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Desire Dynamics in Response to Repeated Indulgent Food Cues

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Student: Jiri Kaan (1008694)
First supervisor: Dr.ir. Ellen van Kleef
Second supervisor: Prof.dr.ir. Hans van Trijp
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Abstract

Individuals who have a relaxed relationship with food, i.e., food legalising, are assumed to attune to internal signals of hunger and satiety, and habituate faster to indulgent foods during consumption. The present study attempted to assess desire dynamics when repeatedly exposed to an indulgent food's cues while simultaneously exploring to what extent the individual trait of food legalising moderates these dynamics. Over five trials, participants were repeatedly exposed to chocolate from the moment they saw it until they stopped eating on their own volition. After each trial desire was measured as salivation and self-reported desire to eat. The results indicated that desire to eat and salivation were not correlated, and did not express a similar rate of habituation to chocolate. Specifically, the sustained increase of salivation indicated sensitization to chocolate instead. Moreover, food legalising did not moderate desire nor salivation dynamics, but did predict eating-related guilt regardless of food intake. Only self-reported desire to eat successfully predicted food intake. The study provides evidence for a misalignment of our physiology with our current food environment, although cognition is able to overrule our bodily needs.

Keywords: desire, salivation, food legalising, habituation, grounded cognition

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1. Introduction

In our Western society, where indulgent foods are available at will, frequent confrontation with their tempting cues seems unavoidable. This constant exposure to tempting food cues may be quite bothersome for those attempting to limit their intake, as the desire to eat may arise incessantly, especially given our innate preference for high-calorie foods (de Vries et al., 2020; Kavanagh et al., 2005). Admittedly, not all desires are necessarily bad; in fact they are a natural part of being human and drive behaviour for a stimulus or experience that is anticipated to be rewarding (Papies & Barsalou, 2015). However, desires are not always aligned with physiological needs and/or the current food environment. For example, encountering subtle tempting food cues may already lead to increased feelings of desire for and consumption of the cued food, even in the absence of hunger (Kavanagh et al., 2005; Proserpio et al., 2017; Tetley et al., 2009). Many people struggle to resist the desire to eat indulgent foods as a result of their current abundance and our innate preferences, and increased food cue reactivity to them is recognized as an important driver of overeating and obesity (Boswell & Kober, 2016; Lowe & Butryn, 2007).

Despite a misalignment between our desires, innate preferences, and the current abundance of indulgent foods, some people are still able to effectively regulate their food intake by actively listening to and acting on internal bodily signals of hunger and satiety (Palascha et al., 2020a). To do so, as part of an internally regulated eating style (IRE), these individuals tend to have a relaxed relationship with food, specifically with indulgent foods (i.e., food legalising). Food legalising entails that all foods, whether healthy or unhealthy, are permitted to be consumed. A non-judgmental relationship with food should save cognitive resources by removing the need to monitor what you eat, which can then be spent on interoception and responding to bodily signals accordingly. As a result, to prevent maladaptive coping mechanisms, indulgent consumption is regarded as a pleasurable experience rather than a troubling situation accompanied by guilt as is common among eaters who have forbidden foods (de Witt Huberts et al., 2013).

Allowing yourself to eat freely may seem counterintuitive at first, especially given that even neutral stimuli that are paired with chocolate elicit a strong desire to eat after a single session in the lab (Van Gucht et al., 2008). However, there is some evidence to suggest that people who score high on food legalising may steadily habituate to indulgent foods, resulting in a behavioural and physiological decline in response to the cued food (Epstein et al., 2009, 2011). For habituation to occur, cognitive effort is required and not having to monitor what you eat and being unencumbered with feelings of guilt could free up the required cognitive resources to accelerate the process (Epstein et al., 2009; Palascha et al., 2020a). In line with this, an intervention study emphasizing a carefree relationship with food, led to reduced eating in response to external food cues (Higgins & Gray, 1998). Moreover, it has been demonstrated that restricting a previously non-forbidden food for as little as five minutes already lead to an intense desire for the restricted food (Mann & Ward, 2001). What is unknown, however, is whether a difference in habituation to indulgent foods as expressed in desire can be observed between people who have a relaxed relationship with food and those who do not.

The aim of this research is, therefore, to assess how desire for an indulgent food changes over time, and whether and to what extent a dispositional trait, food legalising, moderates these dynamics. Specifically, people that score high on food legalising are expected to habituate faster and show a greater decline in desire for indulgent foods than those that score low on food legalising. Moreover, the validity of some characteristics of IRE have already been studied in an isolated manner, but food legalising still has to be assessed (e.g., Palascha et al., 2021a, 2021b). Hence, the current study additionally aims to assess the construct validity of food legalising with help of a physiological measure. This research provides insights in factors that may be contributing to the relatively low success rate of dieting as well as understanding factors that can be protective for individuals to successfully navigate the tempting food environment.

2. Theoretical framework

2.1. Initiation and cessation of eating

To study the desire for indulgent foods and the initiation of eating them, we take a grounded cognition theory of desire and motivated behaviour approach. It consists of three interactive core processes[1], namely situated conceptualizations, pattern completion inference, and simulation (Papies et al., 2017; Papies & Barsalou, 2015). The proposed core processes are assumed to depend on and complement each other, and as a whole play a role in desire and motivated behaviour.

By taking a grounded cognition theory of desire and motivated behaviour approach, we assume that desire arises from (mental) simulations (also referred to as predictions) (Papies et

[1] Like most theories related to memory and cognition, the processes described here can also be affected by random error and/or systemic bias, e.g., the produced conceptual inferences can be a misfit with the situation, or the stored conceptualization is biased to begin with.

al., 2017; Papies & Barsalou, 2015). An internal model is continuously running simulations to figure out what is needed in the future for the body to achieve allostasis (i.e., stability of the body through variation), occasionally leading to affect, for instance experienced as the desire to eat (Barrett, 2017). Simulations that are running may enter the imagery of the mind (i.e., mental stimulation), but are also able to influence desire and motivated behaviour outside of our awareness (Papies et al., 2017; Papies & Barsalou, 2015). For an internal model to be able to run simulations, situated conceptualizations are required. Situated conceptualizations are defined as rewarding past experiences, e.g., eating an energy-dense food, that are stored in memory, and are grounded in neural and peripheral bodily systems. We assume that a food consumption experience is rewarding or not is determined in part by how the brain perceives the food's contribution to the underlying goal of allostasis (e.g., by being energy-dense), and in part by the situational context (e.g., actions taken, sensory information, internal states, thoughts, feelings, people/objects present) in which the food was experienced. As a result, multimodal information concerning the rewarding experience is stored in a situated conceptualization and may contain, but is not limited to, cognition, sensory information, affective experiences, actions, physiological states, goals, and the consumption setting itself, such as the presence of objects or people that in turn may (re-)produce perception, action, and internal states (Barsalou, 1999, 2003, 2009, 2016a, 2016b; Barsalou et al., 2003; Barsalou & Yeh, 2006). By comparing local or global elements of new situations with these stored past experiences (i.e., pattern completion inferences), individuals are able to quickly make sense of a new situation while simultaneously taking in new information. Thus, by having a predictive internal model, the brain is able to rapidly determine how encountering food in a new situation might contribute to the goal of allostasis, by providing us with expertise based on past rewarding experiences, assisting us in thinking, acting, and feeling accordingly. Occasionally, this leads to desire and, in some cases, the decision to eat the food encountered.

For example, simply being exposed to food cues has been shown to activate brain areas indicating that individuals were (mentally) simulating eating and savouring the food (Killgore et al., 2003; Siep et al., 2009; van der Laan et al., 2011; Wang et al., 2004). These brain regions are particularly sensitive to indulgent food cues, high-caloric products, or when perceivers are hungry, and significantly correlate with self-reported desire to eat. Moreover, tempting food and congruent situational cues have been shown to trigger increased visual attention, motor impulses, approach responses, positive affect, salivation, and desire (Brunyé et al., 2013; Kavanagh et al., 2005; Keesman et al., 2016; Nederkoorn et al., 2000; Papies et al., 2022; Tetley et al., 2009; Van Dillen et al., 2013; Veling et al., 2011).

Once a person has initiated eating an indulgent food, and its food cues are repeatedly experienced, e.g., visual, olfactory, and gustatory cues, habituation to these cues (also referred to as sensory characteristics) may lead to the cessation of eating (Epstein et al., 2009). Habituation is defined as a form of associative learning that can influence food intake during one or across multiple eating episodes by showing a reduction among a variety of response systems (e.g., affective/cognitive/physiological/behavioural responses) (Epstein et al., 2009, 2011). For instance, sensory-specific satiety can be seen as a specific case of habituation, where a decline in hedonics leads to satiety that is psychological rather than physiological. The process behind habituation to repeated tempting food cues can be explained by the standard operating procedure (SOP) model and takes a connectionists approach to working memory and long-term memory (Epstein et al., 2009; Wagner, 1981). When initiating an eating session, a memory node representing the stimulus is activated to a high state of activity (A1) and activates associated nodes in memory by means of spreading activation. As the same food cues are repeatedly registered in working memory and matching the representation that is pulled from memory, a probabilistic function based on the intensity of the stimulus determines the rate of decay of the memory node resulting in a decrease in response to the stimuli. As the memory node decays to a lower level of activity (A2), the stimuli is processed in a more peripheral manner. Eventually the node decays to a state of inactivity (I), and processing comes to a full stop, which may be experienced as satiation[2]. Extended across eating sessions, the decay of activity of the memory node leading to habituation is assumed to be influenced not only by the retrieval of the stimulus's representation, but also by the retrieval of its associated context from memory (Epstein et al., 2011). Moreover, the direction of decay is assumed to be unidirectional and there are constraints on how many given nodes can be active at once. For example, when presented with distractions while eating, it has been shown to interrupt/prolong the process of decay, implying that cognitive resources are required for habituation (for review, see Epstein et al., 2009). Thus, if you start eating an indulgent food, a representation in terms of its sensory characteristics is briefly stored in working memory, and if subsequent bites corresponds with the representation, a reduction in stimulus processing and habituation as expressed among a variety of response systems is likely to occur.

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[2] We make no distinction between satiety and satiation. For review, please see e.g., Benelam (2009).

2.2. Grounded cognition and habituation

We propose that grounded cognition and habituation are complementary theories. Both theories account for motivated and reflexive responses towards stimuli and take a connectionist approach to how memory works while accounting for the context of consumption events. Admittedly, habituation theory originally takes a classical approach where exposure to a stimulus is assumed to lead to a response, whereas grounded cognition is predictive instead of reactive. However, we argue that the onset of habituation to a stimulus can be seen as a cognitive, physiological, and/or behavioural manifestation of our internal model adjusting its simulations to achieve allostasis. In other words, habituation is not only a reaction to the real experience of repeated tempting food cues while eating, but it should be interpreted in light of predictive simulations that are constantly running and adapting. Any errors between the predictions and the actual experience must be resolved by the brain by, e.g., adapting internal, bodily states, or actions. A change in internal states (e.g., cognitive, affective), bodily states (e.g., interoception, taste), and actions (e.g., executive, motoric) is thus possibly reflected by habituation to a food as observed in their associated response systems, and vice versa. This way the best fitting situated conceptualization along with its associated action plan is inferred when (re-)encountering a food its sensory characteristics. Moreover, we argue that similar to the SOP model, the rate at which the internal model changes its simulations is dependent on the perceived intensity of the stimulus. The intensity is dependent on the reward value (or reinforcement value, see e.g., Epstein & Carr, 2021) of the consumed food to achieve allostasis and how it is stored in situated conceptualizations. Therefore, as an indulgent food's sensory characteristics are repeatedly experienced, our internal model adapts its simulations based on the intensity of the stimulus, eventually resulting in reduced food cue intensity. This reduced intensity, in turn leads to different simulations, gradually leading to habituation, as can be observed in a variety of response systems.

