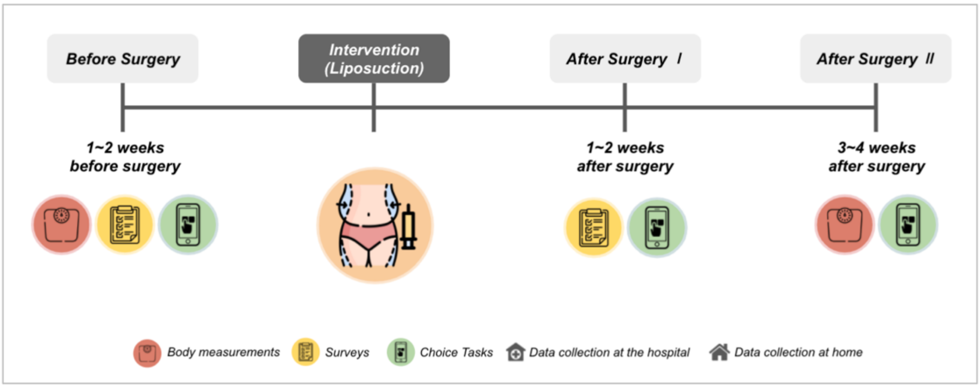

Figure 3.1: Data collection timeline

3.1.3. Measures

The same surveys used in study 1 (YFAS, BES, BSQ, DEBQ, Body perception scale, BIS-11) were used (see 5.1.2. Measures). Also, some major clinical indices, and some other factors that are known to be associated with weight gain have been measured using the following self-report surveys. Clinical indices including depression, anxiety, obsessive-compulsive symptoms, alcohol use, and nicotine dependence are measured using self-report. The objective of collecting clinical measures is to control and examine the effect of the clinical measures, in that 1) liposuction surgery could have an influence on such clinical domains, and 2) such clinical factors are known to be associated with weight gain (Carpiniello et al., 2009).

Body measurements. In study 2, body measurements were collected using inbody machine. Weight and height were measured to the nearest 0.1kg and 0.1cm, and other indices such as body fat mass, skeletal muscle mass, inbody score were collected. As in Figure 3.1, the body measurements were collected twice, 1~2 weeks before the surgery and 3~4 weeks after the surgery.

The Center for Epidemiologic Studies Depression scale. The Center for Epidemiologic Studies Depression scale (CES-D) was invented to measure depression (Radloff, 1977), with 20 items and a 4-point Likert scale of 0 (rarely) to 3 (mostly). The total range of the score is 0 to 60, and the higher score indicates more severe depression (0-9 points, not depressed; 10-15 points, mildly depressed; 16-24 points, moderately depressed; more than 25 points, severely depressed). Here, I used the Korean version of the CES-D translated and validated by Chon et al. (2021), and the internal consistency (Cronbach's α) was .961. (K. K. Chon et al., 2001)

Yale-Brown Obsessive-Compulsive Scale Symptom Checklist. Yale-Brown Obsessive-Compulsive Scale Symptom Checklist (Y-BOCS-SC) is widely used to measure obsessive-compulsive symptomatology (Goodman et al., 1989). I used the checklist to measure the severity of the symptoms, without an additional interview which is used to check the contents of symptoms. I followed (Leckman et al., 1997) for scoring the checklist, and used the Korean version of the Y-BOCS-SC (S. J. Kim et al., 2004). It consists of 58 questions and the response is made with a yes/no binary choice.

State-Trait Anxiety Inventory. The State-Trait Anxiety Inventory (STAI-Y) aims to measure the trait anxiety and the state anxiety in normal populations (Spielberger, 1983). I used a Korean version of STAI-Y, translated and validated by Hahn et al., (1996). It consists of 40 items (20 items each for the trait and state anxiety) and uses a 4-point Likert scale. A higher total score indicates a higher level of state or trait anxiety. The internal consistency of the Korean version of STAI-Y (Cronbach's α) was .92 (Hahn et al., 1996).

The Pittsburgh Sleep Quality Index. The Pittsburgh Sleep Quality Index (PSQI) assesses sleep quality and disturbances over a 1-month time interval (Buysse et al., 1989). I followed the scoring manual of Buysse et al. (1989), where seven component scores (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction) are calculated and then summed up for a single global score. The Korean version PSQI-K was used, and the internal consistency (Cronbach's α) was .69 (Sohn et al., 2012).

Perceived Stress Scale. The Perceived Stress Scale (PSS) is a tool to measure the degree of stress that an individual actually feels and interprets (Cohen & Williamson, 1988). It is a widely used psychological instrument for measuring the global perception of stress. I used the Korean version of PSS, where two factors of positive and negative subscales were reported (Park et al., 2007). The negative subscales indicate higher levels of perceived distress and the positive subscales indicate higher coping ability. Two subscales were summed by reversing the negative scale items, and the higher sum score indicates the higher level of stress.

Rosenberg Self-esteem Scale. The Rosenberg Self-esteem Scale (RSS) was developed to measure the self-esteem of high school students, but is now used to measure the self-esteem of various populations (Rosenberg, 1965). It consists of 10 items, including five positive questions and five negative questions, and uses a 4-

points Likert scale. Higher score indicates higher positive self-esteem. I used the Korean version of RSS (B. J. Chon, 1974).

Positive Affect and Negative Affect Schedule. Positive Affect and Negative Affect Schedule (PANAS) consists of 10 words of positive emotion and 10 words describing negative emotion (Watson et al., 1988). Participants are asked to respond how the words describe their feelings of the past 1 week including current status, on a 5-point Likert scale. The PANAS is widely used as a self-report measure of affection in both community and clinical contexts. The Korean version of the PANAS was translated and validated by Lee et al. (2003), and the internal consistency (Cronbach's α) was .84 (H. H. Lee et al., 2003).

3.1.4. Data analysis

The aim of study 2 was to differentiate food addiction and binge eating disorder by tracking the changes after the weight-loss liposuction surgery. First, I examined the changes after the surgery. Then, to test the first hypothesis that body image concern and dietary restraint would be differently associated with food addiction and binge eating disorder, I conducted the hierarchical linear regression using the 'lm 'function in R and tested whether the change in body image concern and dietary restraint could significantly explain the change in binge eating behavior and food addiction behavior after the surgery (Figure 3.2). Hierarchical linear regression was conducted in two ways: 1) the model controlling changes in clinical indices, and 2) the model controlling changes in other variables such as stress, affection, self-esteem, and impulsivity along with the clinical indices. In both models, the first-level only included the control variables and the variables of interest (change in body image concern and dietary restraint after surgery) were added as independent variables in the second level. To conclude that the variables of interest are responsible for the changes in the dependent variables (binge eating behavior or food addiction behavior), two conditions should be satisfied. First, I conducted an analysis of variance (ANOVA) between the second-level analysis and the first-level analysis; the second level should explain significantly larger variances ($p < .05$) of the dependent variables than the first level analysis. Also, the variables of interest should be statistically significant ($p < .05$) in the second-level analysis. I tested if these two conditions are satisfied to determine whether the change in body image concern and dietary restraint are significant predictors of the change in binge eating behavior but not for the change in food addiction behavior. Additionally, using the covariance structure modeling predicting changes in binge eating behavior and food addiction behavior with changes in body image concern and dietary restraint, I checked whether the results of the hierarchical regression model were consistent even after

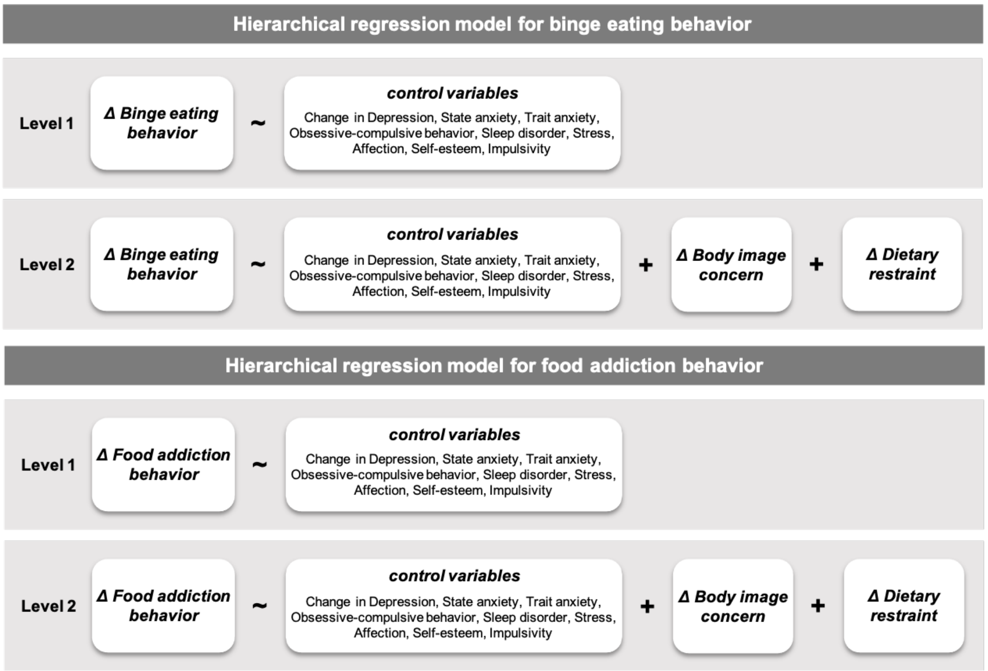

Figure 3.2: Schematics of hierarchical regression model predicting change in binge eating behavior after surgery (top), and change in food addiction behavior (bottom), controlling other relevant variables. The first-level contains control variables only, and the variables of interest (change in body image concern and dietary restraint after surgery) are added as predictors in the second-level.

considering the covariance between binge eating behavior and food addiction behavior. I used an R package called "sem", a toolkit for fitting structural equations in observed variables. General structural equation models were used with all options set as default (Fox, 2006).

The second hypothesis was that there would be a difference between food addiction and binge eating in terms of weight-related decision-making after the weight-loss intervention. First of all, I conducted the correlation analysis to examine the differences in binge eating and food addiction in the relationships with the weight-related parameters (α_{weight}, β_{weight}, λ_{weight}). Then, the hierarchical linear regression model of predicting the changes in the parameter using changes in binge eating behavior and food addiction behavior was tested (Figure 3.3). Here as well, other relevant variables were controlled, and the criteria for determining significant regressors are identical to the hierarchical model in the first hypothesis.

