Situating desire: Situational cues affect desire for food through eating simulations

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Abstract

How do situations influence food desire? Although eating typically occurs in rich background situations, research on food desire often focuses on the properties of foods and consumers, rather than on the situations in which eating takes place. Here, we take a grounded cognition perspective and suggest that a situation that is congruent with consuming a food increases simulations of eating it, which, in turn, affect desire, and the expected and actual liking of the food. We tested this idea in four pre-registered experiments (N = 524). Participants processed an image of a food presented in a congruent situation, an incongruent situation, or no background situation. Compared to the incongruent situation, the congruent situation increased expected liking of the food and desire, and this was partially or fully mediated by eating simulations. The congruent situation also increased salivation, a physiological indicator of preparing to eat. However, there was only weak and indirect evidence for congruence effects on actual liking of the food when tasted. These findings show that situational cues can affect desire for food through eating simulations. Thus, background situations play an important but understudied role in human food desires. We address implications for research using food images, and for applications to promote healthy and sustainable eating behaviour.

Keywords: Grounded cognition, mental simulation, context effects, motivation, desire, eating behaviour, salivation

1. Introduction

How do situations affect desire to consume? Previous work has shown that situational cues can trigger cravings and habits, even if one actually wants to eat or drink less (Field et al., 2008; Neal et al., 2011). Situations also affect how people respond to desires, for example when the presence of others supports people in resisting desires successfully (Hofmann et al., 2012). However, little is known about how simply perceiving situational background cues affects desire, and what the underlying mechanisms are. Most food images used in research are deliberately un-situated, such that no background other than perhaps a standardized white plate is visible (e.g., Blechert et al., 2014; Charbonnier et al., 2016). This does not do justice to the rich, multidimensional situations in which we typically encounter food in daily life, or to psychology's sophisticated expertise on the role of situations in shaping human cognition and behaviour (e.g., Gawronski & Cesario, 2013; Smith & Semin, 2007). Therefore, we aim here to extend our understanding of appetitive motivation by considering the role of situations in food desires. We address how food desires are influenced by the broader background situations in which a food is presented, which includes information about the physical location, time of day, event setting, and possible presence of other people. We show that situational cues can change the desire for, and the expected liking of, a food because they modulate simulations of eating it. Given that eating is ubiquitous in daily life, understanding these effects and the cognitive processes through which situations shape our desire for food could help us to understand the difficulties that many people experience in controlling their eating, and inform theories around appetitive behaviour more generally.

1.1 Situation effects in eating

Situations affect eating behaviour through a variety of processes. Being in a familiar situation, for example, can trigger habits, a powerful predictor of eating behaviour (Riet et al., 2011; Wood & Rünger, 2016). Habits are learned cue-responses associations that are typically assumed to guide behaviour relatively automatically and independently of goals, thus without relying on the expectation or experience of reward. Thus, situations may lead to relatively automatic eating behaviour that is not primarily driven by expectations of enjoyment. However, situations can also affect our experiences and preferences. Research has shown, for example, that being in a setting associated with expensive food can affect food and drink evaluations and choices, and that being immersed in a specific environment can increase attractiveness of foods typically consumed there (Bell et al., 1994; Edwards et al., 2003; Picket & Dando, 2019; Roefs et al., 2006; van Bergen et al., 2021). Similarly, when vividly imagining a specific consumption situation, thinking about eating a food that seems appropriate for that situation evokes more positive emotions, compared to a less appropriate food (Piqueras-Fiszman & Jaeger, 2015). Furthermore, situations can affect eating when the presence of others influences what and how much people eat (for an overview, see Robinson et al., 2014). From this research on specific aspects of situations and experiences, however, we do not know whether background situations in which the food is presented and perceived affect how much people desire and expect to like a specific food, even when they are not currently immersed in the respective situation. In other words, when keeping the food itself constant, how does the background situation affect in a food image how much we desire and expect to enjoy it, and through which mechanism? This is the question that we set out to address.

Research in the domain of conditioning suggests that situational cues may play a key role in the learning processes that lead to food expectancies. As experiments on classical conditioning have shown, an association that was initially learned in one situational context (i.e., conditioning of a stimulus-food expectancy) and then unlearned in another context (i.e., extinction) is often observed again when the initial context is presented again. As Bouton and colleagues have argued, this “renewal” phenomenon suggests that learning of conditioned responses is context-specific, such that a person learns to expect food in response to a stimulus in one situation, but not another (Bouton, 1994; Todd et al., 2014). In other words, these findings show that situational cues are a powerful modulator of stimulus-food expectancies. A situation can also serve as a conditioned stimulus itself, as was shown, for example, by van den Akker and colleagues (van den Akker et al., 2013). Once participants had consciously learned that they would receive a milkshake to drink in a particular virtual reality environment, being exposed to that environment later triggered expectancies and desire to consume a milkshake. This is also consistent with the neuroscience literature on reward learning and motivation, which shows that once reward-related cues have been learned, they effectively predict their associated reward and can initiate motivated behaviour to obtain it (Berridge et al., 2009). Thus, situational cues can both modulate and trigger expectancies of consuming food and of experiencing food reward. Here, we take a grounded cognition perspective and argue that the background situation in which a food is presented, such as the physical location or social situation implied by a setting, may also affect food motivation by shaping simulations of eating a food.

1.2 A grounded cognition perspective on situation effects in eating

Much research on grounded processes in cognition suggests that our knowledge about the world is represented by *simulations*, or partial re-enactments, of perceptual experiences in the relevant modalities (Barsalou, 2008, 2009). Thinking about an object such as a cup or a hammer, for example, leads to activations of brain areas that are also involved when processing the stimulus perceptually or when actually using it (e.g., Martin et al., 1996; Pulvermüller & Fadiga, 2010; Tucker & Ellis, 2001). These simulations help to predict the experience of interacting with the world around us (e.g., knowing how a hammer feels in your hand), and to prepare for effective goal-directed action, based on previous experiences. Such simulations also play a key role in the regulation of motivated behaviour, and specifically in expectations and desire for food.

According to the grounded cognition theory of desire (Papies et al., 2015, 2017; Papies & Barsalou, 2015), every time a food is consumed, the brain stores a rich, *situated conceptualisation* of this experience that includes information about visual and gustatory features of the food, as well as a range of features of the situation, motor actions, affective states, and other information (see Barsalou, 2009). As an example, consuming a muffin when working on a laptop in a coffee house may lay down a representation of the sweet taste and chewy texture of the pastry, as well as the taste and temperature of the accompanying cup of coffee, the sounds of the coffee maker, music, and voices in the café, the sight of the bar, the tables, other people chatting or working, and the motor behaviours of writing, picking up the cup, and picking up the muffin to take a bite.

Later encountering part of this representation can re-activate such a situated conceptualisation, and trigger simulations of its non-present elements. This way, perceiving a food image, a food smell, or cues of a situation where one often eats a food, can trigger simulations of the taste, texture, and pleasure of eating the food, leading for example to activations in the associated brain areas, and to salivation (Barsalou, 2009; Chen et al., 2016; Keesman et al., 2016; Papies & Barsalou, 2015). Without much effort, these simulations can help to interpret the situation and prepare goal-directed action, such as predicting whether eating the food would be enjoyable, and whether one should choose it or not. This account critically differs from current accounts of the habitual regulation of behaviour because in contrast to habits, it ascribes a key role to the expectation of reward. In the coffee house example, merely passing the outside of the café or thinking about working there, may lead to a vivid simulation of the rewarding taste and mouthfeel of a muffin, which may in turn create the desire to consume it, even in the absence of hunger. If these enter conscious awareness, they can be fuelled by conscious imagery of eating and lead to food cravings (see Kavanagh et al., 2005). Based on this theory, we argue that cueing an eating situation, which is typically stored as part of a situated conceptualisation for eating a food, can trigger eating simulations. To the degree that these are associated with reward, they may trigger desire to consume the food and motivate actions to do so.

From this perspective, some situations can be described as congruent with eating a certain food and other situations as incongruent. A congruent consumption situation can be conceptualized as a situation whose features overlap highly with situated conceptualisations of situations where a person has frequently consumed a food or drink previously. In contrast, an incongruent situation is one whose features don't overlap highly with representations of previous situations where the food has been consumed. The features that determine congruence and incongruence could be any of the dimensions of a situated conceptualisation for consuming that food (Papies, 2013; Papies, Tatar, et al., 2020), for example external features such as time, location, objects, actions, other people, and events; or internal features such as affective, cognitive or interoceptive internal states, including those associated with hunger, pleasure, and satiation (Piqueras-Fiszman & Jaeger, 2015).

Given people's unique, rich learning histories of establishing situated conceptualisations of eating across their lives, congruent consumption situations will vary widely across individuals. We expect, however, that for frequently consumed foods within a given cultural context, researchers can establish consumption situations that would be experienced as relatively congruent or relatively incongruent among a majority of consumers.

In addition, it is possible that situated conceptualisations of eating are learned vicariously, for example through observing eating behaviour of other people or through advertisements (see Papies et al., 2017).

Reflecting such situated conceptualisations, previous work has shown that situational information is stored as part of the representation of foods and drinks (Keesman et al., 2018; Papies, 2013; Piqueras-Fiszman & Jaeger, 2015; Ross & Murphy, 1999). When categorising foods, people have been found to refer to the background situations and scripts of eating them ("breakfast foods"; "foods you eat with a spoon"; Ross & Murphy, 1999). When listing features of a food, people often spontaneously describe how or when one would eat it, such as "at a party", "in hot weather", or "with ice-cream" (Papies, 2013), and when describing beverages, participants list situations such as "thirsty", "at work", "meal", or "at the gym" (Papies et al., 2021). Similarly, when describing features that are typically true of alcoholic drinks, participants often refer to consumption settings, such as "on the terrace", "with friends", "weekend", "when the sun is shining" – and they refer to such situational features more than to the hedonic experience of consumption (e.g., "tasty"; Keesman et al., 2018).

1.3 Consumption simulations and desire

Behavioural and neuro-imaging research further demonstrates that food cues trigger spontaneous simulations of eating, which can lead to desire to eat. For example, participants report sensory "images" of eating the food when viewing food pictures (Elder & Krishna, 2012; Larson et al., 2014). When describing foods, people often refer to features that are experienced when eating it (e.g., "is juicy"; McRae et al., 2005). Such "eating simulation features" are used especially for food that is seen as attractive (e.g., "salty", "crunchy", "from the bag", "on the sofa" for potato chips), while food that is seen as less attractive is described more in terms of visual properties and its production ("small", "white", "from Asia", "has to be cooked", for rice; Papies, 2013). Similar patterns occur for sugar-sweetened beverages, which are described more in terms of consumption simulation features ("bubbly", "cold", "sweet") than water (Papies et al., 2021). Neuro-imaging research shows that viewing pictures of food activates brain areas that represent taste and reward information and that are also active during food consumption, again suggesting that eating is *simulated* when conceptual information about food is processed (e.g., Simmons et al., 2005; for a review, see Chen et al., 2016). Again, this pattern of activation is especially likely when the pictures show foods that are seen as attractive and high in calories.

Importantly, such simulations of eating a food increase desire for it, especially if the food is attractive. Elder and Krishna (2012) displayed a food visually in such a way that it did or did not facilitate motor simulations of eating it, for example a bowl of soup with a spoon pointing to the dominant hand vs. pointing away from it. When the spoon pointed towards the dominant hand, participants reported that more images of eating the soup came to mind (i.e., stronger simulations), and this increased purchase intentions, when the food was presented with an attractive-sounding label. Similarly, Munoz-Vilches and colleagues (2019, 2020) showed that actively imagining the process of eating a food, compared to imagining the outcome of eating it, increased preferences for the imagined product, especially if this was highly attractive yet unhealthy. Keesman and colleagues (2016) showed that actively imagining eating a food increased salivation, especially if the food was attractive, and Cornil and Chandon showed that it increased expectations of pleasure (2016; see also Petit et al., 2017). Finally, Piqueras-Fiszman and Jaeger (2015) demonstrated that imagining eating a food in a more congruent context is associated with more positive emotions, possibly because participants retrieved more positive eating memories.

