Grounding desire and motivated behavior: A theoretical framework and review of empirical evidence

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Experiencing and dealing with desire is a central part of human existence. Whether it is for food, drink, sex, fame, social connectedness, or world peace, our desires shape and energize much of our daily life. A large literature, especially in social and health psychology, has focused on the ways in which desires affect our cognition and behavior. Similarly, many studies have outlined ways of handling such desires responsibly, for example, by planning in advance how to respond to them (e.g., Adriaanse, de Ridder, & de Wit, 2009), by thinking about one's long-term goals when tempted to give in to short-term temptations (Fishbach, Friedman, & Kruglanski, 2003; Papies, Potjes, Keesman, Schwinghammer, & van Koningsbruggen, 2014), or by applying mental strategies such as mindfulness (e.g., Alberts, Thewissen, & Raes, 2012; Jenkins & Tapper, in press; Papies, Barsalou, & Custers, 2012).

We know less, however, about how desire arises in the first place. What are the actual psychological mechanisms that produce desires and consequently affect our behavior to fulfill them? What neural mechanisms underlie the psychological processes that lead to desire, and that are associated with behaviors such as indulging in tasty food, drinking expensive wine, or driving across the state to see a loved one? To answer these questions, we develop a grounded theory of desire and motivated behavior, and we review empirical work consistent with it. Our theory does not aim to replace earlier accounts. Instead, we further develop the cognitive, affective, and neural mechanisms that underlie desire, together with the motivated behavior that can follow, attempting to integrate and shed new light on earlier findings, especially in the domains of nonconscious goal-pursuit, habits, and self-regulation.

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We define desire as a psychological state of motivation for a specific stimulus or experience that is anticipated to be rewarding. This state may or may not be consciously experienced. Explaining desire is particularly important given that it often arises and motivates appetitive behavior in the absence of physiological deprivation. Most of us will be familiar with the experience of desire for a certain food, drink, or activity, despite not being hungry, not being thirsty, and actually being quite immersed in another activity. Indeed, there is ample evidence showing that desires can arise purely due to purely cognitive processes, often in response to environmental cues (see also Kavanagh, Andrade, & May, 2005). Much research has shown, for example, that exposure to attractive food can trigger desire to eat and increase eating behavior (e.g., Hill, Magson, & Blundell, 1984; Tetley, Brunstrom, & Griffiths, 2009), along with physiological responses preparing the body to eat (Nederkoorn, Smulders, & Jansen, 2000). Similarly, cue reactivity research has shown that across a variety of substances, substance-related cues reliably trigger cravings (Carter & Tiffany, 1999).

Furthermore, desires arising from cognitive processes and physiological deficits are not always aligned. Conditioning the concept of drinking water, for example, has been shown to increase how much water participants drink, in similar ways but independent of participants' thirst (Veltkamp, Custers, & Aarts, 2011). Smokers attempting to quit often experience cravings in response to smoking cues, even when they wear a nicotine patch that reduces the nicotine deficit and thus eliminates the physiological base for cravings (Tiffany, Cox, & Elash, 2000). What processes produce these powerful desires that do not result from physiological deprivation? In this chapter, we introduce a grounded theory to explain the emergence of desire and its effects on motivated behavior, integrating psychological and neural mechanisms.

Introducing a Grounded Theory of Desire and Motivated Behavior

The theory that we propose makes use of three central constructs that have been suggested to play roles in grounded accounts of conceptual processing more generally, namely, situated conceptualization, pattern completion inference, and simulation (Barsalou, Niedenthal, Barbey, & Ruppert, 2003; Barsalou, 1999, 2003, 2008, 2009, 2011, 2013; Lebois, Wilson-Mendenhall, Simmons, Barrett, & Barsalou, submitted; Wilson-Mendenhall, Barrett, Simmons, & Barsalou, 2011). Specifically, we argue that desire arises when an internal or external cue triggers a *simulation*, or partial re-enactment, of an earlier appetitive experience that was rewarding. Simulating the past experience of eating a delicious scone in a coffee house, for example, could create a strong desire to consume another scone in a coffee shop now. Because the simulation includes psychologically-compelling hedonic and reward qualia (see also Kavanagh et al., 2005), it can motivate consuming a scone even when not hungry.

