Grounding desire: The role of consumption and reward simulations in eating and drinking behaviour

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Abstract

This chapter presents a grounded cognition theory of desire and motivated behaviour, along with empirical evidence that supports it, and discusses implications for self-regulation. The grounded cognition theory of desire suggests that desire arises when an internal or external cue triggers a simulation of an earlier appetitive experience that was rewarding and that has been stored as a situated conceptualization, incorporating information about the setting, actions, events, emotions, etc. Once part of this situated representation is cued, it can re-activate its other elements via pattern completion inferences, and lead to the experience of desire and motivated behaviour. The chapter will review studies supporting this account, using behavioural, physiological, and neuro-imaging methods. Research shows, for example, that food and drink cues (e.g., images, words) trigger spontaneous consumption and reward simulations (e.g., thoughts of eating and enjoying the food), that these simulations lead to desire and bodily preparations to eat (e.g., self-reported cravings, salivation), and that diffusing these simulations with mindfulness-based techniques reduces their effect on desire. The chapter also discusses related findings in research on marketing and food labelling, and addresses implications for interventions.

How does desire arise in the human mind? Most people experience a variety of desires throughout the day, with desires for food, drink, and social interactions most prevalent (Hofmann, Baumeister, Förster, & Vohs, 2012). Often, these desires lead to self-control conflict, as acting on them would interfere with the pursuit of a long-term investment goal. Such conflicts take up cognitive resources, and they typically lead to self-control failures sooner or later (Hofmann, Vohs, & Baumeister, 2012). Thus, desire can have a variety of intrapersonal and interpersonal consequences, making it a topic of key significance in social psychological research. In this chapter, I will present a grounded cognition approach to understanding the emergence of desire, which we have defined previously as the conscious or unconscious state of motivation for a specific stimulus or experience that is anticipated to be rewarding (Papies & Barsalou, 2015). The grounded cognition theory of desire attempts to explain how desire and motivated behaviour arise in response to external cues, using basic cognitive and memory processes, which are often unconscious (Papies & Barsalou, 2015; Papies, Best, Gelibter, & Barsalou, 2017; Papies, Pronk, Keesman, & Barsalou, 2015). Thus, in contrast to work on, for example, the elaborated intrusion theory of desire (Kavanagh, Andrade, & May, 2005), which argues that conscious elaboration of sensory imagery related to consumption plays a key role in desire, the grounded cognition framework assumes that both the desire itself, as well as the processes that contribute to it, can be conscious or nonconscious.

After briefly describing the theory, I will review evidence supporting it in the domains of eating and drinking behaviour. Then, I will discuss how interventions can regulate problematic desires by targeting consumption and reward simulations. Finally, I will briefly address the possible role of simulations in self-regulation and social psychology more generally, and discuss directions for future research.

A grounded cognition theory of desire

The grounded cognition theory of desire suggests that desire arises from consumption and reward simulations in response to appetitive cues, based on previous consumption experiences. Every time we consume a food or drink, we lay down a rich situated memory of this experience that integrates various streams of information, which is referred to as a situated conceptualization (Barsalou, 2003, 2009; Papies & Barsalou, 2015). Such situated conceptualisations can include, for example, sensory information on the taste and texture of the food or drink, visual information on the food or drink and one's surroundings, actions such as reaching out, using utensils, and chewing, information about one's physical state and the social, time, and physical context of eating or drinking, information about accompanying foods or drinks, immediate (bodily, cognitive, emotional and hedonic) consequences of consumption, and short-term or long-term goals related to consumption. As Barsalou and colleagues describe (Barsalou, 2016; Wilson-Mendenhall, Barrett, Simmons, & Barsalou, 2011), these "local" streams of information get integrated into "global" representations that facilitate coherent conceptual interpretations of the events in a given situation (Papies et al., 2017).