In summary, research so far has shown that situations affect eating behaviour, and that people's representations of foods and drinks include information about congruent consumption situations, such as typical eating locations, occasions, or time settings. Furthermore, perceiving foods can trigger simulations of eating and enjoying the food, which can increase desire, especially when the food is attractive. However, no previous work has brought situations, simulations, and desire together, and examined whether cueing background situations, for example in images, affects the simulations that lead to desire for a presented food.

1.4 The present research

Here, we suggest that presenting a specific, liked food in a congruent eating situation will increase spontaneous simulations of eating that food. As we have seen, reading a food word or viewing a food product alone can trigger eating simulations. Viewing it in a background situation that has previously been associated with eating, makes activation of a situated conceptualisation of eating and possibly enjoying the food more likely. This will result in eating and reward simulations that can increase a person's desire for, and expectations of liking, the presented food, compared to a food presented without congruent situational cues, even if the cued situation is not physically present.

Because simulations and expectancies can be superimposed on sensory perception and thus shape experiences (Hansen et al., 2006; Plassmann et al., 2008; see also Elder & Krishna, 2010), we suggest that situationally cued eating simulations might also be able to affect actual liking of a food. When a liked food triggers strong simulations of what it would taste and feel like, these expectancies can affect the actual eating experience in a top-down manner, such that the food tastes better when one simulated it as being very tasty (see Edwards et al., 2003). For example, expecting that a bowl of soup will taste very rich, savoury, and warming, could make one like the same soup more compared to when one expected that it would be watery and bland, unless the difference between expectation and actual experience is too large (Piqueras-Fiszman & Spence, 2015; Plassmann et al., 2008; Woods et al., 2011). Thus, to the degree that a congruent background situation increases the rewarding consumption simulations that are triggered by a food, it may increase not only desire and expected liking, but also actual liking of the food when one eats it.

We report four experiments to test this role of situational cues in desire. We manipulated the congruence of the background situation in which a given food was presented, and examined simulations of eating that food, as well as physiological and self-reported measures of desire, anticipated liking, and actual liking.

Experiment 1a was designed as a first test of the hypothesis that situational congruence during food presentation affects desire for a food through consumption simulations. Participants viewed an image of a food (a bowl of soup) that was placed in either a congruent or an incongruent background situation (a kitchen or a cinema). They then reported simulations of eating the product by responding to items assessing, for example, how much they had imagined eating the food, along with experiencing its taste, its texture, how it would make them feel, how easy this was to imagine, etc. They then reported expected liking of the food and their desire to eat it. Experiment 1a used tomato soup, a moderately tasty food, as a stimulus, which allowed us to assess whether manipulating the situation in which the soup was presented could affect participants' desire for it, while avoiding floor and ceiling effects. Experiment 1b repeated this procedure for 3 low-energy-dense and 3 high-energy-dense foods, further adding a no-background situation control condition. Experiment 2 again used tomato soup as the main stimulus, and also assessed participants' salivation in response to the image, together with their liking of the soup when actually tasting it. Finally, Experiment 3 repeated the procedure used in Experiment 2 but added a reduced-salt version of tomato soup, in order to explore whether situational cues might have a greater effect on the liking of a food when the food itself is less tasty.

Across experiments, we used foods consumed frequently, and that are mildly but not extremely attractive, so that that the foods would trigger rewarding consumption simulations that could increase desire, without ceiling effects, and without simulations reducing desire for unattractive foods (see Elder & Krishna, 2012). Building on the findings that eating situations form part of people's representations of food, we predicted that presenting a food in a congruent situation would increase the eating simulations that are typically triggered by food cues. In other words, we predicted stronger eating simulations for foods presented in congruent compared to incongruent background situations, with unsituated foods falling in between. Building on the evidence that eating simulations can increase desire, especially for attractive foods, we further predicted that these increased eating simulations would lead to an increase in desire and expected liking. Specifically, we predicted that congruent eating situations would increase desire and expected liking, especially for attractive foods, and that this effect would be mediated by eating simulations. Finally, we predicted that congruent situations when perceiving the food would increase liking of the food, through increased eating simulations.

All studies were pre-registered at the Open Science Framework, where the data and analysis scripts are also publicly available (see https://osf.io/pwdtx/?view_only=64c390f9896e497582a6bd06b185c97f). In the Results section, we distinguish confirmatory tests of pre-registered hypotheses from exploratory analyses. The research was approved by the Ethics Committee at Utrecht University, and participants provided informed consent before participating.

2. Experiment 1a

This experiment was designed to test the hypotheses that presenting a food in an incongruent compared to a congruent eating situation would increase eating simulations, expected liking, and desire for the food.

2.1 Method

2.1.1 Participants and design

Eighty-two right-handed students at Utrecht University (21 male, age *M* = 21.27, *SD* = 3.77) participated in exchange for partial course credit and the chance of winning a €25 voucher. A power analysis using G*Power (Faul et al., 2009) with an alpha of .05 suggested that we would need 52 participants to have 80% power to detect a main effect of congruence on self-reported eating simulations with *d* = 0.75. This was informed by Keesman et al., 2016, who found a strong effect, *d* = 1.5, of simulation instructions on self-reported eating simulations. Due to an error in the initial, pre-registered power calculation, we collected data from 82 participants. Participants were randomly assigned to the congruent or incongruent situation condition in an online experiment.

2.1.2 Stimuli

Based on a pre-test (see appendix for details), we selected two images of a bowl of soup in a background situation (a cinema vs. a kitchen; see Figure 1). The background situations in the images were similar in valence, familiarity, and ease of immersing oneself into the situation, but the displayed situations were clearly different in their congruence with eating tomato soup. Tomato soup is a common food in the Netherlands for both lunch and dinner.

Figure 1. The images used for the incongruent (left) and the congruent (right) situation conditions in Experiments 1-3.

2.1.3 Procedure

Participants were asked how long ago they had last eaten, how hungry they were, and whether they were right-handed. Participants were then told that they would be shown an image (one of the images in Figure 1) and were asked to immerse themselves in the image and "to experience the situation depicted as if you are in it with as much detail as possible". This was designed to engage deep, rather than superficial, processing of the images. The instructions made no mention of food or eating. The image was then presented for one minute, with a summary of the instructions above it. Participants then answered simulation questions, questions on liking and desire, questions about healthiness, consumption frequency and liking of soup. All measures were assessed on a 7-point scale, and are described in more detail below. Finally, participants provided demographic information (age, gender, height, and weight).

2.1.4 Simulation questions

We assessed three different aspects of simulations with separate subscales. We measured participants' spontaneous simulations of eating the soup with 6 items (e.g., "I imagined that I was eating the soup", "It was as if I could taste the soup"; $\alpha = 0.84$; adapted from Keesman et al., 2016). We assessed simulations of being in the situation displayed with two questions (“I imagined that I was in the scene”; “I had a very clear image of all the details in the scene”), and ease of simulation with one question (“I found it easy to immerse myself into the situation depicted in the image”; see the appendix for all the questions used).

2.1.5 Liking and desire measures

For our hypothesis tests, we assessed desire (‘How much would you like to eat the soup displayed in the picture right now?’) and expected liking (‘How tasty do you think the soup displayed in the picture would be?’).

2.1.6 Additional questions

We included exploratory measures of intention to buy (‘How likely would you be to buy and eat the soup displayed in the picture?’), and willingness to serve the soup to friends or family (‘Would you serve the soup displayed in the picture to friends or family?’). We also asked participants to rate the perceived healthiness of the soup, how often they ate tomato soup, how often they ate ready-made tomato soup, how much they like tomato soup, how much they like ready-made tomato soup, and their current dieting status.

2.1.7 Analyses

All data processing and analyses for this paper were completed using R (R Development Core Team, 2018, version 3.5). We controlled for self-reported hunger in all hypothesis tests, as pre-registered.

To test our hypotheses for Experiment 1a, we conducted ANCOVAs on the three separate aspects of simulations, on desire, and on expected liking, with hunger as a covariate. We conducted mediation analyses to explore indirect effects through eating simulations. All mediation analyses were conducted with standardized continuous variables using the “mediation” package (Tingley et al., 2014) with N = 5,000 samples (nonparametric bootstrapping).

2.2 Results

Table 1 shows descriptive statistics and correlations for the main study variables. Across conditions, eating simulations were strongly associated with the desire to eat and with expected liking, which also strongly correlated with each other.

Table 1. Means, standard deviations, and Pearson's correlations for the main outcome variables.

	M (*SD*)	Desire to eat	Expected liking
Eating simulations	3.64 (1.39)	.51**	.49**
Desire to eat	3.82 (1.89)	-	.64**
Expected liking	4.46 (1.54)		-

Note. Double asterisks indicate significant correlations at $p < .01$.

2.2.1 Effects of situational congruence

In line with our hypotheses, the congruent situation increased eating simulations, desire, and expected liking of the soup compared to the incongruent situation, as can be seen in Table 2 and Figure 2. These predicted effects remained significant when correcting for multiple comparisons ($p = 0.05/5$). In contrast to our hypotheses and to the strong effect of congruence on eating simulations, there were no effects of congruence on simulations of the eating situation, or on ease of simulation, suggesting that participants were able to immerse themselves equally well in both conditions.

Exploratory analyses showed that the congruent situation also increased the intention to buy and eat the soup $F(1, 79) = 9.253$, $p = .003$, $\eta^2_p = 0.105$, as well as the willingness to serve the soup to friends or family, $F(1, 79) = 4.371$, $p = .0398$, $\eta^2_p = 0.052$, compared to the incongruent situation.

As pre-registered, we also tested for an interaction effect of congruence with hunger on the eating simulations, situation simulations, and ease of simulation. All three tests yielded non-significant results (all $p > .278$).

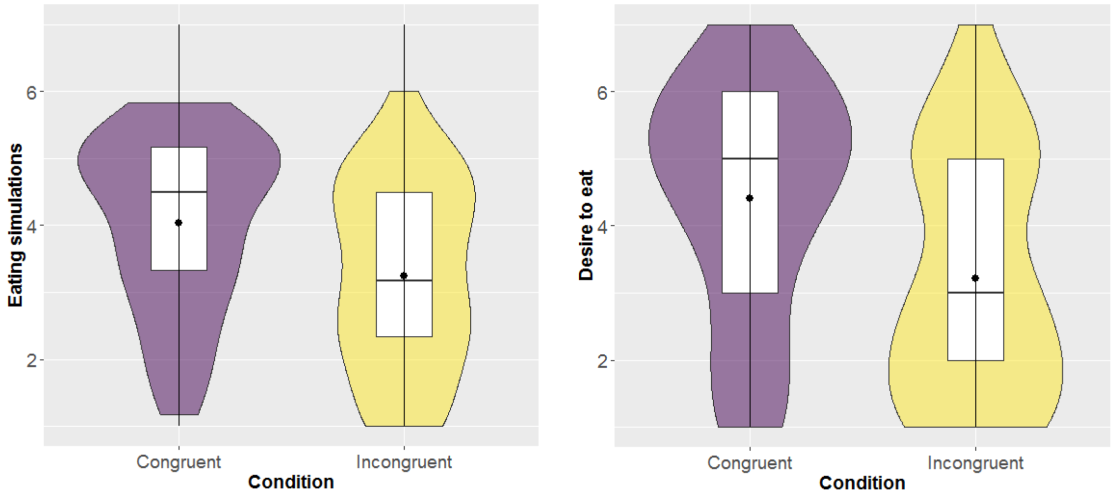
Table 2: Effect of situational congruence on eating simulations and desire (adjusted means).