We assume that such reward simulations are typically situated. When re-experiencing the past consumption of a delicious scone, for example, it is simulated in a background situation, such as a coffee house, including a setting, people, object, action, events, emotions, mentalizing, self-attributions, etc. In our theory, all of this situational content is captured and integrated at the time of the original experience in a comprehensive representation that we refer to as a *situated conceptualization*. We assume that situated conceptualizations of experience are constantly stored in memory, representing the myriad types of situations that people experience, including pleasurable and rewarding appetitive events.

Once a situated conceptualization of a past experience exists in memory, perceiving one of its elements in the current situation can reactivate other elements of the situated conceptualization via *pattern completion inferences*. In other words, perceiving part of the pattern (e.g., a scone in a coffee house display case) can reactivate a larger pattern containing it (e.g., a situated conceptualization established while eating a scone on a previous occasion). Once a pattern is completed in this manner, a multimodal simulation of the previous experience is simulated. If this situated conceptualization contains experiences of pleasure and reward, these experiences are likely to be re-activated during the pattern completion process. As a result, these pattern completion inferences may lead to appetitive behavior, such as consuming the entity that triggered the inference process. Although pattern completion inferences of reward may be experienced consciously, as in cravings, they may often not reach conscious awareness, leading to motivated behavior outside awareness that can be experienced as unintentional or impulsive.

In the next section, we elaborate the mechanisms in this grounded theory of desire and motivated behavior. We begin by describing the situated conceptualizations of reward experiences that constitute the basic representations underlying desire. We then describe how the mechanism of pattern completion inference functions to re-instate a situated conceptualization in the brain and body, once perceiving one of its elements triggers its activation. Finally, we address how simulations function to re-enact reward experiences that engender motivated behavior. We then turn to empirical evidence from the domains of desire for food and alcohol to support the key components of our theory. Finally, we briefly address theoretical and practical implications, together with challenges for further research.

Mechanisms in the Grounded Theory of Desire and Motivated Behavior

Situated Conceptualization

Our theory assumes that people's rewarding experiences become stored in memory as situated conceptualizations. Once stored, a situated conceptualization represents the past situation as a memory. The situated conceptualization can also serve to interpret relevant situations in the future, and to support situated action in them.

Within our theoretical framework, we define a situation broadly, including internal states (e.g., cognitive, affective), bodily states (e.g., interoception, taste), and actions (e.g., executive, motoric); in other words, situations are much more than just environmental settings. Most critically, we assume that a situated conceptualization arises from the situated processing architecture of the brain (Barsalou, 2003, 2009, 2011, 2013; Lebois et al., submitted; Wilson-Mendenhall et al., 2011; Yeh & Barsalou, 2006). In a given situation, as someone perceives and conceptualizes the broadly defined elements of the situation, multiple neural systems simultaneously process these situational elements in parallel. Different neural systems, for example, process objects visible in the environment (the ventral stream), one's own motor behavior (motor and somatosensory cortices, cerebellum, basal ganglia), one's cognitive, affective, and interoceptive states and responses, including goals, reward, and physiological deprivation (lPFC, ACC, mPFC, PCC, OFC, amygdala, insula), and the external setting (parietal lobe, parahippocampal gyrus, retrosplenial cortex).

We assume that each system provides perceptual analysis and qualia of its respective information, as well as conceptual analyses of it. On seeing a scone in a coffee house, for example, the ventral stream performs visual analysis of the physical object and categorizes it as a scone. We similarly assume that perceptual and conceptual analysis occurs on all other aspects of the situation in the respective neural systems. We refer to the conceptualizations that result as "local," given that they process and evaluate one given element of the situation.

We further assume that a coherent global representation of the situation is constructed that integrates these streams of information and interprets them at a higher conceptual level. At the global level of analysis, relations between local situational elements are established (e.g., viewing a setting object as desirable for oneself; performing actions to possess and consume the object). A wide variety of relational concepts may become active to represent global conceptual structure in the situation, such as verbs and event concepts. In general, such relations may establish the significance of an object for oneself; they may explain the relation between having a goal and acting on it; they may help understand how an action produces an outcome in the situation; and so forth. Together, these global conceptualizations create the experience of a coherent meaningful situation.