When a relevant cue is encountered later, for example a visual food cue, this will re-activate the best-matching situated conceptualisation available from previous experiences. From a Bayesian perspective, the best matching situated conceptualisation is one that has been used frequently in the past, and that seems to provide a good fit with current situational cues. Thus, the brain continually attempts to categorise the type of situation that is occurring, by mapping current information onto previously stored situated conceptualisations and activating the conceptualisation that matches what is encountered in the moment (Barsalou, 2009; Papies et al., 2017). Non-present elements of the situated conceptualisation can then be simulated via pattern completion inferences. As a result, an external cue, such as the mere picture of a food, can activate a vivid re-experience of eating the food, including a representation of its taste and texture, motor actions of picking it up to eat it, and other features of a consumption episode, despite no actual food being present. The theory further suggests that this matching process is sensitive to state and trait individual differences, such that, for example an image of pizza encountered when hungry is likely to activate a situated conceptualization of previously eating pizza when hungry. This will make the pizza in the image appear more rewarding than when encountered in a satiated state, when eating pizza previously produced less reward.

Such situated conceptualizations are useful for understanding situations, anticipating likely events, and planning and executing goal-directed action (Barsalou, 2009, 2016). Imagine, for example, passing a cafe in a new city where you have just arrived for a conference. Although you have never been to this cafe or even this city, you recognise this establishment as a place where you can drink coffee and eat snacks, you know how to line up at the counter when you enter, you know that a barista will prompt you for your order, and you know which coffee to choose based on your previous experiences with similar beverages. These predictions and preferences can be generated effortlessly through simulations within the situated conceptualisations of having coffee in a cafe.

Importantly, simulations within situated conceptualisations not only help to interpret situations as they occur and align our behaviour, they can also lead to novel – and possibly problematic – desires (Papies & Barsalou, 2015; Papies et al., 2017). Imagine having entered the cafe in the example above to drink coffee before the start of the conference. As you stand at the counter waiting to order your drink, you see a variety of baked goods in front of you. You spontaneously simulate eating them, imagining their taste, texture, and the resulting hedonic experience. To the degree that any aspect of this simulated experience is rewarding, this will trigger the motivation to enact it. This may lead you to either impulsively purchase a piece of cake, or to experience a conscious craving, which may or may not lead you to order some cake. Critically, the consumption simulations triggered by the sight of the cake help you predict what eating the cake would be like, and the associated reward will determine whether this creates a desire. Thus, consumption simulations within previously stored situated conceptualisations can both help navigate known and less known environments, and also create novel desires and lead to unplanned motivated behaviour, or impulses.

The research reviewed in the next sections supports the core tenets of this theory. It shows that food and drink stimuli trigger consumption and reward simulations, especially if they are attractive, as evidenced in both spontaneous language and in behavioural and neuro-imaging findings. Further evidence shows that consumption and reward simulations lead to desire for the simulated foods and drinks, as shown in behavioural and physiological data. Finally, self-regulation techniques that target consumption and reward simulations can reduce desire.

Appetitive stimuli trigger consumption and reward simulations

A variety of research findings suggest that food and drink cues trigger consumption and reward simulations, especially if they are attractive. In initial studies on this topic, a feature listing task was used to assess participants' mental representations of food and drinks, and the possible role of simulations in these representations, or situated conceptualisations (Papies, 2013). Previous research using the feature listing paradigm has shown that participants describe objects by listing diverse features such as components of the object, visual properties, properties of background situations, and interoceptive states (Wu & Barsalou, 2009). In addition, when participants were asked to simply list typical properties, this led to similar types of properties being generated as asking participants to construct and describe a mental image of the object. This suggests that people spontaneously use conscious mental imagery, or nonconscious simulations, during feature listing (Wu & Barsalou, 2009).

Consumption and reward simulations of food. Applying this paradigm in the food domain (Papies, 2013) participants were asked to list typical features of four attractive foods and four neutral foods (e.g., chips, cookie; cucumber, rice), presented as food words, mixed with non-food filler items (e.g., mattress, sheep). All features were then coded in a hierarchical coding scheme, categorising them as consumption and reward simulation features when they referred to the sensory properties of the food (e.g, taste, texture, temperature), eating context (e.g, time, social setting, physical setting) and immediate positive consequences (e.g., hedonic or bodily consequences). Non-eating simulation categories included visual features, purchase, preparation and storage features, features describing long-term consequences of eating a food, and category and linguistic features, and others. Again, participants were not instructed to simulate or imagine eating the food, or to describe an eating experience, but simply to describe the features that are typically true of the food. Therefore, if they list words that describe the mouthfeel of the food, or a specific eating situation, this may suggest that they simulate eating the food in a relevant context, and describe characteristics of that experience in the feature listing task.