Dependent variable	Congruent situation	Incongruent situation	Effect of covariate hunger	Effect of situational congruence
Eating simulations	$M = 3.994$ $SE = 0.210$	$M = 3.281$ $SE = 0.210$	$p = .172$	**$F(1, 79) = 6.991, p = .010$ $\eta^2_p = 0.081$**
Situation simulations	$M = 4.654$ $SE = 0.184$	$M = 4.370$ $SE = 0.184$	$p = .942$	$F(1, 79) = 1.181, p = .280$ $\eta^2_p = 0.015$
Ease of simulation	$M = 5.183$ $SE = 0.238$	$M = 4.768$ $SE = 0.238$	$p = .666$	$F(1, 79) = 1.719, p = .194$ $\eta^2_p = 0.021$
Desire to eat	$M = 4.281$ $SE = 0.253$	$M = 3.353$ $SE = 0.253$	$p < .001$	**$F(1, 79) = 11.295, p = .001$ $\eta^2_p = 0.125$**
Expected Liking	$M = 4.898$ $SE = 0.227$	$M = 4.029$ $SE = 0.227$	$p = .044$	**$F(1, 79) = 9.390, p = .003$ $\eta^2_p = 0.106$**

2.2.2 Mediation analyses

Exploratory analyses showed that the effect of congruence on desire was mediated by eating simulations, as indicated by a significant indirect effect ($b = 0.203$, 95% CI = 0.041, 0.45, $p = .019$). Out of the total effect of congruence on desire, 41.20% was explained by eating simulations, leaving a non-significant direct effect ($p = .113$). Similarly, the effect of congruence on expected liking was mediated by eating simulations ($b = 0.211$, 95% CI = 0.044, 0.45, $p = .012$), with 37.39% of the total effect on expected liking explained by mediation, leaving a direct effect of $b = 0.353$, 95% CI = -0.021, 0.74, $p = .066$.

We also explored the reverse mediation, assessing an indirect effect of congruence on simulations through desire and expected liking. Indeed, the effect of congruence on simulations was mediated by desire (indirect effect $b = 0.246$, 95% CI = 0.059, 0.52, $p = .011$; 47.96% mediated; direct effect $p = .180$). Similarly, the effect of congruence on simulations was mediated by expected liking (indirect effect *b* = 0.244, 95% CI = 0.06, 0.51, *p* = .010; 47.59% mediated; direct effect *p* = .222).



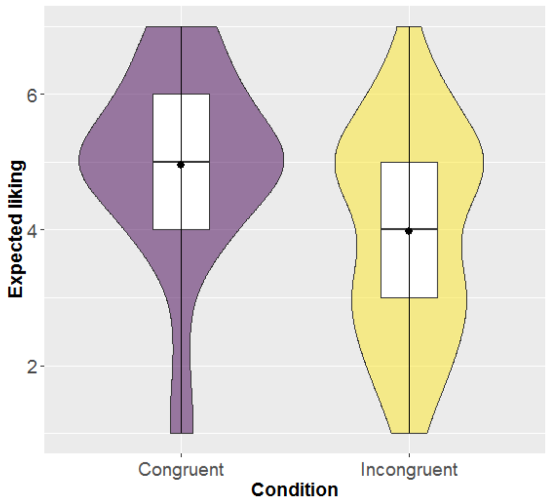


Figure 2. Violin boxplots, showing the distribution of responses in each congruence condition on the measures of eating simulations, desire to eat, and expected liking of the soup (all on 7-point scales). Dots display means, and horizontal lines display medians.

2.3 Discussion

Experiment 1a showed that processing an image of a food in a congruent compared to an incongruent situation of equal valence increased participants' simulations of eating the soup. These simulations, in turn, increased expected liking and desire to eat the soup. Notably, our immersion instructions made no mention of food or eating. Thus, it was merely that the presented situation was compatible with eating the displayed food (in this case, soup) that led participants to imagine its taste and texture and the effects of eating it. Notably, simulations of being in the situation and the ease of simulation were comparable in both conditions. While this was unexpected, it is an important finding that indicates that differences in eating simulations were not due to the incongruent situation being difficult to imagine. Rather, although the soup was present in both images, the incongruent background situation was less likely to trigger spontaneous simulations of eating it.

Exploratory analyses showed not only an indirect effect of congruence on desire and expected liking via eating simulations, but also the reverse indirect effect on simulations via desire and expected liking. While the grounded cognition theory of desire proposes that consumption and reward simulations lead to desire, the reverse pattern is also consistent with previous literature, suggesting that the desire for a food increases imagery of eating it (see Kavanagh et al., 2005). This pattern also shows that simulations are not the only mechanism leading to desire, and that simulations and desire can mutually reinforce each other.

3. Experiment 1b

In Experiment 1b, we added other low-energy-dense and high-energy-dense food products presented in a variety of different background situations. This allowed us to rule out that the effects in Experiment 1a are due to the fact that the kitchen background is generally more strongly associated with eating than the cinema background. Adding more foods and situations also allowed us to ensure that the effect of situational cues on desire through eating simulations was not restricted to soup, to include a larger variety of cues that could contribute to making a situation congruent or incongruent for a given food, and to rule out the alternative explanation that the effects are merely due to participants expecting a soup available at home to be tastier than one in the cinema. Because previous research has shown that participants represent foods and drinks in situations with a wide range of different features such as physical settings, time, social settings, other foods and drinks, events

(Keesman et al., 2018; Papies, 2013; Papies et al., 2021), we added images which contained, for example, cues for different physical settings, different times of day, and a variety of accompanying drinks (see Fig. 3). This increased the variability of situations that could activate situated conceptualisations of eating the presented foods.

Adding more foods also provided the opportunity to test the hypotheses that eating simulations and situation effects would be stronger for attractive, high-energy-dense compared to less attractive, low-energy-dense food. The grounded cognition theory of desire suggests that simulations prepare for and motivate goal-directed action and thus help to achieve desirable, rewarding outcomes. Thus, eating simulations should be stronger for foods that have been encoded with high reward value during previous consumption experiences, because these simulations are more likely to prepare and initiate rewarding behaviours (Papies, 2013; Papies & Barsalou, 2015). Therefore, we expected to conceptually replicate previous research showing that attractive foods trigger stronger eating simulations than neutral foods (a main effect; Papies, 2013). In addition, because situational information features more heavily in representations of attractive compared to neutral foods (Papies, 2013), we predicted a stronger effect of situational congruence on simulations of attractive compared to neutral foods, such that the effect of situations on simulations would be stronger for attractive compared to neutral foods (i.e., an interaction effect).

Because participants would be asked to complete the immersion procedure for each image, and this procedure could be demanding to perform, we decided to use no more than six trials, to strike a balance between increasing power and preventing fatigue. Given that Experiment 1a had shown that situational cues only affect simulations of eating the food, but not the ease of simulation or simulations of the situation more generally, our predictions in Experiment 1b focused on eating simulations and their effects on desire. Given the results of the exploratory mediation analyses of Experiment 1a, we now formally predicted that eating simulations would mediate the effect of situational congruence on desire and expected liking. We also added a no-background situation control condition to explore how it differs from both the congruent and the incongruent situation condition. We did not make formal predictions whether this control condition, which showed the food in an unsituated manner, would differ statistically from the congruent or the incongruent condition, but we expected that it would fall in between.

In sum, we hypothesized as in Experiment 1 that the congruent compared to the incongruent background situation would increase eating simulations, expected liking, and desire, and that the effects on expected liking and desire would be mediated by eating simulations. We further predicted that highly attractive foods would trigger stronger eating simulations than the more neutral foods, and would show a stronger effect of situational congruence on eating simulations.

3.1 Method

3.1.1 Participants and design

One hundred and twenty-two participants were recruited via Prolific Academic and at Utrecht University to complete an online survey (M_{Age} = 25.32, SD_{Age} = 7.27; 61 male). Participants were rewarded €2.34 (£2.00; on Prolific) or partial course credit (offered to student participants). We presented participants with six foods in either a congruent situation, an incongruent situation, or without background situation. Congruence varied within participants (rather than between, as in Experiment 1a), with 2 foods presented in each congruence condition. Assignment of foods to congruence condition was counterbalanced, and participants were randomly assigned to one of the three counterbalancing conditions (see appendix for details). Originally, we planned and pre-registered between-participant

ANCOVA's per food item, as performed in Experiment 1a, and increased the sample size by one third to account for the addition of the control condition.

3.1.2 Stimuli

We included images of three very attractive, high-energy-dense foods (cookies, cocktail nuts, popcorn) and three mildly attractive, low-energy-dense foods (apples, cucumber slices, tomato soup). Using photo editing software, these foods were integrated into 6 situation images (see Figure 3). No food product or situation was presented more than once to the same participant, and the order of images was randomised per participant by the software used (Qualtrics).

3.1.3 Procedure

After providing informed consent, participants were asked how long ago they had last eaten (in minutes) and how hungry they were. Participants were then told that they would be shown several images, and they were asked to immerse themselves in the image, as in Experiment 1a. After each image, participants completed the simulation measure (see appendix) and then indicated their expected liking, their expectations of the product on a number of sensory dimensions (e.g., salty, spicy), their desire to eat the product, intention to buy it, willingness to pay for it (on a slider scale between 0 and €3), and the likelihood of serving the food to friends and family. After viewing all the images, participants indicated how often they eat each food, how healthy they find it, how much they generally like it, and how well they thought each food fitted its background situation (all on a 7-point scale). Finally, participants provided demographic information, as for Experiment 1a.

Figure 3. Each of the foods used in Experiment 1b, shown in a congruent situation, no background situation, or in an incongruent situation.

3.1.4 Analyses

To test our pre-registered hypotheses across the 6 food items, we conducted linear mixed effects regression analyses (using lme 4 package, version 1.1.17, Bates et al., 2015; and MuMIn package, version 1.43.6, Barton, 2019) in which we predicted eating simulations, desire, and expected liking from situational congruence (comparing congruent vs.

incongruent situations), while controlling for hunger and food type[1]. All continuous variables were mean standardized, and categorical variables were deviation-coded. We included random intercepts for participants and foods, and random slopes for the effect of congruence across foods for maximal testing (Barr et al., 2013). To test the hypothesis that the effect of situational congruence on simulations would be stronger for high-calorie-density than for lower-calorie-density foods, we included the interaction term of congruence and food type. To test the hypotheses that eating simulations mediate the effect of congruence on food desire and expected liking, we conducted mediation analyses in the mediation package in R (Tingley et al., 2014) with mixed effects models, including the random intercept for participants and 50,000 simulations of the quasi-Bayesian approximation of the confidence intervals, comparing the congruent and the incongruent condition.

We then used the same multilevel regression and mediation analyses to conduct additional, non-preregistered analyses of the effects of congruence on intention to buy, willingness to pay, and willingness to serve to friends and family. We also assessed differences between the congruent and no situation conditions, and between incongruent and no situation conditions (reported in the supplemental materials).

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[1] This deviates from our pre-registered analyses, which specified separate tests for each individual food. Specifically, the pre-registration for Experiment 1b states that we would examine the effects of congruence on simulations, desire, and expected liking per food product. To reduce the number of statistical tests, however, it later seemed more appropriate to use linear mixed effects regression and to model the effect of congruence as a fixed effect on each of the dependent variables for all foods together, while also taking into account the random intercepts of each food item and each participant, and the slope of congruence across food items.

3.2 Results

Table 3 presents the descriptive statistics and correlations for the main study variables, showing the same pattern of correlations as for Experiment 1a.

Table 3. Means, standard deviations, and Pearson's correlations for the main outcome variables, averaged across the 6 foods.

	M (*SD*)	Desire to eat	Expected liking
Eating simulations	4.26 (1.05)	.55**	.55**
Desire to eat	4.16 (1.06)	-	.69**
Expected liking	5 (0.79)		-

Note. Double asterisks indicate significant correlations at the $p < .001$ level.

3.2.1 Congruence effects on simulations, desire and expected liking

Results of the linear mixed effects models are shown in Table 4. In line with the findings of Experiment 1a and with our hypotheses, a congruent background situation led to stronger eating simulations, desire, and expected liking compared to an incongruent situation (see Figure 4). These predicted effects for desire and expected liking, but not for simulations, remained significant when correcting for multiple comparisons ($p = 0.05/3$).

To examine whether the effect of the congruent vs. the incongruent situation held across all six foods, we inspected the random slopes of congruence across these foods in the linear mixed models, to predict the key variables: eating simulations, desire, and expected liking. The resulting coefficients ranged from .06 to .43 for eating simulations, from 0.24 to 0.51 for desire, and from 0.09 to 0.63 for expected liking. Thus, although the effect of congruence varied across foods, it was consistently positive. As can be seen in Table 4, the mean effect of congruence was also positive and significantly different from 0.

Table 4. Results of mixed effects models that predict eating simulations, desire, and expected liking (confirmatory analyses to test differences between congruent and incongruent situations), and from situational congruence, food type, and the preregistered covariate hunger. Factor levels were deviation coded (congruent 0.5 vs. incongruent situation -0.5). Predictors printed in bold are significant at $p < .05$. The Model R^2 represents the variance explained by the entire model, including fixed and random effects.