Due to grounded cognition and habituation being complementary, it is not surprising that repeatedly imagining eating a food can lead to habituation to the imagined food. Several studies have demonstrated that mere simulations of consumption already lead to habituation, consequently reducing ad libitum food intake of the food imagined, showing that the brain simulates as if the person is already eating, leading to satiation that is psychological rather than physiological (Missbach et al., 2014; Morewedge et al., 2010). Hence, the lower ad libitum food intake was ascribed to a reduction in desire rather than palatability, which could be replicated with different food items. Furthermore, it seems that mentally simulating consumption along with its anticipated reward has an influence on the desire to initiate and continue eating, influencing physiological response systems accordingly, e.g., salivation (Keesman et al., 2016). Cue-elicited salivation is generally defined as a physiological expression that the body is preparing to begin eating, but in addition correlates with the desire to eat and overeating, hence the saying “mouth-watering food” (Jansen et al., 2003; Keesman et al., 2016; Nederkoorn et al., 2000; Papies et al., 2022). Moreover, salivation has been found to show signs of habituation to repeated stimuli, indicating that simulations and inferred action plans change over time (Epstein et al., 1992, 1996). Given that salivation is correlated with desire and has the ability to reflect habituation, as well as the notion that simulations do not always reach the mind's eye, it makes sense to use a cognitive measure of desire, i.e., self-reported desire to eat, and a physiological measure of desire, i.e., salivation to be able compare response systems. Thus, considering the foregoing, we arrive to the following hypotheses:

H1: Repeated exposure to an indulgent food’s cues leads to a decline in salivation (H1a) and self-reported desire to eat (H1b).

H2: Low levels of salivation (H2a) and a low self-reported desire to eat (H2b) in the last trial is associated with lower ad libitum food intake.

2.3. Individual differences in initiation and cessation of eating

The internal model that the brain relies on in its pursuit to predict what is necessary to achieve allostasis seems to be outdated for the current food environment, sometimes leading to a misalignment in desires and bodily needs. To account for these legacy problems in our software, some individuals feel the need to cognitively restrict their intake rendering specific foods, often indulgent in nature, “illegal” to consume. By doing so, not only may the reinforcement value of a forbidden food increase leading to an intense desire for that food, but also cognitive resources are spend on monitoring what you eat instead of enjoying the food in the moment while attuning to sensations of hunger and satiation (Mann & Ward, 2001; Palascha et al., 2020a). For example, an fMRI study showed that individuals with forbidden foods had a heightened response (sensitization) in areas implicating desire, expectation of reward, and goal-defined behaviour when compared to people with a relaxed relationship with food (Coletta et al., 2009). Strikingly, this higher reactivity was only visible after eating for individuals with a cognitively restricted relationship with food. When fasted, they did not display a similar response, but rather only activity in the cerebellum, which is involved in low-level processing of appetitive stimuli. Indicating that having a constrained relationship with food may lead to being out of sync with internal cues of hunger and satiety when opting to eat; a distinguishing feature of those scoring low on food legalisation, and IRE as a whole (Palascha et al., 2020a). Additionally, chronic dieters reported higher levels of self-reported desire to eat, and even intense desire, after repeated exposure to the smell and thought of the food (Fedoroff et al., 2003). Similarly, troubled eaters were found to have an increased salivatory response when exposed to indulgent foods compared to those with a relaxed relationship with food, although this association is not always found (Brunstrom et al., 2004; Herman et al., 1981; Legoff & Spigelman, 1987; Rogers & Hill, 1989; Tepper, 1992). Furthermore, based on the SOP model, habituation requires cognitive effort (Epstein et al., 2009; Missbach et al., 2014). When people scoring low on food legalising predominantly spend cognitive resources on monitoring what they eat, habituation might occur in a delayed rate. Also when considering research indicating that affective memories may last longer than sensory stimuli, it may be vital to avoid pairing unpleasant stimuli with circumstances that compromise habituation (Epstein et al., 2009). In other words, the guilt that is stored in situated conceptualizations of individuals scoring low on food legalising, is likely to be (re-)constructed prior to or while eating an indulgent food, which additionally may lead to a reduced rate of habituation (Barrett, 2017; de Witt Huberts et al., 2013; Kuijer & Boyce, 2014). Thus, considering that having "illegal" foods may lead to a delayed rate of habituation due to I) an increase in the intensity of the stimulus (reinforcement value), II) a misplacement of cognitive resources by having to monitor what you eat, and, III) a potential (re-)construction of eating-related guilt. Hence, we hypothesize the following:

H3: Individuals who score high on food legalising are expected to habituate faster to repeated exposure of indulgent food cues, leading to a quicker decline in salivation (H3a) and self-reported desire to eat (H3b) when compared to people scoring low on food legalising.

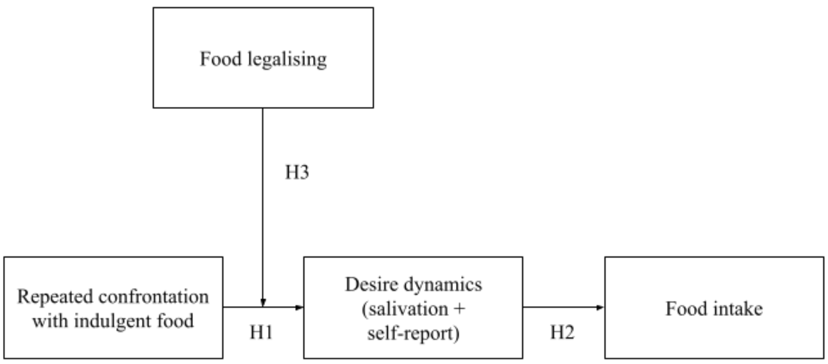

Figure 1 - Conceptual model

3. Methods

3.1. Participants and design

Participants (*N* = 50) were recruited via social media and e-mail lists associated to Wageningen University. The required sample size was calculated with G*Power 3.1.9.7. Maintaining an α error probability of .05, minimum power of .80, and an effect size of f = .176, resulted in a required sample size of > 40 participants. After screening 94 participants, a total of 65 participants were invited to the study. Participants with obesity (BMI > 30) and a history of eating disorders were excluded as it might have altered their salivatory response towards foods (Epstein et al., 1996; LeGoff et al., 1988). Moreover, participants that suffer from dry mouth were excluded (xerostomia score > 15) (Thomson, 2015). Other exclusion criteria were, being male, being a smoker or aiming to quit smoking, having food intolerances/allergies, and low liking for milk chocolate (< 5, on scale of 1 - 10). Furthermore, during the screening, participants had to fill in the items related to food legalising (*M(SD)* = 5.19 (0.99), *Min* = 3.33, *Max* = 7.00) to monitor whether a normal distribution was achieved. A participant who was included in the study and completed it received a €5 gift voucher in exchange for their time. 51 participants showed up of which 50 successfully completed the experiment[3] (Table 1). All participants provided informed consent prior to the screening survey and prior to partaking in the actual study. The study has been reviewed and approved by the Social Sciences Ethical Committee of Wageningen University and was preregistered under DOI 10.17605/OSF.IO/4PS5X.

Table 1. Characteristics of the 50 participants in the current study.

Characteristic	Mean (SD)	Minimum	Maximum
Age (years)	30.36 (14.13)	19.00	69.00
BMI (kg/m^2)	22.21 (2.51)	17.65	28.04
Xerostomia	9.74 (2.26)	5.00	14.00
Liking for chocolate	8.13 (1.09)	5.00	10.00
Food Legalising	5.19 (0.99)	3.33	7.00
Salivation baseline	0.46 (0.27)	0.06	1.15
Desire to eat baseline	3.40 (1.18)	2.00	6.00

[3] After collecting saliva, one participant spat rinsing water and salivation in the paper cup rather than having swallowed the water.

3.2. Materials

Participants in the study were given chocolate, which could be considered a prototypical forbidden indulgent food (Kuijer & Boyce, 2014). The specific chocolate used was commercially available in The Netherlands. One chocolate bar weighed 100 grams and had 24 portions, each of which was ± 4 grams (± 21.6 kcal per portion, 540 kcal in total). The chocolate was served on a small plate containing approximately 50 grams (270 kcal) of chocolate. To collect saliva produced, participants could spit into paper cups that were labelled with numbers 0–5 (average weight of one cup was 4.07 grams). Another cup of water was provided for participants to rinse their mouths with. More water was provided when asked for by the participant. Filled paper cups with spit were weighed on a precision scale (1 mg – 100 g).

3.3. Procedure

Participants were kindly instructed to not consume (much) alcohol the night prior to participation. Moreover, they were instructed to eat/drink as usual and to make sure to show up pleasantly satiated and not too thirsty or hungry. After providing informed consent and prior to exposure to the chocolate, participants were asked how hungry/satiated/thirsty they were and to provide a baseline measure of salivation (Table 3). After exposure, and before eating, participants were asked to spit in a small plastic container again and to report on their level of desire to initiate eating. They were instructed to eat one piece of chocolate during each trial and in the end they were allowed to eat as much of the chocolate as they desired. The five trials took place during one session. After eating, participants were asked to self-report on feelings of guilt they might have experienced after eating the chocolate.

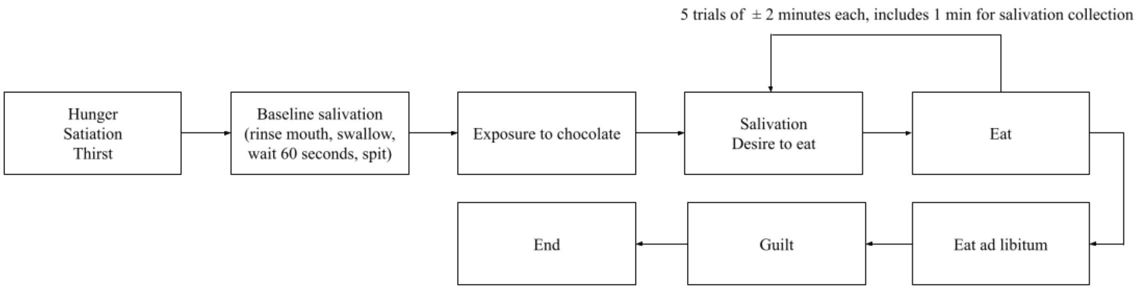

Figure 2 - Study procedure

3.4. Measures

3.4.1. Food legalising

A subscale of MIRES was used to measure food legalising (α = .62) (Palascha et al., 2020b). It consisted of three items, i.e., “I am relaxed about my relationship with food”, “I do not feel guilty if I occasionally overeat”, and “I can eat all foods that I like without guilt” to which participants could respond on a 7-point Likert-type scale (1 = “Completely untrue for me” to 7 = “Completely true for me”). If the first item would be deleted, internal consistency of the items would increase to α = .71. Because food legalising had a relatively low Cronbach's alpha, it was investigated whether this was due to a translation error that made interpretation of item 1 ambiguous. However, after checking both the English (α = .76, N = 44) and Dutch (α = .85, N = 50) version of the screening, it seems that those who participated in the study and scored relatively low on food legalising, still rated item 1 high. Given the small sample size, this had a relatively big impact on Cronbach’s alpha. Therefore, it was decided to continue without deleting item 1.

3.4.2. Xerostomia Inventory Score

The shortened version of the Xerostomia Inventory Score (α = .61) has been used to exclude participants that suffer from dry mouth (Thomson, 2015). The scale was slightly adapted so that participants responded to a 5-point scale (1 = “Never”, 2 = “Hardly ever”, 3 = “Occasionally”, 4 = “Frequently”, 5 = “Always”) instead of a 3-point scale to avoid excluding too many participants.

3.4.3. Salivation

To measure a baseline of salivation participants were asked to first rinse their mouth with water, swallow, look at a wall for 1 minute, keep their lips sealed, to not move their tongue, and to not swallow (see e.g., Papies et al., 2022). Participants then spat all the collected saliva into a paper cup which was weighed beforehand. This paper cup including saliva was then weighed again, and the difference served as a baseline measure of their salivation. After every repeated exposure to the indulgent food and prior to eating, this process was repeated, however they no longer had to stare at the wall for a minute, but at the chocolate.