The results of this study are in line with this account and suggest that participants spontaneously simulate eating the food they are asked to describe, especially if it is attractive. Specifically, the findings showed that participants listed large numbers of consumption and reward simulation features when describing the foods. This was especially the case for the attractive foods, where 53% of listed features were consumption and reward features, compared to 26% for the neutral foods. Neutral foods, on the other hand, were described more heavily in terms of visual features, and production and preparation features. As an example, for the food “chips”, participants listed features such as *salty, crunchy, tasty, at night, with drinks*; whereas for the food “rice”, participants listed features such as *white, small, long, from Asia, neutral taste, has to be cooked*. Additional analyses showed that for attractive foods, the proportion of consumption and reward simulation features correlated with their perceived attractiveness. These findings provide initial support for the hypothesis that attractive foods are represented through simulations of eating and enjoying them. From the perspective of the grounded cognition theory of desire, this may reflect people's own eating experiences, as well as vicarious learning through the eating experiences of others, and advertisements. Indeed, even menu descriptions of unhealthy foods have been shown to focus more on rewarding, sensory eating experiences than the descriptions for healthy food (Turnwald, Jurafsky, Conner, & Crum, 2017), which may contribute to culturally shared representations of these foods.

Consumption and reward simulations of drinks. In a recent set of studies, we extended these findings to understanding the representations of non-alcoholic beverages (Rusz, Best, & Papies, 2019). Participants completed a feature listing task for two sugar-sweetened beverages, bottled water, tap water, and a number of control drinks. In one experiment, the feature listing was implemented with the standard instructions to "list features that are typically true of... ", and drinks were presented as words; in the other experiment, instructions were changed to ask participants "How would you describe this drink right now?", and images of drinks were presented. In both experiments, participants listed more consumption and reward features for the sugar-sweetened beverages than for water, with sensory features being particularly salient for the sugar-sweetened beverages. In addition, the proportion of consumption and reward features correlated with consumption frequency, especially for the sugary drinks. Thus, consuming a drink more often was associated with listing more consumption and reward simulation features, describing its taste, texture, mouthfeel, and hedonic and refreshing properties. In line with the findings for food, this again suggests that appetitive stimuli are represented in terms of consuming and enjoying them, and that these representations are learned from previous experiences.

Similar patterns have been observed for participants' representations of alcoholic drinks (Keesman et al., 2018). Here, we found that participants listed more consumption and reward features for alcoholic beverages that they frequently consume compared to alcohol they don't typically consume and compared to water (but not compared to sugary drinks, which were again heavily represented in terms of sensory features). Critically, the alcoholic drinks were represented particularly in terms of sensory features and in terms of drinking context, more so than in terms of the immediate consequences of consumption, which include hedonic consequences. Within the category of context features, it was particularly the social context that dominated participants descriptions, with example features being *friends* and *having a good time*. In other words, when asked to list features that are "typically true" of their typical alcoholic drink, participants were more likely to mention social drinking situations than the fact that it tastes good. These findings show that alcoholic drinks are strongly represented in terms of consuming them in social situations, or through situated consumption simulations.

Neural evidence for consumption and reward simulations. Neuroimaging research provides further evidence that food cues trigger consumption and reward simulations. Across a variety of studies, the processing of food images during fMRI activates the same brain areas that are implicated in actual eating (for reviews, see Chen, Papies, & Barsalou, 2016; van der Laan, de Ridder, Viergever, & Smeets, 2011). This "core eating network" involves, among others, the primary visual cortex and fusiform gyrus for viewing and recognising the food in an image, the insula and frontal operculum as primary taste areas, the amygdale to attribute attentional salience, the orbitofrontal cortex and ventral striatum for reward prediction and experience, and the cerebellum for anticipated motor activity (Chen et al., 2016). From the grounded cognition perspective, and consistent with the feature listing findings reviewed above, this suggests that people simulate the taste and reward from a food when they process a food picture. Across studies, these brain activations in response to mere food pictures are especially pronounced for palatable foods, again suggesting that consumption and reward simulations are especially likely for attractive stimuli. Again, this may partially reflect direct eating experiences and culturally shared representations (see Turnwald, Jurafsky, et al., 2017), as well as an "evolutionary mismatch" such that our brains have evolved to respond strongly to high-calorie foods, while acting on these responses is not beneficial in today's food-rich environments (Stroebe, Papies, & Aarts, 2008; van Vugt, De Vries, & Li, 2020, this volume).