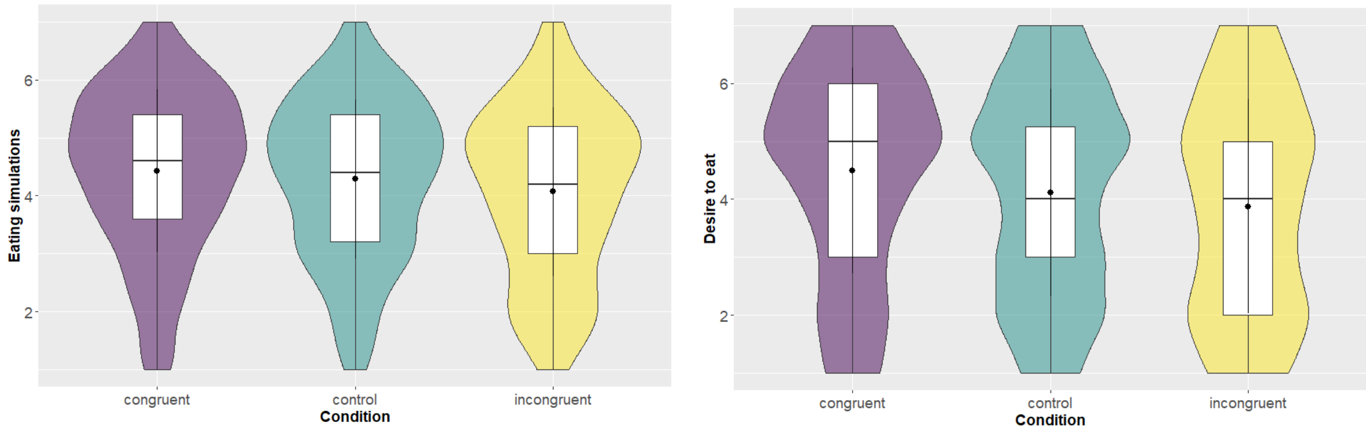
DV	predictor	*b*	*SE*	*t*	*p*	*Model R^2*
Eating simulations	**Congruence**	**0.248**	**0.071**	**2.747**	**.043**	0.498
	Food type	**0.202**	**0.069**	**2.911**	**.007**	
	Hunger	0.035	0.069	0.502	.616	
Desire to eat	**Congruence**	**0.334**	**0.090**	**3.691**	**.003**	0.233
	Food type	-0.064	0.149	-0.432	.679	
	Hunger	**0.172**	**0.052**	**3.292**	**.001**	
Expected liking	**Congruence**	**0.371**	**0.110**	**3.377**	**.011**	.207
	Food type	0.114	0.129	0.887	.397	
	Hunger	0.072	0.052	1.380	.170	

3.2.2 Mediation analyses

As predicted, the effect of congruence on desire was again mediated by eating simulations, indicated by a significant indirect effect (b = 0.142, 95% CI = 0.068, 0.22, p < .001). Out of the total effect of congruence on desire, 42.07% was explained by eating simulations, leaving a direct effect of b = .195, 95% CI = 0.06, 0.33, p = .005.

Similarly, the effect of congruence on expected liking was mediated by eating simulations (b = 0.140, 95% CI = 0.068, 0.22, p < .001), with 36.90% of the total effect on expected liking explained by eating simulations, leaving a direct effect of b = 0.238, 95% CI = 0.104, 0.37, p < .001.

Again, we also explored the reverse mediation, assessing an indirect effect of congruence on simulations through desire and expected liking. Indeed, the effect of congruence on simulations was mediated by desire (indirect effect *b* = 0.160, 95% CI = 0.085, 0.24, $p < .011$; 64.04% mediated; direct effect $p = .10$). Similarly, the effect of congruence on simulations was mediated by expected liking (indirect effect *b* = 0.174, 95% CI = 0.098, 0.25, $p < .0001$; 69.15% mediated; direct effect $p = .18$).



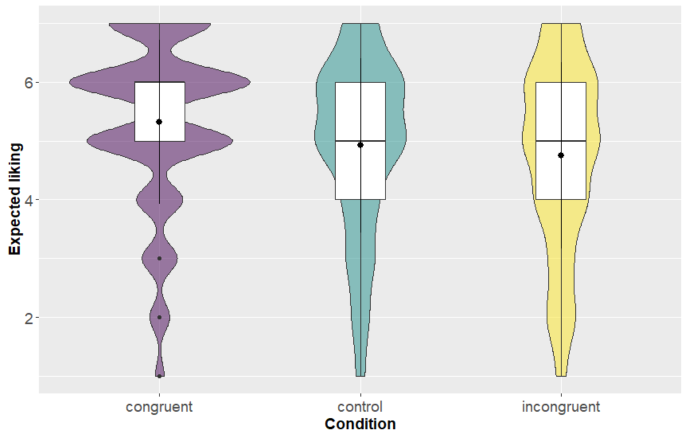


Figure 4. Violin boxplots, showing the distribution of responses across all six foods in each congruence condition on the measures of eating simulations, desire to eat, and expected liking of the soup (all on 7-point scales). Dots display means, and horizontal lines display medians.

3.2 3 Food type effects on eating simulations

As predicted, the results in Table 4 also show that eating simulations were stronger for highly attractive, high-energy dense compared to more neutral, low-energy-dense foods. However, a separate model did not confirm the hypothesis that the effect of congruence on simulations was moderated by food type, as the interaction of congruence and food type was not significant (*b* = -0.034, *SE* = 0.128, *t* = -0.267).

Exploratory analyses (see Supplemental Online Materials, also including intention to buy, and willingness to pay and to serve to friends/family) showed that when comparing both the congruent and the incongruent condition to the no situation control condition, the congruent situation differed from control on some measures, but these differences were small and only one of them remained significant when controlling for multiple comparisons. The incongruent situations did not differ significantly from the control condition on any measure, but all changes were in the expected direction. As expected, the unsituated control condition generally fell in between the congruent and the incongruent background situation conditions.

3.3 Discussion

In line with our hypotheses and Experiment 1a, a congruent compared to an incongruent background situation increased eating simulations, desire, and expected liking across foods, while we should note that the effect for simulations was not significant when correcting for multiple comparisons. Also in line with our hypotheses, eating simulations mediated the effect of situational congruence on desire and expected liking. In both cases, the mediation was only partial, suggesting that congruence also increased desire and expected liking of the foods without increasing eating simulations. In addition, desire and expected liking again also mediated the effect of congruence on eating simulations, suggesting that simulations and desire are closely related and may mutually reinforce each other.

As predicted, eating simulations were higher for unhealthy, high-energy dense foods compared to healthier, low-energy dense foods, but in contrast to our hypothesis, food type did not moderate the effect of situational congruence on simulations. This may reflect the fact that even the healthy foods in this study (apples, cucumber slices, tomato soup) were relatively attractive and frequently consumed, which is in line with the finding that desire and expected liking were comparable for both food types. Thus, although eating simulations were weaker for healthier foods, situational congruence played an equally important role in increasing them.

The experiment was powered for detecting differences between the congruent and incongruent condition, the effect size of which was expected to be larger than the effect size for differences with the control condition, as this was anticipated to fall in between the congruent and incongruent conditions. Nevertheless, we explored differences with the control condition, and found that this differed on some measures from the congruent, but not from the incongruent condition. However, these findings were exploratory and not reliable enough to warrant strong conclusions, other than that the congruence effects may result from both the congruent situations *increasing* eating simulations, expected liking, and desire, and from the incongruent situations *decreasing* them.

4. Experiment 2

Experiment 2 was designed to replicate and extend these findings in two important ways. First, we measured participants' salivation responses when viewing images of food, as salivation is a spontaneous physiological response to the anticipation of eating (Nederkoorn et al., 2000). Previous research has shown that salivation results from eating simulations, that it is stronger in response to cues of attractive than of neutral food, and that it predicts desire for attractive food (Keesman et al., 2016). In other words, viewing a food item triggers a re-enactment of the mental and bodily experience of eating it, including the production of saliva. This prepares for actual ingestion of the food, which is facilitated by saliva in the mouth. As eating simulations are stronger for attractive than for neutral food, salivary responses are also stronger for attractive food. The amount of saliva produced can therefore be seen as an indicator of the motivation to consume the food. Salivation may be considered an implicit measure in the sense that it is effortless, difficult to control, and requires no intention on the part of the participant (De Houwer et al., 2009); it also does not rely on self-reporting.

We predicted that participants would salivate more when viewing food in the congruent compared to the incongruent background situation, reflecting stronger eating simulations and desire. Second, we included an actual tasting of the food. After the immersion procedure, we offered participants a portion of the soup displayed in the picture and assessed how much they liked it. We predicted that the congruent background situation would increase participants' liking of the soup compared to the incongruent background situation, and that this would again be mediated by eating simulations, and by the salivation measure as an indicator of participants' anticipation of eating the soup. Finally, we expected to replicate the findings of Experiment 1 that eating simulations, expected liking, and desire would be higher in the congruent compared to the incongruent situation.

4.1 Method

4.1 1 Participants and Design

We randomly assigned 80 participants to the congruent, incongruent or to the unsituated control condition. Participants were recruited following a Bayesian sequential sampling procedure (Best et al., 2018; Schönbrodt et al., 2017). Thus, we planned to collect data until the Bayes factors of the effect of congruence on liking and salivation both indicated a moderate level of support in favour or against the hypotheses, with $1/3 > BF_{01} > 3$ for both outcome measures, and to start examining the Bayes factors when 26 participants were collected per condition (78 participants in total). This is because a strong effect size (Cohen's $d = 0.8$) in the ANCOVA power analysis indicated a required sample of 26 participants per condition (power = 0.80, alpha = 0.05, one covariate; G*Power version 3.1.9.2; (Faul et al., 2009). The optional stopping conditions were met upon the first check. Participants who had already been scheduled to participate in the following 24h were tested, and the remaining participants were cancelled. In total, 82 students at Utrecht University participated (right-handed, non-smoking, no food allergies). One participant had to be excluded because they indicated being aware of the hypotheses and the conditions of the study, and another due to a technical malfunction. This resulted in a dataset of 80 participants (17 male, age M = 24.68, SD = 9.21). Participants received partial course credit or €4 euro.

During recruitment, participants were instructed to first eat a filling meal and then to fast for three hours (the consumption of water, tea and coffee was allowed) before their scheduled participation. Participants who indicated that they did not comply with these instructions were excluded from participation at that time. The experiment was conducted between 11.00 and 18.00.

4.1 2 Materials

We offered participants ready-made tomato soup, which is commercially available and frequently consumed in The Netherlands. No package or brand information was displayed to participants. We used the same soup images as in Experiment 1a (i.e., soup in a kitchen, soup in a cinema, and soup on a white background).

4.1 3 Procedure

After assessing participants' hunger (M = 4.94, SD = 1.36), we collected a baseline measure of salivation. Participants viewed an image of a block of wood for one minute, and they collected all the saliva in their mouths while keeping their lips sealed, not moving their tongue, and not swallowing. Participants then spat all the collected saliva into a small plastic cup (Keesman et al., 2016; Navazesh & Christensen, 1982). Participants were then given a 3-minute break, during which they read an excerpt of a novel onscreen. The salivation-collection procedure was then repeated, but this time while participants immersed themselves in one of the three images. The salivation-collection cups were weighed, pre- and post-spitting, and the difference served as the dependent variable. Apart from this, the immersion procedure was the same as for Experiment 1a.

Next, participants were asked a number of questions regarding the soup shown (how tasty, salty, savoury, and aromatic they thought the soup would be; and how much they would like to eat it, the desire measure). They then received 250ml of tomato soup in a small bowl, heated to 65 degrees Celsius. They were asked to consume at least one spoonful of the soup and to evaluate it (how much they liked it, followed by questions about various sensory attributes, such as how salty, savoury, aromatic, etc. they found the soup to be). Participants were allowed to consume the soup ad libitum, and to assess how much was consumed, we measured the weight of the soup bowl pre- and post-consumption (mean consumption was 170 ml). Finally, participants indicated purchasing and serving intentions as before, and rated the perceived healthiness of the soup. Then, they completed the simulation measure, as in Experiment 1 (eating simulations $\alpha = 0.66$). Finally, participants provided information on their habits of eating soup and on their demographics (as for Experiment 1). All answers were given on a 7-point scale.