Lastly, for the exploratory analysis on impulsivity and reward dysfunction, I first conducted the correlation analysis respectively for food addiction and binge eating, with impulsivity measured by BIS-11 and reward dysfunction measured by delay discounting rate log(k) of the DDT. Then, for the measures that exhibited a

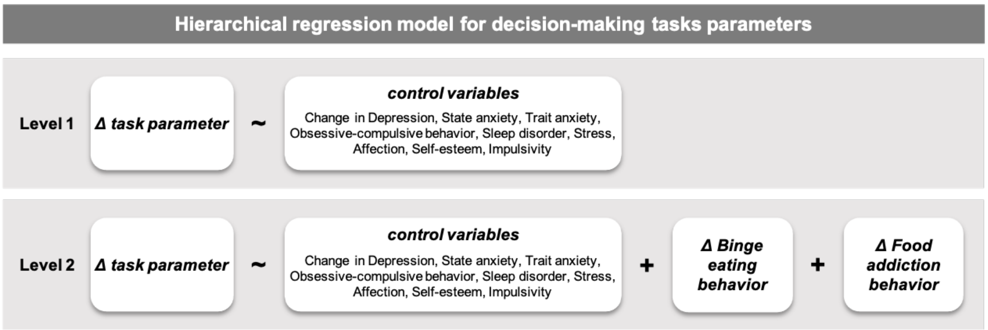

Figure 3.3: Schematics of hierarchical regression model predicting change in parameters of decision-making tasks after surgery. The first-level contains control variables only, and the variables of interest (change in binge eating behavior and food addiction behavior after the surgery) are added as predictors in the second-level.

significant correlation with food addiction or binge eating, I tested the hierarchical regression model of predicting the changes in the impulsivity or reward dysfunction using changes in binge eating behavior and food addiction behavior.

3.2. Results

3.2.1. Difference between food addiction and binge eating in the relationship with dietary restraint and body image concern

Differences in weight-related measures before and after the liposuction surgery are shown in Figure 3.4 and Table 3.1. BMI and body fat ratio decreased significantly after the surgery (BMI, before mean (SD) = 29.57 (4.21), after = 28.17 (3.99), $p < .001$; body fat ratio, before = 32.69 (9.15), after = 29.5 (8.42), $p < .001$). Trait and state anxiety measured by STAI-T (before = 46.08 (9.61), after = 44.59 (9.3), $p < .05$) and STAI-S (before = 44.61 (10.3), after = 41.28 (9.92), $p < .001$) also decreased, as well as Obsessive-Compulsive Disorder (OCD) symptoms (before = 8.46 (8.34), after = 7.1 (9.13), $p < .05$). Perceived stress measured by PSS (before = 20.88 (4.66), after = 22.93 (4.7), $p < .001$), and positive and negative affect measured by PANAS increased significantly (positive affect, before = 13.36 (5.51), after = 23.79 (10.94), $p < .001$; negative affect, before = 12.48 (8.1), after = 18.9 (12.96), $p < .001$).

Body image concern also decreased significantly (before = 143.99 (26.88); after = 138.39 (29.4); $p < .01$), but dietary restraint increased after the surgery (before = 33.27 (6.05), after = 35.33 (5.3), $p < .001$). Interestingly, while binge eating behavior measured by BES decreased after the surgery (before = 17.22 (7.25), after = 15.25 (7.98), $p < 0.01$), food addiction behavior measured by YFAS did not show significant difference before and after the surgery (before, = 4.98 (3.1), after = 4.59

Table 3.1: Demographic data, body measurements and survey data of participants (Study 2)

	Number	percentage
sex		
male	11	10.78%
female	91	89.22%
marriage status		
married	24	23.53%
single	76	74.51%
last education		
high school	22	21.57%
college	73	71.57%
> college	6	5.88%
surgery payment		
self	88	86.27%
parent	4	3.92%
spouse	5	4.90%

	Before			After			Change after surgery		
	Mean(SD)	**95% CI**	**range**	**Mean(SD)**	**95% CI**	**range**	**t**	***p***	**sig**
age	30.64 (7.12)	29.24 - 32.04	19 - 52	30.8 (7.07)					
BMI	29.57 (4.21)	28.74 - 30.39	25 - 44.7	28.17 (3.99)	27.39 - 28.96	23.3 - 44.8	13.184	< .001	***
body fat ratio	32.69 (9.15)	30.9 - 34.49	17.9 - 61.6	29.5 (8.42)	27.85 - 31.16	15.5 - 61.4	12.097	< .001	***
body muscle ratio	25.77 (4.26)	24.93 - 26.6	18.2 - 39.8	25.39 (4.26)	24.55 - 26.22	17.5 - 37.7	3.731	< .001	***
inbody score	63.25 (7.64)	61.74 - 64.75	44 - 77	65.78 (7.33)	64.34 - 67.22	45 - 79	-6.798	< .001	***
body image gap	3.43 (1.1)	3.24 - 3.62	1 - 7	3.12 (1.21)	2.91 - 3.33	0 - 7	3.707	< .001	***
binge eating	17.22 (7.25)	15.79 - 18.64	3 - 42	15.25 (7.98)	13.69 - 16.82	0 - 42	3.074	.003	**
food addiction	4.98 (3.1)	4.37 - 5.59	0 - 11	4.59 (3.36)	3.93 - 5.25	0 - 11	1.451	.15	
body image concern	143.99 (26.88)	138.7 - 149.3	59 - 203	138.39 (29.4)	132.62 - 144.17	57 - 204	2.946	.004	**
DEBQ									
restrained eating	33.27 (6.05)	32.09 - 34.46	16 - 49	35.33 (5.3)	34.29 - 36.37	20 - 46	-4.418	< .001	***
external eating	32.86 (5.96)	31.69 - 34.03	14 - 46	32.46 (5.82)	31.32 - 33.6	15 - 49	0.664	.508	
emotional eating	32.3 (11.64)	30.02 - 34.59	13 - 61	32.02 (11.89)	29.68 - 34.36	13 - 61	0.296	.768	
BIS-11	67.53 (9.12)	65.74 - 69.32	45 - 99	67.97 (9.58)	66.09 - 69.85	43 - 97	-0.685	.495	
attentional impulsiveness	17.35 (3.71)	16.62 - 18.08	11 - 31	17.42 (3.49)	16.74 - 18.11	11 - 31	-0.256	.798	

non-planning impulsiveness	27.68 (4.35)	26.82 - 28.53	14 - 38	27.69 (4.5)	26.8 - 28.57	13 - 37	-0.032	.974	
motor impulsiveness	22.5 (3.44)	21.82 - 23.18	13 - 33	22.86 (4.04)	22.07 - 23.66	14 - 33	-1.125	.263	
CES-D	15.68 (9.07)	13.9 - 17.46	0 - 54	15.54 (9.96)	13.58 - 17.5	1 - 50	0.16	.873	
STAI									
STAI-S	44.61 (10.3)	42.59 - 46.63	24 - 79	41.28 (9.92)	39.34 - 43.23	21 - 69	3.7	< .001	***
STAI-T	46.08 (9.61)	44.19 - 47.97	26 - 76	44.59 (9.3)	42.76 - 46.42	23 - 76	2.231	.028	*
OCD	8.46 (8.34)	6.82 - 10.1	0 - 37	7.1 (9.13)	5.3 - 8.89	0 - 46	2.05	.043	*
PSQI-K	6.47 (2.47)	5.98 - 6.96	2 - 16	7.03 (3.32)	6.38 - 7.68	1 - 20	-1.791	.076	
RSS	28.82 (5.08)	27.83 - 29.82	12 - 39	29.07 (5.15)	28.06 - 30.08	10 - 39	-0.759	.45	
PSS	20.88 (4.66)	19.97 - 21.8	6 - 35	22.93 (4.7)	22.01 - 23.85	8 - 33	-3.878	< .001	***
PANAS									
positive	13.36 (5.51)	12.28 - 14.45	0 - 27	23.79 (10.94)	21.65 - 25.94	0 - 45	-9.837	< .001	***
negative	12.48 (8.1)	10.89 - 14.07	0 - 42	18.9 (12.96)	16.36 - 21.45	0 - 52	-4.887	< .001	***

(*: $p < .05$, **: $p < .01$; ***: $p < .001$)

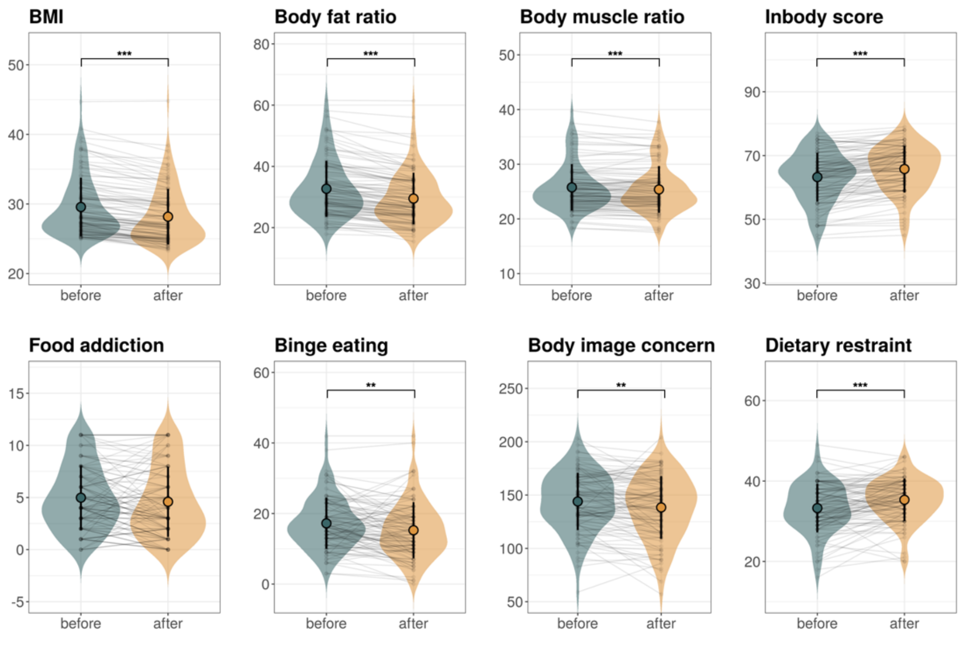

Figure 3.4: Differences in weight-related measures before and after the surgery. (*: $p < .05$, **: $p < .01$; ***: $p < .001$)

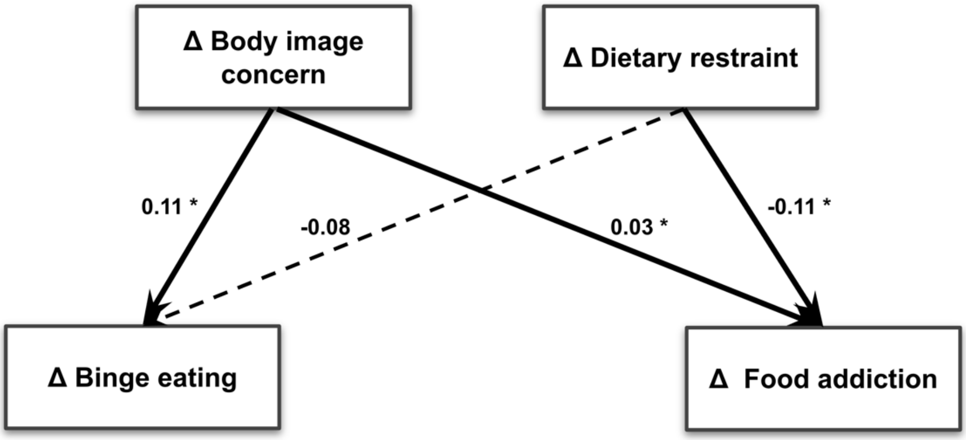

Figure 3.5: Covariance structure model of change in body image concern and change in dietary restraint explaining change in binge eating behavior and food addiction behavior after the surgery. Each number indicates beta estimates of the regression. (*: $p < .05$, **: $p < .01$; ***: $p < .001$)

(3.36), $p = .15$), implying the difference between food addiction and binge eating. Table 3.2 is the result of the hierarchical regression model predicting change in binge eating behavior while controlling other relevant variables. Body image concern was a significant predictor of the change in binge eating behavior ($\beta = 0.235$, $p < .05$), but dietary restraint was not a significant predictor ($\beta = -0.133$, $p = 0.309$). In contrast, for food addiction behavior, the results showed that changes in body image concern and dietary restraint were not associated with the change in food addiction behavior (Table 3.3).