Consumption and reward simulations contribute to desire

The research discussed so far has demonstrated that attractive foods and drinks can elicit simulations of consuming and enjoying them. Next, I will review findings showing that these simulations in turn contribute to desire for these stimuli, and that this is again especially likely for attractive foods and drinks.

Correlational findings. In an initial test of the association between simulations and desire, we assessed the relation of consumption and reward simulation features produced for 8 unhealthy food words with participants self-reported desire for these foods. We found that indeed, the proportion of consumption and reward simulation features predicted desire (Papies, Tatar, Best, Barsalou, & Tavoulari, 2018). Importantly, this relationship remained when controlling for participants' typical frequency of consuming each food, which itself was a strong predictor of desire to eat it. Thus, consumption and reward simulations explained unique variance in people's consumption motivation in addition to consumption habits.

In our recent experiments assessing representations of non-alcoholic beverages (Rusz et al., 2019), we also assessed desire by asking how much participants would currently like to drink each drink. We further assessed consumption habits by asking participants how often they typically consume each drink. As in the desire for food described above, we found that consumption habits were the strongest predictor of desire to consume a drink. In line with the grounded cognition theory of desire, however, when controlling for habits, consumption and reward simulations predicted desire for sugary drinks, but not for water. Together, these studies suggest that attractive foods and drinks are not only more likely to elicit consumption and reward simulations, but that these simulations are also more likely to predict the motivation to consume, compared to neutral foods and drinks.

We also assessed the relation between simulations and desire in the domain of alcohol. In the feature listing study described above (Keesman et al., 2018), we measured participants' desire to consume alcohol by assessing their current cravings, and by probing their preference for a voucher for an alcoholic drink or a non-alcoholic drink as an additional reward for participating in the study. In line with our findings that social context features were especially salient for frequently consumed alcoholic drinks, we found that these features were also correlated with alcohol cravings, and with participants' preference for an alcohol voucher, as a behavioural measure of alcohol desire. Social context features were also correlated with a higher frequency of intrusive alcohol-thoughts in participants' daily lives. Together, these findings suggest that thinking about alcohol in terms of the social situations one consumes it in makes it particularly attractive and hard to resist.

Experimental findings. While the work discussed so far has provided correlational evidence for the relation between consumption and reward simulations and desire, there is also some experimental evidence for this relationship, suggesting a causal effect. In one recent experiment, we used the amount of saliva in response to viewing foods as an implicit measure of desire (Keesman, Aarts, Vermeent, Häfner, & Papies, 2016). Salivary responses to food and food cues have been argued to reflect the body's preparation to eat (Nederkoorn, Smulders, &

Jansen, 2000; Tepper, 1992), and can therefore be seen as a measure of desire. Critically, they occur without effort or intention on the part of the participant, and they are difficult or even impossible to control, thus showing key features of automatic measurement processes and implicit measures (De Houwer, Teige-Mocigemba, Spruyt, & Moors, 2009). Thus, simply measuring the amount of salivation produced in response to different foods may be particularly suited to studying the motivation to eat these foods, without effects of socially desirable responding. Participants in this experiment were exposed to three different food stimuli one at a time, namely a neutral food (bread with cheese), an attractive food (bowl of crisps), and a sour food (slice of lemon), in addition to a non-food stimulus for a baseline saliva measure (block of wood). Half of participants were instructed to merely look at the object for one minute, while the other half of participants were instructed to vividly imagine eating the object for one minute. During this time, participants let all saliva accumulate in the mouth, which was then spit into a cup and weighed by the experimenter. Afterwards, we assessed participants' eating simulations in response to each stimulus ("I imagined that I was eating the object"), as well as their desire ("I would have liked to eat the object").

In line with previous findings, we found that even without being instructed to imagine eating the food, participants reported stronger eating simulations for the attractive compared to the neutral and the sour food, and for neutral food compared to the non-food item. This again suggests that participants spontaneously simulate eating a food that they are exposed to, especially if this is attractive. The pattern for salivation was very similar, with higher salivation for the attractive than for the neutral food, and for the neutral food than for the non-food object. The level of salivation in response to the sour food was highest, probably reflecting the body's response to protect the teeth from the acidity of the lemon. Importantly, the instruction to imagine eating the object increased salivation for all stimuli, but most strongly for the attractive food. In other words, eating simulations increased the body's preparation to eat, especially when the presented food was attractive. Thus, both correlational and experimental evidence demonstrate that consumption simulations increase desire, especially for attractive food and drink.

