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# Food cravings prospectively predict decreases in perceived self-regulatory success in dieting

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ABSTRACT

Food cravings are assumed to hamper dieting success, but most findings are based on cross-sectional studies. In the current study, female students were tested at the beginning of their first semester at university and six months later. They completed the Food Cravings Questionnaire-Trait-reduced (FCQ-T-r), the disinhibition subscale of the Eating Inventory, and the Perceived Self-Regulatory Success in Dieting Scale, and their height and weight were measured. Scores on the FCQ-T-r prospectively predicted higher disinhibition and lower perceived self-regulatory success in dieting after six months. Although FCQ-T-r scores did not predict increases in body mass index (BMI) directly, a serial mediation model revealed an indirect effect of FCQ-T-r scores at baseline on BMI after six months via increased disinhibition scores and decreased perceived self-regulatory success in dieting. To conclude, the current results provide evidence for a prospective relationship between trait food craving and decreases in dieting success. Furthermore, they suggest a possible mediator of this association (i.e., increases in disinhibited eating) as well as an indirect effect on body weight. Measurement of trait food craving may be a useful tool for predicting or monitoring treatment changes and relapse in eating- and weight disorders.

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## 1. Introduction

Food craving can be defined as a strong, irresistible desire to consume a specific type of food (Hormes & Rozin, 2010). Although experiencing food craving momentarily is a transient state, several self-report questionnaires measure the frequency and/or intensity of food cravings in general, which is often referred to as trait or tonic food craving (Boswell & Kober, 2016; Hallam, Boswell, DeVito, & Kober, 2016). Questionnaire-based and laboratory studies suggest that high trait food craving scores are associated with more frequent consumption of high-calorie foods in general and higher intake of such foods in the laboratory (Chao, Grilo, White, & Sinha, 2014; Hofmann et al., 2016; Martin, O'Neil, Tollefson, Greenway, & White, 2008). Studies that applied food diaries, however, have been less consistent. For example, food cravers reported a descriptively, but not significantly, higher energy intake than non-cravers in a small sample (Hill, Weaver, & Blundell, 1991). In another study, only female, but not male, food cravers reported higher energy intake than non-cravers (Lafay et al., 2001).

Individuals most frequently report food cravings as the reason for failing to adhere to a diet (Hall & Most, 2005). Similarly, trait food craving based on self-report have been associated with lower self-reported dieting success and higher body mass index (BMI) cross-sectionally (e.g., Chao et al., 2014; Franken & Muris, 2005; Meule & Blechert, in revision; Meule, Lutz, Vögele, & Kübler, 2012a; Meule, Westenhöfer, & Kübler, 2011). In contrast, interventional studies have produced mixed findings. For example, both surgical and non-surgical weight-loss treatment studies have often reported reductions in food cravings, with larger reductions being associated with greater weight loss (Batra et al., 2013; Leahey et al., 2012; Martin, O'Neil, & Pawlow, 2006; Martin et al., 2011b). However, no robust relations have been found between baseline levels of food cravings and weight loss (Martin, McClernon, Chellino, & Correa, 2011a). While higher trait food craving scores at baseline were related to higher weight loss in a behavioral weight-loss treatment study (Batra et al., 2013), pre-surgical trait food craving scores did not predict post-surgical weight loss in bariatric patients (Leahey et al., 2012). Finally, more frequent cue-elicited food cravings before surgery predicted higher

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**Table 1**
Descriptive statistics of and correlations between study variables.

