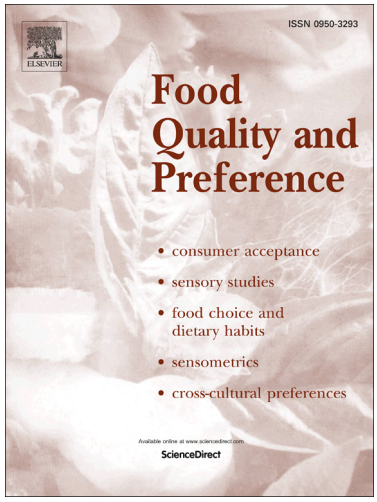

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When and how do explicit measures of food craving predict implicit food evaluation? A moderated mediation model

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Abstract

Research findings about relationships between trait-like eating behaviors and implicit food evaluations have been inconsistent. This may be partially attributed to the state-dependent nature of implicit food evaluations. In the current studies, relationships between trait and state chocolate craving, current hunger, and implicit evaluation of chocolate were examined. In study 1 (n = 64; 70% females), neither trait nor state chocolate craving were directly associated with implicit evaluation of chocolate. However, higher state chocolate craving was associated with more positive implicit evaluation of chocolate when current hunger was high. A moderated mediation model revealed an indirect effect of trait chocolate craving on implicit evaluation of chocolate via state chocolate craving only in hungry participants. This moderated mediation model was replicated in a sample of female individuals (n = 66; study 2) and in a sample of children and adolescents (n = 146; 47% females; study 3). Results support previous reports in that implicit food evaluations are influenced by state-dependent variables such as current craving and hunger. Moreover, implicit food evaluations are influenced by trait-like eating behaviors as well, inasmuch as these give rise to states of high motivational needs.

Keywords

Chocolate; Craving; Hunger; Implicit Association Test; Implicit food evaluation

1. Introduction

Food craving can be defined as an intense desire to consume a specific food, of which chocolate is the most often craved one in Western societies (Richard, Meule, Reichenberger, & Blechert, 2017; Rozin, Levine, & Stoess, 1991; Weingarten & Elston, 1991). Although experiencing food craving is a momentary and transient state, some individuals experience it more frequently and intensely than others, which is often referred to as trait or tonic food craving (Boswell & Kober, 2016; Hallam, Boswell, DeVito, & Kober, 2016). Individuals with high trait food craving demonstrate elevated reactivity to high-calorie food cues as evidenced by heightened food imagery-induced craving (Tiggemann & Kemps, 2005), increases in food cue-induced craving (Meule, Hermann, & Kübler, 2014; Meule, Skirde, Freund, Vögele, & Kübler, 2012), approach bias towards high-calorie food cues (Brockmeyer, Hahn, Reetz, Schmidt, & Friederich, 2015), and elevated activations in reward-related brain areas in response to high- vs. low-calorie food cues (Ulrich, Steigleder, & Grön, 2016).

In addition to these studies, which investigated trait food craving in general, a number of studies have examined trait chocolate craving in particular. In accordance with the above-mentioned findings, high trait chocolate cravers had elevated activations in reward-related brain areas in response to chocolate cues (Asmaro et al., 2012; Miedl, Blechert, Meule, Richard, & Wilhelm, in revision) and showed an attentional bias towards these cues (Kemps & Tiggemann, 2009; Smeets, Roefs, & Jansen, 2009; Werthmann, Roefs, Nederkoorn, & Jansen, 2013). However, one study reported that although high trait chocolate cravers rated chocolate pictures as more pleasurable than low trait chocolate cravers did, they showed a potentiated startle response, indicating an implicit negative affective evaluation (Rodríguez, Fernández, Cepeda-Benito, & Vila, 2005). Thus, it may be that results from explicit and implicit measures of food evaluations diverge.

A widely used and well-validated measure of implicit, affective evaluations is the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998) or Single-Category Implicit Association Test (SC-IAT; Karpinski & Steinman, 2006). Numerous attempts have been made to show relationships between eating-related individual differences and food-related IATs. However, such studies have mostly yielded equivocal findings (for an overview see Roefs et al., 2011). For example, it has been suggested recently that "for implicit measures of associations with food, it may be too simplistic to just study group differences such as overweight vs. healthy-weight people or high- vs. low-restrained eaters" (Roefs, Houben, & Werthmann, 2015; p. 335). Similarly, trait chocolate craving was not associated with implicit evaluation of chocolate as measured with a SC-IAT in a study on the effects of a chocolate-inhibition training on chocolate craving and consumption (Houben & Jansen, 2015), pointing to the existence of one or several moderating variables or indirect relationships between explicit and implicit measures.