We also tested whether eating and drinking simulations can be affected by cues signalling consumption situations. Appetitive stimuli are typically not encountered and enjoyed in isolation, but in rich situations that, according to the grounded cognition theory of desire, are stored as part of the situated conceptualisations of these stimuli. Thus, situational cues should be able to trigger consumption and reward simulations, or to increase the likelihood that an appetitive stimulus activates a situated conceptualisation of consuming and enjoying a food or drink, and therefore increase consumption simulations and desire.

To test whether information about consumption situations can indeed affect desire, we conducted an experiment comparing situated and non-situated alcohol stimuli. We manipulated whether a variety of alcoholic drinks were presented in a congruent drinking context (e.g., an ale in a pub), an incongruent drinking context (e.g., a cocktail in a business meeting), or no context. Participants were assigned to one of these conditions and briefly immersed themselves in each image, before rating their consumption simulations ("I imagined that I was drinking the... ", "It was as if I could taste the...") and desire. Results showed that desire was higher for drinks presented in a congruent compared to an incongruent context, with the no-context control condition in between. Importantly, the effect of congruence on desire was mediated by consumption simulations. In other words, an image of an appropriate drinking situation increased participants' spontaneous simulations of drinking the alcohol presented, which in turn increased desire to drink it. In a similar series of experiments in the domain of food, we found that presenting a food in a congruent eating context, compared to an incongruent or no context, increased eating simulations, expected liking, salivation, and desire (Papies, Stekelenburg, Smeets, Zandstra, & Dijksterhuis, 2019). Context had an indirect effect on expected liking, desire, and actual liking, through eating simulations. In other words, viewing a food in a matching eating context increased simulations of eating it, which increased desire to eat it and actual enjoyment. This is in line with the grounded cognition theory of desire, as it suggests that situational information is stored along with information of the sensory features of products, and can contribute to rewarding re-experiences and desire through pattern completion inferences. These experiments provide further evidence that consumption and reward simulations, which can be enhanced by context features, play a key role in the emergence of desire in response to appetitive cues.

Findings from food marketing. Evidence from the domain of marketing research shows that specific motor simulations, for example of picking up a food, may also play an important role in desire. These findings extend previous work showing that people spontaneously simulate interacting with objects they are presented with in their habitual way, for example picking up a teapot with one's dominant hand (Tucker & Ellis, 1998). Indeed, for images of both household products and food, people spontaneously simulate picking them up and engaging with or consuming them with their dominant hand, and being able to do this contributes to their preference for these products or their motivation to consume them (Eelen, Dewitte, & Warlop, 2013; Elder & Krishna, 2012). As an example, when the fork next to a piece of apple pie or the spoon in a bowl of yoghurt face the dominant hand of the perceiver, this increases spontaneous eating simulations and purchase intentions for desirable products. However, when the dominant hand is blocked, for example because participants press a clamp in their hand, this effect disappears (Elder & Krishna, 2012) – presumably because blocking the physical resource required for the action of picking up the spoon or fork interferes with mentally simulating this action, in turn reducing desire for the food. Other work, too, has shown that preventing the simulation of holding or interacting with a food or drink by occupying one's dominant hand can reduce the perceived attractiveness of the objects; conversely, engaging in relevant movements (e.g, approaching an image) or holding an object that facilitates interacting with the food can increase desire (Shen & Sengupta, 2012; Shen, Zhang, & Krishna, 2016). These findings suggests that motor simulations of picking up a food, as a specific aspect of consumption simulations, play an important role in the desire for food.