| $n = 120$ | $M$ | $SD$ | Range | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Variables at baseline* | | | | | | | | | | | |
| 1. Food cravings | 38.5 | 10.3 | 20–62 | – | 0.655* | −0.212* | 0.231* | 0.737* | 0.580* | −0.293* | 0.242* |
| 2. Disinhibition | 7.09 | 3.16 | 1–16 | – | – | −0.359* | 0.328* | 0.534* | 0.709* | −0.380* | 0.324* |
| 3. Perceived self-regulatory success in dieting | 12.0 | 3.33 | 3–20 | – | – | – | −0.491* | −0.178 | −0.400* | 0.681* | −0.458* |
| 4. Body mass index (kg/m$^2$) | 22.1 | 2.71 | 15.1–29.7 | – | – | – | – | 0.148 | 0.347* | −0.315* | 0.952* |
| *Variables after six months* | | | | | | | | | | | |
| 5. Food cravings | 36.7 | 11.0 | 19–79 | – | – | – | – | – | 0.709* | −0.277* | 0.150 |
| 6. Disinhibition | 6.73 | 3.42 | 1–15 | – | – | – | – | – | – | −0.466* | 0.329* |
| 7. Perceived self-regulatory success in dieting | 11.9 | 3.21 | 4–18 | – | – | – | – | – | – | – | −0.352* |
| 8. Body mass index (kg/m$^2$) | 22.2 | 2.65 | 15.4–29.6 | – | – | – | – | – | – | – | – |

* $p < 0.050$.

weight loss after surgery, but more frequent feelings of guilt resulting from cravings before surgery predicted lower weight loss after surgery (Crowley et al., 2012). To conclude, although there is ample evidence from cross-sectional studies showing that higher trait food craving scores are associated with higher intake of high-calorie foods, lower dieting success, and higher BMI, there is inconclusive evidence that trait food craving scores can predict such outcomes prospectively.

In the current study, trait food craving, disinhibited eating, and perceived dieting success were assessed in female students at the beginning of their first semester and were re-assessed after six months. Based on cross-sectional studies, which tested food cravings as predictor of perceived dieting success (Meule & Blechert, in revision; Meule et al., 2011), it was expected that higher trait food craving scores at baseline would predict lower perceived dieting success after six months (food cravings ➔ dieting success). As food cravings likely translate into lower dieting success via increased food intake (Martin et al., 2008), it was hypothesized that the relationship between trait food craving at baseline and lower perceived dieting success after six months would be mediated by increased disinhibited eating (food cravings ➔ disinhibited eating ➔ dieting success). Based on cross-sectional studies, which tested food cravings as predictors of BMI (Burton, Smit, & Lightowler, 2007; Joyner, Gearhardt, & White, 2015), it was expected that higher trait food craving scores at baseline would result in higher BMI after six months. Finally, based on cross-sectional studies, which tested perceived dieting success as predictor of BMI (dieting success ➔ BMI) (Meule & Blechert, in revision; Meule, Hofmann, Weghuber, & Blechert, 2016), it was hypothesized that the relationship between food cravings and BMI would be mediated by increases in disinhibition and decreases in perceived dieting success (food cravings ➔ disinhibited eating ➔ dieting success ➔ BMI).

## 2. Methods

### 2.1. Participants and procedure

One-hundred and thirty-three female university freshmen were recruited at the University of Würzburg, Germany. They provided informed consent and participated in two laboratory sessions at the beginning of their first and second semester, during which they completed several questionnaires, and their height and weight were subsequently measured. Parts of these data have been published previously (Meule et al., 2014a; Meule & Platte, 2016). Complete data of all measures used in the current analyses were available for $n = 120$ participants. Mean period between the two measurements was $M = 170$ days ($SD = 9.01$). Mean age was $M = 20.1$ years ($SD = 2.80$), mean body weight was $M = 62.9$ kg ($SD = 8.86$), and mean BMI was $M = 22.1$ kg/m$^2$ ($SD = 2.71$). Nine participants (7.50%) were underweight (BMI < 18.5 kg/m$^2$), 95 participants (79.2%) had normal weight (BMI = 18.5–24.9 kg/m$^2$), and 16 participants (13.3%) were overweight (BMI ≥ 25.0 kg/m$^2$). Forty participants (33.3%) indicated that they were currently restricting their food intake to control their weight (e.g., by eating less or avoiding certain foods).[1]