Because of such heterogeneity, more attention has been devoted to possible state mediators, that is, which circumstances or motivational states affect the relationship between explicit and implicit measures. For example, it has been suggested that correspondence of explicit and implicit measures may depend on dispositional (e.g., eating-related trait measures) or situational factors (e.g., need states or self-regulatory resources; c.f., Friese, Hofmann, & Schmitt, 2009). In line with this, there is evidence that scores on food-related IATs are subject to state-dependent effects and momentary circumstances such as time of day (Haynes, Kemps, & Moffitt, 2016), food deprivation (Seibt, Häfner, & Deutsch, 2007), and current hunger (Stafford & Scheffler, 2008). Similarly, more positive implicit food evaluation has been associated with higher current food craving and consumption (Haynes, Kemps, Moffitt, & Mohr, 2015; Kemps, Tiggemann, Martin, & Elliott, 2013; Wang et al., 2016). Thus, examining state-dependent influences on food-related IATs, such as current hunger and

current food craving, might help in addressing the current inconsistencies regarding the associations between eating-related individual differences and implicit food evaluations.

In the current studies, we examined relationships between trait and state chocolate craving, current hunger, and implicit evaluation of chocolate. Study 1 was a re-analysis of a previous study, in which both trait and state chocolate craving were associated with implicit evaluation of chocolate as assessed with a SC-IAT (Richard, Meule, Friese, & Blechert, 2017). Here, we examined whether this relationship between trait chocolate craving and implicit evaluation of chocolate was mediated by state chocolate craving measured prior to the SC-IAT. Moreover, as current hunger and food deprivation have been found to influence performance on food-related IATs, we explored if and how hunger may moderate the relationships between trait and state chocolate craving and implicit evaluation of chocolate (see Figure 1A). As these relationships were based on post-hoc analyses, two additional studies were analyzed in order to replicate findings from study 1.

2. STUDY 1

2.1 Methods

2.1.1 Participants

Data were taken from a study on the effects of chocolate deprivation in a group of high trait chocolate cravers and a group of low trait chocolate cravers, results of which are reported elsewhere (Richard, Meule, Friese, et al., 2017). A total of 131 individuals completed the chocolate version of the Food Cravings Questionnaire-Trait-reduced (Meule & Hormes, 2015) online. To recruit separate groups of high vs. low trait chocolate cravers, individuals scoring in the upper and lower tertiles of the distribution were contacted via telephone and interviewed for eligibility (exclusion criteria were currently being on a diet and having food allergies). As the aim of the current analyses was to investigate relationships between trait and state chocolate craving, hunger, and implicit evaluation of chocolate in general, only data in the non-deprived condition were used, that is, when participants maintained their habitual levels of chocolate consumption prior to laboratory testing. For this, complete data were available for 64 participants (45 women, 70.3%). Sex distribution did not differ between high trait chocolate cravers (10 men) and low trait chocolate cravers (9 men, $\chi^2_{(1)} = 0.14$, $p = .705$). Mean age was $M = 24.6$ years ($SD = 4.96$, Range: 18-40) and mean body mass index (BMI) was $M = 21.9$ kg/m² ($SD = 2.17$, Range: 17.7-27.5). Descriptive statistics of and correlations between study variables are displayed in Table 1.

2.1.2 Measures

Food Cravings Questionnaire-Trait-reduced (FCQ-T-r). The chocolate version of the 15-item FCQ-T-r (Meule & Hormes, 2015) was used for assessing trait chocolate craving. The scale asks about the frequency and intensity of chocolate cravings in general with response categories ranging from *never/not applicable* to *always*. Items are scored on a six-

point scale and, thus, total scores can range between 15 and 90. Higher scores indicate higher trait chocolate craving. Internal consistency was $\alpha = .972$ in the current study.

Food Cravings Questionnaire-State (FCQ-S). The chocolate version of the 15-item FCQ-S (Meule & Hormes, 2015) was used for assessing state chocolate craving and current hunger. The scale asks about the intensity of current chocolate craving (12 items) and hunger (3 items) with response categories ranging from *strongly disagree* to *strongly agree*. Items are scored on a five-point scale and, thus, scores on the chocolate craving subscale can range between 12 and 60 and scores on the hunger subscale can range between 3 and 15. Higher scores indicate higher state chocolate craving and hunger, respectively. Internal consistencies were $\alpha = .937$ (chocolate craving subscale) and $\alpha = .855$ (hunger subscale).