Finally, research on food labels and food descriptions provides further support for the role of simulations in desire, albeit indirectly. Field experiments by Turnwald and Crum (2017; 2019), for example, have shown that labelling vegetable-based dishes with sensory-focused terms (e.g., "Sweet Sizzlin' Green Beans and Crispy Shallots"), compared to health-focused terms (e.g, "Light 'n Low Carb Green Beans and Shallots"), increased consumers' choices and taste ratings of these dishes. Research from our own lab further suggests that eating simulations may be underlying these effects, as self-reported eating simulations in response to such labels correlated strongly with desire (Papies et al., 2018). Conversely, foods that are labelled by emphasising their healthy features, for example being low in salt or low in fat, are expected by consumers to taste less salty and fatty and to be liked less. Consequently, they are indeed liked less in taste tests, compared to the same products without such health-relevant labels (e.g., Kahkonen & Tuorila, 1998; Liem, Miremadi, Zandstra, & Keast, 2012). These findings make sense from a simulation perspective, as they suggest that the health labels induce a specific simulation of eating food low in salt or fat, based on previous experiences, which likely is associated with reduced reward. Even though these simulations may not reach conscious awareness, they nevertheless affect expectancies and actual experiences of a product.

Previous work indeed supports the account that eating simulations created by food descriptions and food labels may create expectancies around the sensory and hedonic properties of a food, which then affect motivation to consume, and also actual consumption experiences. The central role of expectancies was demonstrated in a seminal study by Yeomans and colleagues (2008), who offered their participants a novel food, smoked salmon ice-cream. When this was presented as "ice-cream", it was liked much less than when it was presented as "frozen savoury mousse" or with the uninformative label "Food 386", as the label "ice-cream" led to the expectation of a sweet and fruity flavour. Thus, it seems that the eating simulations that are triggered by food labels can be experienced as expectancies of what a food will taste like, which then affect actual experiences.

Consistent with this reasoning, neuro-imaging research (Grabenhorst, Rolls, & Bilderbeck, 2008) has shown that tasting a savoury solution that is labelled as "rich and delicious flavor" leads to higher pleasantness ratings and stronger associated reward activations in the brain, compared to tasting the same solution labelled as "boiled vegetable water". Similarly, tasting orange juice labelled as "extra sweet", compared with the same juice labelled as "less sweet", was associated with stronger activations in primary taste areas and higher sweetness ratings (Woods et al., 2011). Thus, food labels may trigger very specific sensory and reward simulations, which are then superimposed on the actual taste perception and affect consumer experience (for similar effects in the domain of colour, see Hansen, Olkkonen, Walter, & Gegenfurtner, 2006). Such experiences, in turn, will update existing situated conceptualisations of the products involved, and affect future consumption decisions.

Targeting consumption and reward simulations can reduce desire

The research discussed so far has described how simulations are triggered by external cues, how they are based on previous experiences, and how they contribute to desires for foods and drinks. What are the implications of these findings for self-regulation? Given that desires often lead to costly self-control conflicts, how can problematic desires be prevented, or how can they be reduced once they have arisen?

Cueing and training interventions. In previous work, I have introduced the distinction between cueing interventions and training interventions to target the nonconscious processes that often lead to self-control failure (Papies, 2016b, 2016a, 2017b), to facilitate the development of interventions that are grounded in strong theory and fundamental research (Fiedler, 2020, this volume). In brief, this approach assumes that the failure to enact conscious intentions in health behaviour (i.e., the intention-behaviour gap) often results from situational cues triggering nonconscious cognitive processes that affect behaviour outside of conscious awareness. As an example, while a consumer may have the intention to purchase only healthy, unprocessed foods during grocery shopping, a highly salient promotion of savoury snacks in the store may lead to an impulsive purchase of unhealthy foods, thereby creating an intention-behaviour gap. From this perspective, to prevent such effects and thus bridge the intention-behaviour gap, interventions should either change the situational cues (e.g., remove salient promotions of unhealthy foods; see Best & Papies, 2017) or change the cognitive structures that lead to unhealthy behaviours when triggered by situational cues (e.g., reduce the positive affect or approach impulses associated with unhealthy foods). I will now discuss cueing and training interventions in more detail, and address how they relate to consumption and reward simulations.