### 2.2. Measures

#### 2.2.1. Food Cravings Questionnaire-Trait-reduced (FCQ-T-r)

Trait food craving was assessed with the FCQ-T-r (Meule, Hermann, & Kübler, 2014b). The scale consists of fifteen items (e.g., "If I am craving something, thoughts of eating it consume me.", "Food cravings invariably make me think of ways to get what I want to eat."), which are scored on a six-point scale ranging from *never/not applicable* to *always*. Higher scores indicate more frequent and/or more intense food craving experiences in general. Internal consistency was $\alpha = 0.904$ at baseline and $\alpha = 0.929$ after six months.

#### 2.2.2. Disinhibition

Disinhibited eating tendencies were assessed with the disinhibition subscale of the *Eating Inventory* (formerly Three-Factor Eating Questionnaire; Pudel & Westenhöfer, 1989; Stunkard & Messick, 1985). The scale consists of sixteen items (e.g., "I usually eat too much at social occasions, like parties and picnics.", "Sometimes when I start eating, I just can't seem to stop.") with different response formats. Higher scores indicate higher disinhibition. Internal consistency was $\alpha = 0.727$ at baseline and $\alpha = 0.786$ after six months.

#### 2.2.3. Perceived Self-Regulatory Success in Dieting Scale (PSRS)

Perceived self-regulatory success in dieting was assessed with the PSRS (Meule, Papies, & Kübler, 2012b). The scale

[1] We thank one of the reviewers for pointing out that it cannot be determined by PSRS scores alone if participants are actually currently dieting or have ever engaged in dieting (also see Nguyen & Polivy, 2014). Therefore, we explored if current dieting status at baseline predicted PSRS scores after six months. After controlling for the influence of PSRS scores at baseline ($b = 0.63$, $SE = 0.07$, $p < 0.001$), being a dieter at baseline was associated with lower PSRS scores after six months ($b = -1.07$, $SE = 0.46$, $p = 0.021$). Thus, this prospective relationship suggests that participants reporting low self-regulatory success in dieting as measured with the PSRS have indeed engaged in dieting attempts in the past. Including current dieting status at baseline as covariate in the serial mediation model presented in Section 3.4, however, did not change the indirect effect of trait food craving on BMI (bootstrap estimate 0.001, $SE = 0.001$, 95% CI [0.0002, 0.01]).

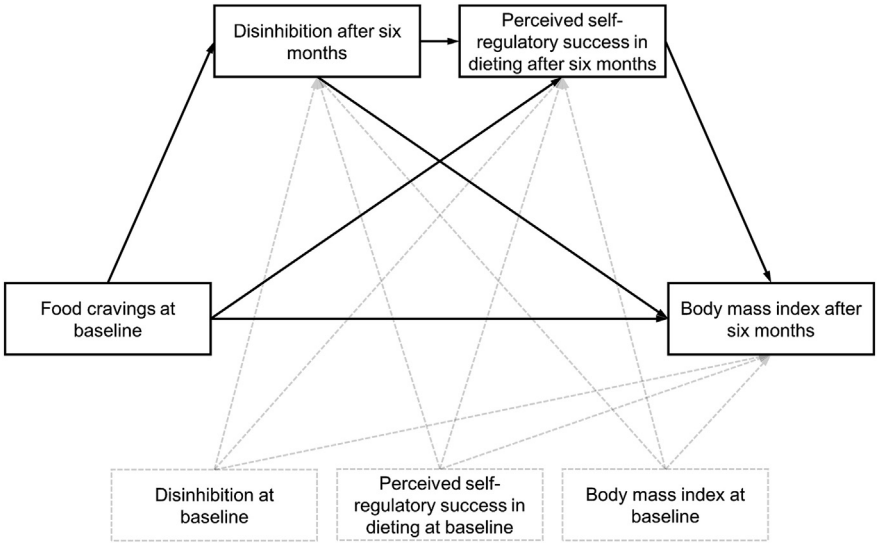


**Fig. 1.** Conceptual serial mediation model, in which scores on the Food Cravings Questionnaire-Trait-reduced at baseline were used for predicting body mass index after six months via disinhibition and Perceived Self-Regulatory Success in Dieting Scale (PSRS) scores after six months as mediating variables. Disinhibition scores, PSRS scores, and body mass index at baseline were included as covariates.