Single Category – Implicit Association Test (SC-IAT). A SC-IAT (Karpinski & Steinman, 2006) was used for assessing implicit evaluation of chocolate. In block 1, participants practiced the categorization of positive and negative target words (20 trials), followed by two critical testing blocks (70 trials each). In the testing blocks, participants sorted stimuli into one of three categories labeled *unpleasant, pleasant*, and *chocolate*, with *chocolate* being grouped with *unpleasant* in one block and with *pleasant* in the other block. The evaluative categories were represented by ten negative words (fear, sadness, hate, accident, pain, violence, enemy, evil, war, loss) and ten positive words (vacation, celebration, freedom, joy, peace, gift, happiness, laugh, love, summer). The target category was represented by ten chocolate pictures taken from the food-pics database (Blechert, Meule, Busch, & Ohla, 2014; picture numbers: 0056, 0159, 0189, 0289, 0290, 0291, 0293, 0441, 0501, and 0506). The task was programmed using Eprime 2.0 Professional (Psychology Software Tools, Inc., Sharpsburg, PA, USA). Participants were seated at a distance of 50 centimeters to a 23-inch LCD monitor. Positive and negative words were presented in Arial

Black font. Chocolate pictures were presented with a resolution of 600 × 450 pixels and words with a resolution of 288 × 77 pixels against a white background.

In every trial, a stimulus appeared and remained on the screen until the participant responded or a maximum of 1700 ms had elapsed (in which case participants were prompted to respond faster). Inter-trial interval was 150 ms. Erroneous responses were signaled by a red cross. In the first testing block, *d* was the response key for negative words and *l* was the response key for positive words and chocolate pictures. In the second testing block, the assignment of chocolate pictures was reversed such that negative words and chocolate pictures shared the *d* key and positive words were sorted on the *l* key.

As both pictures and half of the words were sorted to the same side, response bias to that side might arise. Thus, the frequency of words and chocolate pictures was adjusted so that the proportion of the *d* and *l* response keys was 3:4 in the first testing block and 4:3 in the second testing block, respectively (Friese, Hofmann, & Wänke, 2008). Block order was the same across participants because the focus was on relative differences between high and low trait chocolate cravers and not on absolute SC-IAT effects (Egloff & Schmukle, 2002; Gawronski, 2002).

D600 scores were calculated from mean reaction time difference between the two critical testing blocks divided by the standard deviation of all correct response times within both blocks and a 600 ms addition as penalties for errors (Greenwald, Nosek, & Banaji, 2003). Non-responses (i.e., when latencies were longer than 1700 ms; 1.10% of trials) and responses < 400 ms (2.20% of trials) were eliminated from analyses (Greenwald et al., 2003; Karpinski & Steinman, 2006). Higher D600 scores indicate higher implicit evaluation of chocolate. For determining internal consistency, D600 scores were calculated for four mutually exclusive subsets of trials. For these four D600 scores, internal consistency was α = .785.

2.1.3 Procedure

The study was approved by the ethics committee of the University of Salzburg and participants signed informed consent before commencing the study. Participants completed the FCQ-T-r online at home before participating in laboratory testing individually. In the laboratory, participants completed the FCQ-S before performing the SC-IAT. A comprehensive description of recruitment and testing procedure can be found in Richard, Meule, Friese, et al. (2017).

2.1.4 Data Analyses

Mediation testing was conducted based on linear regression analyses using PROCESS for SPSS (Hayes, 2013). Specifically, a moderated mediation model was tested with trait chocolate craving (0 = low trait chocolate cravers, 1 = high trait chocolate cravers) as independent variable, state chocolate craving as mediating variable, implicit evaluation of chocolate as outcome variable, and hunger as moderating variable. Hunger may potentially impact all three paths of this model: high trait chocolate cravers may experience higher state chocolate craving and show a higher implicit evaluation of chocolate when being hungry in particular and higher state chocolate craving may be associated with a higher evaluation of chocolate in hungry individuals in particular. Therefore, model number 59 in PROCESS was chosen, in which all three paths of the mediation model are potentially moderated (Figure 1A).