Effective cueing interventions should be designed to ensure that external cues no longer trigger consumption and reward simulations that lead to problematic desires. As discussed in Best & Papies (2017), such "cueing interventions" have been implemented successfully, for example, in the domain of smoking, where the introduction of bland packaging for cigarettes, and the salience of other people smoking and of smoking paraphernalia through smoking bans in public spaces, has markedly reduced the prevalence of smoking and rates of uptake among adolescents. Such interventions targeting the micro-environment around where a consumer behaviour takes place (Hollands et al., 2017) have the benefit that they can easily be scaled up to affect large groups of consumers at relatively low cost. Again, their effectiveness rests in ensuring that external cues don't trigger problematic consumption and reward simulations, either by removing "tempting" cues, or by introducing cues that will reduce the reward of appetitive cues (e.g., cues that activate health goals, or health implications of an appetitive stimulus; see Best & Papies, 2017; Stroebe, van Koningsbruggen, Papies, & Aarts, 2013). Cueing interventions can also be used to trigger consumption and reward simulations for desirable foods and drinks, as recent work has shown that, for example, food labels that trigger consumption and reward simulations can increase the attractiveness and choice of meat-free foods (Papies, Daneva, & Semyte, 2019; Turnwald & Crum, 2019; see Walton & Brady, this volume, for other "positive" interventions that may work through changing the situated conceptualisations that are activated to interpret a situation).

Alternatively, "training interventions" can be designed to change the situated conceptualisations that lead to problematic desires and behaviours once they are activated by situational cues (Papies, 2016b, 2017b). For example, a computerised training where one repeatedly processes negative affective stimuli along with specific foods or drinks (i.e., evaluative conditioning), or repeatedly withholds motor approach responses to tempting stimuli (i.e., inhibitory control training) could change the content of one's situated conceptualisations involving those food or drink items, such that they are less likely to later evoke problematic desires or approach impulses (e.g., Hollands & Marteau, 2015; Stice, Lawrence, Kemps, & Veling, 2016). Thus, the goal of these types of interventions is to reduce the likelihood that problematic desires or appetitive behaviours are enacted automatically in response to external cues.

Mindfulness-based training interventions. Recently, we have specifically investigated the potential of mindfulness-based training interventions to reduce impulses, cravings, and choices of attractive, unhealthy foods. In these brief interventions, participants are shown images of attractive foods, among other stimuli, and are instructed to observe all responses that they may have to these stimuli as "mere mental events". Specifically, without any mention of mindfulness or meditation, they are asked to simply notice all thoughts, emotions and experiences in response to the pictures, and to consider them as mental states that arise and dissipate, without one having to act on them (Papies, 2017a; Papies, Barsalou, & Custers, 2012; Papies et al., 2015). In essence, then, participants are trained to observe their consumption and reward simulations, and to see them come and go (Keesman, Aarts, Häfner, & Papies, 2017; Papies et al., 2015; Tapper, 2017). Indeed, participants' responses to open-ended questions in various studies show that this is indeed what happens, as participants describe observing thoughts about eating the food, enjoying its taste and texture, and eating situations (e.g., Keesman, Aarts, Hafner, & Papies, 2019). Results from two sets of experiments show that applying this so-called "decentering" perspective to various food stimuli in a training phase can reduce impulsive approach responses, hypothetical and actual choices, and explicit cravings for unhealthy foods to the same and similar food stimuli in a subsequent test phase (Papies et al., 2012, 2015). Similar work has suggested that applying such a "decentering" or "cognitive defusion" approach to chocolate can reduce chocolate consumption over a 5-day period (Jenkins & Tapper, 2014), and that it can also reduce cravings for addictive substances (e.g., cigarettes; Westbrook et al., 2013). Among experienced meditators, the degree to which they report spontaneously applying a "decentered" perspective to food thoughts throughout their daily lives is associated with reduced food cravings (Keesman, Papies, Aarts, & Häfner, 2019; Papies, Winckel, & Keesman, 2016).

Recent work provides more insight into the mechanisms underlying these effects. In a series of studies (Keesman, Aarts, et al., 2019), participants were instructed to first retrieve a memory of an attractive food, or in another study, they were exposed to a tasty snack on the table in front of them. Then, they were asked to apply the "decentering" perspective of viewing their thoughts as mere mental events, or a control perspective. We then measured the strength and vividness of participants imagery of eating the food (i.e., their consumption simulations), as well as their cravings, by assessing self-reported food cravings and salivation in response to the food. Results showed that applying decentering did not reduce consumption and reward simulations compared to the control perspective, but it reduced cravings and salivation (Keesman, Aarts, et al., 2019). Indeed, our ongoing work suggests that applying decentering reduces the association between consumption and reward simulations and desire (Tatar, Barsalou, & Papies, 2019). In other words, applying decentering does not reduce the degree to which participants spontaneously think about eating and enjoying the food, but it reduces the degree to which these thoughts lead to desire to actually consume the food.