3.4.4. Desire to eat

We assessed desire to eat with a single item "How much would you like to eat the chocolate in front of you right now?" to which participants could respond on a 7-point Likert-type scale (1 = "Not at all" to 7 = "Very much"). The measure was adapted from Papies et al. (2022).

3.4.5. Food Intake

The chocolate was pre-weighed and post-weighed to determine how much the participants had eaten during the experiment and the difference in weight (grams) functioned as the outcome variable for food intake.

3.4.6. Eating-related guilt

Three questions about eating-related guilt (α = .84) were adapted from a study done by de Witt Huberts et al. (2013). To assess guilt specifically related to eating, three questions addressed how guilty participants felt about having eaten the chocolate: "How guilty do you feel about eating the chocolate?"; "How guilty do you feel about the amount of chocolate you have eaten?"; "How guilty do you feel about eating?". Answers were rated on a 7-point Likert scale ranging from 1 = "Not at all" to 7 = "Very much". The three items were averaged into a scale indicating eating-related guilt.

3.5. Control variables

3.5.1. Satiation, hunger, and thirst

Satiation, hunger, and thirst were each measured with one single-item measure, "How full do you feel", "How hungry do you feel?", and "How thirsty do you feel?" to which participants could respond on a 7-point Likert-type scale (1 = "Not at all" to 7 = "Very much").

3.5.2. Body Mass Index

Body Mass Index (BMI) was calculated with help of respondents' self-reported height and weight during the screening of the participants (BMI = kg/m^2). Individuals with a higher BMI, and thus most likely a history of overeating, show enhanced reward responses to cues of attractive foods (Chen et al., 2016). Moreover, obese individuals produce saliva for a longer time after being repeatedly exposed to the same food cues when compared to non-obese individuals (Epstein et al., 1996). Thus, BMI (>30) was an exclusion criterium and was controlled for in the analyses.

3.6. Analysis

Statistical analyses were performed in R and considered significant at $p \leq .05$ (R Core Team, 2021). First of all, correlations were conducted for all study variables to describe the data. Furthermore, repeated measures correlations were ran specifically for desire and salivation over trials to gain insight in differing patterns between-participants and within-participants (Bakdash & Marusich, 2017). Within-subject repeated measures analyses of variance (rANOVA) were conducted with desire to eat and salivation as dependent variable with trials as independent variable with and without control variables. Assumptions for normality were met, but sphericity was corrected for in the analyses for desire to eat ($\varepsilon = 0.51$) and salivation ($\varepsilon = 0.74$) using Greenhouse-Geisser estimates. Findings of the rANOVA for salivation were reported without controlling for hunger, thirst, satiation, liking, or BMI as there were no significant effects of the covariates. Only hunger was a significant covariate and controlled for in the rANOVA for desire to eat. Pairwise comparisons with Bonferroni adjustment were used to assess differences between trials. Additionally, food legalising was added as a covariate in the rANOVA to test its potential moderating effect, as adding a covariate also returns an interaction term. If the interaction effect was significant, it would be further explored using simple slopes analyses. Moreover, simple regressions were conducted with food intake as dependent variable with desire to eat and salivation levels in the last trial as independent variables. Lastly, an exploratory moderated regression analysis was conducted to test the effect of food legalising on the relationship between food intake and eating-related guilt.

4. Results

4.1. Descriptive statistics

To explore the data, correlation tables with descriptive statistics are presented in Table 2 and 3. To test the assumption that salivation and self-reported desire to eat are correlated, Pearson correlations were calculated (Table 2). The results indicated that self-reported desire and salivation do not correlate significantly with one another for every trial. Furthermore, total self-reported desire and total salivation were found to have no significant correlation. In fact, a repeated measures correlation demonstrated a weak significant negative correlation between salivation and desire ($r(199) = -.19$, $p = .007$, 95% CI [-.32, -.05]) within individuals.

Table 3 describes the descriptive statistics and correlations of all other study variables. Hunger was positively correlated with total self-reported desire to eat and with thirst. Age was found to be negatively correlated with hunger and satiety. The total self-reported desire to eat was positively correlated with food intake. Food legalising had a weak negative correlation with both weight and length, but was not significantly correlated with BMI. Moreover, there was a not completely unexpected moderate negative correlation between food legalising and guilt.

4.2. Confirmatory analyses

To investigate the relationship between the repeated confrontation with an indulgent food (trials) and the desire to eat, a rANOVA was conducted. The results revealed that there was a significant effect of trials on the desire to eat, $F(2.04, 100.01) = 18.92$, $p < .0001$, $\eta^2 = .07$[4]. Pairwise comparisons adjusted with Bonferroni indicated a non-significant initial increase in self-reported desire to eat at trial 2, non-significant decrease at trial 3, and a significant decrease at trial 4 (*Mdiff* = -.36, *SDdiff* = -.03, $p < .0001$), and 5 (*Mdiff* = -.34, *SDdiff* = .18, $p < .01$). This suggested that the hypothesis (H1a) could be accepted as there was a significant decline in desire to eat over time (Figure 3A).

Similarly, a rANOVA yielded a significant relationship between trials and saliva production $F(2.97, 145.63) = 26.61$, $p < .0001$, $\eta^2 = 0.146$. Several trial specific significant outliers were

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[4] After including hunger $F(1, 48) = 6.68$, $p < .05$, $\eta^2 = .10$ as covariate (Figure 5C), the within-subjects effect of trials increased $F(2.03, 97.34) = 18.75$, $p < .0001$, $\eta^2 = .08$. However, these findings should be interpreted with caution because hunger cannot be considered a time constant covariate in a repeated measures design where participants are eating.

found for salivation[5], but kept in the dataset according to the preregistration. Pairwise comparisons adjusted with Bonferroni indicated a significant initial increase in salivation at trial 2 (*Mdiff* = .37, *SDdiff* = .20, $p < .0001$), and a non-significant change at trial 3, 4, and 5. Therefore, no support was provided for the hypothesis (H1b), because there was an initial increase in salivation followed by stabilization rather than a decline (Figure 3B).

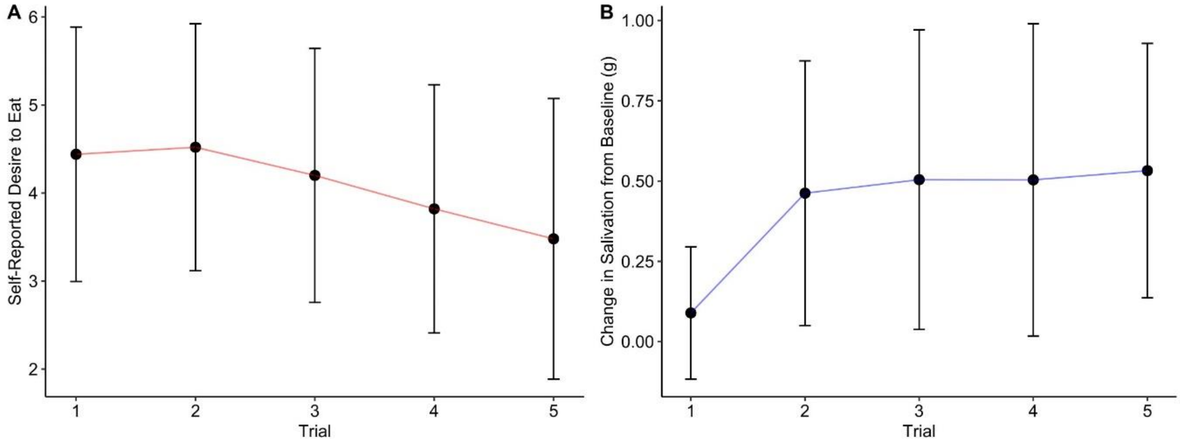

Figure 3 - A = Desire to eat per trial. B = Salivation per trial. Error bars reflect the SD of the mean at various time points.

To analyse whether people who score high on food legalising habituate faster when confronted repeatedly with indulgent foods leads to a steeper decline in desire when compared to people who score low on food legalising, a rANOVA was conducted with food legalising added as covariate to see whether further exploration with a simple slopes analysis was worthwhile. However, no significant interaction effect was found between trials and food legalising on the self-reported desire to eat $F(2.09, 100.40) = 1.704$, $p = .186$, $\eta^2 = .007$, after being corrected for sphericity using Greenhouse-Geisser, thus not further explored with simple slopes analysis. Thus, providing no evidence for the hypothesis (H3a). Moreover, no significant interaction effect was found between trials and food legalising on salivation levels on salivation levels $F(3.05, 146.53) = 2.384$, $p = .071$, $\eta^2 = .015$, after correcting for sphericity using Greenhouse-Geisser. Thus, providing no evidence for the hypothesis (H3b).

[5] After excluding outliers in the analysis, the results showed that there was a significant effect of the repeated confrontation with indulgent food on salivation produced, $F(3.37, 148.29) = 29.67$, $p < .0001$, $\eta^2 = 0.19$.

Lastly, the level of desire to eat reported by participants in the last trial (5) did explain a significant amount of the variance in food intake , $F(1, 48) = 24.78$, $p < .001$, $R^2 = .341$, $R^2_{adjusted} = .327$. The regression coefficient ($B = 2.97$, 95% CI [2.36, 3.55]) indicated that an increase in one level of desire to eat in the last trial corresponded on average to an increase of 2.97 in total food intake (Figure 4A). Thus, providing support for the alternative hypothesis (H2a). However, a simple regression yielded no significant relationship between salivation levels in the last trial and food intake[6] $F(1, 48) = 0.106$, $p = .747$, thus providing no support for the a priori hypothesis (H2b).

4.3. Exploratory analyses

After conducting a moderated regression we found that food intake does not significantly predict levels of eating-related guilt, but food legalising does $F(3, 46) = 6.680$, $p < .000$, $R^2 = .304$. The regression coefficient ($B = -.703$, 95% CI [-1.026, -.380], $p < .000$) indicates that an increase of one level in food legalising, leads to .703 lower self-reported guilt (Figure 4B). The interaction effect between food intake and food legalising was non-significant ($B = -.038$, 95% CI [-.080, .005], $p = .085$).

Fitting food legalising as a moderator in a quadratic regression model with trials as a predictor of self-reported desire to eat (Figure 5A), yielded no significant interaction effect between trials and food legalising ($B = -0.013$, $p = .214$), nor did adding a quadratic term improve the model $F(4, 245) = 7.69$, $p < .000$, $R^2 = .11$ when compared to a linear model $F(3, 246) = 9.79$, $p < .000$, $R^2 = .11$. Furthermore, adding a quadratic term explained more variance in salivation $F(2, 247) = 18.7$, $p < .000$, $R^2 = .13$, $R^2_{adjusted} = .12$ with significant regression coefficients $Trial = 0.41$ and $Trial^2 = -0.05$ when compared to a linear model $F(1, 248) = 24.86$, $p < .000$, $R^2 = .09$, $R^2_{adjusted} = .09$. Although, no significant interaction effect was found after adding food legalising as a moderator to this model ($B = 0.003$, $p = .37$) (Figure 5B).

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[6] After excluding outliers, a simple regression still yielded a non-significant relationship between the last trial of salivation and food intake, $F(1, 38) = 0.324$, $p = .573$. Also after standardizing salivation, no significant relationship was found $F(1, 48) = 0.106$, $p = .747$.