This model is based on two regression analyses. In the first regression analysis, state chocolate craving was predicted by trait chocolate craving, hunger, and the trait chocolate craving × hunger interaction. In the second regression analysis, implicit evaluation of chocolate was predicted by trait chocolate craving, hunger and the trait chocolate craving × hunger interaction as well as by state chocolate craving and the state chocolate craving × hunger interaction (Table 2). Predictor variables were mean-centered before calculating the

product terms. Significant interactions were followed up with simple slopes analyses at high (+1 *SD*) and low (−1 *SD*) values of the moderator variable. Indirect (i.e., mediating) effects were evaluated with 95% bias-corrected confidence intervals based on 10,000 bootstrap samples. When the confidence interval does not span zero, the indirect effect can be considered statistically significant. If the presence of such an indirect effect depends on the value of a moderating variable (here: hunger), this is an indication of moderated mediation. Recently, Hayes (2015) introduced a formal test of moderated mediation based on a parameter termed the *index of moderated mediation*. Note, however, that this index of moderated mediation cannot be applied to models in which a continuous variable is used as moderator of both the path between the independent variable and the mediating variable and the path between the mediating variable and the outcome variable (Hayes, 2015), as is the case with the model displayed in Figure 1A.

2.2 Results

High trait chocolate cravers had higher trait and state chocolate craving than low trait chocolate cravers (Table 1). However, trait and state chocolate craving were not significantly associated with implicit evaluation of chocolate (Table 1). In the moderated mediation model, trait chocolate craving predicted state chocolate craving (Table 2). In turn, state chocolate craving and hunger interactively predicted implicit evaluation of chocolate (Table 2). Higher state chocolate craving was associated with a higher implicit evaluation of chocolate when current hunger was high (+1 *SD*, $b = 0.02$, $SE = 0.01$, $p = .005$), but not when hunger was low (−1 *SD*, $b = -0.003$, $SE = 0.01$, $p = .688$). Furthermore, there was an indirect effect of trait chocolate craving on implicit evaluation of chocolate via state chocolate craving when current hunger was high (+1 *SD*, effect = 0.46, $SE = 0.20$, 95%CI [0.15, 0.93]), but not when current hunger was low (−1 *SD*, effect = 0.01, $SE = 0.13$, 95%CI [−0.26, 0.25]).

As hunger did not moderate relationships of trait chocolate craving with state chocolate craving and implicit evaluation of chocolate, we further tested a model, in which hunger only moderated the relationship between state chocolate craving and implicit evaluation of chocolate (model number 14 in PROCESS; see Figure 1B). This model yielded similar results: state chocolate craving and hunger interactively predicted implicit evaluation of chocolate (b = .004, SE = 0.002, p = .023) and there was an indirect effect of trait chocolate craving on implicit evaluation of chocolate via state chocolate craving when current hunger was high (+1 SD, effect = 0.42, SE = 0.15, 95%CI [0.17, 0.76]), but not when current hunger was low (−1 SD, effect = 0.02, SE = 0.13, 95%CI [−0.25, 0.27]). The index of moderated mediation was significant (index = 0.07, SE = 0.03, 95%CI [0.02, 0.14]). Including sex as covariate did not change results.

3. STUDY 2

Study 1 suggested a moderated mediation model, in which higher trait chocolate craving had an indirect effect on more positive implicit evaluation of chocolate through higher state chocolate craving, but only when participants were hungry. As this model was based on post-hoc analyses of previously published data, we aimed to replicate the obtained results in an independent sample in study 2. In contrast to study 1, participants were not grouped into high and low trait chocolate cravers but continuous scores on the FCQ-T-r were used as independent variable.

3.1 Methods

3.1.1 Participants

Sixty-six female university students participated in the study. Mean age was $M = 20.3$ years ($SD = 2.27$, Range: 18-30) and mean BMI was $M = 21.2$ kg/m² ($SD = 2.71$, Range: 15.6-30.9). Descriptive statistics of and correlations between study variables are displayed in Table 3.

3.1.2 Measures

The same measures as in study 1 were used. Internal consistencies were $\alpha = .937$ (FCQ-T-r), $\alpha = .903$ (FCQ-S chocolate craving subscale), $\alpha = .862$ (FCQ-S hunger subscale), and $\alpha = .754$ (SC-IAT) in the current study.

3.1.3 Procedure

The study was approved by the ethics committee of the University of Salzburg and participants signed informed consent before commencing the study. Participants completed the FCQ-T-r online at home before participating in laboratory testing individually. In the

laboratory, participants completed the FCQ-S before performing the SC-IAT. They received course credits as reimbursement for participation.