Lastly, as shown in Figure 3.5, the results from the covariance structure model were consistent with the hierarchical regression analyses. The variances of change in binge eating behavior was significantly explained by change in body image concern (B = 0.11, SE = 0.128, $p < .001$), and also for food addiction behavior (B = 0.033, SE = 0.013, $p < .05$). The difference between the two regressions was significant ($p < .05$): change in body image concern could explain the change in binge eating behavior significantly better than the change in food addiction behavior. In contrast, change in dietary restraint could not explain change in binge eating behavior (B = -0.082, SE = 0.128, $p = .522$), but could explain food addiction behavior (B = -0.111, SE = 0.055, $p < .05$). However, the difference between the two regressions was not significant ($p = .82$). Thus, the association with body image concern showed a significant difference between binge eating and food addiction, while the relationship with dietary restraint did not differ significantly.

Table 3.2: Hierarchical regression analysis predicting change in binge eating behavior with change in body image concern and dietary restraint after the surgery

Step	*significant predictors*	*R^2 (adj)*	*F*	*df*	*B (SE)*	*β*	*t*	*p*	*sig*
1		0.239 (0.155)	2.859	91					
	Δ STAI-T				0.39 (0.132)	0.409	2.945	0.004	**
	Δ OCD				0.32 (0.092)	0.333	3.468	< 0.001	***
2		0.3 (0.206)	3.179	89					
	Δ Body image concern				0.079 (0.033)	0.235	2.392	0.019	*
	Δ Dietary restraint				-0.133 (0.13)	-0.097	-1.023	0.309	
	Δ Trait anxiety				0.392 (0.129)	0.411	3.036	0.003	**
	Δ OCD				0.268 (0.093)	0.28	2.876	0.005	**
ANOVA		255.704	3.878	2				0.024	*

(*: $p < .05$, **: $p < .01$; ***: $p < .001$)

Table 3.3: Hierarchical regression analysis predicting change in food addiction behavior with chance in body image concern and dietary restraint after the surgery

Step	*significant predictors*	*R^2 (adj)*	*F*	*df*	*B (SE)*	*β*	*t*	*p*	*sig*
1		0.145 (0.051)	1.544	91					
	no significant predictors								
2		0.213 (0.107)	2.009	89					
	Δ Body image concern				0.022 (0.015)	0.158	1.515	0.133	
	Δ Dietary restraint				-0.12 (0.059)	-0.207	-2.051	0.043	*
ANOVA		51.236	3.852	2				0.025	*

(*: $p < .05$, **: $p < .01$; ***: $p < .001$)

The results from the hierarchical regression model and the covariance structure model partially supported the first hypothesis: binge eating and food addiction could be distinguished in terms of the relationship with body image concern. Binge eating behavior decreased after the weight-loss intervention, and the reduction could be explained by the reduction of body image concern, even after controlling changes in the other indices. Conversely, food addiction behavior did not decrease after the intervention, and the change could not be explained by body image concern nor dietary restraint.

3.2.2. Difference between food addiction and binge eating in weight-related decision-making tasks parameters

Figure 3.6 shows the changes in parameters of the decision-making tasks before and after the liposuction surgery. Significant changes were found only in the monetary-gain risk-seeking parameter $\alpha_{monetary}$ (before mean (SD) = 0.532 (0.321), after mean (SD) = 0.641 (0.417)), $p < .01$); risk-seeking toward monetary gain increased. However, there was no significant correlation found between any of the weight-related decision-making tasks parameters (α_{weight}, β_{weight}, and λ_{weight}) and food addiction behavior nor binge eating behavior (Figure C.1, Figure C.2). Hierarchical regression model also did not reveal any significant association between the task parameters and binge eating behavior nor food addiction (see Appendix C for more details). Thus, the second hypothesis that food addiction and binge eating could be dissociated in terms of weight-related decision-making has not been supported.

3.2.3. Difference between food addiction and binge eating in impulsivity and reward dysfunction

Among three subscales of impulsivity measured by BIS-11 (attentional impulsivity, non-planning impulsivity, and motor impulsivity) as shown in Figure 3.7, significant correlation was detected between binge eating behavior and motor impulsivity ($r = .261$, $p < .05$, $\rho = 0.171$, $p = .087$), and food addiction behavior and attentional impulsivity ($r = -.177$, $p = .075$, $\rho = -.234$, $p < .05$): binge eating behavior was negatively associated with motor impulsivity, while food addiction behavior was positively associated with attentional impulsivity. The hierarchical regression model partially supported the findings. In Table 3.4, increase in food addiction behavior significantly explained increase in attentional impulsivity level ($\beta = 0.267$, $p < .05$), while the direction was the opposite for the binge eating behavior ($\beta = -0.269$, $p < .05$). Table 3.5 shows the results of the hierarchical regression model predicting motor impulsivity. Change in motor impulsivity level after the intervention could be explained significantly by the change in binge eating behavior ($\beta = -0.237$, $p < .05$), but the ANOVA result between the first and the second level was not significant ($p = .142$). For the reward dysfunction, I investigated the delay discounting rate $\log(k)$ obtained from the DDT. No significant correlation was detected neither with food addiction behavior nor binge eating behavior (Figure C.2), and the hierarchical regression model (Table C.7) also did not reveal any significant findings. In short, only in attentional impulsivity among the three subscales of impulsivity, significant relationships were detected with food addiction behavior and binge eating behavior,

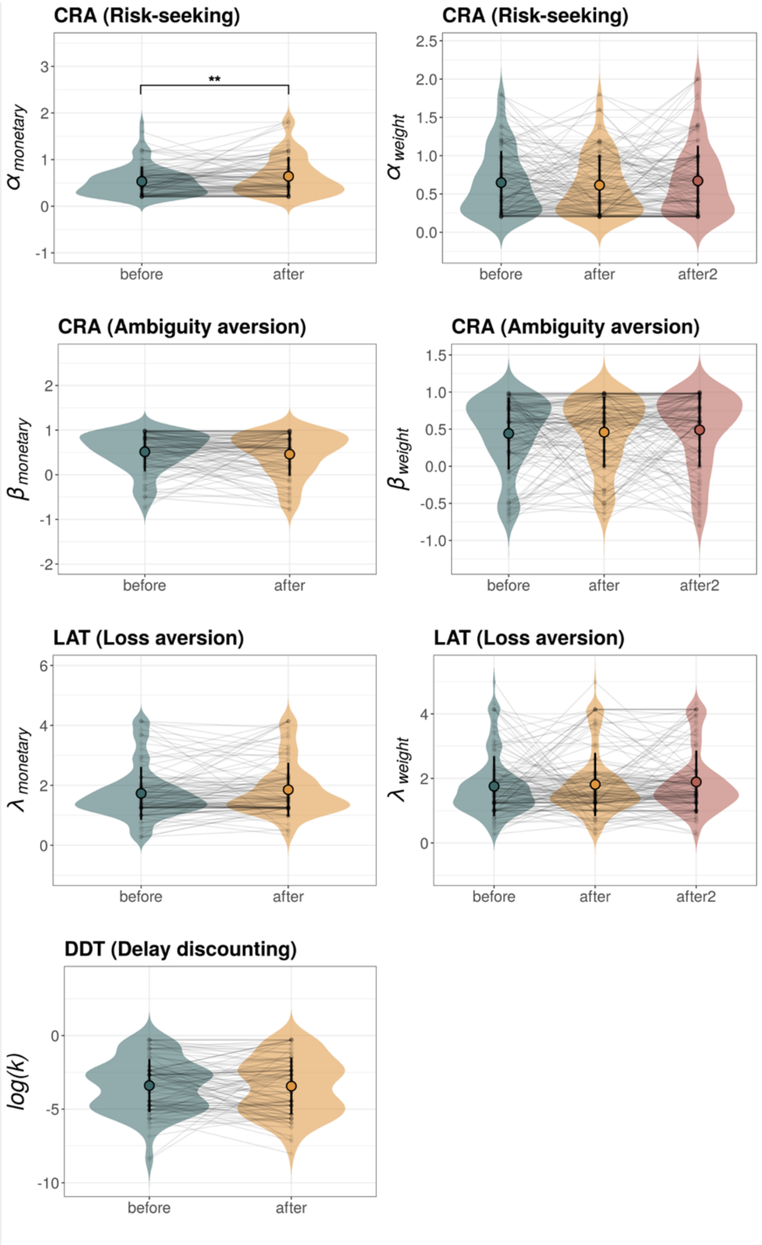

Figure 3.6: Differences in decision-making tasks' parameters before and after the surgery. Monetary versions of the decision-making tasks were performed twice, before and after the surgery (1 in the x axis, before surgery; 2 in the x axis, after surgery). Weight-related versions were performed three times, once before the surgery, and twice after the surgery in 1-2 weeks (see Figure 3.1) (*: $p < .05$, **: $p < .01$; ***: $p < .001$)