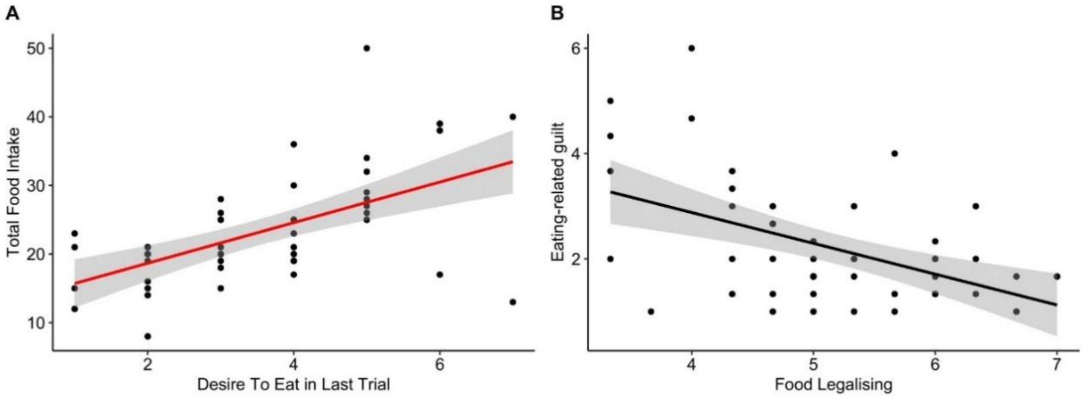

Figure 4 - A = Desire to eat as predictor of food intake, B = Food legalising as predictor of eating-related guilt

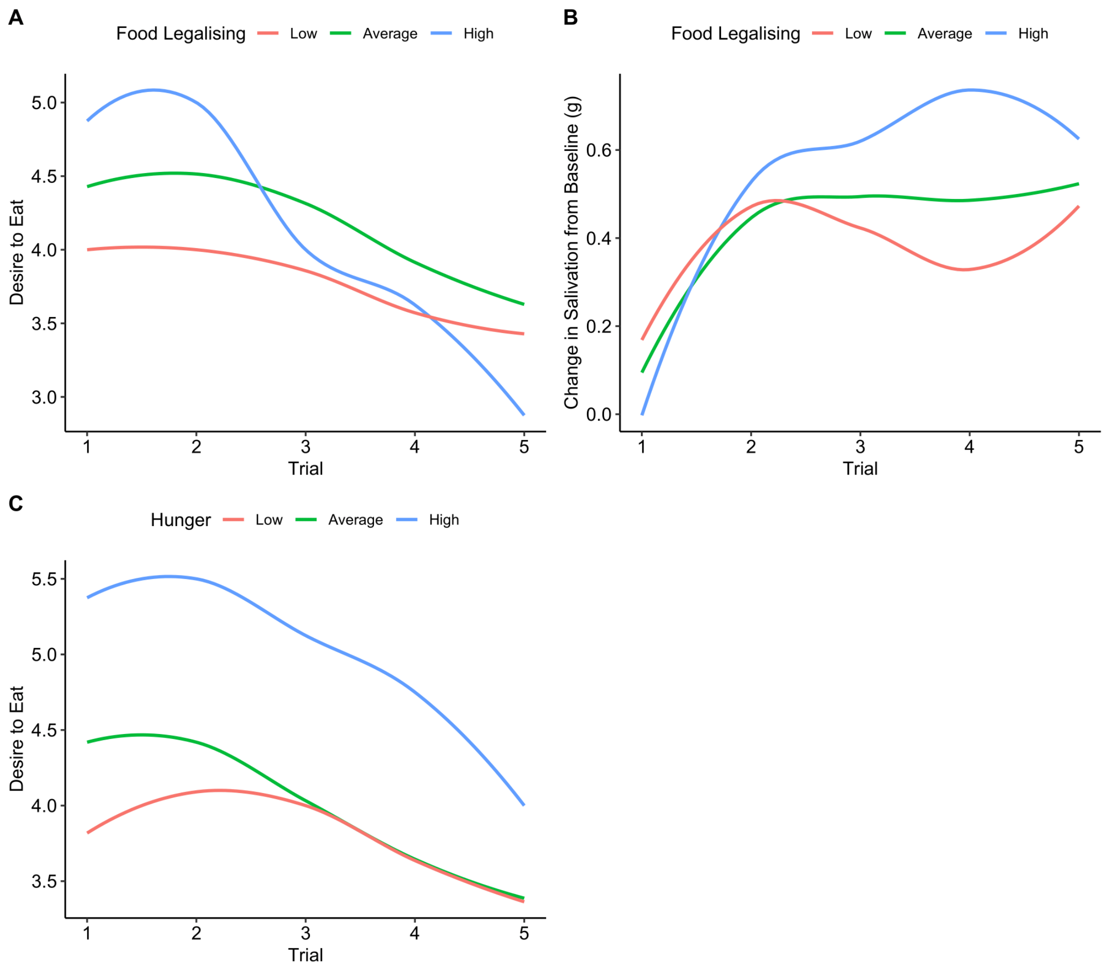

Figure 5 - A =Desire to eat moderated by food legalising over trials, B = Salivation moderated by food legalising over trials, C = Hunger as covariate for desire to eat over trials.

Table 2. Descriptive Statistics and Correlations for Salivation (S) and Desire to Eat (D) per Trial (1-5) and Total (N = 50).

Variable	M (SD)	1	2	3	4	5	6	7	8	9	10	11
1. S1	0.09 (0.21)	-										
2. S2	0.46 (0.41)	.25	-									
3. S3	0.50 (0.47)	.35*	.81**	-								
4. S4	0.50 (0.49)	.30*	.78**	.84**	-							
5. S5	0.53 (0.40)	.29*	.67**	.78**	.69**	-						
6. S total a	2.09 (1.68)	.44**	.89**	.95**	.92**	.85**	-					
7. D1	4.44 (1.45)	-.21	.01	-.05	-.01	-.01	-.04	-				
8. D2	4.52 (1.40)	-.35*	-.07	-.13	-.19	-.06	-.16	.84**	-			
9. D3	4.20 (1.44)	-.12	-.09	-.10	-.15	.02	-.10	.74**	.75**	-		
10. D4	3.82 (1.41)	-.19	-.12	-.14	-.23	-.03	-.16	.65**	.73**	.92**	-	
11. D5	3.48 (1.59)	-.10	-.14	-.17	-.26	-.02	-.17	.55**	.68**	.89**	.90**	-
12. D total b	20.46 (6.58)	-.21	-.09	-.13	-.19	-.02	-.14	.84**	.89**	.96**	.93**	.90**

[a] S total is the sum of S1:S5.
[b] D total is the sum of D1:D5.
*p < .05. **p < .01.

Table 3. Descriptive Statistics and Correlations for Variables (N =50).

Variable	*M (SD)*	1	2	3	4	5	6	7	8	9	10	11
1. Hunger	2.38 (1.09)	-										
2. Thirst	3.66 (1.26)	.56**	-									
3. Satiety	4.30 (1.31)	-.18	.04	-								
4. Liking	8.13 (1.09)	.21	.31*	-.07	-							
5. Xerostomia	9.74 (2.26)	.09	-.03	.10	-.04	-						
6. Age	30.36 (14.13)	-.28*	-.21	-.47**	.14	-.07	-					
7. BMI	22.21 (2.51)	-.15	-.09	-.24	-.23	.00	.52**	-				
8. Guilt	2.19 (1.14)	.01	.18	.16	.24	.00	-.07	-.19	-			
9. Salivation total	2.09 (1.68)	-.02	.01	.23	.25	-.19	-.00	-.11	.20	-		
10. Desire total	20.46 (6.58)	.35*	-.03	-.22	.20	.26	.09	.04	-.04	-.14	-	
11. Food intake	23.04 (8.08)	.03	-.09	-.20	.21	.38**	.26	.16	-.11	-.13	.58**	-
12. Food legalising [a]	5.19 (.99)	-.06	-.27	.02	-.03	-.20	.00	-.12	-.51**	.09	.23	.25

[a] Food legalising was measured on a scale of 1 – 7.
$^{*}p < .05$. $^{**}p < .01$.

5. Discussion

5.1. Desire dynamics: mind versus body

The current study examined the influence of repeated confrontations with an indulgent food its cues on desire dynamics, including how much an individual trait (food legalising) moderates these dynamics. Although salivation has been found to correlate with the desire to eat an indulgent food, the results of this study revealed that salivation does not correlate with desire (see e.g., Keesman et al., 2016). This applied to the correlations of desire and salivation between trials, between total correlated sums of the trials, and repeated measures correlation even revealed a weak significant negative correlation within individuals during an eating session. These results suggest that salivation is mostly an indicator of physiological preparations to eat instead of an indicator of desire (Nederkoorn et al., 2000). The discrepancy in the repeated measures analysis of variance further demonstrated this non-significant correlation between salivation and desire to eat. Despite the noticeable individual differences, in line with our hypothesis (H1a), self-reported desire to eat did decline on average over time, however contrary to our expectations (H1b), salivation levels showed a significant initial increase after which it remained relatively stable. That different response systems show different rates of habituation to a stimulus is in line with previous work (see e.g., Jordan et al., 2000). The unexpected finding that salivation would not habituate to chocolate at the same rate as the desire to eat can be explained in various ways. First, the current study consisted of only five trials while having to follow instructions, which could have slowed the rate of habituation due to a slower degradation of the memory node to lower states of activity, implying that habituation to chocolate as expressed by salivation could still occur at a later time. Second, self-reported desire to eat is metacognitive and not an objective measure of affect, possibly leading to biased results (Kavanagh et al., 2005). Third, the initial increase and stabilization resembles sensitization to the chocolate as opposed to habituation. Sensitization can be accounted for by the SOP model, although the co-occurrence of habituation and sensitization is perhaps better explained by the dual-process theory of habituation (Groves & Thompson, 1970; Uribe-Bahamonde et al., 2021). SOP can account for sensitization by assuming that the repetition of a food in a given context can result in conditioned emotional responses that enhance the response to the habituating stimulus itself, hence obscuring the rate of habituation (Wagner & Vogel, 2010; as cited in Uribe-Bahamonde et al., 2021). However, the dual-process theory by Groves and Thompson (1970) argues that habituation and sensitization can co-occur as it is caused by two different inferred processes that act independently which can occur in relative isolation as manifested in various response systems, as found in our results. Moreover, they argue that sensitization is not necessarily dependent on emotional conditioning to the context, but rather the reinforcing value of a stimulus. We speculate that the reinforcing value of chocolate, as how it stored in situated conceptualizations, is relatively high given that, from an evolutionary standpoint, humans have a strong innate preference for similar energy-dense foods, regardless of hedonic valuations (de Vries et al., 2020). Therefore, it is not surprising that habituation and sensitization can co-occur for an energy-dense food as chocolate. Hence, the two different patterns may have indicated a conflict between physiology and cognition as a result of exposure to an indulgent food, providing a possible explanation as to why chocolate is known as a prototypical forbidden food for those low in food legalising (Kuijer & Boyce, 2014). On the one hand, the body prepares to continue eating this energy-dense food as indicated by increased and sustained salivation, but on the other hand, we may believe that we should stop eating indulgent foods, resulting in habituation to chocolate as shown by a reduction in self-reported desire to eat (Nederkoorn et al., 2000).

5.2. Individual differences in desire dynamics

A difference in the rate of habituation was expected for those scoring low in food legalising due to an increase in the intensity of the stimulus (reinforcement value), having to monitor what they eat, and a (re-)construction of eating-related guilt. While there were observable differences in the rate of habituation as expressed by salivation and the desire to eat for different levels of food legalising, these differences were not significant, so no evidence was provided in support of our hypotheses. When examining salivation and desire prior to or after food intake/exposure, the findings are consistent with previous research while contradicting others that have studied individuals who restrict intake and/or certain food groups and their salivation/desire at similar moments (Boswell & Kober, 2016; Ferriday & Brunstrom, 2011; Nederkoorn & Jansen, 2002; Rogers & Hill, 1989; Tetley et al., 2009). The lack of a significant interaction between food legalising and trials on both outcome variables could be attributed to the relatively small effect-size combined with the small sample size, as well as a lack of low food legalising scores. Furthermore, it should be noted that whether individuals with low food legalising have a higher reinforcement value and monitor what they eat while eating could only have been inferred from the habituation rates in this study design. Finally, in accordance with an internally regulated eating style, these findings may imply that the study design was insufficient to assess differences in habituation rates, given that an internally regulated eating style, and thus food legalising, is not necessarily expressed in a single eating session, but rather across a lifestyle of consumption events (Palascha et al., 2020a). Therefore, firm conclusions about the potential moderating effect of food legalising on habituation rates among various response systems and its underlying mechanisms cannot be drawn yet.