3.1.4 Data Analyses

As hunger did not moderate relationships of trait chocolate craving with state chocolate craving and implicit evaluation of chocolate in study 1, we again tested a moderated mediation model, in which hunger only moderated the relationship between state chocolate craving and implicit evaluation of chocolate (Figure 1B; model number 14 in PROCESS; Hayes, 2013). This model is based on two regression analyses. In the first regression analysis, state chocolate craving was predicted by trait chocolate craving. In the second regression analysis, implicit evaluation of chocolate was predicted by trait chocolate craving, state chocolate craving, hunger, and the state chocolate craving × hunger interaction (Table 4). In contrast to study 1, continuous FCQ-T-r scores were used as independent variable. Predictor variables were mean-centered before calculating the product terms. Significant interactions were followed up with simple slopes analyses at high (+1 *SD*) and low (−1 *SD*) values of the moderator variable. Indirect (i.e., mediating) effects were evaluated with 95% bias-corrected confidence intervals based on 10,000 bootstrap samples. As a test of moderated mediation, the index of moderated mediation was used (Hayes, 2015).

3.2 Results

Higher trait chocolate craving was correlated with higher state chocolate craving (Table 3). Furthermore, there was a small, but statistically significant, positive correlation between state chocolate craving and hunger, and a small, but statistically not significant, positive correlation between state chocolate craving and implicit evaluation of chocolate (Table 3). In the moderated mediation model, trait chocolate craving predicted state chocolate craving (Table 4). In turn, state chocolate craving and hunger interactively predicted implicit evaluation of chocolate (Table 4). Higher state chocolate craving was associated with a higher

implicit evaluation of chocolate when current hunger was high (+1 *SD*, $b = 0.03$, $SE = 0.01$, $p = .001$), but not when hunger was low (−1 *SD*, $b = -0.002$, $SE = 0.01$, $p = .869$).

The indirect effect of trait chocolate craving on implicit evaluation of chocolate via state chocolate craving was significant when current hunger was high (+1 *SD*, effect = 0.01, $SE = 0.004$, 95%CI [0.002, 0.02]), but not when current hunger was low (−1 *SD*, effect = −0.0004, $SE = 0.003$, 95%CI [−0.01, 0.01]). The index of moderated mediation was significant (index = 0.001, $SE = 0.001$, 95%CI [0.0004, 0.003]). Including BMI as covariate did not change results.

4. STUDY 3

Study 2 replicated the moderated mediation model found in study 1 in young university students. In study 3, we examined whether this finding would generalize to individuals with a different age and body weight. Specifically, study 3 included a sample of children and adolescents with large variance and range in BMI.

4.1 Methods

4.1.1 Participants

Data were obtained from a study on food craving and consumption in children and adolescents, results of which are reported elsewhere (Hofmann et al., 2016; Meule, Hofmann, Weghuber, & Blechert, 2016). One-hundred sixty-six children and adolescents were recruited to participate in the study. However, 20 participants were excluded from analyses due to incorrect completion of the laboratory tasks (n = 3) and missing values on hunger ratings (n = 6) or measures of state and trait chocolate craving (n = 11). Complete datasets were obtained from 146 individuals (70 females, 47.9%) with a mean age of 13.7 years (SD = 2.32, Range: 10-18) and an age- and gender-specific mean standardized BMI (zBMI) of 1.24 (SD = 1.50, Range: −2.20-3.60), based on German reference values (Kromeyer-Hauschild et al., 2001). Descriptive statistics of and correlations between study variables are displayed in Table 5.

4.1.2 Measures

Trait chocolate craving. A single-item question ("How much do you like chocolate in general?") was used for assessing trait chocolate craving. Participants responded to a five-point scale ranging from *not at all* to *very much*. Thus, higher scores indicate higher chocolate craving in general.

State chocolate craving. A single-item question ("How much do you want to eat chocolate right now?") was used for assessing state chocolate craving. Participants responded

to a five-point scale ranging from *not at all* to *very much*. Thus, higher scores indicate higher state chocolate craving.

Food Cravings Questionnaire-State (FCQ-S). The hunger subscale of the FCQ-S (Meule, Lutz, Vögele, & Kübler, 2012) was used for assessing current hunger. The three items are scored on a five-point scale with response categories ranging from *strongly disagree* to *strongly agree*. Thus, scores can range between 3 and 15 and higher scores indicate higher feelings of hunger. Internal consistency was $\alpha = .791$ in the current study.

Single Category – Implicit Association Test (SC-IAT). The same SC-IAT as in study 1 and 2 was used. Internal consistency was $\alpha = .823$ in the current study.