consists of three items ("How successful are you in watching your weight?", "How successful are you in losing extra weight?", "How difficult do you find it to stay in shape?"), which are scored on a seven-point scale anchored not *successful/not difficult* and *very successful/very difficult*. Higher scores indicate higher perceived self-regulatory success. Internal consistency was $\alpha = 0.690$ at baseline and $\alpha = 0.756$ after six months, which is comparable to other studies (Meule, Papies, et al., 2012b).

### 2.3. Data analyses

Descriptive statistics of and correlations between study variables are displayed in Table 1. Linear regression analyses were used to examine whether FCQ-T-r scores at baseline predicted disinhibition scores, PSRS scores, and BMI after six months, when controlling for baseline values of these variables. In order to be able to establish unidirectional causal relationships, it was also examined whether disinhibition scores, PSRS scores, and BMI at baseline predicted FCQ-T-r scores after six months, when controlling for FCQ-T-r scores at baseline.

Finally, an integrative serial mediation model was tested using PROCESS for SPSS (Hayes, 2013). This model is based on three linear regression analyses. In the first regression analysis, the first mediator (here: disinhibition scores after six months) is predicted by the independent variable (here: FCQ-T-r scores at baseline). In the second regression analysis, the second mediator (here: PSRS scores after six months) is predicted by both the independent variable and the first mediator. In the third regression analysis, the outcome variable (here: BMI after six months) is predicted by the independent variable, the first mediator, and the second mediator. Disinhibition scores, PSRS scores, and BMI at baseline were used as covariates (Fig. 1). Indirect effects were evaluated with 95% bias-corrected confidence intervals based on 10,000 bootstrap samples.

## 3. Results

### 3.1. Predicting disinhibition after six months

After controlling for the influence of disinhibition scores at baseline ($b = 0.63$, $SE = 0.09$, $p < 0.001$), FCQ-T-r scores at baseline positively predicted disinhibition scores after six months ($b = 0.07$, $SE = 0.03$, $p = 0.018$). In contrast, disinhibition scores at baseline did not predict FCQ-T-r scores after six months ($b = 0.31$, $SE = 0.29$, $p = 0.277$), after controlling for the influence of FCQ-T-r scores at baseline ($b = 0.72$, $SE = 0.09$, $p < 0.001$).

### 3.2. Predicting perceived self-regulatory success in dieting after six months

After controlling for the influence of PSRS scores at baseline ($b = 0.63$, $SE = 0.07$, $p < 0.001$), FCQ-T-r scores at baseline negatively predicted PSRS scores after six months ($b = -0.05$, $SE = 0.02$, $p = 0.023$). In contrast, PSRS scores at baseline did not predict FCQ-T-r scores after six months ($b = -0.08$, $SE = 0.21$, $p = 0.717$), after controlling for the influence of FCQ-T-r scores at baseline ($b = 0.78$, $SE = 0.07$, $p < 0.001$).

### 3.3. Predicting BMI after six months

After controlling for the influence of BMI at baseline ($b = 0.92$, $SE = 0.03$, $p < 0.001$), FCQ-T-r scores at baseline did not predict BMI after six months ($b = 0.01$, $SE = 0.01$, $p = 0.414$). Similarly, BMI at baseline did not predict FCQ-T-r scores after six months ($b = -0.10$, $SE = 0.26$, $p = 0.714$), after controlling for the influence of FCQ-T-r scores at baseline ($b = 0.79$, $SE = 0.07$, $p < 0.001$).