Moreover, as shown by our exploratory analysis, those who scored low on food legalisation (trait) reported more eating-related guilt (state) than those scoring high, suggesting that they may have been preoccupied with feelings of guilt while eating. Comparable to restrained eaters, those who scored low on food legalising experienced eating-related guilt, regardless of food intake (de Witt Huberts et al., 2013). We speculate that, similar to how anxiety can suppress saliva production, eating-related guilt that is stored in situated conceptualizations and is (re-)constructed in the moment can suppress saliva production (Barrett, 2017; Rogers & Hill, 1989). In other words, where SOP argues that sensitization occurs due to a conditioned emotional response in a context, our findings could indicate a more complex interplay of how reinforcement value and affect related to the stimulus are stored in situated conceptualizations. Thus, the findings show that people who have a carefree relationship with food are not afflicted by guilt and can eat as much as they want, whereas others experience guilt regardless of how much they have eaten, possibly reflected by a lower saliva production.

5.3. Desire and motivated behaviour

Lastly, per our hypothesis (H2a), the analysis demonstrated that self-reported desire to eat in the previous trial can significantly predict total food intake, whereas most recent salivation levels could not (H2b). The findings partly contradict previous research where both cognitive and physiological reactivity predicted food intake (for review see, Boswell & Kober, 2016). In line with dual-process theory of habituation, these findings may imply that cognitive response systems can trump physiological desires (Groves & Thompson, 1970). The two inferred mechanisms that underlie sensitization and habituation are assumed to interact and together yield the final common behavioural outcome, i.e., food intake. Even though desire does not always lead to motivated behaviour, in this case, participants seemed to have behaved according to their metacognitive experience of desire (Papies & Barsalou, 2015).

5.4. Limitations

The onset of habituation to chocolate as bodily conveyed by salivation has not been observed within five trials. We were unable to support the alternative hypothesis based on the available data, but this does not rule out the possibility that saliva production does not decrease later after consuming chocolate or that it is delayed due to the distracting effects of following instructions. Additionally, the generalizability of this study is limited due to the noticeable spread of the data in both desire and salivation. Furthermore, it should be emphasized that employing a self-reported measure of desire to eat may add bias, which is commonly found with these types of measures. Another noteworthy limitation of this study is the lack of participants who scored low on food legalising. This was partly expected given the promotion of chocolate during the participant recruitment process and partly involved the interpretation of the construct items. Some participants who scored low on food legalising failed to respond or withdrew at the last minute. Considering the small effect size, the sample size could have influenced the non-significance of food legalising's moderating role. Moreover, especially those that did score low on food legalising might have felt observed by partaking in the study, which may have influenced their cognition, physiology, and actual behaviour. Furthermore, because the study was conducted in an experimental setting, i.e., in a classroom, it is likely that the situation was incongruent with an average consumption experience, influencing the desire to eat and salivation in participants (Papies et al., 2022).

5.5. Future research

While five trials are enough for some stimuli to witness habituation as expressed in salivation along with self-reported measures, for future studies with chocolate it is recommended to include more trials (see e.g., Epstein et al., 1992). Moreover, to increase the reliability of desire to eat in the study, it is recommended to control for hunger in participants as indicated by its significance as a covariate. Because SOP is not properly theorized to explain the co-occurrence of sensitization and habituation, the current study's theoretical framework could be enriched by including the dual-process theory of habituation by Groves & Thompson (1970). To further dissect the role of food legalising in desire dynamics, it is recommended to test its specific underlying mechanisms that are theorized to lead to slower habituation rates, i.e., I) an increased reinforcement value, II) distraction by having to monitor what you eat, and III) negative affect, specifically eating-related guilt. When replicating this specific study, it is recommended to include more participants and low food legalising scores to study its effect on habituation rates. Finally, it would be interesting to elicit how chocolate is stored in situated conceptualizations in order to continue studying the eating behaviour of people who have a carefree relationship versus those who do not.

5.6. Conclusion

Given the limitations, repeated exposure to an indulgent food its sensory qualities leads to physiological sensitization as expressed in saliva production and cognitive habituation as expressed in self-reported desire to eat. Due to this, salivation is not considered to be a physiological indicator of desire when studying chocolate. Even though physiological and cognitive response systems can simultaneously show sensitization and habituation to chocolate, the behavioural outcome, food intake, suggests that the cognitive response system overrules bodily processes. Food legalising did not lead to a significant interaction effect with habituation rates for physiological or cognitive response systems, although different trends could be observed. Lastly, regardless of food intake, those scoring low on food legalising did report higher levels of eating-related guilt when compared to those scoring high on food legalising. The findings can be interpreted as evidence for a physiologic misalignment with the current food environment.

6. Ethical statement

Informed consent was given by participants prior to the screening and before actual participation in the study. Moreover, the Social Sciences Ethical Committee of Wageningen University has approved this study before the collection of data. The study was preregistered at DOI 10.17605/OSF.IO/4PS5X.

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8. References

Bakdash, J. Z., & Marusich, L. R. (2017). Repeated measures correlation. *Frontiers in Psychology*, *8*(MAR), 1–13. https://doi.org/10.3389/fpsyg.2017.00456

Barrett, L. F. (2017). The theory of constructed emotion: an active inference account of interoception and categorization. *Social Cognitive and Affective Neuroscience*, *12*(1), 1–23. https://doi.org/10.1093/scan/nsw154

Barsalou, L. W. (1999). Perceptual symbol systems and emotion. *Behavioral and Brain Sciences*, *22*(4), 612–613. https://doi.org/10.1017/S0140525X99252144

Barsalou, L. W. (2003). Situated simulation in the human conceptual system. *Language and Cognitive Processes*, *18*(5–6), 513–562. https://doi.org/10.1080/01690960344000026

Barsalou, L. W. (2009). Simulation, situated conceptualization, and prediction. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1521), 1281–1289. https://doi.org/10.1098/rstb.2008.0319

Barsalou, L. W. (2016a). On Staying Grounded and Avoiding Quixotic Dead Ends. *Psychonomic Bulletin & Review*, *23*(4), 1122–1142. https://doi.org/10.3758/s13423-016-1028-3

Barsalou, L. W. (2016b). Situated conceptualization offers a theoretical account of social priming. *Current Opinion in Psychology*, *12*, 6–11. https://doi.org/10.1016/j.copsyc.2016.04.009

Barsalou, L. W., Niedenthal, P. M., Barbey, A. K., & Ruppert, J. A. (2003). Social Embodiment. *Psychology of Learning and Motivation*, *43*, 43–92. http://www.sciencedirect.com/science/article/pii/S0079742103010119

Barsalou, L. W., & Yeh, W. (2006). The situated nature of concepts. *American Journal of Psychology*, *119*(3), 349–384.

Benelam, B. (2009). Satiation, satiety and their effects on eating behaviour. *Nutrition Bulletin*, *34*(2), 126–173. https://doi.org/10.1111/j.1467-3010.2009.01753.x

Boswell, R. G., & Kober, H. (2016). Food cue reactivity and craving predict eating and weight gain: A meta-analytic review. *Obesity Reviews*, *17*(2), 159–177. https://doi.org/10.1111/obr.12354

Brunstrom, J. M., Yates, H. M., & Witcomb, G. L. (2004). Dietary restraint and heightened reactivity to food. *Physiology and Behavior*, *81*(1), 85–90. https://doi.org/10.1016/j.physbeh.2004.01.001

Brunyé, T. T., Hayes, J. F., Mahoney, C. R., Gardony, A. L., Taylor, H. A., & Kanarek, R. B. (2013). Get in My Belly: Food Preferences Trigger Approach and Avoidant Postural

Asymmetries. *PLoS ONE*, *8*(8), 1–9. https://doi.org/10.1371/journal.pone.0072432

Chen, J., Papies, E. K., & Barsalou, L. W. (2016). A core eating network and its modulations underlie diverse eating phenomena. *Brain and Cognition*, *110*, 20–42. https://doi.org/10.1016/j.bandc.2016.04.004

Coletta, M., Platek, S., Mohamed, F. B., van Steenburgh, J. J., Green, D., & Lowe, M. R. (2009). Brain Activation in Restrained and Unrestrained Eaters: An fMRI Study. *Journal of Abnormal Psychology*, *118*(3), 598–609. https://doi.org/10.1037/a0016201

de Vries, R., Morquecho-Campos, P., de Vet, E., de Rijk, M., Postma, E., de Graaf, K., Engel, B., & Boesveldt, S. (2020). Human spatial memory implicitly prioritizes high-calorie foods. *Scientific Reports*, *10*(1), 1–6. https://doi.org/10.1038/s41598-020-72570-x

de Witt Huberts, J. C., Evers, C., & de Ridder, D. T. D. (2013). Double trouble: Restrained eaters do not eat less and feel worse. *Psychology and Health*, *28*(6), 686–700. https://doi.org/10.1080/08870446.2012.751106

Epstein, L. H., & Carr, K. A. (2021). Food reinforcement and habituation to food are processes related to initiation and cessation of eating. *Physiology and Behavior*, *239*(July), 113512. https://doi.org/10.1016/j.physbeh.2021.113512

Epstein, L. H., Carr, K. A., Cavanaugh, M. D., Paluch, R. A., & Bouton, M. E. (2011). Long-term habituation to food in obese and nonobese women. *American Journal of Clinical Nutrition*, *94*(2), 371–376. https://doi.org/10.3945/ajcn.110.009035

Epstein, L. H., Paluch, R., & Coleman, K. J. (1996). Differences in salivation to repeated food cues in obese and nonobese women. *Psychosomatic Medicine*, *58*(2), 160–164. https://doi.org/10.1097/00006842-199603000-00011

Epstein, L. H., Rodefer, J. S., Wisniewski, L., & Caggiula, A. R. (1992). Habituation and dishabituation of human salivary response. *Physiology and Behavior*, *51*(5), 945–950. https://doi.org/10.1016/0031-9384(92)90075-D

Epstein, L. H., Temple, J. L., Roemmich, J. N., & Bouton, M. E. (2009). Habituation as a determinant of human food intake. *Psychological Review*, *116*(2), 384–407. https://doi.org/10.1037/a0015074

Fedoroff, I., Polivy, J., & Herman, C. P. (2003). The specificity of restrained versus unrestrained eaters' responses to food cues: General desire to eat, or craving for the cued food? *Appetite*, *41*(1), 7–13. https://doi.org/10.1016/S0195-6663(03)00026-6

Ferriday, D., & Brunstrom, J. M. (2011). I just can't help myself: Effects of food-cue exposure in overweight and lean individuals. *International Journal of Obesity*, *35*(1), 142–149. https://doi.org/10.1038/ijo.2010.117

Groves, P. M., & Thompson, R. F. (1970). Habituation: A dual-process theory. *Psychological Review*, *77*(5), 419–450. https://doi.org/10.1037/h0029810

Herman, C. P., Polivy, J., Klajner, F., & Esses, V. M. (1981). Salivation in Dieters and Don-dieters. *Appetite*, *2*(4), 356–361. https://doi.org/10.1016/S0195-6663(81)80021-9

Higgins, L. C., & Gray, W. (1998). Changing the body image concern and eating behaviour of chronic dieters: The effects of a psychoeducational intervention. *Psychology and Health*, *13*(6), 1045–1060. https://doi.org/10.1080/08870449808407449

Jansen, A., Theunissen, N., Slechten, K., Nederkoorn, C., Boon, B., Mulkens, S., & Roefs, A. (2003). Overweight children overeat after exposure to food cues. *Eating Behaviors*, *4*(2), 197–209. https://doi.org/10.1016/S1471-0153(03)00011-4

Jordan, W. P., Strasser, H. C., & McHale, L. (2000). Contextual control of long-term habituation in rats. *Journal of Experimental Psychology: Animal Behavior Processes, 26*(3), 323–339. https://doi.org/10.1037/0097-7403.26.3.323