We refer to the combined local and global conceptualizations of a situation's elements as a *situated conceptualization.* Most basically, a situated conceptualization supports understanding a situation at both the local and global levels, thereby allowing a person to interpret what is going on in a situation, and to produce relevant cognitive, affective, and bodily processes, and importantly, behavior. At a general level, we assume that situated conceptualization underlies all cognitive activity, not just desire (e.g., Barsalou, 2013). Within the domain of desire, a situated conceptualization of a reward experience is the distributed pattern of information that was processed earlier during the rewarding event, now represented and grounded in the brain in terms of various situated elements and their conceptual integration. We suggest that such situated conceptualizations of rewarding experiences play a key role in desire.

As an example, consider the experience of spending an evening with some friends while watching a George Clooney movie. In this situation, all of the neural systems described above produce perceptual experience, along with conceptual interpretation that will help you understand the situation and regulate your behavior. Some of these neural systems may be producing streams of information about the environment you are in, for example, your living room, sitting on the sofa, next to your friends, with a bowl of chips on the table. Another neural system may be controlling your motor actions, such as leaning forward and grabbing chips to eat, along with taste, somatosensory, and visual feedback. At the same time, neural systems processing affective and bodily states may produce various related experiences, such as reward from eating the chips, and excitement from suspense in the movie. Another neural system may continually establish the self-relevance of the events, reflecting your identity and goals, such as being a good host, and feeling socially connected. All these elements are grounded in perceptual, interoceptive, and motor systems, and become stored together as an integrated distributed pattern in memory. This pattern can later be re-activated by relevant cues, for example, when you walk through the grocery store, see a bag of potato chips somewhere, and think about the pleasure and fun of eating chips together with friends (see Papies, 2013).

Pattern Completion Inferences within Situated Conceptualizations

An important function of situated conceptualizations is to provide us with relevant information about the current situation and to facilitate situated action by retrieving information from similar earlier experiences. Once stored as a distributed memory pattern, a situated conceptualization can potentially be cued by any of its elements later on, and can then re-instate itself by re-activating other elements and triggering simulations of these perceptions, bodily states, and actions. This activity may then color our experience, control our behavior, and influence our subjective experience in the current situation. We suggest that pattern completion inferences produce these effects (Barsalou, 2003, 2009, 2013; Barsalou et al., 2003).

When you encounter a situation that shares features with situated conceptualizations stored in memory, a Bayesian retrieval process may be triggered to find the situated conceptualization that best fits the current situation (Barsalou, 2011; cf. Chater, Tenenbaum, & Yuille, 2006; M. Jones & Love, 2011). From the Bayesian perspective, the best fitting situated conceptualization reflects both the frequency with which it has been relevant in the past, and the quality of its fit to the current situation.

Once a situated conceptualization has been retrieved, elements that are not directly activated by the current situation itself may be inferred as pattern completion inferences. In other words, various elements of a situated conceptualization can become active without being triggered directly by anything present in the current situation. Returning to our example, just seeing chips in the grocery store may not only re-activate the mouth-feel of consuming snacks rich in salt and fat, but also its hedonic pleasure, the positive affect of feeling connected with one's friends, and the desire to see another George Clooney movie. Desire, as we will argue in more detail below, may often be the result of this pattern completion process, with external cues inducing motivation for a stimulus that was previously part of a rewarding experience.

A key assumption of our approach is that any element of a situated conceptualization can serve as a cue for retrieving the rest; no one part of the conceptualization is privileged (although some parts may function more effectively under specific conditions, for a wide variety of reasons; see Papies & Barsalou, 2014). Under some conditions, appetitive desires could be triggered when the sight, smell, sound, or feel of an appetitive object activates a situated conceptualization of previously consuming the object (e.g., foods, drinks, drugs). Under other conditions, various other elements from the same situated conceptualizations could also activate them, including the associated settings, people, objects, emotions, self-attributions, bodily states, actions, etc. (see Papies, 2013). Regardless of the initial trigger of the situated conceptualization, once it's running, the pattern completion inferences it produces have the ability to motivate appetitive behavior in the current situation, independently of any physiological need state. This may also explain why desires are so prevalent in daily life (e.g., Hofmann, Vohs, & Baumeister, 2012), as their numerous triggers in our living environment are hard to control.