These findings suggest that the mechanisms underlying decentering effects may be slightly different than those of another prominent technique to address consumption simulations or imagery, namely loading working memory. Food cravings and the underlying conscious consumption imagery require working memory capacity, especially its visual subcomponent (Harvey, Kemps, & Tiggemann, 2005; Meule, Skirde, Freund, Vögele, & Kübler, 2012). This is consistent with predictions of the elaborated intrusion theory of desire (Kavanagh et al., 2005). Importantly, substantial research on interventions derived from this theory has shown that once food cravings have been induced, loading working memory, for example by visual imagery instructions or visually demanding tasks, can effectively reduce cravings (e.g., Andrade, Pears, May, & Kavanagh, 2012; Hamilton, Fawson, May, Andrade, & Kavanagh, 2013; Kemps, Tiggemann, & Christianson, 2008). Presumably, working memory load reduces cravings because it interferes with the imagery that sustains them – in contrast to "decentering" interventions that rather than reducing imagery itself, reduce its effect on desire.

Together, research so far on "decentering" and working memory load as intervention tools seems to suggest that targeting consumption and reward simulations early on can *prevent* their effect to produce cravings, and that targeting conscious consumption and reward imagery can *reduce* cravings, once they have fully developed. In any case, conscious and nonconscious simulations of eating and enjoying a food contribute to problematic desires, and tools that target these simulations are promising in the context of health interventions.

Summary and future research

This chapter has reviewed research on key predictions of the grounded cognition theory of desire, which proposes that consumption and reward simulations contribute to desire. The studies have shown that people spontaneously describe food and drink in terms of sensory, contextual, and hedonic features of consuming it, especially if they consume it often, and especially if it is attractive. Images of attractive food have been shown to activate the same areas for sensory and reward processing that are involved in actually eating attractive food, again suggesting that people simulate eating when they process food cues. These consumption and reward simulations, whether indexed by participants' spontaneous descriptions or self-reports, or experimentally induced, contribute to the motivation to consume the respective foods and drinks, again especially if they are attractive. Labelling products with words that reflect consumption and reward simulations, or showing products in background situations that facilitate such simulations, increases simulations and in turn, desire. Finally, interventions that target consumption and reward simulations, either by diffusing them as "mere mental events" or by reducing the working memory capacity needed to sustain them as conscious mental imagery, can prevent and reduce problematic cravings.

Key areas for future research include, for example, the degree of automaticity of these consumption and reward simulations. Previous research has suggested that simulations may require some cognitive resources, as research has shown that the hedonic value of attractive foods is not fully activated if a perceiver is under high cognitive load (Van Dillen, Papies, & Hofmann, 2013). However, no work so far has tested directly whether, for example, working memory capacity affects consumption and reward simulations in a similar way as it affects conscious mental imagery (Harvey et al., 2005). Future research should also examine in more detail how rewarding simulations of long-term goal pursuit can most effectively be stimulated (Andrade, Khalil, Dickson, May, & Kavanagh, 2016), and whether techniques that have been shown to validate or invalidate attitudes, for example nodding or shaking one's head while processing attitudinal messages, similarly affect how people relate to simulations (see Petty & Brinol, 2020, this volume). Related to this, little is known about how individual differences in health motivation affect consumption and reward simulations, and how external reminders of long-term goals (e.g., health goal primes) affect simulations that typically contribute to problematic desires.

Finally, future work could integrate this perspective with related research on simulations in social psychology more broadly. Simulations could play a role, for example in prejudice reduction, prosocial behaviour, action control, episodic future thinking, the anticipation of reward from social media behaviour or substance use, deciding whether one will fit into a prospective workplace, or preventing aggressive behaviour if one anticipates that aggression is not accepted by one's peers (e.g., Atance & O'Neill, 2001; Blanton & Burrows, 2020, this volume; Crisp & Turner, 2009; Gaesser, Shimura, & Cikara, 2019; Krahe, 2020, this volume; Kross & Chandhok, 2020, this volume; Martiny-Huenger, Martiny, Parks-Stamm, Pfeiffer, & Gollwitzer, 2017; Schmader, Bergsieker, & Hall, 2020, this volume). Establishing these mechanisms in more detail could help to generate a comprehensive account of the role of simulations in motivated behaviour, and thus facilitate effective, empirically grounded interventions.

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