Kavanagh, D. J., Andrade, J., & May, J. (2005). Imaginary Relish and Exquisite Torture: The Elaborated Intrusion Theory of Desire. *Psychological Review*, *112*(2), 446–467. https://doi.org/10.1037/0033-295X.112.2.446

Keesman, M., Aarts, H., Vermeent, S., Häfner, M., & Papies, E. K. (2016). Consumption simulations induce salivation to food cues. *PLoS ONE*, *11*(11), 1–16. https://doi.org/10.1371/journal.pone.0165449

Killgore, W. D. S., Young, A. D., Femia, L. A., Bogorodzki, P., Rogowska, J., & Yurgelun-Todd, D. A. (2003). Cortical and limbic activation during viewing of high- versus low-calorie foods. *NeuroImage*, *19*(4), 1381–1394. https://doi.org/10.1016/S1053-8119(03)00191-5

Kuijer, R. G., & Boyce, J. A. (2014). Chocolate cake. Guilt or celebration? Associations with healthy eating attitudes, perceived behavioural control, intentions and weight-loss. *Appetite*, *74*, 48–54. https://doi.org/10.1016/j.appet.2013.11.013

LeGoff, D. B., Leichner, P., & Spigelman, M. N. (1988). Salivary response to olfactory food stimuli in anorexics and bulimics. *Appetite*, *11*(1), 15–25. https://doi.org/10.1016/S0195-6663(88)80018-7

Legoff, D. B., & Spigelman, M. N. (1987). Salivary response to olfactory food stimuli as a function of dietary restraint and body weight. *Appetite*, *8*(1), 29–35. https://doi.org/10.1016/S0195-6663(87)80024-7

Lowe, M. R., & Butryn, M. L. (2007). Hedonic hunger: A new dimension of appetite? *Physiology and Behavior*, *91*(4), 432–439. https://doi.org/10.1016/j.physbeh.2007.04.006

Mann, T., & Ward, A. (2001). Forbidden fruit: Does thinking about a prohibited food lead to its consumption? *International Journal of Eating Disorders*, *29*(3), 319–327. https://doi.org/10.1002/eat.1025

Missbach, B., Florack, A., Weissmann, L., & König, J. (2014). Mental imagery interventions reduce subsequent food intake only when self-regulatory resources are available. *Frontiers in Psychology*, *5*(NOV), 1–11. https://doi.org/10.3389/fpsyg.2014.01391

Morewedge, C. K., Huh, Y. E., & Vosgerau, J. (2010). Thought for Food: Imagined Consumption Reduces Actual Consumption. *Science*, *330*(6010), 1530–1533. https://doi.org/10.1126/science.1195701

Nederkoorn, C., & Jansen, A. (2002). Cue reactivity and regulation of food intake. *Eating Behaviors*, *3*(1), 61–72. https://doi.org/10.1016/S1471-0153(01)00045-9

Nederkoorn, C., Smulders, F. T. Y., & Jansen, A. (2000). Cephalic phase responses, craving and food intake in normal subjects. *Appetite*, *35*(1), 45–55. https://doi.org/10.1006/appe.2000.0328

Palascha, A., van Kleef, E., de Vet, E., & van Trijp, H. C. M. (2020a). Internally regulated eating style: a comprehensive theoretical framework. *British Journal of Nutrition*, *126*(1), 138–150. https://doi.org/10.1017/S0007114520003840

Palascha, A., van Kleef, E., de Vet, E., & van Trijp, H. C. M. (2020b). Development and validation of the Multidimensional Internally Regulated Eating Scale (MIRES). *PLOS ONE*, *15*(10), e0239904. https://doi.org/10.1371/journal.pone.0239904

Palascha, A., van Kleef, E., de Vet, E., & van Trijp, H. C. M. (2021a). The effect of a brief mindfulness intervention on perception of bodily signals of satiation and hunger. *Appetite*, *164*(March), 105280. https://doi.org/10.1016/j.appet.2021.105280

Palascha, A., van Kleef, E., de Vet, E., & van Trijp, H. C. M. (2021b). Self-reported sensitivity to physiological signals of satiation and hunger: Assessment of construct validity. *Personality and Individual Differences*, *182*, 111054. https://doi.org/10.1016/J.PAID.2021.111054

Papies, E. K., & Barsalou, L. W. (2015). Grounding desire and motivated behavior : A theoretical framework and review of empirical evidence. *The Psychology of Desire*, *31*(30), 33–60. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.477.2320&rep=rep1&type=pdf

Papies, E. K., Best, M., Gelibter, E., & Barsalou, L. W. (2017). The Role of Simulations in Consumer Experiences and Behavior: Insights from the Grounded Cognition Theory of

Desire. *Journal of the Association for Consumer Research*, *2*(4), 402–418. https://doi.org/10.1086/693110

Papies, E. K., van Stekelenburg, A., Smeets, M. A. M., Zandstra, E. H., & Dijksterhuis, G. B. (2022). Situating desire: Situational cues affect desire for food through eating simulations. *Appetite*, *168*(March 2021), 105679. https://doi.org/10.1016/j.appet.2021.105679

Proserpio, C., de Graaf, C., Laureati, M., Pagliarini, E., & Boesveldt, S. (2017). Impact of ambient odors on food intake, saliva production and appetite ratings. *Physiology and Behavior*, *174*, 35–41. https://doi.org/10.1016/j.physbeh.2017.02.042

R Core Team. (2021). *R: A language and environment for statistical computing. R Foundation for Statistical Computing*. https://www.r-project.org/.

Rogers, P. J., & Hill, A. J. (1989). Breakdown of dietary restraint following mere exposure to food stimuli: Interrelationships between restraint, hunger, salivation, and food intake. *Addictive Behaviors*, *14*(4), 387–397. https://doi.org/10.1016/0306-4603(89)90026-9

Siep, N., Roefs, A., Roebroeck, A., Havermans, R., Bonte, M. L., & Jansen, A. (2009). Hunger is the best spice: An fMRI study of the effects of attention, hunger and calorie content on food reward processing in the amygdala and orbitofrontal cortex. *Behavioural Brain Research*, *198*(1), 149–158. https://doi.org/10.1016/j.bbr.2008.10.035

Tepper, B. J. (1992). Dietary restraint and responsiveness to sensory-based food cues as measured by cephalic phase salivation and sensory specific satiety. *Physiology and Behavior*, *52*(2), 305–311. https://doi.org/10.1016/0031-9384(92)90276-8

Tetley, A., Brunstrom, J., & Griffiths, P. (2009). Individual differences in food-cue reactivity. The role of BMI and everyday portion-size selections. *Appetite*, *52*(3), 614–620. https://doi.org/10.1016/j.appet.2009.02.005

Thomson, W. M. (2015). Dry mouth and older people. *Australian Dental Journal*, *60*(S1), 54–63. https://doi.org/10.1111/adj.12284

Uribe-Bahamonde, Y. E., Jorquera, O. E., Becerra, S. A., & Vogel, E. H. (2021). SOP-habituation laboratory: An interactive tool for simulating the basic behavioral features of habituation. *Behavior Research Methods*, *53*(5), 2120–2126. https://doi.org/10.3758/s13428-021-01548-y

van der Laan, L. N., de Ridder, D. T. D., Viergever, M. A., & Smeets, P. A. M. (2011). The first taste is always with the eyes: A meta-analysis on the neural correlates of processing visual food cues. *NeuroImage*, *55*(1), 296–303. https://doi.org/10.1016/j.neuroimage.2010.11.055

Van Dillen, L. F., Papies, E. K., & Hofmann, W. (2013). Turning a blind eye to temptation:

How cognitive load can facilitate self-regulation. *Journal of Personality and Social Psychology*, *104*(3), 427–443. https://doi.org/10.1037/a0031262

Van Gucht, D., Vansteenwegen, D., Van den Bergh, O., & Beckers, T. (2008). Conditioned craving cues elicit an automatic approach tendency. *Behaviour Research and Therapy, 46*(10), 1160–1169. https://doi.org/10.1016/j.brat.2008.05.010

Veling, H., Aarts, H., & Papies, E. K. (2011). Using stop signals to inhibit chronic dieters' responses toward palatable foods. *Behaviour Research and Therapy*, *49*(11), 771–780. https://doi.org/10.1016/j.brat.2011.08.005

Wagner, A. R. (1981). SOP: A model of automatic memory processing in animal behavior. In *Information processing in animals* (pp. 15–58). Psychology Press.

Wagner, A. R., & Vogel, E. (2010). Associative modulation of US processing: Implications for understanding of habituation. In *Computational models of conditioning* (pp. 150–185).

Wang, G. J., Volkow, N. D., Telang, F., Jayne, M., Ma, J., Rao, M., Zhu, W., Wong, C. T., Pappas, N. R., Geliebter, A., & Fowler, J. S. (2004). Exposure to appetitive food stimuli markedly activates the human brain. *NeuroImage*, *21*(4), 1790–1797. https://doi.org/10.1016/j.neuroimage.2003.11.026

Bakdash, J. Z., & Marusich, L. R. (2017). Repeated measures correlation. *Frontiers in Psychology*, *8*(MAR), 1–13. https://doi.org/10.3389/fpsyg.2017.00456

Barrett, L. F. (2017). The theory of constructed emotion: an active inference account of interoception and categorization. *Social Cognitive and Affective Neuroscience*, *12*(1), 1–23. https://doi.org/10.1093/scan/nsw154

Barsalou, L. W. (1999). Perceptual symbol systems and emotion. *Behavioral and Brain Sciences*, *22*(4), 612–613. https://doi.org/10.1017/S0140525X99252144

Barsalou, L. W. (2003). Situated simulation in the human conceptual system. *Language and Cognitive Processes*, *18*(5–6), 513–562. https://doi.org/10.1080/01690960344000026

Barsalou, L. W. (2009). Simulation, situated conceptualization, and prediction. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1521), 1281–1289. https://doi.org/10.1098/rstb.2008.0319

Barsalou, L. W. (2016a). On Staying Grounded and Avoiding Quixotic Dead Ends. *Psychonomic Bulletin & Review*, *23*(4), 1122–1142. https://doi.org/10.3758/s13423-016-1028-3

Barsalou, L. W. (2016b). Situated conceptualization offers a theoretical account of social priming. *Current Opinion in Psychology*, *12*, 6–11. https://doi.org/10.1016/j.copsyc.2016.04.009

Barsalou, L. W., Niedenthal, P. M., Barbey, A. K., & Ruppert, J. A. (2003). Social Embodiment. *Psychology of Learning and Motivation*, *43*, 43–92. http://www.sciencedirect.com/science/article/pii/S0079742103010119

Barsalou, L. W., & Yeh, W. (2006). The situated nature of concepts. *American Journal of Psychology*, *119*(3), 349–384.