4.1.3 Procedure

The study was approved by the ethics committee of the University of Salzburg and participants (and, when appropriate, their parents) signed informed consent before commencing the study. Participants were tested individually and completed all measures in the laboratory. They completed the single-item questions on trait and state chocolate craving and the hunger subscale of the FCQ-S before performing the SC-IAT. Participation was remunerated with €20.

4.1.4 Data Analyses

Here, we again tested a moderated mediation model, in which hunger only moderated the relationship between state chocolate craving and implicit evaluation of chocolate (Figure 1B; model number 14 in PROCESS; Hayes, 2013). Thus, data analyses were identical with study 2.

4.2 Results

Higher trait chocolate craving was correlated with higher state chocolate craving, which was in turn correlated with higher hunger. However, none of these variables were significantly correlated with implicit evaluation of chocolate (Table 5). In the moderated mediation model, trait chocolate craving predicted state chocolate craving. In turn, state chocolate craving and hunger interactively predicted implicit evaluation of chocolate (Table 6). Higher state chocolate craving was associated with a higher implicit evaluation of chocolate when current hunger was high (+1 *SD*, $b = 0.10$, $SE = 0.04$, $p = .024$), but not when hunger was low (−1 *SD*, $b = -0.06$, $SE = 0.05$, $p = .168$).

The indirect effect of trait chocolate craving on implicit evaluation of chocolate via state chocolate craving was significant when current hunger was high (+1 *SD*, effect = 0.08, $SE = 0.03$, 95%CI [0.02, 1.44]), but not when current hunger was low (−1 *SD*, effect = −0.03, $SE = 0.04$, 95%CI [−0.11, 0.04]). The index of moderated mediation was significant (index = 0.02, $SE = 0.01$, 95%CI [0.003, 0.03]). Including sex or BMI as covariate did not change results.

5. Discussion

The present studies examined the question of when and how explicit measures of food craving go along with implicit measures of food evaluation. We focused on possible mediating and moderating variables that may explain why explicit and implicit measures sometimes converge or diverge. Thus, relationships between trait and state chocolate craving, current hunger, and implicit evaluation of chocolate were examined in three studies.

Neither trait nor state chocolate craving were directly associated with implicit evaluation of chocolate. Also, no direct relationships were found between hunger and implicit evaluation of chocolate. However, mediation and moderation effects were found: higher trait chocolate craving was indirectly related to more positive implicit evaluation of chocolate via higher state chocolate craving, but only in hungry participants. Hence, our results are in line with previous suggestions that relationships between eating-related individual differences and implicit food evaluations are more complex than assumed and, thus, simple group comparisons (e.g., obese vs. normal-weight individuals, high vs. low trait chocolate cravers) do not reveal consistent findings (Roefs et al., 2015; Roefs et al., 2011). For instance, results mirror findings showing that trait chocolate craving was not directly associated with implicit evaluation of chocolate (Houben & Jansen, 2015) and that implicit food evaluation may be primarily influenced by state-dependent circumstances (e.g., Haynes et al., 2016), such as food deprivation or hunger (Seibt et al., 2007; Stafford & Scheffler, 2008). Similarly, stronger explicit–implicit relationships have been documented under circumstances of low cognitive capacity or depleted self-regulatory resources (Friese et al., 2008; Hofmann & Friese, 2008). These findings lead to the conceptualization of implicit food evaluations (here: performance on a SC-IAT) as less trait-like but being subject to dynamic changes in associated state variables (here: state food craving and hunger). Therefore, coherence of eating-related individual differences and implicit food evaluations may be stronger when individuals are in

high motivational need states (Appelhans, French, Pagoto, & Sherwood, 2016; Hofmann & Van Dillen, 2012).

While it is now fairly well understood that trait food craving is a predisposition for experiencing state food cravings (e.g., Meule, Hermann, et al., 2014; Richard, Meule, Reichenberger, et al., 2017), state food cravings can occur spontaneously or in the presence of craved foods (Hallam et al., 2016). Furthermore, state food cravings may dissociate from feelings of hunger under certain circumstances since they can occur without a nutritional deprivation (Meule, 2016). What follows from this is that explicit–implicit relationships between trait food craving and implicit food evaluation may oscillate within a person across the day, depending on the presence of state food craving and/or hunger. Therefore, one may ask for the causal direction of the variables tested in our moderated mediation models. Importantly, testing for mediation effects implies a causal chain between variables. The order of variables in our mediation models (trait chocolate craving → state chocolate craving/hunger → implicit evaluation of chocolate) followed the order of variables in sequential time (i.e., time-ordering of measurements) and conceptual time (i.e., time-ordering of concept emergence; Tate, 2015). Sequentially, trait chocolate craving was measured before state chocolate craving and hunger, which in turn were measured before the SC-IAT was performed. Conceptually, as trait food craving represents a rather stable construct whereas state food craving is transient in nature (Meule, Beck Teran, et al., 2014), it is reasonable that trait craving levels were manifested before and influenced state craving levels. Finally, as state chocolate craving was assessed before the SC-IAT and the SC-IAT appears to be a state-dependent measure as well, it is yet again reasonable that state chocolate craving and hunger were manifested before and influenced implicit evaluation of chocolate. To summarize, we would argue that our mediation models provide decent support for the causal chain of higher trait chocolate craving levels leading to higher levels of state chocolate craving, which in turn lead to higher implicit evaluation of chocolate in hungry participants. To strengthen this