### 3.4. Serial mediation model

Food cravings at baseline predicted higher disinhibition after six months, which in turn predicted lower perceived self-regulatory

**Table 2**
Regression coefficients in the serial mediation analysis.

| Predictor variables | Outcome variables | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Disinhibition after six months | | | Perceived self-regulatory success in dieting after six months | | | Body mass index after six months | | |
| | *b* | *SE* | *p* | *b* | *SE* | *p* | *b* | *SE* | *p* |
| *Variables at baseline* | | | | | | | | | |
| Food cravings | **0.07** | **0.03** | **0.014** | −0.02 | 0.03 | 0.495 | 0.01 | 0.01 | 0.545 |
| Disinhibition | 0.54 | 0.09 | <0.001 | 0.01 | 0.11 | 0.907 | 0.01 | 0.04 | 0.765 |
| Perceived self-regulatory success in dieting | −0.15 | 0.08 | 0.051 | 0.60 | 0.08 | <0.001 | 0.07 | 0.03 | 0.039 |
| Body mass index (kg/m$^2$) | 0.08 | 0.09 | 0.387 | 0.09 | 0.09 | 0.319 | 0.94 | 0.03 | <0.001 |
| *Variables after six months* | | | | | | | | | |
| Disinhibition | – | – | – | **−0.20** | **0.09** | **0.029** | −0.04 | 0.03 | 0.250 |
| Perceived self-regulatory success in dieting | – | – | – | – | – | – | **−0.10** | **0.03** | **0.003** |

*Notes.* Regression coefficients for the path of the independent variable (i.e., food cravings) predicting the first mediator (i.e., disinhibition after six months), the first mediator predicting the second mediator (i.e., perceived self-regulatory success in dieting after six months), and the second mediator predicting the outcome variable (body mass index after six months) are printed in boldface. Disinhibition, perceived self-regulatory success in dieting, and body mass index at baseline were used as covariates (see Fig. 1).

success in dieting, which in turn predicted higher BMI after six months (Table 2). There was an indirect effect of FCQ-T-r scores at baseline on BMI after six months via disinhibition and PSRS scores after six months (bootstrap estimate 0.001, $SE = 0.001$, 95% CI [0.0002, 0.01]).[2]

## 4. Discussion

The current study investigated the longitudinal relationship between trait food craving scores, disinhibited eating, and perceived dieting success. It was found that trait food craving at baseline prospectively predicted increases in disinhibited eating and decreases in perceived dieting success. Contrary to expectations, trait food craving scores did not predict increases in BMI. However, a serial mediation model revealed an indirect positive effect of food cravings on BMI via disinhibition and dieting success. Note that, in contrast to widely held beliefs about mediation testing, it is indeed possible to establish such indirect effects in the absence of a direct or total effect (Zhao, Lynch, & Chen, 2010).

These findings extend cross-sectional associations between trait food craving scores and other eating-related measures that have been previously reported (e.g., Cepeda-Benito, Gleaves, Williams, & Erath, 2000; Meule et al., 2014b). Specifically, having a high susceptibility to experience food cravings may be causally involved in a higher tendency to engage in disinhibited eating and in perceiving weight regulation as unsuccessful. In contrast, disinhibition and dieting success at baseline were not predictive of increases in food cravings after six months, suggesting that associations between these measures are not bidirectional. Although food cravings did not predict BMI directly, it appeared that they did so indirectly via eating-related measures. Of note, however, is that only the relations of food cravings with disinhibition and dieting success allow a causal interpretation as the relations between the other variables in the mediation model (i.e., disinhibition ➔ dieting success ➔ BMI) were cross-sectional (i.e., solely based on the second measurement). Indeed, testing the prospective relationship between disinhibited eating and perceived dieting success revealed that it may be bidirectional (Footnote 2). However, reversing these variables in the serial mediation model did not yield an indirect effect of trait food craving on BMI, supporting validity of our initially hypothesized model.