Benelam, B. (2009). Satiation, satiety and their effects on eating behaviour. *Nutrition Bulletin*, *34*(2), 126–173. https://doi.org/10.1111/j.1467-3010.2009.01753.x

Boswell, R. G., & Kober, H. (2016). Food cue reactivity and craving predict eating and weight gain: A meta-analytic review. *Obesity Reviews*, *17*(2), 159–177. https://doi.org/10.1111/obr.12354

Brunstrom, J. M., Yates, H. M., & Witcomb, G. L. (2004). Dietary restraint and heightened reactivity to food. *Physiology and Behavior*, *81*(1), 85–90. https://doi.org/10.1016/j.physbeh.2004.01.001

Brunyé, T. T., Hayes, J. F., Mahoney, C. R., Gardony, A. L., Taylor, H. A., & Kanarek, R. B. (2013). Get in My Belly: Food Preferences Trigger Approach and Avoidant Postural Asymmetries. *PLoS ONE*, *8*(8), 1–9. https://doi.org/10.1371/journal.pone.0072432

Chen, J., Papies, E. K., & Barsalou, L. W. (2016). A core eating network and its modulations underlie diverse eating phenomena. *Brain and Cognition*, *110*, 20–42. https://doi.org/10.1016/j.bandc.2016.04.004

Coletta, M., Platek, S., Mohamed, F. B., van Steenburgh, J. J., Green, D., & Lowe, M. R. (2009). Brain Activation in Restrained and Unrestrained Eaters: An fMRI Study. *Journal of Abnormal Psychology*, *118*(3), 598–609. https://doi.org/10.1037/a0016201

de Vries, R., Morquecho-Campos, P., de Vet, E., de Rijk, M., Postma, E., de Graaf, K., Engel, B., & Boesveldt, S. (2020). Human spatial memory implicitly prioritizes high-calorie foods. *Scientific Reports*, *10*(1), 1–6. https://doi.org/10.1038/s41598-020-72570-x

de Witt Huberts, J. C., Evers, C., & de Ridder, D. T. D. (2013). Double trouble: Restrained eaters do not eat less and feel worse. *Psychology and Health*, *28*(6), 686–700. https://doi.org/10.1080/08870446.2012.751106

Epstein, L. H., & Carr, K. A. (2021). Food reinforcement and habituation to food are processes related to initiation and cessation of eating. *Physiology and Behavior*, *239*(July), 113512. https://doi.org/10.1016/j.physbeh.2021.113512

Epstein, L. H., Carr, K. A., Cavanaugh, M. D., Paluch, R. A., & Bouton, M. E. (2011). Long-term habituation to food in obese and nonobese women. *American Journal of Clinical Nutrition*, *94*(2), 371–376. https://doi.org/10.3945/ajcn.110.009035

Epstein, L. H., Paluch, R., & Coleman, K. J. (1996). Differences in salivation to repeated food cues in obese and nonobese women. *Psychosomatic Medicine*, *58*(2), 160–164. https://doi.org/10.1097/00006842-199603000-00011

Epstein, L. H., Rodefer, J. S., Wisniewski, L., & Caggiula, A. R. (1992). Habituation and dishabituation of human salivary response. *Physiology and Behavior*, *51*(5), 945–950. https://doi.org/10.1016/0031-9384(92)90075-D

Epstein, L. H., Temple, J. L., Roemmich, J. N., & Bouton, M. E. (2009). Habituation as a determinant of human food intake. *Psychological Review*, *116*(2), 384–407. https://doi.org/10.1037/a0015074

Fedoroff, I., Polivy, J., & Herman, C. P. (2003). The specificity of restrained versus unrestrained eaters' responses to food cues: General desire to eat, or craving for the cued food? *Appetite*, *41*(1), 7–13. https://doi.org/10.1016/S0195-6663(03)00026-6

Ferriday, D., & Brunstrom, J. M. (2011). I just can't help myself: Effects of food-cue exposure in overweight and lean individuals. *International Journal of Obesity*, *35*(1), 142–149. https://doi.org/10.1038/ijo.2010.117

Groves, P. M., & Thompson, R. F. (1970). Habituation: A dual-process theory. *Psychological Review*, *77*(5), 419–450. https://doi.org/10.1037/h0029810

Herman, C. P., Polivy, J., Klajner, F., & Esses, V. M. (1981). Salivation in Dieters and Don-dieters. *Appetite*, *2*(4), 356–361. https://doi.org/10.1016/S0195-6663(81)80021-9

Higgins, L. C., & Gray, W. (1998). Changing the body image concern and eating behaviour of chronic dieters: The effects of a psychoeducational intervention. *Psychology and Health*, *13*(6), 1045–1060. https://doi.org/10.1080/08870449808407449

Jansen, A., Theunissen, N., Slechten, K., Nederkoorn, C., Boon, B., Mulkens, S., & Roefs, A. (2003). Overweight children overeat after exposure to food cues. *Eating Behaviors*, *4*(2), 197–209. https://doi.org/10.1016/S1471-0153(03)00011-4

Jordan, W. P., Strasser, H. C., & McHale, L. (2000). Contextual control of long-term habituation in rats. *Journal of Experimental Psychology: Animal Behavior Processes*, *26*(3), 323–339. https://doi.org/10.1037/0097-7403.26.3.323

Kavanagh, D. J., Andrade, J., & May, J. (2005). Imaginary Relish and Exquisite Torture: The Elaborated Intrusion Theory of Desire. *Psychological Review*, *112*(2), 446–467. https://doi.org/10.1037/0033-295X.112.2.446

Keesman, M., Aarts, H., Vermeent, S., Häfner, M., & Papies, E. K. (2016). Consumption simulations induce salivation to food cues. *PLoS ONE*, *11*(11), 1–16. https://doi.org/10.1371/journal.pone.0165449

Killgore, W. D. S., Young, A. D., Femia, L. A., Bogorodzki, P., Rogowska, J., & Yurgelun-Todd, D. A. (2003). Cortical and limbic activation during viewing of high- versus low-calorie foods. *NeuroImage*, *19*(4), 1381–1394. https://doi.org/10.1016/S1053-8119(03)00191-5

Kuijer, R. G., & Boyce, J. A. (2014). Chocolate cake. Guilt or celebration? Associations with healthy eating attitudes, perceived behavioural control, intentions and weight-loss. *Appetite*, *74*, 48–54. https://doi.org/10.1016/j.appet.2013.11.013

LeGoff, D. B., Leichner, P., & Spigelman, M. N. (1988). Salivary response to olfactory food stimuli in anorexics and bulimics. *Appetite*, *11*(1), 15–25. https://doi.org/10.1016/S0195-6663(88)80018-7

Legoff, D. B., & Spigelman, M. N. (1987). Salivary response to olfactory food stimuli as a function of dietary restraint and body weight. *Appetite*, *8*(1), 29–35. https://doi.org/10.1016/S0195-6663(87)80024-7

Lowe, M. R., & Butryn, M. L. (2007). Hedonic hunger: A new dimension of appetite? *Physiology and Behavior*, *91*(4), 432–439. https://doi.org/10.1016/j.physbeh.2007.04.006

Mann, T., & Ward, A. (2001). Forbidden fruit: Does thinking about a prohibited food lead to its consumption? *International Journal of Eating Disorders*, *29*(3), 319–327. https://doi.org/10.1002/eat.1025

Missbach, B., Florack, A., Weissmann, L., & König, J. (2014). Mental imagery interventions reduce subsequent food intake only when self-regulatory resources are available. *Frontiers in Psychology*, *5*(NOV), 1–11. https://doi.org/10.3389/fpsyg.2014.01391

Morewedge, C. K., Huh, Y. E., & Vosgerau, J. (2010). Thought for Food: Imagined Consumption Reduces Actual Consumption. *Science*, *330*(6010), 1530–1533. https://doi.org/10.1126/science.1195701

Nederkoorn, C., & Jansen, A. (2002). Cue reactivity and regulation of food intake. *Eating Behaviors*, *3*(1), 61–72. https://doi.org/10.1016/S1471-0153(01)00045-9

Nederkoorn, C., Smulders, F. T. Y., & Jansen, A. (2000). Cephalic phase responses, craving and food intake in normal subjects. *Appetite*, *35*(1), 45–55. https://doi.org/10.1006/appe.2000.0328

Palascha, A., van Kleef, E., de Vet, E., & van Trijp, H. C. M. (2020a). Internally regulated eating style: a comprehensive theoretical framework. *British Journal of Nutrition*, *126*(1), 138–150. https://doi.org/10.1017/S0007114520003840

Palascha, A., van Kleef, E., de Vet, E., & van Trijp, H. C. M. (2020b). Development and validation of the Multidimensional Internally Regulated Eating Scale (MIRES). *PLOS*

ONE, *15*(10), e0239904. https://doi.org/10.1371/journal.pone.0239904

Palascha, A., van Kleef, E., de Vet, E., & van Trijp, H. C. M. (2021a). The effect of a brief mindfulness intervention on perception of bodily signals of satiation and hunger. *Appetite*, *164*(March), 105280. https://doi.org/10.1016/j.appet.2021.105280

Palascha, A., van Kleef, E., de Vet, E., & van Trijp, H. C. M. (2021b). Self-reported sensitivity to physiological signals of satiation and hunger: Assessment of construct validity. *Personality and Individual Differences*, *182*, 111054. https://doi.org/10.1016/J.PAID.2021.111054

Papies, E. K., & Barsalou, L. W. (2015). Grounding desire and motivated behavior : A theoretical framework and review of empirical evidence. *The Psychology of Desire*, *31*(30), 33–60. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.477.2320&rep=rep1&type=pdf

Papies, E. K., Best, M., Gelibter, E., & Barsalou, L. W. (2017). The Role of Simulations in Consumer Experiences and Behavior: Insights from the Grounded Cognition Theory of Desire. *Journal of the Association for Consumer Research*, *2*(4), 402–418. https://doi.org/10.1086/693110

Papies, E. K., van Stekelenburg, A., Smeets, M. A. M., Zandstra, E. H., & Dijksterhuis, G. B. (2022). Situating desire: Situational cues affect desire for food through eating simulations. *Appetite*, *168*(March 2021), 105679. https://doi.org/10.1016/j.appet.2021.105679

Proserpio, C., de Graaf, C., Laureati, M., Pagliarini, E., & Boesveldt, S. (2017). Impact of ambient odors on food intake, saliva production and appetite ratings. *Physiology and Behavior*, *174*, 35–41. https://doi.org/10.1016/j.physbeh.2017.02.042

R Core Team. (2021). *R: A language and environment for statistical computing. R Foundation for Statistical Computing*. https://www.r-project.org/.

Rogers, P. J., & Hill, A. J. (1989). Breakdown of dietary restraint following mere exposure to food stimuli: Interrelationships between restraint, hunger, salivation, and food intake. *Addictive Behaviors*, *14*(4), 387–397. https://doi.org/10.1016/0306-4603(89)90026-9

Siep, N., Roefs, A., Roebroeck, A., Havermans, R., Bonte, M. L., & Jansen, A. (2009). Hunger is the best spice: An fMRI study of the effects of attention, hunger and calorie content on food reward processing in the amygdala and orbitofrontal cortex. *Behavioural Brain Research*, *198*(1), 149–158. https://doi.org/10.1016/j.bbr.2008.10.035

Tepper, B. J. (1992). Dietary restraint and responsiveness to sensory-based food cues as measured by cephalic phase salivation and sensory specific satiety. *Physiology and*

Behavior, *52*(2), 305–311. https://doi.org/10.1016/0031-9384(92)90276-8

Tetley, A., Brunstrom, J., & Griffiths, P. (2009). Individual differences in food-cue reactivity. The role of BMI and everyday portion-size selections. *Appetite*, *52*(3), 614–620. https://doi.org/10.1016/j.appet.2009.02.005

Thomson, W. M. (2015). Dry mouth and older people. *Australian Dental Journal*, *60*(S1), 54–63. https://doi.org/10.1111/adj.12284

Uribe-Bahamonde, Y. E., Jorquera, O. E., Becerra, S. A., & Vogel, E. H. (2021). SOP-habituation laboratory: An interactive tool for simulating the basic behavioral features of habituation. *Behavior Research Methods*, *53*(5), 2120–2126. https://doi.org/10.3758/s13428-021-01548-y

van der Laan, L. N., de Ridder, D. T. D., Viergever, M. A., & Smeets, P. A. M. (2011). The first taste is always with the eyes: A meta-analysis on the neural correlates of processing visual food cues. *NeuroImage*, *55*(1), 296–303. https://doi.org/10.1016/j.neuroimage.2010.11.055

Van Dillen, L. F., Papies, E. K., & Hofmann, W. (2013). Turning a blind eye to temptation: How cognitive load can facilitate self-regulation. *Journal of Personality and Social Psychology*, *104*(3), 427–443. https://doi.org/10.1037/a0031262

Van Gucht, D., Vansteenwegen, D., Van den Bergh, O., & Beckers, T. (2008). Conditioned craving cues elicit an automatic approach tendency. *Behaviour Research and Therapy*, *46*(10), 1160–1169. https://doi.org/10.1016/j.brat.2008.05.010

Veling, H., Aarts, H., & Papies, E. K. (2011). Using stop signals to inhibit chronic dieters' responses toward palatable foods. *Behaviour Research and Therapy*, *49*(11), 771–780. https://doi.org/10.1016/j.brat.2011.08.005

Wagner, A. R. (1981). SOP: A model of automatic memory processing in animal behavior. In *Information processing in animals* (pp. 15–58). Psychology Press.