Simulation

We assume that when pattern completion inferences are produced, they are realized as simulations of the inferred situational elements, rather than as symbolic descriptions of them. Thus, our grounded theory of desire and motivated behavior is built on the assumption that the various elements comprising situated conceptualizations are grounded in the neural and peripheral bodily systems that produce perception and action, including the production and perception of internal states (Barsalou, 1999). When, for example, a scone activates a situated conceptualization of eating a scone previously, the taste, reward, and actions inferred from the pattern completion process are reenacted in the gustatory, reward, and motor systems. In other words, the brain and body begin operating as if one were eating the scone. Because the same systems are running to produce the inferences that were running during consumption, the inferences that result often appear highly realistic, thereby becoming motivationally compelling.

Simulation can be viewed as the result of two basic processes: capture and reenactment (Barsalou, 1999, 2008). During an actual experience in a situation, the states of the neural systems active that process its various elements are captured in the respective systems, as described earlier for situated conceptualization. Over time, as the same kind of experience occurs repeatedly, related memories become captured across the same systems, such that an increasingly entrenched network becomes established. After eating many scones, for example, a network becomes established that aggregates the accumulated experience of eating scones into a distributed conceptual structure that represents the category (e.g., Barsalou, 2012; Martin, 2001, 2007). In other words, this increasingly entrenched network captures the aggregated experience of the category across all of the brain areas that process elements of the relevant situations. Although the resultant network reflects extensive experience, we assume that it also reflects strong genetic constraints on the underlying architecture that processes situation elements and links them together in association areas (Barsalou, 1999, 2008; Simmons & Barsalou, 2003). Thus, this account reflects both nativist and empiricist contributions.

Once the network representing a category becomes established, it can then be used to reenact instances of the category in their absence. By reactivating the network, it can reproduce the kind of brain state active when experiencing a category member. Reactivating the network of situated processing areas active when eating scones, for example, partially reproduces the type of brain states active when actually experiencing scones. We refer to these reproduced brain states as "simulations," given that the brain is simulating the kind of state that it would be in if it were experiencing a category instance.

We do not assume that a simulation ever reinstates a previous experience exactly. Instead, we assume that simulations typically reenact previous experiences partially, and that they can be biased and distorted in a variety of ways. We further assume that simulations can take diverse forms, ranging from simulating a specific category instance to simulating an average prototype, or simulating specific features of the category in rule-like manners (Barsalou, 1999). Importantly for our account here, we assume that simulations often operate unconsciously and implicitly, independent of intentional executive processing. When simulations do become conscious, they produce the diverse forms of imagery reported across multiple literatures (e.g., Jeannerod, 1995; Kosslyn, 1980, 1994), which have been suggested to play a role in desire for appetitive stimuli, too (Kavanagh et al., 2005). Finally, we assume that simulations support diverse forms of cognitive processing, including high-level perception, categorization, attention, working memory, long-term memory, language, thought, emotion, and social cognition (Barsalou, 2008).

Much empirical evidence supports diverse forms of simulation across the modalities (e.g., Barsalou, 2008; Kiefer & Barsalou, 2013; Pulvermueller, 2013). When people represent visual features during conceptual processing, in the absence of physical objects, they often represent them with simulation in visual areas (e.g., Goldberg, Perfetti, & Schneider, 2006; Hsu, Frankland, & Thompson-Schill, 2012; Kellenbach, Brett, & Patterson, 2001; Martin, 2007). For example, when people are asked to verify that an object has a particular form or color, they represent these form and color properties with visual simulations. Similarly, when people represent the auditory properties of objects conceptually, they often represent them with simulations in auditory areas (e.g., Kiefer, Sim, Herrnberger, Grothe, & Hoenig, 2008). Finally, research indicates that when people conceptually represent the functions of objects and the actions performed on them, they do so with motor simulations (e.g., Pulvermueller, 2013).