Interpretation of findings is limited by the selective sample of female students, the relatively short period between measurements, and the reliance on self-report measures. Specifically, as there are sex differences regarding the types of foods craved as well as the frequency and intensity of food cravings and their correlates (Hormes, Orloff, & Timko, 2014; Lafay et al., 2001; Osman & Sobal, 2006; Zellner, Garriga-Trillo, Rohm, Centeno, & Parker, 1999), it may be that food cravings do not predict disinhibited eating and dieting success or may predict them differently in men. Furthermore, changes in disinhibition, dieting success, and BMI were examined across six months and it may be that results would be different when examining longer follow-up periods, during which larger variations in eating behaviors and body weight are likely to occur. Finally, food cravings, disinhibition, and dieting success were based on self-reports, which can potentially be biased. Thus, future studies may consider assessing these variables with measures that capture participants' eating behavior in everyday life such as ecological momentary assessment.

To conclude, the current results show that a higher susceptibility for experiencing food cravings prospectively predicts disinhibited eating and lower perceived dieting success and may indirectly relate to weight gain. Thus, they extend and support previous mediation analyses based on cross-sectional data, in which a causal influence of trait food craving on perceived dieting success was assumed (Meule & Blechert, in revision; Meule et al., 2011). Measuring trait food craving (e.g., with the FCQ-T-r) may be a useful tool for predicting or monitoring treatment changes in patients with eating disorders and obesity. Importantly, future studies may also examine if trait food craving scores at the end of treatment are able to predict relapse (e.g., binge eating episodes) or weight regain after treatment.

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[2] We thank one of the reviewers for pointing out the possibility that perceived dieting success at baseline may also predict increases in disinhibited eating, that is, that the relationship proposed in the serial mediation model (disinhibition ➔ dieting success) may be reversed. Indeed, lower PSRS scores at baseline predicted higher disinhibition scores after six months ($b = -0.17$, $SE = 0.07$, $p = 0.016$), after controlling for the influence of disinhibition scores at baseline ($b = 0.70$, $SE = 0.07$, $p < 0.001$). However, higher disinhibition scores at baseline also predicted lower PSRS after six months ($b = -0.16$, $SE = 0.07$, $p = 0.031$), after controlling for the influence of PSRS scores at baseline ($b = 0.60$, $SE = 0.07$, $p < 0.001$). Note that this relationship cannot be seen in the regression weights displayed in Table 2 as there were several other predictor variables included in that regression analysis (including disinhibition scores after six months). Thus, it indeed appears that the relationship between disinhibited eating and perceived dieting success is bidirectional. However, we also tested a simple mediation model of PSRS scores at baseline predicting BMI after six months via disinhibition scores after six months (while controlling for baseline BMI and disinhibition), which did not yield an indirect effect (bootstrap estimate 0.002, $SE = 0.01$, 95% CI [−0.01, 0.02]). Similarly, testing a serial mediation model of FCQ-T-r scores at baseline predicting BMI at six months via PSRS scores and disinhibition scores after six months (i.e., the same model as in Section 3.4, but with the order of the two mediators reversed) did not yield an indirect effect (bootstrap estimate −0.0003, $SE = 0.0004$, 95% CI [−0.002, 0.0001]). Instead, testing a simple mediation model, in which disinhibition scores at baseline prospectively predicted BMI after six months via PSRS scores after six months (while controlling for baseline BMI and PSRS scores) did indeed reveal an indirect effect (bootstrap estimate 0.02, $SE = 0.01$, 95% CI [0.003, 0.04]). We conclude that although it seems that the relationship between disinhibited eating and perceived dieting success is bidirectional, there were no indirect effects when testing mediation models, in which perceived dieting success preceded disinhibited eating, thus supporting our initially hypothesized model (food cravings ➔ disinhibition ➔ dieting success ➔ BMI).

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