4.1.4 Analyses

We conducted ANCOVAs, as in Experiment 1a, on eating simulations, desire, expected liking, actual liking, and salivation, and the same mediation analyses as in Experiment 1a, contrasting the congruent and the incongruent conditions for which the experiment was powered. Because determination of our sample size relied on Bayesian analyses, we also computed Bayes factors for the effect of condition on simulations, desire, expected liking, salivation, and actual liking. Finally, to test our pre-registered mediation hypotheses, we conducted two additional mediation analyses to examine whether eating simulations and salivation mediate the effect of congruence on liking.

4.2 Results

Table 5 shows the descriptive statistics and correlations for the main study variables. Eating simulations again correlated with desire and expected liking, and they also correlated with salivation. Salivation further correlated with desire to eat and expected liking. Actual liking correlated with expected liking and desire, which also correlated with each other. Actual liking was slightly higher than expected liking, $t(79) = -2.035$, $p = .045$, $d = 0.227$.

Table 5. Means, standard deviations, and Pearson's correlations for the main study variables.

	M (*SD*)	Desire to eat	Expected liking	Actual liking	Saliva-tion
Eating simulations	4.47 (1.06)	.35**	.52**	.08	.24*
Desire to eat	5.19 (1.45)	-	.76**	.44**	.22*
Expected liking	5.12 (1.25)		-	.30**	.23*
Actual liking	5.46 (1.26)			-	.16
Salivation (difference from baseline)	0.19 (0.27)				-

Note. The salivation score consists of the salivation (in grams) during the simulation task minus salivation during the baseline measure. All other variables were measured on a 7-point scale. Single or double asterisks indicate significant correlations at the $p < .05$ or $p < .01$ level, respectively.

4.2.1 Situational congruence effects

4.2.1 1 Confirmatory analyses. In a replication of Experiment 1, the congruent situation increased eating simulations, desire, and expected liking, compared to the incongruent situation (see Table 6 and Figure 5). When correcting for multiple comparisons ($p = .05/5$), the effect on desire, which was strongly influenced by hunger, was no longer statistically significant, with all other effects remaining.

An ANCOVA with baseline salivation and hunger as covariates showed that the congruent background situation also increased salivation compared to the incongruent situation (see Table 6). We also tested whether the same pattern of results would be obtained by an analysis of saliva difference scores, where baseline saliva weight was subtracted from saliva weight in response to the food image. This ANCOVA on saliva difference scores, which compared the congruent and the incongruent condition with only hunger as a covariate, revealed a similar (slightly larger) effect of congruence, F (1, 51) = 11.460, p = .001, η^2_p = .183 as the pre-registered ANCOVA.

In contrast to our predictions, congruence did not affect participants' liking of the soup when they actually tasted it. Pre-registered tests of interaction effects between congruence and hunger on liking also showed no significant interaction, p = .976.

Table 6. Effect of situational congruence on eating simulations and desire-related variables (adjusted means). All of these tests were confirmatory tests of pre-registered hypotheses.

Dependent variable	Congruent condition	Control condition	Incongruent condition	Effect of covariate hunger	Effect of congruence (congruent vs. incongruent)
Eating simulations	*M* = 4.871, *SE* =.179	*M* = 4.519, *SE* = 0.187	*M* = 4.012, *SE* = 0.179	*p* = .081	**F(1, 51) = 11.774, p = .001 η^2_p = 0.179**
Desire to eat	*M* = 5.616, *SE* = 0.252	*M* = 5.039, *SE* = 0.263	*M* = 4.903, *SE* = 0.252	*p* = .004	**F(1, 51) = 4.322, p = .043 η^2_p = 0.078**
Expected Liking	*M* = 5.695, *SE* = 0.211	*M* = 4.885, *SE* = 0.219	*M* = 4.787, *SE* = 0.211	*p* = .02	**F(1, 51) = 9.578, p = .003 η^2_p = 0.158**
Salivation (in grams)	*M* = 0.681, *SE* = 0.048	*M* = 0.540, *SE* = 0.053	*M* = 0.459, *SE* = 0.048	*p* = .052	**F(1, 50) = 8.466, p = .005 η^2_p = 0.145**
Actual liking	*M* = 5.327, *SE* = 0.263	*M* = 5.577, *SE* = 0.234	*M* = 5.488, *SE* = 0.263	*p* = .177	F(1, 51) = 0.159, p = .692 η^2_p = 0.003

There was no significant effect of congruence on the intention to buy the product (p = .999) or the intention to serve it to friends or family (p = .713), possibly because these were assessed after the soup was tasted and so were less affected by congruence manipulation.

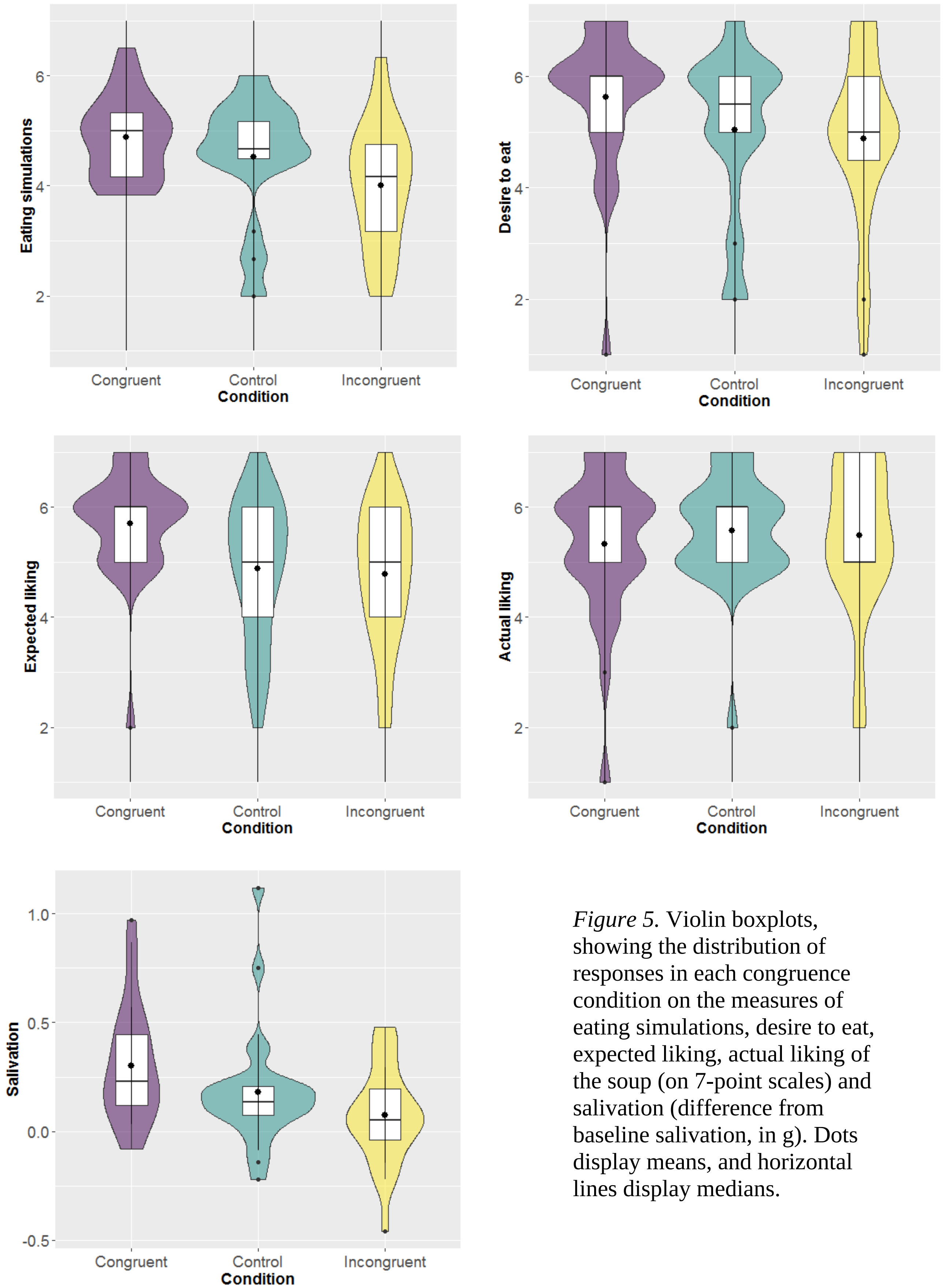


Figure 5. Violin boxplots, showing the distribution of responses in each congruence condition on the measures of eating simulations, desire to eat, expected liking, actual liking of the soup (on 7-point scales) and salivation (difference from baseline salivation, in g). Dots display means, and horizontal lines display medians.

4.2.1.2 Exploratory analyses. Hunger did not significantly interact with congruence on eating simulations, desire, expected liking, or salivation (all $p > .13$).

Compared to the unsituated control condition, the congruent condition increased expected liking of the viewed food ($F(1, 50) = 7.116$, $p = .010$, $\eta^2_p = .125$), and slightly increased salivation ($F(1, 49) = 3.265$, $p = .077$, $\eta^2_p = 0.062$), but it did not increase eating simulations ($p = .178$) or desire ($p = .115$). The incongruent condition differed slightly from the control condition on eating simulations ($p = .098$), and did not differ from the control condition on eating, desire, expected liking, salivation, or actual liking (all $p > .354$).

4.2.2 Mediation analyses

In a replication of Experiment 1, eating simulations mediated the effect of a congruent background situation on participants' desire to eat the soup, relative to an incongruent situation, such that the indirect effect, $b = 0.287$, 95% CI = 0.072, 0.61, $p = .015$, explained 58.18% of the total effect, leaving a non-significant direct effect ($p = .337$). Eating simulations also mediated the effect of congruence on expected liking of the soup, $b = 0.470$, 95% CI = 0.194, .84, $p = .0008$, with 63.55% of the total effect explained by the mediation, leaving a non-significant direct effect ($p = .116$). Eating simulations did not mediate the effects on actual liking, $p = .956$, in contrast to our hypothesis.

We also tested the hypothesis that salivation mediates the effect of congruence on liking of the soup, and found some evidence for an indirect effect, $b = 0.210$, 95% CI = 0.024, 0.053, $p = .047$, in the absence of a direct effect, $p = .633$.

As in Exp. 1, we also explored the indirect effect of congruence on simulations through desire and expected liking. The effect of congruence on simulations was not strongly mediated by desire (indirect effect $b = 0.168$, 95% CI = 0.011, 0.61, $p = .064$; 20.32% mediated; direct effect $b = 0.658$, 95% CI = 0.098, 1.15, $p = .017$), but was mediated by expected liking (indirect effect *b* = 0.422, 95% CI = 0.131, 0.90, *p* = .003; 51% mediated; direct effect *p* = .156).

4.2.3 Bayesian analyses

Because the pre-registered stopping rule for our sample size decision relied on Bayesian statistics to test Hypotheses 1 and 2 (congruence effects on liking and salivation), we report here the Bayes factors for these tests. Specifically, we ran a Bayesian linear regression to test the effect of congruence on actual liking, controlling for hunger (Hypothesis 1), and compared this to a base model with only hunger as a covariate. The Bayes factor BF_{10} of 0.285, provided moderate support for the null hypothesis of no difference between congruence conditions, which is in line with the frequentist hypothesis test. We then ran a Bayesian linear regression to test the effect of congruence on salivation, controlling for hunger and baseline salivation (Hypothesis 2), and compared this to a base model with hunger and baseline salivation as the only covariates. Also in line with the frequentist test, the Bayes factor BF_{10} of 16.812 provided strong support for the alternative hypothesis.

For the sake of completeness, we computed Bayes factors for the effect of condition on simulations (BF_{10} = 25.134), desire (BF_{10} = 1.374), and expected liking (BF_{10} = 10.854) using the same procedure by comparing the full model against a model that only included the covariate hunger. Thus, these Bayesian tests are largely in line with the frequentist tests, showing that situational congruence increases salivation, eating simulations and expected liking, with weaker effects on desire, and no effects on actual liking.

4.3 Discussion

This experiment replicated the key findings of Experiments 1a and 1b by showing that situational congruence affected eating simulations, expected liking, and desire. The effect on desire was relatively weak and did not survive correction for multiple comparisons. This may be due to the fact that participants had fasted for three hours and therefore, hunger overrode some of the situation effects on the desire to eat the soup.