Increasing research demonstrates that simulations may also represent more abstract concepts, both literally (e.g., Wilson-Mendenhall, Simmons, Martin, & Barsalou, 2013) and metaphorically (e.g., Lacey, Stilla, & Sathian, 2012). Similarly, when people encounter affective stimuli and experience emotion as pattern completion inferences, these inferences are realized as simulations of previous emotion, both cognitively and bodily (e.g., Barrett, 2006, 2013; Lench, Flores, & Bench, 2011; Wilson-Mendenhall et al., 2011). Finally, and most importantly for our account here, much research demonstrates that when people encounter food stimuli, they simulate the experience of eating them (e.g., Barrós-Loscertales et al., 2012; Simmons, Martin, & Barsalou, 2005; van der Laan, de Ridder, Viergever, & Smeets, 2011). As people encounter a picture of tasty dessert, for example, they simulate the experience of eating it, and how rewarding it would be to consume, especially if hungry.

The Motivational Potential of Simulated Bodily States in Grounded Desire

Once a simulated experience of consuming something is running, it has the potential to be highly motivating, especially for appetitive stimuli, for which the situated conceptualizations triggered are particularly likely to lead to simulations of behavior that has earlier produced rewarding experiences. As several lines of research show, for example, perceiving a tasty food induces automatic approach impulses (Papies et al., 2012; Seibt, Häfner, & Deutsch, 2007; Veling, Aarts, & Papies, 2011). Similarly, as people become more motivated to consume food or pursue casual sex, they become increasingly likely to choose appetitive stimuli (Papies, Pronk, Keesman, & Barsalou, 2014; Seibt et al., 2007; Simpson & Gangestad, 1992). We suggest that as pattern completion inferences from situated conceptualizations for past experiences become active, the simulations that express these inferences can induce appetitive behavior.

Even though physiological deprivation may often contribute to the emergence of desire (e.g., Veltkamp, Aarts, & Custers, 2009), desire can also develop when situational cues trigger a situated conceptualization of a reward experience in the absence of deprivation. Because situational simulations, together with the bodily reenactments they include, re-create hedonic experiences, they can be so compelling and motivating that they induce appetitive behavior on their own. If, for example, one typically eats chips on relaxed Friday nights with friends while sitting on the sofa, these situated conceptualizations become stored in memory, together with the bodily states associated with desiring chips, tasting their crunchy saltiness, and feeling satisfaction on having consumed them. When experiencing any of these situational elements on a future occasion, one of these situated conceptualizations is likely to become active, thereby reproducing many aspects of these earlier situations, including the associated internal states. Just relaxing on the sofa alone on a Tuesday night might then be enough to make one wander toward the kitchen cabinet in search of a salty snack, independent of one's hunger.

Explaining Individual and Situational Differences in Grounded Desire

This grounded theory of desire naturally explains situational and individual differences in desire that people experience. Specifically, both situational and individual differences in desire can be understood as differences in situated conceptualizations that have become established in memory, as a function of the different motivational states and resulting reward experiences stored at the time of the respective experiences.

Central to this account is our assumption that different levels of reward value become represented in situated conceptualizations, resulting from different levels of internal motivational states such as hunger, thirst, sexual motivation, etc. at the time (Papies, Pronk, et al., 2014). Consider the different situated conceptualizations that result when different states are associated with the same appetitive behavior. For example, one might have a highly rewarding pizza experience when very hungry, but only a mildly rewarding pizza experience when slightly hungry. Later, the different internal states encoded in the resulting two situated conceptualizations may serve as cues for retrieving these situated conceptualizations. Thus, when one encounters pizza while very hungry vs. mildly hungry, the best-fitting situated conceptualization will be retrieved, namely, the one that best matches one's current hunger. As a result, a pizza may appear highly attractive or only mildly attractive, reflecting the prior reward experience simulated.