Wagner, A. R., & Vogel, E. (2010). Associative modulation of US processing: Implications for understanding of habituation. In *Computational models of conditioning* (pp. 150–185).

Wang, G. J., Volkow, N. D., Telang, F., Jayne, M., Ma, J., Rao, M., Zhu, W., Wong, C. T., Pappas, N. R., Geliebter, A., & Fowler, J. S. (2004). Exposure to appetitive food stimuli markedly activates the human brain. *NeuroImage*, *21*(4), 1790–1797. https://doi.org/10.1016/j.neuroimage.2003.11.026

9. Appendix

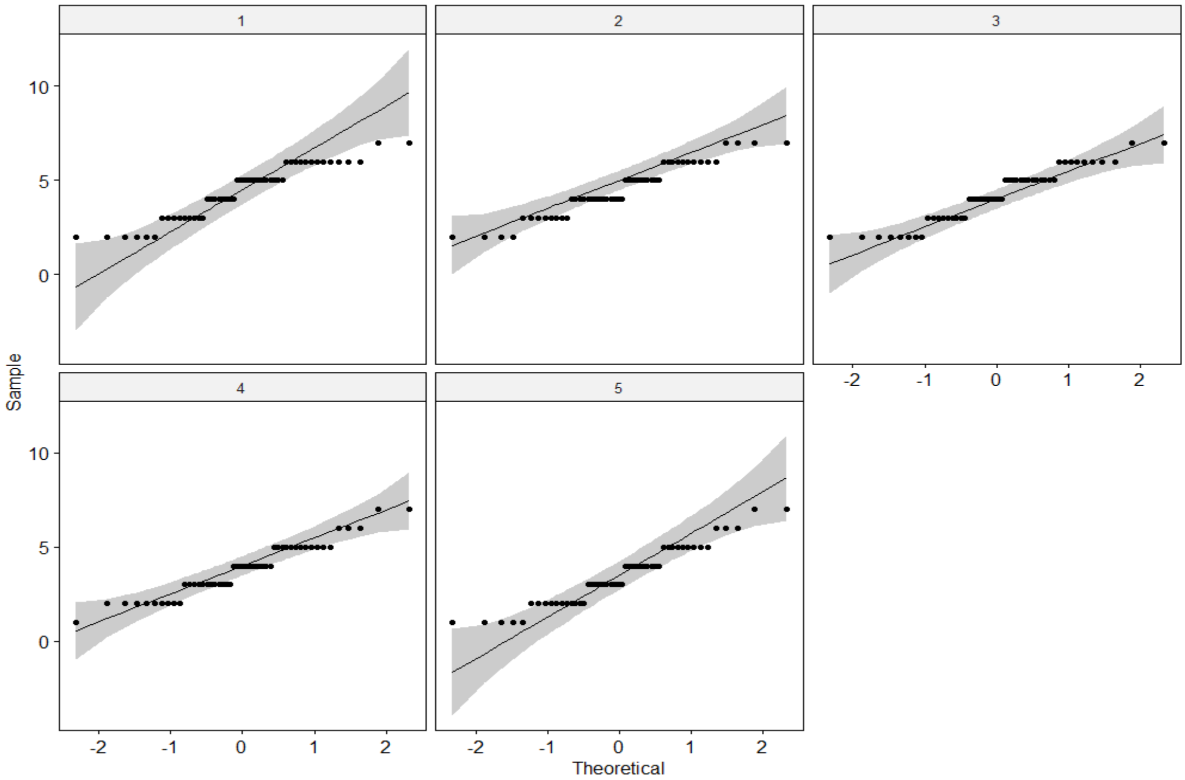

Figure 6 - QQ-plot desire to eat values trial 1 – 5.

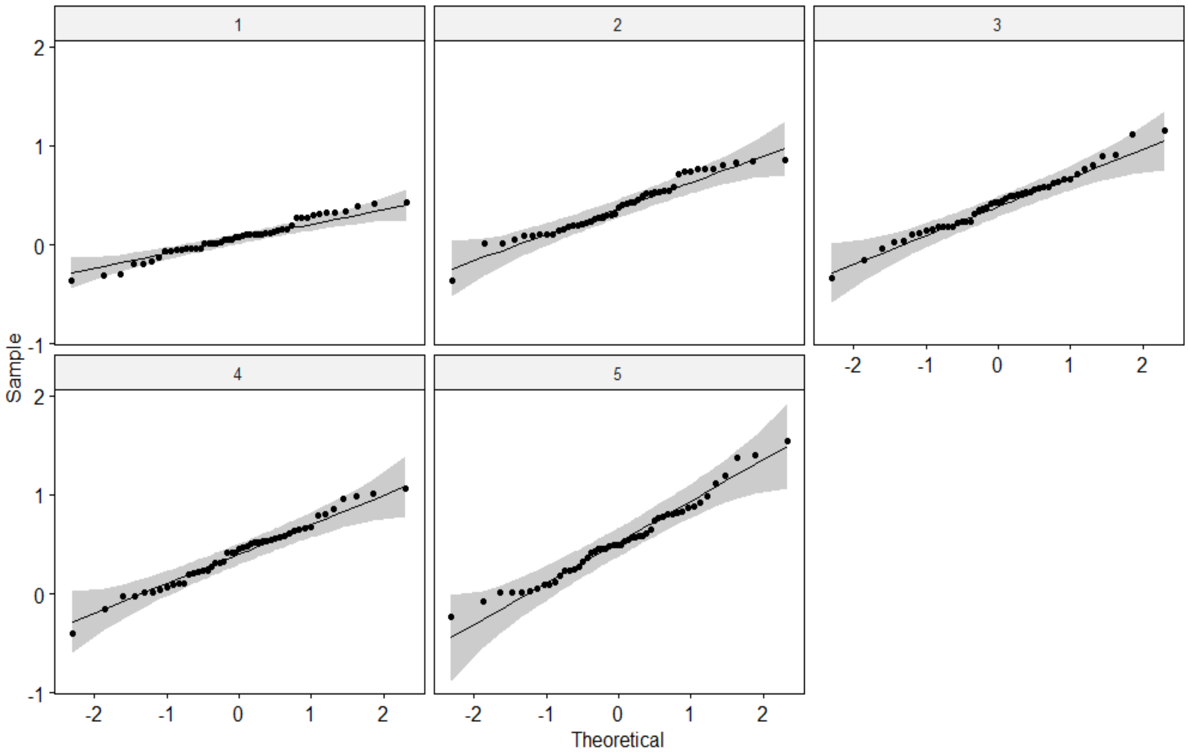

Figure 7 - QQ-plot salivation values trial 1 – 5.

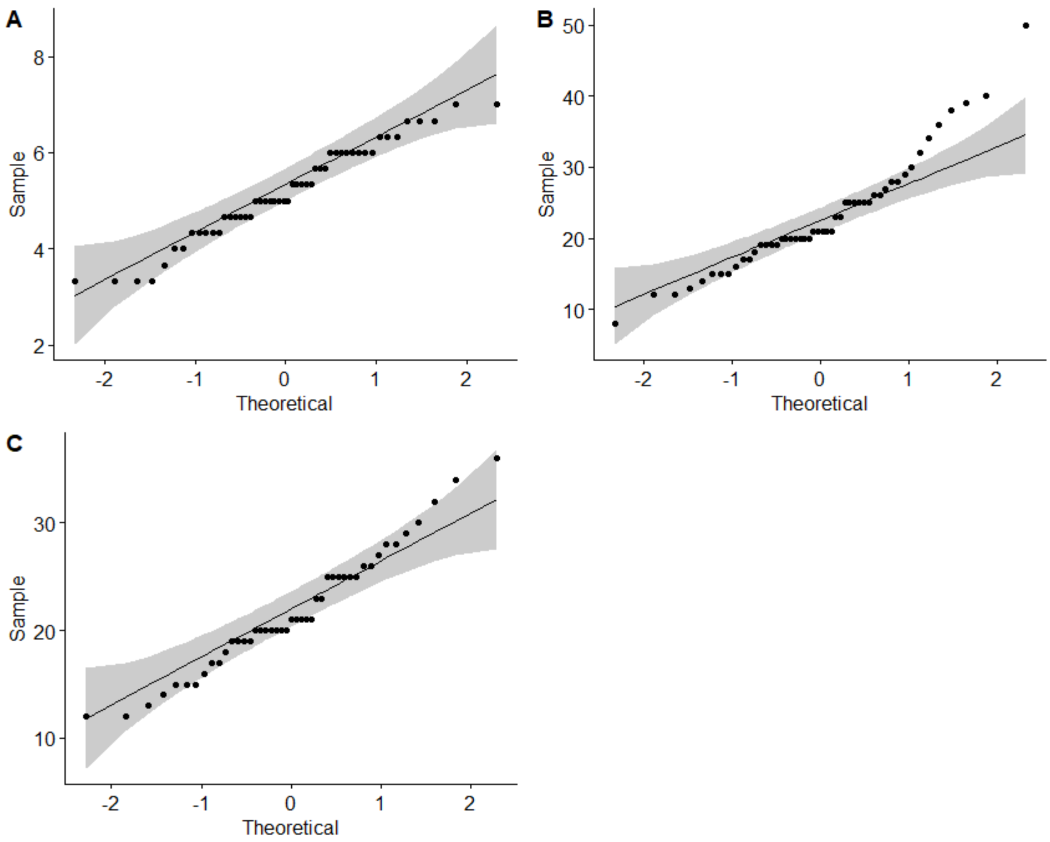

Figure 8 - QQ-plots: A = Food legalising, B = Food intake, C = Food intake without outliers.

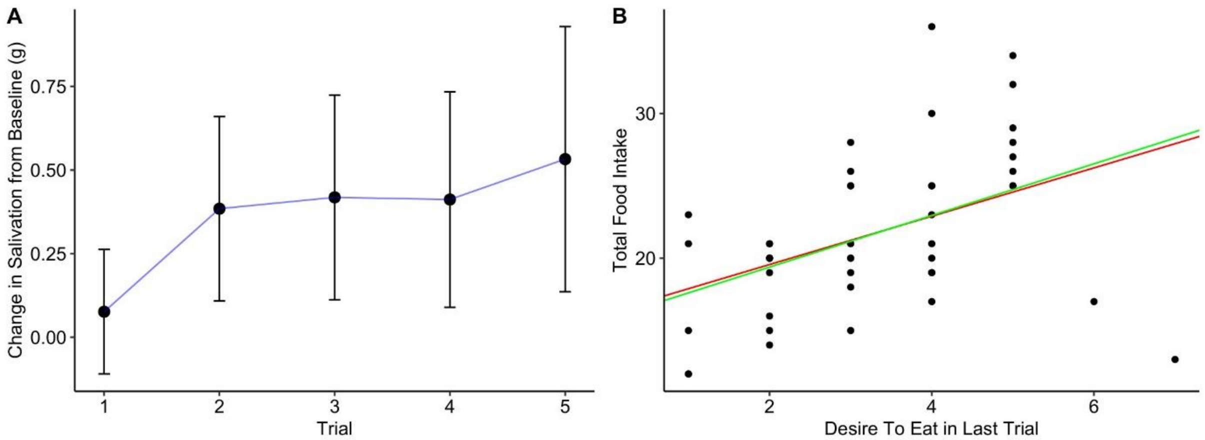

Figure 9 - A = Salivation over time excluding outliers, B = Desire to eat as predictor of food intake. The red line represents the fitted OLS regression line and the green line represents the fitted GLS regression line.