These results also extend Experiment 1 by confirming the hypothesis that situational congruence affects salivation, a physiological indicator of food desire. Contrary to our predictions, congruence did not affect participants' liking of the soup, and salivation did not play a role in an effect on actual liking. This might be because participants had to wait for a few minutes after viewing the food image before tasting the soup, creating a delay during which the effects of an eating simulation could have dissipated. For this reason, we omitted saliva collection in Experiment 3. It is also possible that the bottom-up sensory effects of the tasting of the soup overrode the top-down effects of simulations, reducing the potential effect of situational congruence. In other words, participants may have been positively surprised by the soup, which eliminated any situation effect. This would be consistent with the mean ratings of actual liking, which were higher than participants' expected liking of the soup. Experiment 3 also addressed this issue.

5. Experiment 3

Here, we added a new condition in which participants tasted a less tasty, reduced-salt version of the tomato soup used in Experiment 2. Reducing salt intake is important for public health (e.g., Wyness et al., 2012) and could help to prevent high blood pressure and other health concerns (e.g., Aburto et al., 2013). However, salt-reduced products tend to be liked less by consumers than their normal (higher salt) versions (Liem et al., 2011). Possibly, simulations of a rewarding eating experience can be used to prevent this decline in liking by boosting eating simulations and expected liking. We note that Experiment 2 did not provide evidence that a congruent background situation image increased participants' liking of the standard soup used in this experiment. However, we reasoned that this may have been due to the soup tasting better than expected and thus overriding a potential situation effect. Thus, we wanted to test again whether a congruent background situation could trigger eating simulations that increase liking of a food that might buffer a product against the negative sensory effects of salt reduction.

5.1 Method

5.1 1 Participants and design

We randomly assigned 240 participants to the conditions of a 3 (condition: congruent situation vs. incongruent situation vs. unsituated control) by 2 (soup variant: reduced salt vs. high salt) between-subjects design. We recruited right-handed participants without food allergies (M_{Age} = 43.21, SD_{Age} = 13.88; 82 male) using a commercial research agency and paid €10 for participation. The sample size was determined by the budget available for the study. A post-hoc sensitivity analysis in G* Power (Faul et al., 2007) suggested that this provided 80% power to detect a medium effect (f = .22) of the congruent vs. the incongruent condition. As before, participants had fasted for 3 hours.

5.1.2 Stimulus Material

We used the same images as those used in Experiment 2**.** To produce the high-salt and the low-salt variants of the soup with the same texture and appearance, we diluted the soup with water (200ml water per 570ml soup). In the low-salt condition, we served this diluted soup as is; in the high-salt condition, we added 2.26 grams of salt per 570 ml of the diluted soup (+65% of original salt content) to create the high-salt variant. This produced soup with a somewhat higher salt level than that of the commercially available soup. A convenience sample of 14 employees at Unilever (Vlaardingen, NL) tasted and rated both variants of the soup in a counterbalanced order. Eleven participants reported a preference for the higher-salt over the low-salt variant. Overall, the mean liking rating for the high-salt soup was 4.86 (SD = 0.86), and 4.21 (SD = 1.37) for the low-salt soup, which a one-tailed paired samples t-test indicated as a statistically significant difference in the expected direction, $t(13) = 1.80$, $p = .048$, $d = 0.481$. This pre-test thus revealed the expected preference for the standard, higher salt soup. Again, no product or brand information was given to participants.

5.1.3 Procedure

The procedure used was almost identical to that used in Experiment 2, with the exceptions that data was collected in small groups of participants and that we did not assess salivation. We slightly extended the simulation scales (see appendix, eating simulation scale $\alpha = 0.84$) and added some exploratory questions at the end of the session (relating to, for example, participants' habitual use of salt, and willingness to pay).

5.1.4 Analyses

As confirmatory analyses, we conducted the same ANCOVAs and mediation analyses as those performed in Experiments 1a and 2. These analyses examined the effect of situational congruence on eating simulations, desire, expected and actual liking, and whether eating simulations mediate the effects on desire and liking. We also explored the effects of congruence on the liking of each soup variant separately to assess whether the congruent situation could override the effect of salt reduction on actual liking.

5.2 Results

As Table 7 shows, eating simulations again correlated with desire and expected liking, and here also weakly with actual liking of the soup. As in Experiment 2, actual liking of the soup correlated with desire, and slightly less with expected liking. Again, actual liking of the soup was higher than expected liking, $t(239) = -2.848$, $p = .005$, $d = .184$

Table 7. *Means, standard deviations, and Pearson's correlations for the main outcome variables.*

	M (*SD*)	Desire to eat	Expected liking	Actual liking
Eating simulations	3.79 (1.45)	.45**	.45**	.16*
Desire to eat	4.72 (1.56)	-	.72**	.32**
Expected liking	4.51 (1.31)		-	.22**
Actual liking	4.81 (1.30)			-

Note. Single or double asterisks indicate significant correlations at the $p < .05$ or $p < .01$ level, respectively.

5.2.1 Manipulation check

A manipulation check on taste evaluation of the soup was performed to verify a preference for the high-salt soup variant. An ANCOVA controlling for hunger showed higher liking scores for the high-salt ($M = 5.072$, $SE = 0.115$) than for the low-salt soup ($M = 4.545$, $SE = 0.115$) $F(1, 237) = 10.690$, $p = .001$, $\eta^2_p = 0.043$.

5.2.2 Situational congruence effects

5.2.2.1 Confirmatory analyses. As Table 8 and Figure 6 show, the congruent condition increased eating simulations, desire, and expected liking compared to the incongruent condition. These findings are in line with our hypotheses and replicate the findings of Experiments 1 and 2. When correcting for multiple comparisons ($p = 0.05/4$), the effect on eating simulations was no longer statistically significant, with all other effects remaining.

In contrast to our hypotheses, and as in Experiment 2, the congruent compared to the incongruent condition did not increase actual liking of the soup (see Table 8).

5.2.2.2 Exploratory analyses. Exploratory tests of the effects of congruence on the liking of each soup variant also did not provide evidence of an effect in the high salt ($p = .516$) or the low salt conditions ($p = .164$) separately. Comparing the congruent with the unsituated control condition showed that the congruent condition increased both desire for and expected liking of the soup, $F(1, 154) = 15.331$, $p < .001$, $\eta^2_p = 0.091$, and $F(1, 154) = 27.972$, $p < .001$, $\eta^2_p = 0.124$, respectively, but it did not increase eating simulations, $p = .11$. The incongruent condition did not differ from the unsituated control condition on any of the four measures, all $p > .168$.

Exploratory analyses of intention to buy the soup, willingness to pay for the soup, and willingness to serve the soup to friends or family did not reveal any significant effects of congruence.

Table 8. Effect of situational congruence on eating simulations and desire-related variables (adjusted means). All of these tests were confirmatory tests of pre-registered hypotheses.

Dependent variable	Congruent condition	Control condition	Incongruent condition	Effect of covariate hunger	Effect of congruence (congruent vs. incongruent)
Eating simulations	$M = 4.077$, $SE = 0.156$	$M = 3.681$, $SE = 0.159$	$M = 3.582$, $SE = 0.152$	$p = .005$	**$F(1, 159) = 5.139$, $p = .025$ $\eta^2_p = 0.031$**
Desire to eat	$M = 5.393$, $SE = 0.164$	$M = 4.538$, $SE = 0.150$	$M = 4.228$, $SE = 0.160$	$p = .010$	**$F(1, 159) = 25.686$, $p < .001$ $\eta^2_p = 0.139$**
Expected Liking	$M = 5.152$, $SE = 0.140$	$M = 4.306$, $SE = 0.128$	$M = 4.084$, $SE = 0.137$	$p = .932$	**$F(1, 159) = 29.746$, $p < .001$ $\eta^2_p = 0.158$**
Actual liking	$M = 4.963$ $SE = 0.143$	$M = 4.811$ $SE = 0.144$	$M = 4.650$ $SE = 0.139$	$p = .023$	$F(1, 159) = 2.445$, $p = .120$ $\eta^2_p = 0.015$

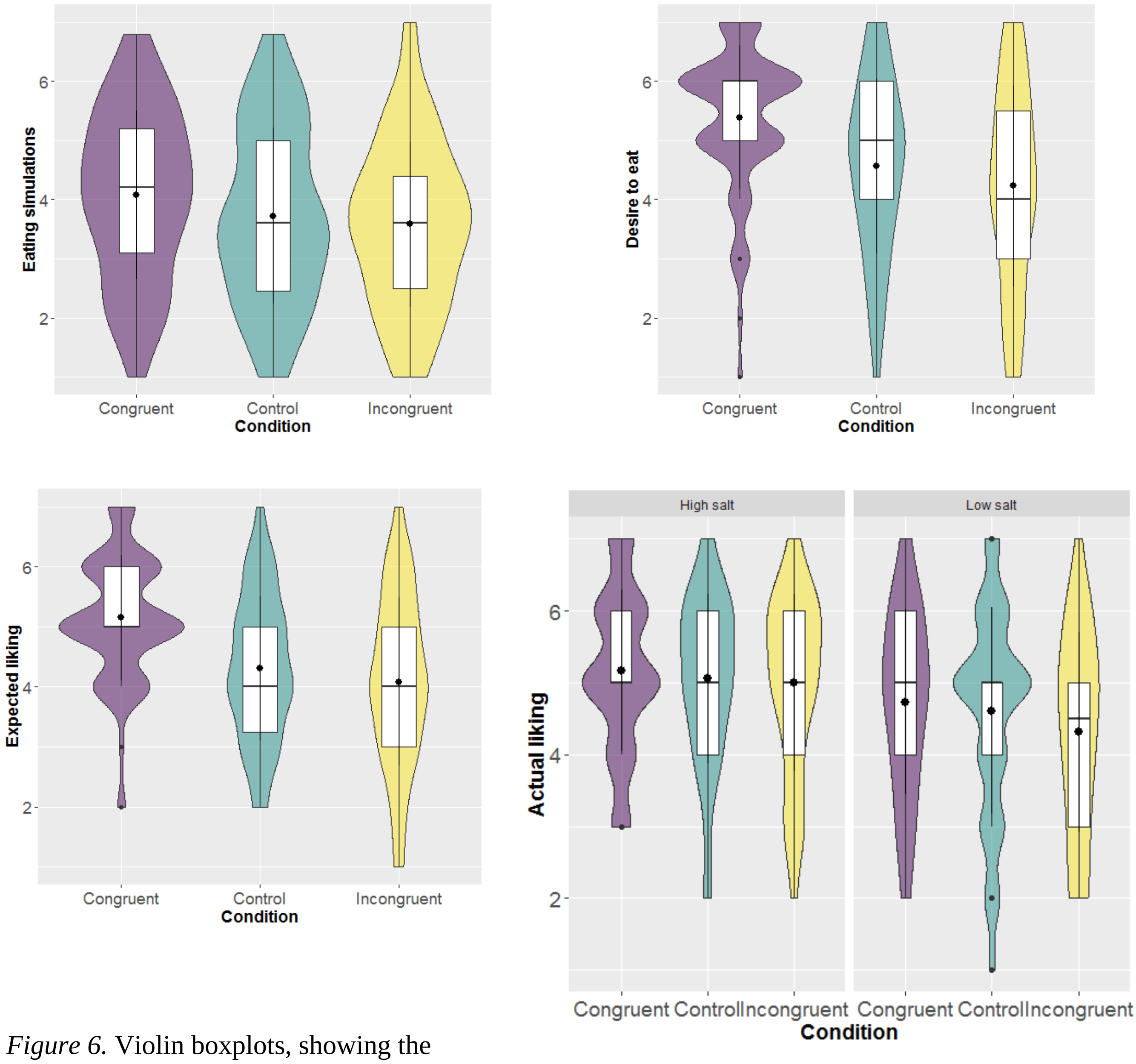


Figure 6. Violin boxplots, showing the distribution of responses in each congruence condition on the measures of eating simulations, desire to eat, and expected liking of the soup. Dots display means, and horizontal lines display medians.