Effects of more enduring individual differences, such as reward sensitivity or sexual motivation, may similarly be explained from differences in situated conceptualizations (see also Papies, Pronk, et al., 2014). To the extent that different individuals vary in motivation at the trait level, the respective differences in motivational states and resulting reward experiences will become stored in their situated conceptualizations associated with appetitive behavior. Whereas some individuals might experience intense hedonic pleasure on consuming highly sweet deserts, other individuals might experience queasiness on consuming such desserts. As a result, when these two groups of individuals encounter the same sweet dessert, the pattern completion inferences that result may simulate very different bodily experiences, differentially motivating approach vs. avoidance responses towards it.

In this manner, situated conceptualizations reflect variations in reward representations and desire across situations and across individuals, thereby having the potential to explain the statistical subtlety that characterizes individual differences in desire and motivated behavior.

Empirical Evidence

We now turn to evidence that speaks to the situated nature of desire and to the possible roles of situated conceptualizations, pattern completion inferences, and simulation. Focusing on the domains of food and alcohol, this review does not aspire to be exhaustive, but merely to give a brief overview of research that is relevant for our account. The studies we discuss originate from diverse areas and theoretical backgrounds, but we suggest that their findings can be understood and integrated coherently by means of the theoretical framework suggested here.

Desire for food

Various studies suggest that representations of desirable foods are situated. From the perspective of our account, we expect that food memories are embedded in situated conceptualizations that become established during eating experiences. We further predict that cuing these situated representations will trigger simulations of rewarding eating experiences in neural and bodily systems as pattern completion inferences.

A large set of behavioral findings supports the situated nature of food representations. When categorizing foods, people make use of categories that describe when or how one typically eats a food (e.g., appetizers, snack foods; foods you eat with a spoon; Blake, Bisogni, Sobal, Devine, & Jastran, 2007; Ross & Murphy, 1999). Similarly, when describing eating and food in general, people refer to situated features of consuming it, such as hunger, eating with family and friends, enjoyment, and comfort (Keller & van der Horst, 2013). Specific types of foods are even referred to by their situated function as "comfort foods," implying that these are food items typically eaten in times of distress. While preferences for comfort foods differ between different individuals and groups (e.g., between men and women), such foods tend to be high in fat and/or sugar, and are heavily associated with memories of earlier rewarding eating situations (e.g., Locher, Yoels, Maurer, & van Ells, 2005; Wansink, Cheney, & Chan, 2003). These findings suggest that attractive foods are represented in relevant eating situations, including internal bodily and affective states, as well as features of the eating environment.

A recent study using a feature listing task confirms these findings and further demonstrates the richness of the situated representations that people have of food, particularly when this food is highly rewarding (Papies, 2013). In this study, participants were presented with words for four tempting foods (e.g., chips, cookies) and four neutral foods (e.g., apple, rice), and listed "features that are typically true of these concepts." In line with the earlier findings described above, participants listed various features describing the situated nature of food, such as when, where, why and with whom one eats the foods (e.g., TV; on the sofa; to treat yourself; eat sociably together) and the hedonic pleasure that results (e.g., tasty, delicious). Both hedonic and situation features were listed more often for tempting compared to neutral foods, and the situation features were much more varied and detailed for tempting foods. In addition, participants heavily made use of features describing the sensory experience of eating a tempting food, such as its taste, texture, and temperature (e.g., sweet, salty, savory, crunchy, creamy), and again, they did so much more for tempting than for neutral food. In contrast, participants situated neutral foods quite differently. Specifically, for neutral foods, participants much more often described visual features (e.g., green, round, small) and slightly more features related to the production, purchase, and preparation of the foods (e.g., grows on a tree, comes in bags, has to be cooked). Correlational analyses also showed that participants were more likely to describe a situated eating experience for tempting foods when they reported that they found this food very attractive and had a strong desire to eat it.

From our theoretical perspective, participants retrieve situated conceptualizations of earlier experiences with a food when asked to describe its features. When they find the food very attractive, the situated conceptualization is particularly likely to contain simulations of eating the food, as this produced the earlier rewarding experiences. They then proceed to describe the content of these situated conceptualizations, listing their features via pattern completion inferences to food cues. The situated conceptualizations that participants retrieve for tempting food most likely reflect idiosyncratic rewarding eating experiences, as participants describe features of eating and enjoying the food in rich background situations.