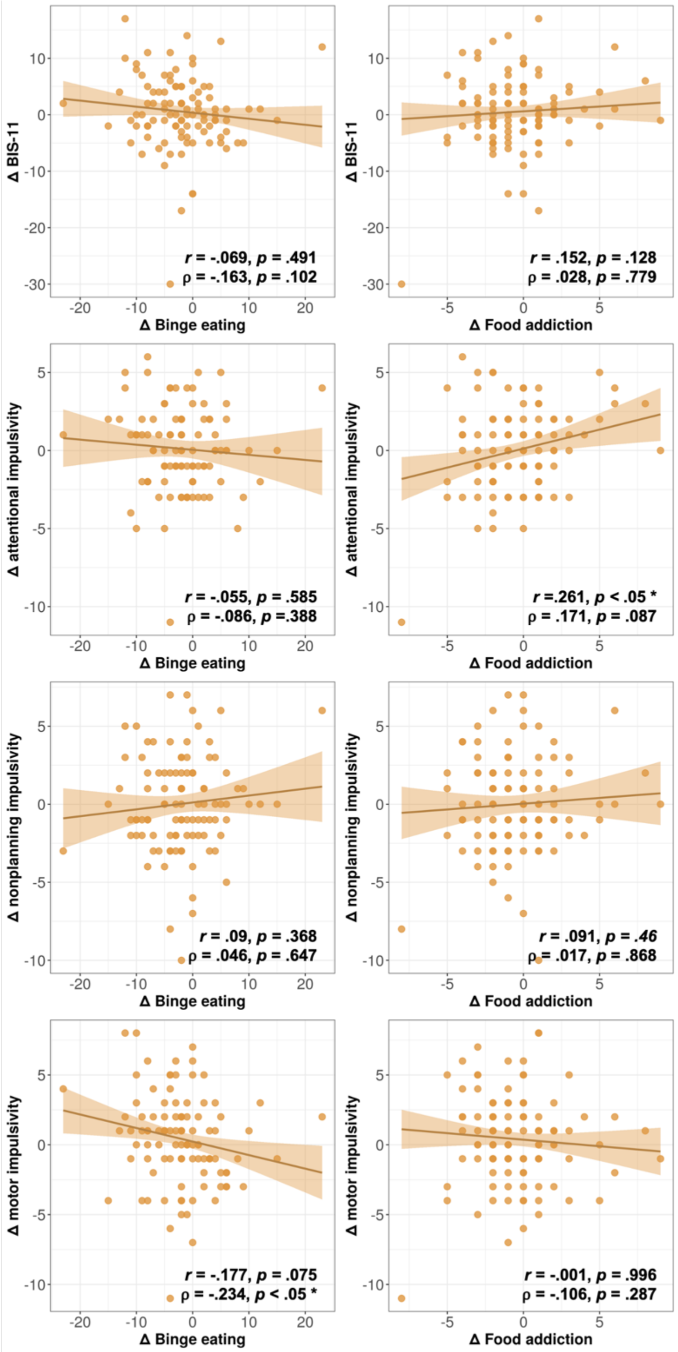

Figure 3.7: Correlation between change in binge eating behavior (A), food addiction behavior (B) and change in impulsivity measure BIS-11 and its subscales. The change is calculated by subtracting the estimated parameter values before the surgery from the values after the surgery. The regression line is a robust regression, r stands for pearson's correlation and ρ stands for a robust correlation coefficient.

Table 3.4: Hierarchical regression analysis predicting change in attentional impulsivity with change in binge eating behavior and food addiction behavior

Step	*significant predictors*	*R^2 (adj)*	*F*	*df*	*B (SE)*	*β*	*t*	*p*	*sig*
1		0.091 (-0.021)	0.814	90					
	no significant predictors								
2		0.178 (0.057)	1.47	88					
	Δ Binge eating behavior				-0.113 (0.049)	-0.269	-2.328	0.022	*
	Δ Food addiction behavior				0.265 (0.109)	0.267	2.422	0.017	*
	Δ Trait anxiety				0.144 (0.061)	0.359	2.37	0.02	*
ANOVA		64.939	4.709	2				0.011	*

(*: $p < .05$, **: $p < .01$; ***: $p < .001$)

Table 3.5: Hierarchical regression analysis predicting change in motor impulsivity with change in binge eating behavior and food addiction behavior

Step	*significant predictors*	*R^2 (adj)*	*F*	*df*	*B (SE)*	*β*	*t*	*p*	*sig*
1		0.091 (-0.021)	0.814	90					
	no significant predictors								
2		0.13 (0.002)	1.015	88					
	Δ Binge eating behavior				-0.12 (0.06)	-0.237	-1.992	0.049	*
	Δ Food addiction behavior				0.072 (0.136)	0.06	0.532	0.596	
ANOVA		42.225	1.994	2				0.142	

(*: $p < .05$, **: $p < .01$; ***: $p < .001$)

but in the opposite direction: food addiction behavior and attentional impulsivity were positively associated, while binge eating behavior and attentional impulsivity showed negative associations.

3.3. Discussion

The aim of study 2 was to examine whether food addiction and binge eating could be distinguished in terms of 1) the relationship with body image concern and dietary restraint, 2) the relationship with weight-related decision-making patterns, and also 3) the relationship with impulsivity and reward dysfunction. Multiple findings supported the dissociation between food addiction and binge eating. First, changes after the weight-loss liposuction surgery reduced binge eating behavior but not food addiction behavior. Second, reduction in binge eating behavior after the weight-loss intervention was significantly predicted by the reduction in body image concern even after controlling other relevant variables including clinical indices, which was not found in food addiction behavior. Lastly, reduction in food addiction behavior could significantly predict the reduction in attentional impulsivity but binge eating behavior could not. However, among the weight-related decision-making parameters, there was no significant difference between food addiction and binge eating. Overall, binge eating behavior and food addiction behavior could be distinguished when tracking changes after the weight-loss liposuction surgery.

Changes after weight-loss surgery in our study are consistent with existing literature. Reduction in body measurements and improvement in body satisfaction have been consistently reported, and also reduction in symptoms of BED or other eating disorders has been reported both in short- and long- term (Ben-Porat et al., 2020; Niego et al., 2007; Saariniemi et al., 2015; Wadden et al., 2011). Clinical changes that have been detected in our results were the decrease of state and trait anxiety measured by STAI-S and STAI-T, and symptoms of OCD measured by Y-BOCS. Though findings of the long-term effect are still controversial, existing literature has reported that most patients experience a reduction in anxiety in a short period after weight-loss surgery (Ribeiro et al., 2018; Sarwer et al., 2005). For the decrease in Y-BOCS, since OCD symptoms have been known to have a positive correlation with BMI and BED, the results could be due to reduction in BMI and binge eating behavior after the weight-loss surgery (O'Neill et al., 2010). Lastly, according to previous obesity literature (Lazzeri et al., 2015; Pasco et al., 2013), an increase in perceived stress measured by PSS could be induced by repetitive surgery which is the case in our study, and the increase in positive affect could be explained by the increase of body satisfaction, while negative affect could be due to several limitations after the surgery. However, these changes after surgery should be longitudinally tracked with other confounding variables in further studies.

BED symptoms have been consistently reported to decrease after weight-loss surgery. While most of the literature has targeted bariatric surgery (Ben-Porat et al., 2020; Niego et al., 2007; Wadden et al., 2011), Saariniemi et al. (2015) investigated the outcome of aesthetic liposuction surgery, as our study, and reported a reduction of eating disorder and improve body satisfaction after surgery. However, whether weight-loss surgery alleviates food addiction symptoms is yet to be conclusive, as well as whether the effects of the surgery differ in food addiction and binge eating (Ben-Porat et al., 2020; Ivezaj et al., 2017; Koball et al., 2020; Pepino et al., 2014;

Sevinçer et al., 2016). In a recent longitudinal study investigating the outcome of sleeve gastrectomy after 3, 6, and 12 months, the prevalence of binge eating decreased significantly over 1-year consistently, while that of food addiction decreased up to 6 months but increased after 12 months (Ben-Porat et al., 2020). In contrast, Sevinçer et al. (2016) have reported a reduction in food addiction diagnosis in 6 and 12 months after the surgery, and Pepino et al. (2014) reported a reduction in YFAS scores 6 weeks after the surgery. In our study, the weight-loss intervention did not impact food addiction behavior, but only affected binge eating behavior. Note that time point of follow-up of our study was 1~2 weeks, which is relatively shorter than the literature, no difference in food addiction behaviors might be due to this difference in data collection time point. Another possibility is that the difference between binge eating and food addiction in a short period of time after weight-loss surgery might indicate dissociative mechanisms under the two constructs, which could provide several implications on the effectiveness of the weight-loss intervention for BED and food addiction. Whether weight-loss surgery is an effective treatment for BED has been controversial, and literature focusing on food addiction is scarce. However, investigating the differential effect of weight-loss surgery on the two constructs is in critical need. First, it would provide a hint on understanding the mechanism. For example, for the treatment of food addiction, reduction of body weight might not be the critical factor. Thus, further studies should investigate short- and long-term effects of weight-loss surgery in food addiction and BED in a large sample of longitudinal studies, and which would help to provide individualized treatment for each type of overweight.

Unlike food addiction, the surgery significantly reduced the binge eating behavior, and our results suggest that the reduction could be explained by the reduction of body image concern. However, interpretation of these results should be done with caution because while body image concern decreased, dietary restraint increased in general, which were both pointed out as risk factors preceding binge eating episodes in some individuals. Previous studies have also reported an increase in retrained eating measured by DEBQ after weight-loss surgery (Pepino et al., 2014; Souilm & Shokre, 2018), and one of the possible explanations for the increase in dietary restraint after the surgery would be that obesity clinic emphasizes diet control, since a high-calorie diet could cause a recurrence of weight gain. Also, since liposuction surgery costs a lot, the money spent could encourage dieting after the surgery.

Another finding to note is that food addiction and binge eating displayed a dissociative relationship with attentional impulsivity measured by BIS-11: change in food addiction was in the same direction with the change in attentional impulsivity, showing positive association, and binge eating showed a negative association. While our findings suggest the difference in the relationship with attentional impulsivity, previous literature has each suggested attentional impulsivity as a risk factor of food addiction (Dawe & Loxton, 2004; Meule et al., 2017) and BED (Dawe & Loxton, 2004; Hege et al., 2015; Mobbs et al., 2011). However, since there is few research that has compared BED and food addiction focusing on impulsivity and its subscales, further investigation using multiple measures of impulsivity is required to confirm the possibility of different mechanisms between food addiction and binge eating in terms of impulsivity.

With several differences observed between food addiction and binge eating, it could be supported that two constructs possess underlying differences though they are both associated with pathological overeating and obesity. However, our second hypothesis that the two constructs would display differences also in weight-related decision-making was not supported. Note that no significant relationship was found with the decision-making tasks parameters, which includes the weight-loss related risk-seeking parameter α_{weight}, weight-loss related ambiguity aversion parameter β_{weight}, and weight-gain aversion parameter λ_{weight}, as well as delay discounting rate $\log(k)$, which was used to measure reward dysfunction in our exploratory analysis. One possibility is that the timepoint of post-surgical data collection would be too short for the decision-making features to be altered. Another explanation would be due to the nature of the decision-making tasks: it could be closer to a trait that remains stable over time, rather than states that could easily change. Also, note that 106 participants whose parameters got stuck to the boundaries had to be excluded from the analysis, it is worthwhile to check the parameter range and re-test the relationship between the variables without this estimation issue. Since this study is an ongoing project collecting more samples and also planning a 3-month follow-up data collection, further examination of the relationship between variables is needed.

Several limitations should be considered. First, due to the high covariance between BED and food addiction behavior, which were consistently reported in previous literature (Gearhardt et al., 2012; Schulte et al., 2016), I had to examine the difference between the two concepts relying on the scales within identical samples. Future studies could benefit by collecting large samples and dissociating the group differences between individuals with food addiction but no BED versus individuals with BED but no food addiction. High covariance between food addiction and BED makes it hard for researchers to study unique features of each construct , but at the same time, high covariance is the reason why the unique features of BED and food addiction should be investigated.

Second, I relied on self-report surveys in measuring binge eating behavior, food addiction behavior, and other clinical indices. Thus, the degree of each clinical index might be inaccurate compared to the actual diagnosis by experts. Third, while the results suggest the dissociation between food addiction and binge eating, the causal mechanisms underlying each concept and body image concern, dietary restraint, and weight-related decision-making could not be addressed. Due to the complexly intertwined relationships between the constructs, a clever experimental design to resolve the covariance is required in future research.