causal interpretation, future research may manipulate state variables (e.g., by inducing craving with a cue exposure or employing a food deprived vs. sated condition) or use longitudinal designs.

Although three independent samples with a broad range of BMI and both sexes were investigated, interpretation of results is limited to predominantly young participants. As food cravings decline with increasing age (Pelchat, 1997), results may be different in middle-aged or older adults. Furthermore, as the sample of study 3 comprised children and adolescents aged between 10 and 18 years, we cannot preclude that younger participants had problems in understanding the verbal hunger and craving measures. Therefore, future studies may use pictorial rating scales (e.g., Bennett & Blissett, 2014) when investigating hunger and craving in children and adolescents. Moreover, as we did not measure actual chocolate intake, it is not possible to infer whether the variables measured in the current studies would similarly predict chocolate consumption. Yet, as more positive implicit evaluation of chocolate has previously been found to relate to higher chocolate consumption (e.g., Wang et al., 2016) and the relationship between implicit food evaluation and food intake was mediated by current craving (Haynes et al., 2015), it may well be that implicit evaluation of chocolate would have predicted subsequent chocolate consumption via state chocolate craving after the SC-IAT.

If this is the case, the present results may inform future efforts that utilize explicit measures (e.g., self-reports on trait food craving) and implicit measures (e.g., SC-IAT) in studying determinants of food intake in general or of overeating in particular. This may have implications for research on the etiology of eating and weight disorders as well as for prevention and treatment: in individuals with high trait food craving, a training for managing tempting situations may be particularly effective when applied in the presence of hunger (i.e., when self-regulatory resources are low) than when sated (Cheval, Audrin, Sarrazin, & Pelletier, 2017; Gibson & Desmond, 1999). On a more general level, results illustrate that

389 explicit and implicit measures cohere under certain circumstances that resemble biologically
390 relevant situations. As hunger represents a potential survival threat, several response systems
391 (e.g., neural, behavioral) need to be attuned toward mitigation of such threats. Positive
392 implicit food evaluations might therefore be a correlate of such neuro-behavioral programs.

393

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in study 1

ge	High trait chocolate cravers (n = 36)	Low trait chocolate cravers (n = 28)	t	p	1.	2.	3.	4.
	M (SD)	M (SD)						
31	56.1 (12.1)	22.1 (6.98)	13.2	< .001	–			
48	32.6 (8.48)	17.9 (6.94)	7.47	< .001	.757 (p < .001)	–		
3	6.33 (3.25)	6.32 (2.75)	0.02	.988	.017 (p = .892)	.136 (p = .284)	–	
1.52	0.32 (0.41)	0.25 (0.54)	0.64	.525	.207 (p = .104)	.190 (p = .132)	−.185 (p = .143)	–

Table 2

Unstandardized regression coefficients of the moderated mediation model in study 1

Predictor variables	Outcome: State chocolate craving			Outcome: Implicit evaluation of chocolate		
	b	*SE*	*p*	*b*	*SE*	*p*
Trait chocolate craving	14.8	1.97	< .001	−0.17	0.16	.292
Hunger	0.45	0.33	.181	−0.04	0.02	.043
Trait chocolate craving × hunger	0.36	0.68	.600	−0.01	0.05	.832
State chocolate craving	-	-	-	0.02	0.01	.046
State chocolate craving × hunger	-	-	-	0.01	0.002	.048