Much empirical work further shows that situated cues associated with attractive food and eating can trigger hedonic thoughts, cravings, and eating behavior, which is consistent with our prediction that activating a situated conceptualization of a rewarding eating experience can lead to desire. Brief descriptions of eating situations involving high-calorie foods, for example, trigger hedonic thoughts about food in chronic dieters, who have trouble resisting such indulgences (Papies, Stroebe, & Aarts, 2007). Being exposed to the sight or smell of attractive food triggers cravings and facilitates overeating, again especially among participants who have difficulties regulating their eating (e.g., Fedoroff, Polivy, & Herman, 1997; Rogers & Hill, 1989). Notably, these effects are specific for the cued food (Fedoroff, Polivy, & Herman, 2003), suggesting that the desires triggered activate specific situated conceptualizations, rather than a general desire to eat.

Physiological and neuroimaging research examining responses to food cues further support a grounded cognition perspective on desire. When exposed to attractive food cues, people respond as if they were actually eating or preparing to eat the food, reflecting simulations in neural and bodily systems. First consider how food cues trigger salivation (as originally proposed by Pavlov decades ago). Numerous studies show that exposure to attractive food triggers increased salivation in anticipation of food intake, especially in participants who have trouble regulating their eating behavior and maintaining a healthy diet (Brunstrom, Yates, & Witcomb, 2004; Ferriday & Brunstrom, 2011; Naumann, Trentowska, & Svaldi, 2013), especially for preferred foods (Rogers & Hill, 1989). From our perspective, attractive food cues activate situated conceptualizations that produce eating simulations via pattern completion inferences, thereby increasing salivation in anticipation of consumption.

Much neuroimaging research further shows that our brains respond to food cues in similar ways as if we were actually eating, tasting, and enjoying the respective foods. Viewing attractive food pictures or even just reading food words activates brain areas similar to actually eating these foods, including primary and secondary taste cortices (anterior insula, frontal operculum) and reward areas (orbitofrontal cortex; e.g., Barrós-Loscertales et al., 2012; Simmons et al., 2005; van der Laan et al., 2011). These effects are particularly pronounced for high-calorie foods and for hungry perceivers, and they correlate with individual reports of hunger and desire for food (Killgore et al., 2003; Siep et al., 2009; Wang et al., 2004). Furthermore, these effects are stronger in individuals who experience difficulty resisting high-calorie foods, such as overweight individuals and those at risk for overweight

(Stice, Spoor, Ng, & Zald, 2009; Stice, Yokum, Burger, Epstein, & Small, 2011). These findings demonstrate that attractive food triggers simulations of eating the food in the same brain areas that become active when actually eating it, and may reflect the reward typically experienced.

Cognitive labels can affect these neural responses and also the associated subjective experiences. In one study, tasting a food stimulus that was labeled as “rich and delicious” increased activation in reward areas in the brain, compared to tasting the same stimulus when it was labeled “boiled vegetable water” (Grabenhorst, Rolls, & Bilderbeck, 2008). Woods and colleagues (2011) showed that tasting the same drink with labels suggesting different levels of sweetness changed neural responses in the primary taste cortex, as well as participants’ experiences of the drink’s sweetness. Similarly, labels suggesting that a wine was more expensive increased reward responses in the brain when tasting it, along with judged pleasantness (Plassmann, O’Doherty, Shiv, & Rangel, 2008). We suggest that such labels activate fitting situated conceptualizations and specific simulations in sensory regions in the brain, which become superimposed on the actual taste perception and thus affect experience (cf. Hansen, Olkkonen, Walter, & Gegenfurtner, 2006). Not only neural responses, but even hormonal responses to food can be modulated by food labels, as shown by a study where a milkshake that was labeled “indulgent” rather than “sensible” triggered a steep decline in the gut peptide ghrelin after consumption, suggesting a state of physiological satiety (Crum, Corbin, Brownell, & Salovey, 2011). Again it appears that the food label and appearance trigger a specific simulation that then affects our neural and physiological responses and actual sensory and hedonic experiences.