The findings of study 2 have several implications. First of all, existing literature on change after a weight-loss liposuction surgery has rarely compared food addiction and binge eating in prospective studies. By using the data before and after the liposuction surgery, evidence for the difference between food addiction and binge eating could be suggested. Second, study 2 investigated multiple factors of the changes after weight-loss surgery. The weight-loss intervention has been widely used as a treatment for obesity, and its effectiveness has been studied regarding problematic eating behaviors. While the surgery could reduce BMI, body fat, binge eating behavior, and even body image concern, it does not target food addiction behavior directly, and there is a possibility that binge eating behavior could re-occur, since dietary restraint increased after the surgery. Thus, the results suggest that merely losing weight would be the best solution for obesity if an obese individual has other eating pathologies or food addiction, and individualized treatment targeting the unique risk factors of each concept should be implemented.

Chapter 4. Conclusion

Multiple theories explaining eating disorders including BED contain overvaluation of one's body, which is cognitively expressed as body image concern and dietary restraint, and behaviorally expressed as weight-loss pursuing behaviors. In this paper, I tried to capture the difference between food addiction and binge eating in terms of the cognitive features and also in terms of the behavioral decision-making patterns, in order to answer the question of whether food addiction differs from BED.

In study 1, I validated the newly developed weight-related decision-making tasks that were designed using the ADO framework. As expected, the weight-related choice parameters could better explain the weight-related individual differences better than the monetary versions of the decision-making tasks. By using the ADO framework, the individual parameters could be estimated within 20-30 trials, with high accuracy. This enabled the application of the weight-related decision-making tasks in real-life settings, in the local obesity clinic in study 2. Along with the different patterns in the relationship with body image concern and dietary restraint, food addiction and binge eating were heterogeneous in the relationship with attentional impulsivity as well, a shared feature known as a risk factor of both food addiction and binge eating.

This paper aimed to examine the difference between food addiction and BED, which could be a stepping stone in food addiction research. While the focus of this paper was the unique mechanisms of BED, future research should also address whether the suggested unique mechanisms of food addiction could be ruled out in BED. Also, future research should be expanded toward developing treatment and intervention for each concept. Due to the complexly intervened nature of the two concepts, different responsiveness to identical treatment, or discrepancy in the effective treatment could be another strong evidence for the validity of the food addiction concept.

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Appendix A. Decision-making tasks and parameters

Monetary choice under risk and ambiguity task. The monetary version of the CRA task assesses how individuals make decisions under risky and ambiguous situations (Levy et al., 2010). Participants are asked to indicate a preference between two options: earning money with a fixed probability of 50% (fixed option), or earning money with a varying probability or a varying level of ambiguity (variable option). In Figure 2.2 "monetary CRA", the red part of each option corresponds to the probability of getting a reward written on the top of the box, and the blue part of each option corresponds to the probability of getting the bottom one. In the risky trials, the variable option displays a higher reward with a lower probability of winning compared to the fixed option. In the ambiguous trials, the variable option contains a gray box which is located in the middle of the boundary of the red and blue parts, leaving the probabilities ambiguous. There are four experimental parameters that describe a single trial, which were optimized on each trial using the ADO framework: the winning probability of a variable option (chosen among 13%, 25%, 38%), the level of ambiguity of a variable option (chosen among 25%, 50%, 75%), the amount of reward for a variable option and a fixed option (both increase by ₩2,000 from ₩5,000 to ₩39,000, and the amount of reward for the variable option should be greater than the fixed option). I used the linear model for the CRA task based on the previous literature (Levy et al., 2010), where subjective utility U is computed as

$$U = \left(P - \beta \cdot \frac{A}{2}\right) \cdot R^{\alpha}$$

where P is the winning probability, A is the level of ambiguity, and R is the amount of monetary reward. α refers to the risk-seeking parameter (α > 1, risk-seeking; α = 1, risk-neutral; α < 1, risk-averse), and β refers to the ambiguity-aversion parameter (β > 0, ambiguity-averse; β = 0, ambiguity-neutral; β < 1, ambiguity-seeking). Using the softmax choice rule, a probability of choosing the variable option over the fixed option (P_variable) could be predicted as

$$P_{variable} = \{1 + \exp\left(-\gamma\left(U_{variable} - U_{fixed}\right)\right)\}^{-1}$$

where γ represents a participant's choice inconsistency, and U_variable and U_fixed are calculated based on the first equation. Each participant's three model parameters are estimated using Bayesian inference via grid approximation within the ADO framework based on the behavioral responses of the monetary CRA task (a total of 30 trials). In the ADO, each parameter is estimated based on the pre-defined grid space (α, 10 points from [0.2, 2]; β, 11 points from [-1, 1]; γ, 5 points from [1, 5]).

The following analyses will focus on the two parameters: the monetary-gain related risk-seeking parameter $\alpha_{monetary}$ and the monetary-gain related ambiguity aversion parameter $\beta_{monetary}$.

Weight-related choice under risk and ambiguity task. I developed a weight-related version of the CRA task by modifying monetary gain into weight loss (Figure 2.2 "weight CRA"). I aimed to measure how individuals make decisions under risky and ambiguous situations of choosing a weight loss program, and estimate the individual differences in risk-seeking and ambiguity-aversive attitudes in the weight-loss domain. Every task detail including the experimental parameters, and the model and parameters are identical to the monetary version of the CRA task except that monetary gain corresponds to weight-loss: α_{weight} and β_{weight} each refers to the weight-loss related risk-seeking parameter and the weight-loss related ambiguity aversion parameter, and the amount of weight loss in a variable option increases by 0.2kg from 0.5kg to 3.9kg. Higher α_{weight} indicates that the individual could tolerate the risk of weight-loss failure and chooses the risky option in order to lose a larger amount of weight, and lower β_{weight} indicates that the individual could tolerate the ambiguity and chooses the ambiguous option in order to lose a larger amount of weight: weight-loss pursuing behavior could be captured by higher α_{weight} and lower β_{weight}.

Monetary loss aversion task. The monetary version of the LAT was developed to estimate how sensitive an individual is to losing money compared to earning money (Sokol-Hessner et al., 2009), based on the idea of the prospect theory that 1) people would much rather avoid losing money than they would earn money, 2) the psychological impact of losing a certain amount of money can be twice as greater as earning the exact same amount, and 3) there are individual differences in loss aversion with some individuals showing greater avoidance in choosing situations with possible losses (Tversky & Kahneman, 1991).

As shown in Figure 2.2 "monetary LAT", participants chose between two options based on their preference: earning large amounts of money with 50% chance but another 50% chance of losing money (gamble option), or earning a relatively smaller amount of money with 100% chance of winning (sure option). There are two experimental parameters that are optimized on each trial based on the ADO framework: the amount of monetary gain (increase by ₩2,000 from ₩10,000 to ₩40,000) and monetary loss (increase by ₩1,000 from ₩5,000 to ₩20,000) in a gamble option. The most informative set of experimental parameters are selected by the ADO framework using the quantitative model described below.

I estimated the individual differences in loss aversion based on the nonlinear stochastic choice model following the previous study (Sokol-Hessner et al., 2009).

Subjective utility U for the amount of reward x are computed separately for gains (x >= 0) and losses (x < 0) as

$$u(x) = \begin{cases} x^{\rho}\ (if\ x\ \geq 0) \\ -\lambda \cdot (-x^{\rho})(if\ x < 0) \end{cases}$$

where ρ is the risk-seeking parameter, and λ is the loss aversion parameter. If ρ-value is greater than 1, a participant is more risk-seeking; if ρ-value equals 1, a participant is risk-neutral; if ρ-value is smaller than 1, a participant is risk-averse. Greater risk-seeking indicates that a participant would overestimate the option, while risk-neutral means that a participant would interpret the amount as it is. The utility of the loss domain (x < 0) is computed by multiplying the loss aversion parameter λ. A λ-value greater than 1 indicates a tendency to overemphasize monetary loss relative to monetary gain. Based on the procedure in Sokol-Hessner et al., (2009) the probability to choose a gamble option P is computed using a softmax function as

$$p(gamble) = \{1 + \exp\left(\theta\big(u(gamble) - u(sure)\big)\right)\}^{-1}$$

where U_gamble and U_sure are subjective utilities for gamble and sure options, respectively, and θ is the inverse temperature parameter that represents a participant's response inconsistency. The grid space for model parameters was determined as follow: ρ, 20 points from [0.25, 5]; λ, 20 points from [0.25, 5]; θ , 5 points from [1, 5]. In short, each participant's three model parameters are estimated using Bayesian inference via grid approximation within the ADO framework based on the behavioral responses of the monetary LAT task (a total of 20 trials). The following analyses will focus on the loss-aversion parameter $\lambda_{monetary}$, which represents individual differences in attitude toward monetary loss.

Weight-related loss aversion task. I developed the weight-related version of LAT by modifying the monetary version of LAT: changing monetary gain into weight loss, and monetary loss into weight gain (Figure 2.2 "weight LAT"). I aimed to measure the individual difference in weight-gain aversion, avoidance in choosing situations with possible weight gain. Every task detail including the experimental parameters, the quantitative model, and the model parameters is identical to the monetary version of the LAT except that monetary loss corresponds to weight-gain and monetary gain corresponds to weight-loss: λ_{weight} is a weight-gain aversion parameter, and the amount of weight loss in a gamble option increases by 0.2kg from 1kg to 4kg, and the amount of weight gain in a gamble option increases by 0.1kg from 0.5kg to 2kg. The weight-aversion parameter λ_{weight}, which represents individual differences in attitude toward weight gain, will be a focus of the following analyses. Individuals with lower λ_{weight} are more likely to not consider the possibility of weight gain, and choose the gamble option if they could lose weight: weight-loss pursuing behavior could be captured by lower $\lambda_{weight.}$

Monetary delay discounting task. Delay discounting is one dimension of impulsivity that measures how individuals prefer small but immediately available rewards compared to large but delayed rewards (Ahn et al., 2020; Reynolds et al., 2006). Note that overeating could be interpreted as choosing immediate reward of eating versus long-term reward such as health, and previous literature reported that obesity, weight gain, BED, and FA are associated with high delay discounting rate (Fitzpatrick et al., 2013; Green & Myerson, 2004; Steward et al., 2017; VanderBroek-Stice et al., 2017), I aimed to assess individual differences in discounting delayed rewards.

$$U = \left(R \cdot \frac{1}{(1 + kD)}\right)$$

where reward amount R after delay D is discounted by the discounting rate k. To estimate the choice probability P of choosing the LL over the SS options on each trial, I used the softmax function:

$$P_{LLoverSS} = \{1 + \exp\left(\tau\big(U(SS) - U(LL)\big)\right)\}^{-1}$$

where Vss and Vll are subjective values of the SS and the LL options, τ represents a participant's choice inconsistency. The grid space for model parameters was determined as follow: τ, 10 points from [0.45454545, 4.54545455]; log(*k*) , 30 points from [-8.9132, -0.2971]. In short, each participant's two model parameters are estimated using Bayesian inference via grid approximation within the ADO framework based on the behavioral responses of the monetary DDT task (a total of 20 trials). The following analyses will focus on the delay discounting rate log(*k*).