Table 3

Descriptive statistics of and correlations between variables in study 2

n = 66	*M*	*SD*	Range	1.	2.	3.	4.
1. Food Cravings Questionnaire-Trait-reduced (chocolate version)	38.5	14.1	17-81	–			
2. Food Cravings Questionnaire-State (chocolate craving subscale)	22.0	8.09	12-40	.527 ($p < .001$)	–		
3. Food Cravings Questionnaire-State (hunger subscale)	7.33	3.00	3-14	.155 ($p = .214$)	.279 ($p = .023$)	–	
4. Single Category Implicit Association Test (D600 score)	0.25	0.43	−0.68-1.43	.174 ($p = .163$)	.237 ($p = .056$)	−.113 ($p = .366$)	–

Table 4

Unstandardized regression coefficients of the moderated mediation model in study 2

Predictor variables	Outcome: State chocolate craving			Outcome: Implicit evaluation of chocolate		
	b	*SE*	*p*	*b*	*SE*	*p*
Trait chocolate craving	0.30	0.06	< .001	−0.0004	0.004	.934
State chocolate craving	-	-	-	0.01	0.01	.089
Hunger	-	-	-	−0.04	0.02	.048
State chocolate craving × hunger	-	-	-	0.01	0.002	.013

Table 5

Descriptive statistics of and correlations between variables in study 3

n = 146	*M*	*SD*	Range	1.	2.	3.	4.
1. Single-item question on trait chocolate craving	3.69	1.01	1-5	–			
2. Single-item question on state chocolate craving	2.66	1.23	1-5	.534 ($p < .001$)	–		
3. Food Cravings Questionnaire-State (hunger subscale)	7.77	3.24	3-15	.203 ($p = .014$)	.310 ($p < .001$)	–	
4. Single Category Implicit Association Test (D600 score)	0.20	0.45	−1.08-1.77	−.053 ($p = .529$)	.069 ($p = .406$)	.036 ($p = .664$)	–

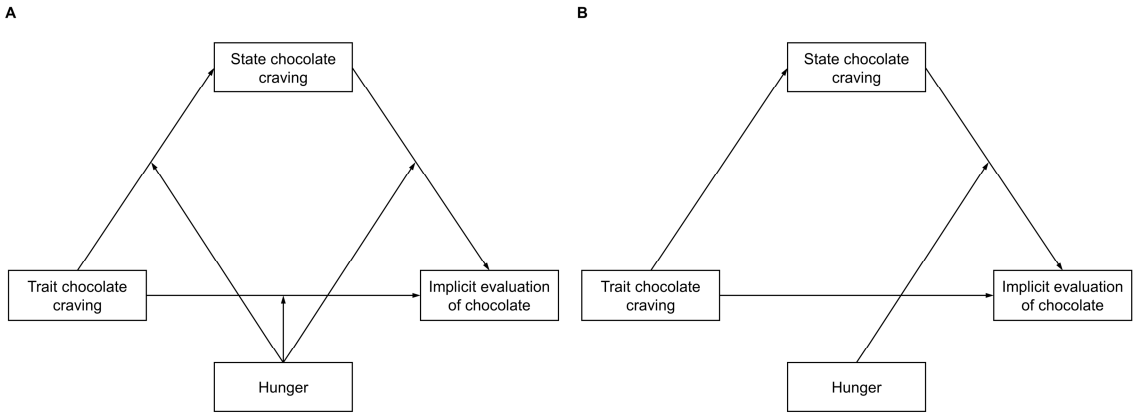
Table 6

Unstandardized regression coefficients of the moderated mediation model in study 3

Predictor variables	Outcome: State chocolate craving			Outcome: Implicit evaluation of chocolate		
	b	*SE*	*p*	*b*	*SE*	*p*
Trait chocolate craving	0.65	0.09	< .001	−0.05	0.04	.237
State chocolate craving	-	-	-	0.04	0.04	.294
Hunger	-	-	-	0.01	0.01	.677
State chocolate craving × hunger	-	-	-	0.02	0.01	.013

Figure Caption

Figure 1. (A) Moderated mediation model tested in study 1, in which current hunger was used as moderator of the relationship between trait and state chocolate craving, between trait chocolate craving and implicit evaluation of chocolate, and between state chocolate craving and implicit evaluation of chocolate. (B) As current hunger only moderated the relationship between state chocolate craving and implicit evaluation of chocolate but not the other paths in study 1, this moderated mediation model was tested in study 2 and study 3.



Highlights

- Chocolate craving, hunger, and implicit evaluation of chocolate were examined.
- Higher trait chocolate craving was related to higher levels of state chocolate craving.
- Trait chocolate craving was indirectly related to implicit evaluation of chocolate.
- Higher levels of current hunger moderated this indirect relationship.