5.2.3 Mediation analyses

5.2.3.1 Confirmatory Analyses. As hypothesized, the effects of congruence on desire and expected liking were mediated by eating simulations (desire: b = 0.107, 95% CI = 0.022, 0.22, p = .022, 14.57% of the total effect mediated, leaving a direct effect of b = .625, 95% CI = 0.335, 0.90, p <.001; expected liking: b = 0.124, 95% CI = 0.024, 0.24, p = .024, 15.62% of the total effect mediated, leaving a direct effect of b = .668, 95% CI = 0.404, 0.93, p <.001).

As further hypothesized, the indirect effect of congruence on actual liking via eating simulations was also significant, while controlling for hunger and soup variant (β = 0.072, 95% CI = 0.010, 0.19, p = .032), with 31.96% of the total effect mediated by eating simulations and no significant direct effect, p > .29. This finding contrasts with the results of Experiment 2, possibly due to this experiment having more power. It shows an indirect effect of congruence on liking through eating simulations, in the absence of a significant total effect (Hayes, 2009). In other words, this finding suggests that although liking was not generally higher in the congruent compared to the incongruent condition, the congruent background image affected liking indirectly by increasing participants' simulations of eating the soup.

5.2.3.2 Exploratory analyses. Finally, we explored whether congruence had an indirect effect on liking through expected liking, again despite the absence of a total effect. We found evidence for this indirect effect, β = 0.210, 95% CI = 0.076, 0.38, p = .002, with 93.11% of the total effect mediated by expected liking. In other words, this finding from an exploratory test suggests that although liking was not generally higher in the congruent compared to the incongruent condition, the congruent background image affected liking indirectly by increasing participants' *expectations of liking* the soup.

Finally, we again explored the indirect effect of congruence on simulations through desire and expected liking. Indeed, the effect of congruence on simulations was mediated by desire (indirect effect *b* = 0.251, 95% CI = 0.143, 0.39, $p < .0001$; 72.57% mediated; direct effect $p = .536$) and by expected liking (indirect effect *b* = 0.311, 95% CI = 0.186, 0.46, $p < .0001$; 89.89% mediated; direct effect $p = .789$).

5.3 Discussion

This experiment replicated the key findings of the previous experiments by showing that situational congruence affected eating simulations, expected liking, and desire. The effect on eating simulations was relatively weak and did not survive correction for multiple comparisons. Again, however, we found that the effects on expected liking and desire were mediated by eating simulations, while the reverse mediation was also significant. As in Experiment 2, and in contrast to Experiments 1a and 1b, there was no effect of congruence on related measures of food attractiveness, such as willingness to buy or serve the food to friends or family. This may be because these variables were measured after tasting the soup, so that the actual eating experience overrode the effects of situational congruence of the background image.

Congruence again did not have a significant total effect on participants' liking of the soup, even when the soup had been manipulated to be less tasty due to salt reduction. This did not support our reasoning that the delay between viewing the background image and tasting the soup in Experiment 2, or the surprisingly tasty soup, could explain the absence of a congruence effect on liking. Possibly, the congruence effect is not strong enough to affect liking in the presence sensory and hedonic information when eating the food. Alternatively, the effect may be small. and as the sensitivity analysis showed, the study was underpowered to reliably detect a small effect. Indeed, despite the absence of such a total effect, we did find the predicted indirect effect of situational congruence on liking via eating simulations (and albeit exploratory, through expected liking). The effect on eating simulations was stronger (albeit still below the medium effect size that the experiment was powered for), and may therefore contribute to this indirect effect. This suggests that via shaping thoughts about what the soup would taste and feel like, the effect of background situations lingered long enough to somewhat modulate participants' eating experience.

6. General Discussion

We presented four pre-registered experiments to test the idea that the background situation in which a food is presented can affect its attractiveness. As predicted, our findings showed that processing an image of a food in a congruent compared to an incongruent situation increased desire and expected liking of the food. A congruent situation also increased the viewers' salivation, a physiological indicator of anticipation to eat or even desire. The evidence for an effect on eating simulations was weaker, remaining significant after corrections for multiple comparisons only in Exp. 1a and 2. However, eating simulations partially or fully mediated the effect on desire, expected liking, and even actual liking. Overall, our findings consistently showed that the background situation in which a food is perceived affects desire for the food and expected liking, and that at least part of this is due to simulations of eating the food.

We also found evidence that, in line with previous research (Keesman et al., 2016; Papies, 2013), high-energy-dense food triggered stronger eating simulations than low-energy-dense foods. However, the effect of a congruent background situation in boosting simulations and desire was the same for low and high-energy-dense foods, in contrast to our hypothesis. Finally, there was very little evidence for an effect of situational congruence on actual liking. Only in Experiment 3 did we observe indirect congruence effects on food liking, through eating simulations and through expected liking. In the absence of total effects of congruence on liking, congruence affected liking indirectly through eating simulations and expected liking. Thus, eating simulations and expected liking are possible routes through which situational congruence affected participants' eating experience, even in a laboratory setting when the image of the background situation was no longer visible. When a total effect is not significant, indirect effects can still occur and be meaningful and important to interpret (Rucker et al., 2011). In addition to the possibility of a false-positive or a false-negative explaining this discrepancy, it is possible that the total effect is weaker than the indirect effect (i.e., the effect of congruence on simulations, and the effect of simulations on liking), or that the dependent variable (i.e., liking) has more measurement error, so that the experiment is underpowered to detect an overall main effect on liking. Thus, it is conceivable that a stronger, more reliable total effect on actual liking would emerge if this effect was measured with less error and a larger sample (see Rucker et al., 2011). It is also possible that this effect only reliably occurs if the cued, congruent background situation is still present during consumption (see also van Bergen et al., 2021),

Given the mixed evidence so far, it is also possible that the congruence of the background situations only affects desire and expected liking, and does not influence subsequent hedonic experiences in a consistent manner. This would be consistent with the neuroscientific literature on the distinction between liking and wanting, and how these responses are triggered by learned cues. Specifically, research has shown that reward-associated cues can trigger dopaminergic, wanting-like responses to drug or food cues, even if they don't reliably increase liking, or hedonic pleasure during consumption (e.g., Morales & Berridge, 2020). It has been proposed that a dissociation between liking and wanting could play a role in, for example, some cases of obesity, binge eating disorders, or food addiction, where individuals display extreme incentive salience attributed to foods, without parallel increases in liking (Morales & Berridge, 2020). However, this dissociation may be less likely to characterise responses to a stimulus like tomato soup among healthy participants. It is also not clear whether our desire measure indeed reflects the kind of incentive salience that the term “wanting” refers to in the neuroscientific literature, or whether it captures “more cognitive forms of desire that involve declarative goals or explicit expectations of future outcomes” (Berridge et al., 2009). However, even if the measures in the current experiment were not able to adequately capture this distinction between liking and wanting, the literature does suggest that different neural and psychological processes may affect actual liking vs. desire in our experiments, beyond top-down effects of simulations and *expected* liking, as we had initially hypothesised. Thus, the effects of situational congruence on actual hedonic experiences and their underlying mechanisms remain an important topic for future research.

Future research could also attempt to distinguish between individuals for whom the congruent situation is imbued with reward value based on the learned association with attractive food, and those for whom this situational cue is used as information to predict the details of the reward itself. This would parallel the distinction between “sign trackers” and “goal trackers” in neuroscientific research on Pavlovian learning (Clark et al., 2012), and could help to differentiate why for some individuals, congruent situational cues boost desire more than for others (see Sarter & Phillips, 2018).

Our findings are consistent with work showing that spontaneous consumption simulations increase appetitive motivation (e.g., Elder & Krishna, 2012; Shen et al., 2016; for a review, see Papies et al., 2017), and that instructions to simulate the process of eating increase desire for the imagined food (Keesman et al., 2016; Muñoz-Vilches et al., 2019, 2020; Xie et al., 2016). Our findings that desire and expected liking mediate the effect on eating simulations are also consistent with research showing that the motivation to eat can increase consumption imagery, suggesting that imagery and desire can mutually and iteratively reinforce each other, especially if they reach conscious awareness (see Kavanagh et al., 2005; Tiggemann & Kemps, 2005). Our research adds to this body of work by showing that images of rich background situations in which a food would typically be consumed can enhance this process. In other words, the desire for the food observed in our studies is not simply a conditioned response to the food, but it depends on the match with the situation: the same food stimulus is more desirable in a congruent than in an incongruent situation, partly because this situation facilitates simulations of actually eating it (see also van Bergen et al., 2021).

Our studies identify a mechanism through which situations affect eating behaviour that clearly differs from habits, In the experiments presented here, contextual cues triggered simulations of eating and of what it would be like to eat a food, which lead to desire. This points to a more reward-based mechanisms than automatic cueing of behaviour. It is possible that this mechanism is completely separate from habitual behaviour. However, it is also possible that it explains some of what is typically assumed to be habitual behaviour, suggesting that reward expectations may play a role as well in at least some habits. Future research should address this possibility.

6.1 Applied and research implications

Our findings that situational cues can increase desire and expected liking of relatively healthy food has implications for efforts to increase the consumption of healthy and sustainable food, for example via health-promoting materials, advertising, packaging, and choice architectures. Such efforts may benefit from healthy and sustainable foods being systematically shown and available in a variety of feasible consumption situations, in order to create representations of a wide variety of congruent consumption episodes for such foods.

In other words, attempts to promote healthy choices should enable consumers to establish situated conceptualisations of eating healthy foods and drinks in a large number of situations. This approach is certainly not the norm. Consider for example advertising for bottled water, a healthy drink. This typically focuses on long-term health consequences, such as staying young, or natural and pure and natural origins of the water. Advertising for unhealthy sugar-sweetened beverages, on the other hand, typically uses richly situated images of summer and social sharing, and language referring to taste and feeling. This is likely to lead to consumers learning memory patterns of such situations being appropriate for consuming sugary drinks, rather than water. Given that labels emphasising health properties (e.g., reduced salt) typically reduce expectations of liking and desire (Liem et al., 2012; Turnwald & Crum, 2019), establishing associations with consumption situations may be more effective at promoting healthy and sustainable behaviour than communicating the long-term benefits of consumption.

Evoking rewarding consumption simulations is likely not limited to situational images, but can also be done through language. Consistent with our findings, presenting healthy and sustainable foods with simulation-inducing language can increase consumption simulations, perceived attractiveness, choice, and actual liking, compared to communicating health benefits (Bacon et al., 2018; Papies, Johannes, et al., 2020; Turnwald & Crum, 2019). At the same time, recent work has shown that the words used to describe healthy menu options are more likely to refer to health benefits, rather than to sensory and hedonic experiences that evoke rewarding consumption simulations (Turnwald et al., 2017). The same has been found for plant-based ready-meals in supermarkets, which were less likely to be described with language reflecting rewarding consumption experiences than meat-based ready-meals (Papies, Johannes, et al., 2020). Future research may examine the cultural processes and eating habits that contribute to the dominant associations between unhealthy foods and sensory and social pleasure, and how these can be re-shaped into food preferences that favour long-term individual and planet health (Willett et al., 2019).

Although there was no total effect of the background situation on actual liking of the food during eating, our findings showed that expected liking, and to a lesser degree eating simulations, played an indirect role in actual liking. Again, it is possible that power was too low to reliably detect a total effect of congruence on liking, but it is also possible that there is simply no true effect on actual liking. Thus, these effects should be interpreted with caution unless they are replicated in a separate study. However, the indirect effects of congruence on liking through simulations and expected liking are in line with research showing that anticipated sensory and hedonic experiences, for example "low-salt" labels, expensive prices tags, and immersive context manipulations, can affect expectancies and actual consumption experiences (e.g., Deliza & MacFie, 1996; Liem et al., 2012; Plassmann et al., 2008; van Bergen et al., 2021), and more generally that context cues and simulations can affect perception in a top-down manner (e.g., Hansen et al., 2006; Krishna & Schwarz, 2014). The question whether situational cues can affect actual liking, for example through simulations and expected liking, is important for stimulating repeated healthy choices. Specifically, only if a manipulation, for example through in-store advertising or on the food package, increases the actual liking of a product, will it increase the chances of repeat purchases. This may contribute to the formation of healthy habits, which is key to healthy and sustainable eating patterns. For this to happen, stronger situational cues, which are also present at the time of consumption, may be necessary. At the same time, to avoid contrast effects, cues that increase expected liking should probably not raise expectations around the food too much beyond what the food can actually "deliver" (Piqueras-Fiszman & Spence, 2015; Si & Jiang, 2017). Whether and how situational cues can effectively be used to affect actual liking and repeat purchases remains an important topic for future research.