Appendix B. Comparison of decision-making task parameters between study1 and study2

I conducted the correlation analyses performed in study1 using the data collected from the clinic samples of study2 (see 2.1.4. Data analysis for the method), and compared the results from the community samples (study1) and the obese clinic samples who registered for liposuction surgery (study2). See 2.2 Results for the results of study1.

As in Figure B.1, I conducted correlation analysis between the monetary and weight-related versions. Before the surgery, correlations between the two versions were significant for all three parameters before and after the surgery; risk-seeking parameters in the CRA task (α_{weight} and $\alpha_{monetary}$, $r = .512, p < .001, \rho = .559, p < .001$), ambiguity aversion parameters in the CRA task (β_{weight} and $\beta_{monetary}$, $r = .367, p < .001$, $\rho = .329$, $p < .001$), and the loss aversion parameters in the LAT task (λ_{weight} and $\lambda_{monetary}$, $r = .269, p < .01, \rho = .416, p < .001$). The pattern remained consistent after the surgery (α_{weight} and $\alpha_{monetary}$, $r = .413$, $p < .001$, $\rho = .432$, $p < .001$; β_{weight} and $\beta_{monetary}$, $r = .35, p < .001, \rho = .456, p < .001$; λ_{weight} and $\lambda_{monetary}$, $r = .496, p < .001, \rho = .549, p < .001$).

As shown in Figure B.2, the estimated parameters from the community samples and the clinic samples (before surgery) showed significant differences (β_{weight}, study1 mean (SD)= 0.679 (0.335), study2 = 0.461 (0.474), $p < .0701$; λ_{weight}, study1 = 2.491 (0.99), study2 = 1.73 (0.903), $p < .001$; $\alpha_{monetary}$, study 1 = 0.734 (0.363), study2 = 0.532 (0.321), $p < .001$; $\lambda_{monetary}$, study1 = 2.27 (1.01), study2 = 1.73 (0.881), $p < .001$except for the monetary ambiguity aversion parameter $\beta_{monetary}$ (study1 = 0.619 (0.366), study2 = 0.515 (0.439), $p = .076$), and the weight-related risk-seeking parameter α_{weight} (study 1 = 0.759 (0.478), study2 = 0.674 (0.411), $p = .181$). To examine the patterns of the parameters, elastic net was used in predicting the clinic samples from the community samples. Dependent variable was whether the individual is from study 2 or study 1, whether the individual is seeking for a weight-loss liposuction surgery or not. First, the elastic net was performed using all data collected in study 1 (N = 93) and study 2 (N = 102) (Figure B.3A), smaller weight-gain aversion parameter λ_{weight} had the highest predictive power of the classification, followed by higher delay discounting rate from DDT. The mean AUC (area under the ROC curve) score of the test dataset was 0.82. Then, the elastic net was also performed using data of the dieters in study 1 (N = 47) and all data from study 2 (N = 102) (Figure B.3B), to examine whether the parameters could distinguish individuals who are trying to use liposuction surgery for weight-loss from individuals who are currently on a diet. The mean AUC score of the model was 0.78, and the most predictive variable was the higher delay discounting rate, followed by the lower weight-gain loss aversion parameter λ_{weight}. Overall, weight-related parameters displayed higher predictive ability in classifying individuals who registered for loss-aversion liposuction surgery, compared to the monetary parameters. Also, the higher delay discounting rate was reported as significant predictors in both models, which is consistent with previous literature that individuals with obesity, binge eating disorder, or food addiction display a higher delay discounting rate compared to healthy controls (Fitzpatrick et al., 2013; Steward et al., 2017; VanderBroek-Stice et al., 2017).

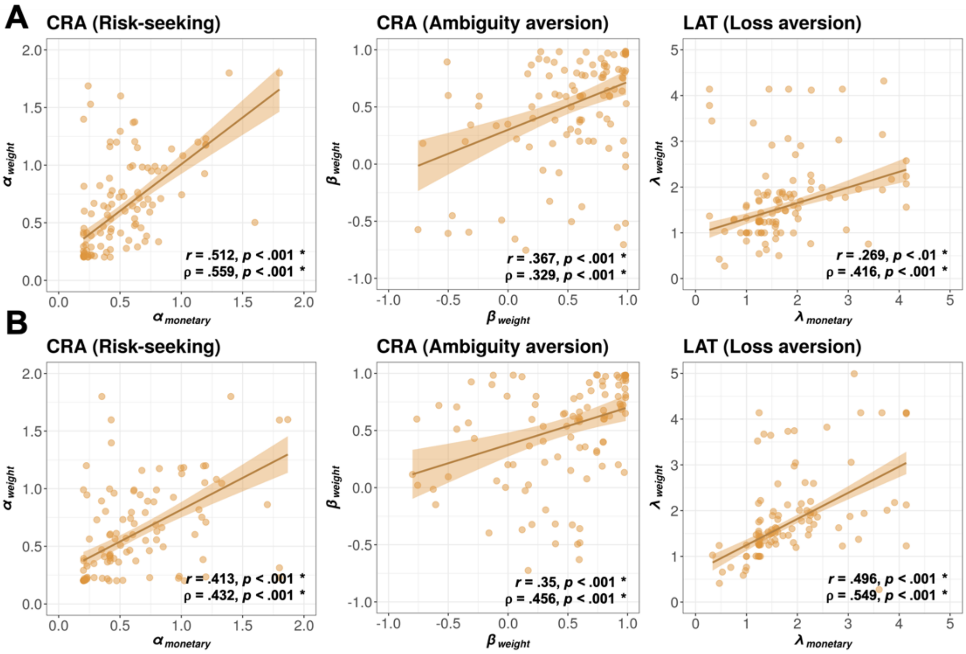

Figure B.1: Correlations between monetary and weight-related parameters (A) before and (B) after the surgery. The x axis is estimated parameter value of the monetary version of each task, and the y axis is from the weight-related version ($\alpha_{monetary}$, monetary-gain risk-seeking parameter; α_{weight}, weight-loss risk-seeking parameter; $\beta_{monetary}$, monetary-gain ambiguity aversion parameter; β_{weight}, weight-loss ambiguity aversion parameter; $\lambda_{monetary}$, monetary-loss aversion parameter; λ_{weight}, weight-gain aversion parameter). The regression line is a robust regression, *r* stands for pearson's correlation and *ρ* stands for a robust correlation coefficient. abbreviations: CRA, Choice under Risk and Ambiguity; LAT, Loss Aversion Task.

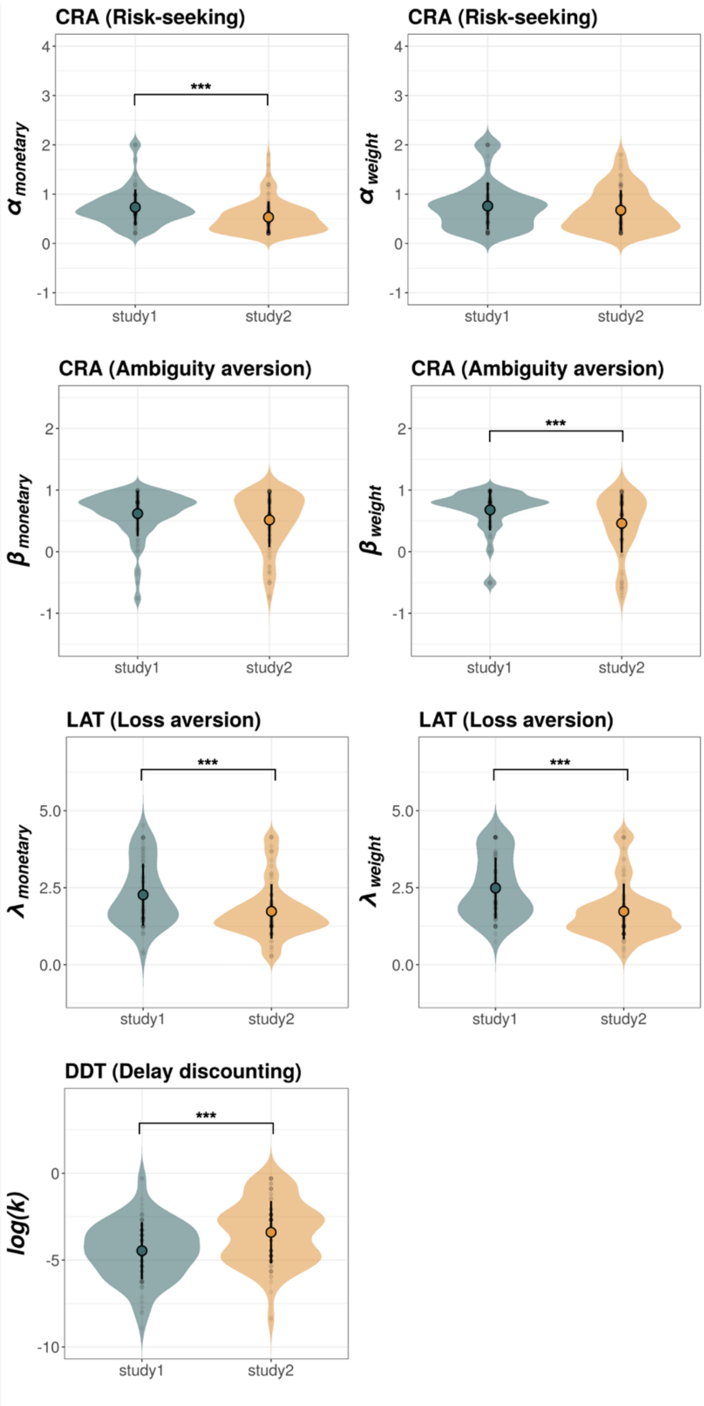

Figure B.2: Comparisons of parameter estimates from decision-making tasks between study1 and study2. Study 1 data were collected from community samples (N = 93), and study2 were collected from clinic samples (N = 54) who were all obese (BMI > 25) and who registered for a liposuction weight-loss surgery. (*: $p < .05$, **: $p < .01$; ***: $p < .001$)

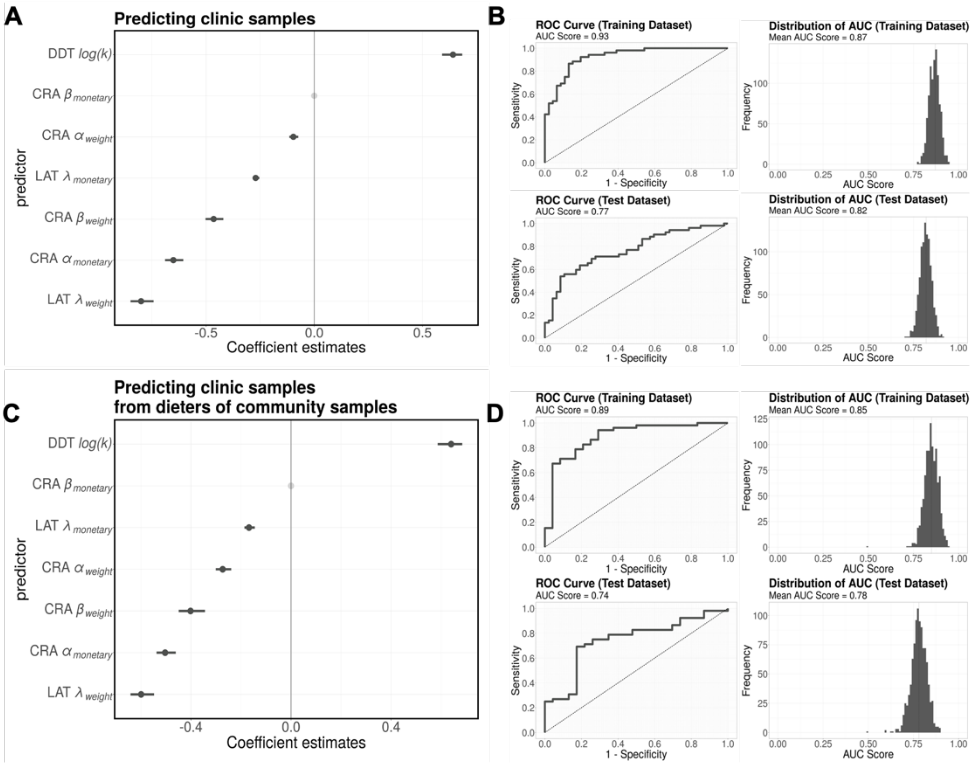

Figure B.3: Multivariate patterns of decision-making task parameters classifying clinic samples seeking for liposuction surgery (study2) from the community sample (study1). (A), (C) Variables with black point (mean) with error bar (95% confidence interval) are significant predictors for the classification, and variables with gray color are those whose effects are shrunk to 0 by the elastic net. (B), (D) The left figures are representative ROC curves (receiver operating characteristic curves) for training and test datasets. The x axis is false positive rate (1- specificity), and the y axis is true positive rate (sensitivity). The right figures are distributions of the AUC (area under the ROC curve) values on the training and test sets over 1,000 random divisions of training/test datasets (see 2.1.4. data analysis). Top two figures (A) and (B) are the results classifying clinic samples (n = 54) from community samples (n = 93), and the bottom figures (C) and (D) are the results classifying clinic samples from the dieters of the community samples (n = 47).

Appendix C. Supplementary figures and tables

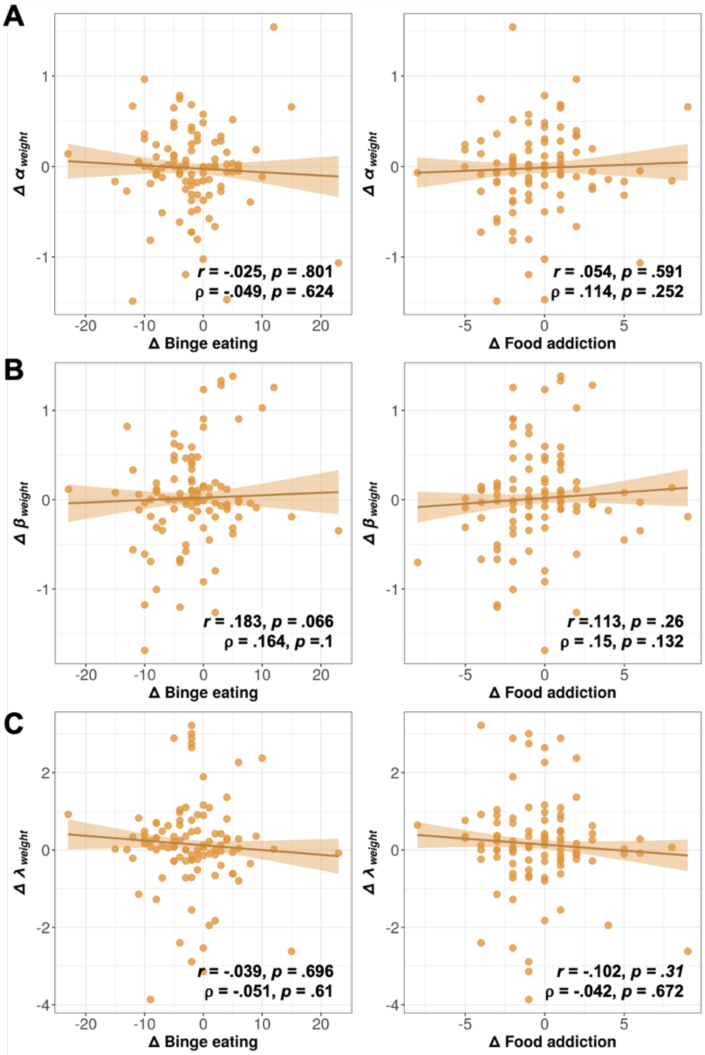

Figure C.1: Correlation between change in binge eating behavior (left), food addiction behavior (right) and change in weight-related tasks parameter. (A) weight-loss related risk-seeking parameter α_{weight}, (B) weight-loss related ambiguity aversion parameter β_{weight}, (C) weight-gain aversion parameter λ_{weight}. The change in value after surgery was calculated by subtracting the estimated parameter values before the surgery from the values after the surgery. The regression line is a robust regression, *r* stands for pearson's correlation and *ρ* stands for a robust correlation coefficient.

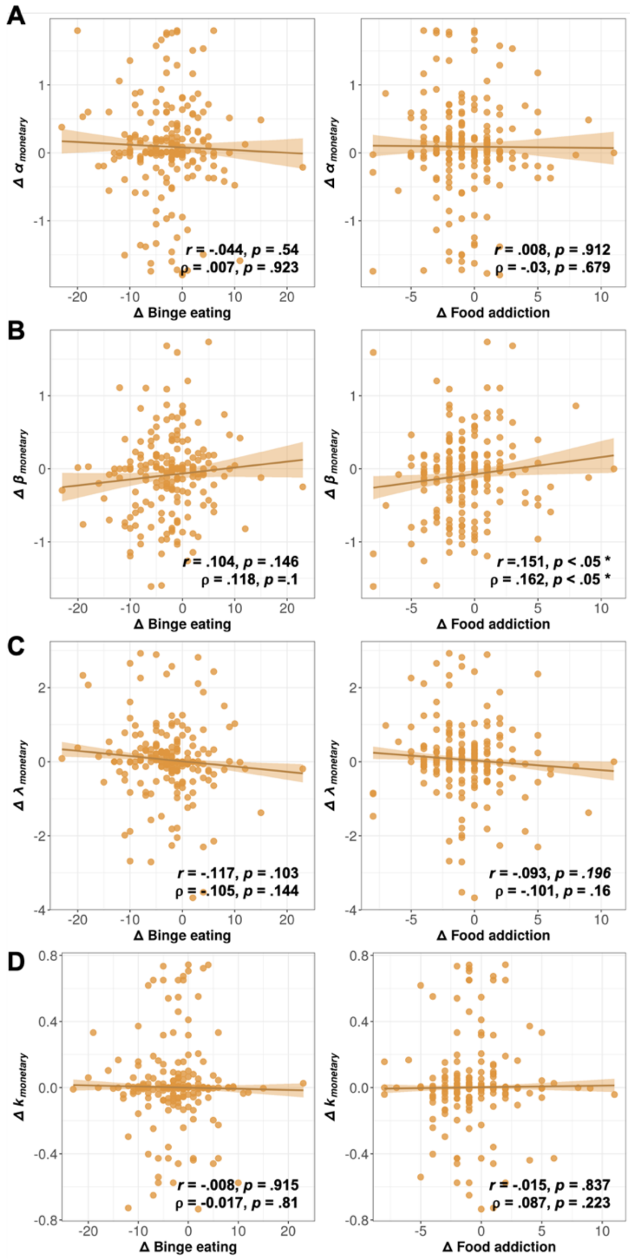

Figure C.2: Correlation between change in binge eating (left), food addiction (right) and change in monetary decision-making tasks parameters. (A) monetary-gain related risk-seeking parameter $\alpha_{monetary}$ from monetary CRA task (B) monetary-gain related ambiguity aversion parameter $\beta_{monetary}$ from the monetary CRA task (C) monetary-loss aversion parameter $\lambda_{monetary}$ from the monetary LAT task (D) monetary delay discounting rate k from the DDT. The change in value after surgery was calculated by subtracting the estimated parameter values before the surgery from the values after the surgery. The regression line is a robust regression, *r* stands for pearson's correlation and *ρ* stands for a robust correlation coefficient. (*: $p < .05$, **: $p < .01$; ***: $p < .001$)

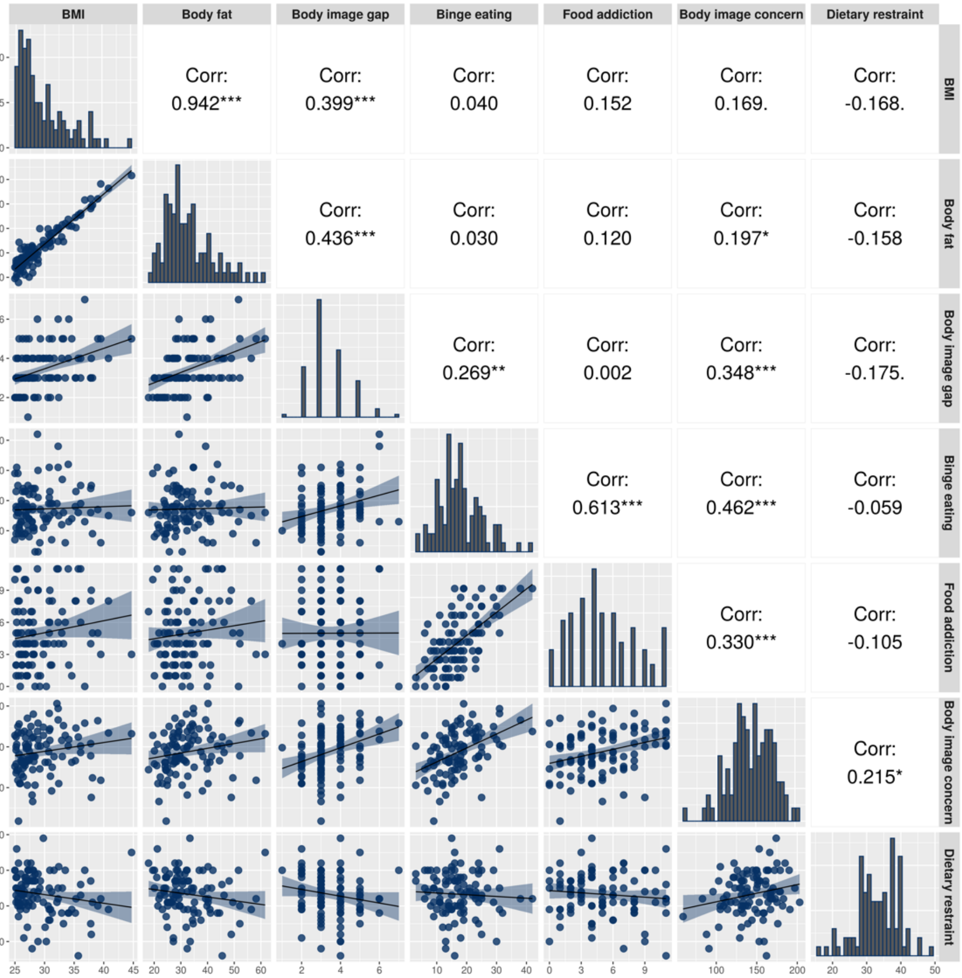

Figure C.3: Correlations between weight-related measures before the surgery (*: $p < .05$, **: $p < .01$; ***: $p < .001$)