Our findings also have implications for research involving images of food. Typically, such images present foods without background situations on a white background. Sometimes, each food is presented on the same plate, regardless of the specific food item; sometimes foods are displayed without dishes altogether. A number of databases of food pictures have recently been created that allow researchers to access large numbers of such food pictures, to increase consistency and experimental control (e.g., Blechert et al., 2014; Charbonnier et al., 2016; Foroni et al., 2013). While we fully recognise the urge to standardise the experimental stimuli used in research, and the need for strong experimental control, our findings suggest that food images without any background situation may not be optimally suited for triggering desire in research participants. Such stimuli may also not accurately reflect how research participants mentally represent food stimuli. As a result, their use may limit both the internal and the ecological validity of some research findings. How to best situate appetitive stimuli for research purposes may be an important question for future research.

6.2 Strengths and Limitations

We preregistered all our experiments in order to ensure transparency, we kept a clear distinction between confirmatory and exploratory findings, and we replicated the key hypotheses tests in four experiments. Although the reliance on power analyses is a strength, we did not power for a direct comparison between the congruent and control condition, which would likely have a smaller effect size than the comparison between the congruent and the incongruent conditions. Thus, at this point, our findings only allow us to conclude that it is possible that both the congruent and the incongruent conditions contribute to the congruence effects, by increasing and decreasing simulations, desire, and expected liking, respectively. Tests of the differences with the unsituated control condition should be interpreted with caution until they are repeated with appropriately larger samples.

After correcting for multiple comparisons, the effect of situational congruence on eating simulations was not significant in Experiments 1b and 3. In addition, in these experiments the effect of congruence on simulations was smaller than the effect on desire and expected liking, and the hypothesised mediation through eating simulations was only partial, leaving a significant direct effect of congruence on desire and expected liking. Thus, although the effect on eating simulations was clearly present in all four experiments and always in the expected direction, it may not tell the whole story of how background situations affect motivation for food – at least if simulations are assessed by explicit, self-report ratings scales, as was done here. In future research, experimental manipulations of simulations could provide more insights into their possible causal role in situational effects on desire. Elder and Krishna (2012) showed that if the dominant hand was blocked, visual cues that can trigger motor simulations of picking up eating utensils no longer increased eating simulations and intention to buy. A similar approach might be used here, albeit to block simulations of eating more comprehensively than motor simulations in response to eating utensils. Future research may also establish whether other psychological processes than eating simulations contribute to the effect of background situations on desire, for example habits or social norms. Specifically, a more habitual behaviour may be experienced as more desirable in a given situation, without relying on simulations; similarly a background situation may activate the representation of a behaviour that seems normative and therefore desirable, again without relying on eating simulations.

Another potential limitation is the lab setting that we used to study effects on desire and liking of food. This clearly has low ecological validity for daily eating behaviour, as it does not represent people's typical eating situations. At the same time, keeping the eating situation constant is the only way in which the effect of the background situation in which the food is presented on desire can be examined independently of the situation in which it is eaten. This allows us to establish the effects of situational cues that could be implemented in food advertising and packaging aiming to affect choices for later consumption. Similarly, examining the effects on actual liking in a setting that is not associated with eating, be it of the target food or other foods, may be the only way to assess liking without potential confounds of food-specific congruence with features of the eating environment. Previous research has established that immersion in different situations affects taste perception and taste preferences for food and alcohol (Betancur et al., 2020; Picket & Dando, 2019; van Bergen et al., 2021). Future research may therefore seek to establish whether, for example, congruence of food and situation during presentation interacts with congruence during eating in meaningful ways.

Finally, we only studied a predominantly Western culture that relies quite heavily on prepared and processed foods, and is exposed to extensive food marketing. Therefore, we cannot easily generalise to different cultures with other eating and food communication habits and therefore, different food representations. When replicating this work in other food cultures, researchers would need to ensure that the foods and background situations chosen for the study match the eating habits of the target population.

6.3 Conclusion

Across four experiments, we showed that presenting a food in a congruent compared to an incongruent background situation made the food more attractive. This effect was to a large extent driven by increased simulations of eating the soup, which tended to be enhanced by the congruent situation. However, the congruence of the background situation did not reliably translate into greater actual liking of the food. These findings are in line with the growing body of research on the role of simulations of previously encoded experiences in motivated behaviour, and point to promising avenues to use situational cues to stimulate healthy and sustainable eating.

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Author contributions

EKP developed the study concept. AvS, MS, EHZ and EKP developed the study design, and GBD provided feedback on the study design. AvS performed all data collection under supervision of EKP and MS, as well as the analysis preparation. EKP performed the statistical analyses reported here, and AvS and EKP drafted the manuscript. All authors provided revisions and approved the final version of the manuscript for submission.

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Appendix

Pretest for image selection

We conducted a pre-test (N = 31) to select a congruent and an incongruent image that are similar in valence, familiarity, and ease of immersing oneself, but that display situations that are clearly different in their congruence with eating tomato soup. Participants were asked to rate nine images (four potentially congruent situations and five potentially incongruent situations), each in two versions. First, participants rated a version of each image that contained no food product to assess: the valence of the image; the valence of the situation in the image; familiarity with the situation in the image; and their ability to imagine being in the situation. Next, participants rated a second version of each image, in which the food product had been added. They again rated how well they could imagine being in that situation, and how well eating tomato soup fitted into the situation.

We selected one image pair (see Figure 1, showing tomato soup in a cinema vs. in a kitchen) on the basis that both images were similar in valence, familiarity, and general ease of simulation (all $p > .47$). The congruent image received significantly higher scores for ease of simulation when tomato soup was included than the incongruent image, and higher scores for congruence with eating tomato soup (all $p < .001$). The congruent image chosen depicts a bowl of soup placed on a kitchen table, from the perspective of a person seated at a table, with utensils typically associated with eating soup (soup pan, coaster, spoon, napkin, bread, and a partially visible bowl of soup for another person) also displayed. The incongruent image suggests the same visual perspective but displays a bowl of soup in a cinema, next to utensils that are not typically associated with eating soup (sunglasses, cinema ticket).

Simulation Scales Experiments 1a and 2

All items were answered on 7-point scales from "not at all" to "very much".

Eating simulations:

I imagined that I was eating the soup.

It was as if I could taste the soup.

It was as if I could feel the texture of the soup in my mouth.

I imagined how eating the soup would make me feel.

It was as if I could feel the warmth coming from the soup.

I imagined using a spoon to eat the soup.

Simulations of being in the situation:

I imagined that I was in the scene.

I had a very clear image of all the details in the scene.

I imagined a sociable situation.

I experienced the feeling that it was time to eat.

Ease of simulation:

I found it easy to immerse myself into the situation depicted in the image.

Experiments 1b and 3

All items were answered on 7-point scales from "not at all" to "very much".

Eating simulations:

I imagined that I was eating the [… / soup].

It was as if I could taste the [… / soup].

It was as if I could smell the [… / soup].

It was as if I could feel the texture of the [… / soup] in my mouth.

I imagined how eating the [… / soup] would make me feel.

Simulations of being in the situation:

I imagined that I was in the situation.

I had a very vivid image of the situation.

Simulation of time:

I imagined the time of day that goes with the situation.

I experienced the feeling that it was time to eat.

Simulation valence:

I imagined a sociable situation.

I imagined a situation that made me feel good.

Ease of simulation:

I found it easy to immerse myself in the situation.

I was able to immerse myself in the situation.

Appendix Table 1

Combinations of foods and situation images shown in each counterbalancing condition in Experiment 1b.

	Tomato Soup	**Popcorn**	**Cucumber slices**	**Cookies**	**Apples**	**Cocktail nuts**
Counterbalance condition 1	Congruent *(kitchen table)*	Congruent *(cinema)*	Incongruent *(coffee shop)*	Incongruent *(kitchen & salad)*	No situation	No situation
Counterbalance condition 2	No situation	No situation	Congruent *(kitchen & salad)*	Congruent *(coffee shop)*	Incongruent *(party)*	Incongruent *(daytime table)*
Counterbalance condition 3	Incongruent (*cinema*)	Incongruent *(kitchen table)*	No situation	No situation	Congruent *(daytime table)*	Congruent *(party)*

Results of mixed effects models in Experiment 1b

Results of mixed effects models that predict eating simulations, desire, and expected liking (confirmatory analyses to test differences between congruent and incongruent context), and intention to buy and willingness to pay (exploratory analyses) from context, product type and hunger. Factor levels were deviation coded (congruent 0.5 vs. incongruent context -0.5; congruent 0.5 vs. no-context -0.5; incongruent 0.5 vs. no-context -0.5; high-energy-dense 0.5 vs. low-energy-dense -0.5). Separate models were constructed to compare the three context conditions to each other. Predictors printed in bold are significant at $p < .05$. The Model R^2 represents the variance explained by the entire model, including fixed and random effects.

DV	*Predictors*	**Congruent vs. incongruent context**				**Congruent context vs. no context**				**Incongruent context vs. no context**			
		b	*SE*	*t*	*p*	*b*	*SE*	*t*	*p*	*b*	*SE*	*t*	*p*
Eating simulations	Context	**0.248**	**0.071**	**2.747**	**.043**	0.095	0.097	0.977	.376	-0.157	0.078	-2.013	.095
	Product type	**0.202**	**0.069**	**2.911**	**.007**	-0.046	0.044	-1.046	.319	0.122	0.079	1.540	.157
	Hunger	0.035	0.069	0.502	.616	0.071	0.069	1.023	.308	0.091	0.068	1.347	.180
	Model R^2	0.498				0.492				0.449			
Desire to eat	Context	**0.334**	**0.090**	**3.691**	**.003**	**0.194**	**0.083**	**2.330**	**.037**	-0.145	0.078	-1.859	.067
	Product type	-0.064	0.149	-0.432	.679	-0.068	0.189	-0.362	.731	-0.068	0.158	-0.429	.684
	Hunger	**0.172**	**0.052**	**3.292**	**.001**	**0.137**	**0.057**	**2.406**	**.018**	**0.144**	**0.058**	**2.502**	**.014**
	Model R^2	0.233				0.304				0.278			
Expected liking	Context	**0.371**	**0.110**	**3.377**	**.011**	**0.261**	**0.080**	**3.280**	**.001**	-0.118	0.130	-1.173	.272
	Product type	0.114	0.129	0.887	.397	0.039	0.239	0.164	.875	0.108	0.144	0.832	.429
	Hunger	0.072	0.052	1.380	.170	0.022	0.053	0.409	.683	0.023	0.054	0.430	.668
	Model R^2	.207				0.245				0.191			
Intention to buy	Context	**0.304**	**0.110**	**2.765**	**.030**	**0.208**	**0.085**	**2.438**	**.028**	-0.097	0.084	-1.152	.267
	Product type	0.052	0.055	0.944	.365	-0.054	0.172	-0.316	.763	-0.097	0.101	-0.958	.372
	Hunger	0.042	0.035	1.215	.227	0.037	0.057	0.650	.517	0.036	0.057	0.629	.530
	Model R^2	0.195				0.263				0.216			
Willingness to pay	Context	**0.261**	**0.081**	**3.200**	**.004**	0.079	0.069	1.144	.255	-0.174	0.083	-2.090	.057
	Product type	0.091	0.220	0.411	.695	0.140	0.261	0.538	.610	0.083	0.212	0.391	.709
	Hunger	0.024	0.055	0.441	.660	0.013	0.062	0.214	.831	0.010	0.058	0.180	.858
	Model R^2	0.281				0.426				0.337			
Willingness to serve to friends/ family	Context	**.238**	**.084**	**2.846**	**.012**	.151	.085	1.774	.106	-.090	.074	-1.214	.226
	Product type	.323	.153	2.115	.076	.116	.161	0.722	.496	.209	.141	1.486	.191
	Hunger	.026	.057	0.451	.653	.013	.061	0.211	.833	.008	.062	0.131	.896
	Model R^2	.297				.363				.332			

Note: confirmatory analyses of pre-registered hypotheses are indicated by grey shading; other results are from exploratory analyses.