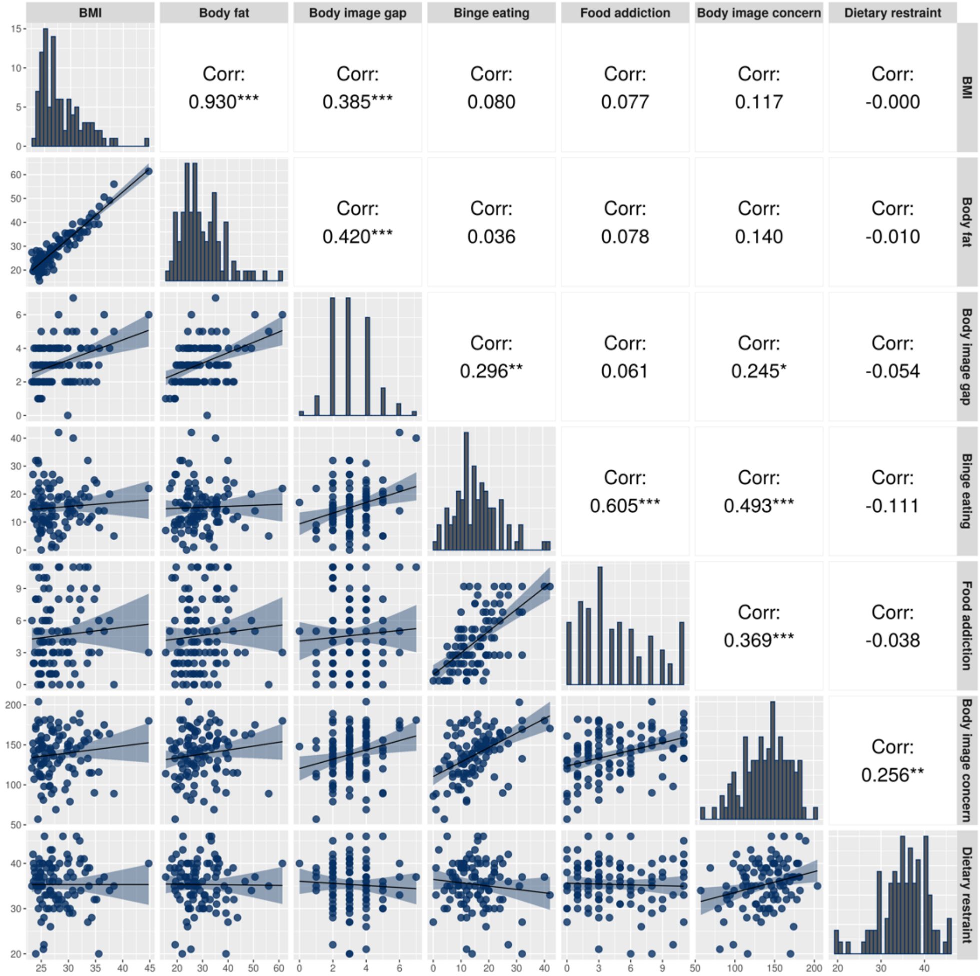

Figure C.4: Correlations between weight-related measures after the surgery (*: $p < .05$, **: $p < .01$; ***: $p < .001$)

Table C.1: Hierarchical regression analysis predicting change in $\alpha_{monetary}$ in the monetary version of the CRA task with change in binge eating and food addiction

Step	***significant predictors***	***R^2 (adj)***	***F***	***df***	***B (SE)***	***β***	***t***	***p***	***sig***
1		0.094 (-0.017)	0.844	90					
	no significant predictors								
2		0.101 (-0.031)	0.764	88					
	Δ Binge eating				-0.006 (0.008)	-0.098	-0.815	0.417	
	Δ Food addiction				0.008 (0.017)	0.056	0.485	0.629	
ANOVA		0.136	0.386	2				0.681	

(*: $p < .05$, **: $p < .01$; ***: $p < .001$)

Table C.2: Hierarchical regression analysis predicting change in $\beta_{monetary}$ in the monetary version of the CRA task with change in binge eating and food addiction

Step	***significant predictors***	***R^2 (adj)***	***F***	***df***	***B (SE)***	***β***	***t***	***p***	***sig***
1		0.099 (-0.011)	0.9	90					
	no significant predictors								
2		0.115 (-0.016)	0.877	88					
	Δ Binge eating				0.003 (0.01)	0.038	0.314	0.754	
	Δ Food addiction				0.026 (0.023)	0.128	1.116	0.267	
ANOVA		0.471	0.773	2				0.465	

(*: $p < .05$, **: $p < .01$; ***: $p < .001$)

Table C.3: Hierarchical regression analysis predicting change in $\lambda_{monetary}$ in the monetary version of the LAT task with change in binge eating and food addiction

Step	*significant predictors*	*R^2 (adj)*	*F*	*df*	*B (SE)*	*β*	*t*	*p*	*sig*
1		0.114 (0.006)	1.056	90					
	no significant predictors								
2		0.117 (-0.013)	0.899	88					
	Δ Binge eating				-0.003 (0.017)	-0.024	-0.2	0.842	
	Δ Food addiction				-0.018 (0.039)	-0.052	-0.455	0.65	
ANOVA		0.261	0.148	2				0.863	

(*: $p < .05$, **: $p < .01$; ***: $p < .001$)

Table C.4: Hierarchical regression analysis predicting change in α_{weight} in the weight version of the CRA task with change in binge eating and food addiction

Step	*significant predictors*	*R^2 (adj)*	*F*	*df*	*B (SE)*	*β*	*t*	*p*	*sig*
1		0.048 (-0.068)	0.415	90					
	no significant predictors								
2		0.052 (-0.088)	0.374	88					
	Δ Binge eating				-0.004 (0.009)	-0.053	-0.429	0.669	
	Δ Food addiction				0.011 (0.02)	0.062	0.525	0.601	
ANOVA		0.092	0.193	2				0.825	

(*: $p < .05$, **: $p < .01$; ***: $p < .001$)

Table C.5: Hierarchical regression analysis predicting change in β_{weight} in the weight version of the CRA task with change in binge eating and food addiction

Step	***significant predictors***	***R^2 (adj)***	***F***	***df***	***B (SE)***	***β***	***t***	***p***	***sig***
1		0.08 (-0.032)	0.716	90					
	no significant predictors								
2		0.109 (-0.023)	0.825	88					
	Δ Binge eating				0.016 (0.01)	0.189	1.569	0.12	
	Δ Food addiction				0.006 (0.023)	0.028	0.245	0.807	
ANOVA		0.852	1.391	2				0.254	

(*: $p < .05$, **: $p < .01$; ***: $p < .001$)

Table C.6: Hierarchical regression analysis predicting change in λ_{weight} in the weight version of the LAT task with change in binge eating and food addiction

Step	***significant predictors***	***R^2 (adj)***	***F***	***df***	***B (SE)***	***β***	***t***	***p***	***sig***
1		0.084 (-0.028)	0.752	90					
	no significant predictors								
2		0.088 (-0.047)	0.653	88					
	Δ Binge eating				0.001 (0.023)	0.006	0.047	0.962	
	Δ Food addiction				-0.031 (0.052)	-0.07	-0.598	0.551	
ANOVA		0.563	0.181	2				0.834	

(*: $p < .05$, **: $p < .01$; ***: $p < .001$)

Table C.7: Hierarchical regression analysis predicting change in delay discounting rate log(*k*) of the Delay discounting task with change in binge eating behavior and food addiction behavior

Step	***significant predictors***	R^2 ***(adj)***	***F***	***df***	***B (SE)***	***β***	***t***	***p***	***sig***
1		0.143 (0.038)	1.361	90					
	no significant predictors								
2		0.149 (0.023)	1.182	88					
	Δ Binge eating behavior				0.025 (0.036)	0.082	0.694	0.49	
	Δ Food addiction behavior	2.393	0.309	2				0.735	
ANOVA		0.143 (0.038)	1.361	90					

(*: $p < .05$, **: $p < .01$; ***: $p < .001$)

국문초록

섭식 절제와 신체 이미지에 대한 지나친 걱정은 역설적으로 과식과 관련이 있다고 알려져 있다. 폭식 장애와 음식 중독은 모두 과식을 동반하며 체중 증가로 인해 섭식 절제와 신체 이미지에 대한 걱정이 증가할 수 있다는 공통점이 존재하지만, 폭식 장애만이 섭식 절제 및 과도한 신체 이미지 걱정이 원인으로 작용할 수 있다고 제안되었다. 이러한 폭식 장애의 고유한 특성은 경험적 근거를 통해 뒷받침되고 있지만, 음식 중독에서 해당 특성들이 존재하지 않는다는 것에 대한 실험적 근거는 부족한 실정이다. 따라서, 음식 중독 개념의 타당성을 확보하기 위해서는 섭식 절제와 신체 이미지에 대한 걱정이 음식 중독과 폭식 장애에 있어서 서로 다른 역할을 한다는 것이 밝혀질 필요성이 있다. 또한, 섭식 절제와 신체 이미지에 대한 과도한 걱정은 체중과 관련된 의사 결정을 변화시킬 수 있음에도 불구하고, 이러한 체중 관련 의사 결정 측면에서 음식 중독과 폭식장애의 차이는 연구된 바 없다. 따라서, 본 연구에서는 적응적 실험 최적화 (Adaptive Design Optimization, ADO)를 사용하여 체중 관련 의사 결정 과제를 개발하였고, 이는 연구 1(N = 93)에서 체중과 관련된 변인을 설명하는 유용한 도구임이 확인되었다. 연구 2(N = 102)에서는 지방흡입수술을 실시할 예정인 비만인 환자들을 대상으로 수술 전 후에 자료를 수집한 후 계층적 회귀모델을 이용하여 음식중독, 폭식행동, 섭식 절제, 신체에 대한 걱정의 관계 변화를 추적하였다. 또한, 연구 1 에서 검증된 과제를 사용하여 체중과 관련된 의사결정의 측면에서 음식 중독과 폭식 행동 사이에 서로 다른 패턴이 나타나는지 여부를 확인하였으며, 공통된 위험 요인으로 알려진 충동성에서 차이가 나타나는 지 살펴보았다. 연구 결과는 섭식 절제와 신체 이미지에 대한 걱정이 폭식 행동의 변화를 설명하는 데 있어서만 중요한 역할을 하고, 폭식 행동과 음식 중독은 주의 충동성 측면에서도 서로 반대의 양상을 보인다는 것이 확인되었다.

주요어: 음식중독, 폭식장애, 섭식절제, 체중 및 체형에 대한 걱정, 체중과 관련된 의사결정

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