Research on cross-modal effects during food perception and eating behavior has demonstrated that, not only cognitive labels, but also cues from other modalities can affect experience of eating. The color of food, for example, is a strong cue for expectations with regard to eating experiences, and significantly facilitates flavor identification (Spence, Levitan, Shankar, & Zampini, 2010), presumably by serving as a cue to retrieve a fitting situated conceptualization of eating that specific food. Further, research has shown that a variety of sounds related to eating can similarly affect what we expect of a food, how much we like it, and how much we eat (for a review, see Spence & Shankar, 2010). In one study, for example, hearing the sound of bacon sizzling in a pan increased participants’ perceptions of bacon flavor in a product they tasted, compared to a different sound, suggesting that the sound may have activated a simulation of bacon taste that then increased actual taste perceptions (Spence, Shankar, & Blumenthal, 2010). Such results suggest that cross-modal cues retrieve situated conceptualizations of specific eating experiences, which then lead to partial simulations of the associated tastes, which in turn strengthen actual taste experiences.

All of these findings are consistent with our grounded perspective on desire, indicating that both linguistic labels and non-linguistic cues belong to situated memories of eating experiences. As a result, perceiving these cues can trigger simulations of eating that then influence actual eating experiences.

Desire for alcohol

Situated conceptualizations of reward experiences also appear to play central roles in the desire for alcohol. As we will see, much research on alcohol cues and alcohol outcome expectancies demonstrates powerful effects of such cues on desire and motivated behavior.

Drinking alcohol is in part represented in terms of beliefs about the effects of alcohol, such as becoming more sociable, relaxed, or happy when drinking. Consistent with our grounded theory of desire, alcohol expectancies can be viewed as situated memories that have been established idiosyncratically and thus vary strongly with individual experiences (see B. T. Jones, Corbin, & Fromme, 2001; Stein, Goldman, & Del Boca, 2000). Additionally the degree to which one expects a reward experience from drinking has been shown to motivate and increase consumption (for an overview, see Reich, Below, & Goldman, 2010). Experimental studies have further shown that priming outcome expectancies with word cues (e.g., "confident", "sociable", "sexy"), leads to increased drinking, especially among heavy drinkers (Stein et al., 2000). Conversely, interventions designed to challenge such outcome expectancies have sometimes been shown to reduce drinking (e.g., having participants notice that they experience positive outcomes typically associated with alcohol, even though they consumed placebo drinks; see B. T. Jones et al., 2001).

Extensive work on the effects of alcohol cues shows that exposing participants to contextual cues for drinking (e.g., a bar environment, alcohol-related pictures, the smell of alcohol, the sight of alcoholic beverages) activates alcohol-related thoughts and approach impulses, and increases the desire to drink (for reviews, see Field, Schoenmakers, & Wiers, 2008; Wiers & Stacy, 2006). In the context of drinking habits, Sheeran and colleagues (2005) demonstrated that exposing students to words related to socializing increased the accessibility of the concept for drinking and the motivation to drink, but only among habitual drinkers, presumably because these cues activated situated conceptualizations of drinking in social contexts for them. From the perspective of our theory, we interpret these findings as showing that outcome expectancies and situated alcohol cues constitute elements of situated conceptualizations for rewarding drinking experiences. Thus exposure to these cues can activate these situated conceptualizations, and via pattern completion inferences, trigger the desire to drink.

Further research in this domain similarly shows that activating situated conceptualizations of drinking alcohol can trigger pattern completion inferences that represent various consequences of drinking (in the absence of actual alcohol consumption). Mere priming with alcohol-related words among social drinkers, for example, has been shown to produce cognitive responses typically associated with alcohol, such as performing worse on cognitive tasks (Fillmore, Carscadden, & Vogel-Sprott, 1998), aggressive thoughts (Bartholow & Heinz, 2006), and judging women as more attractive (Friedman, McCarthy, Förster, & Denzler, 2005).

Furthermore, alcohol cues trigger embodied responses that suggest partial simulations of drinking experiences. Exposure to alcohol-related cues in neuroimaging studies, for example, has been shown to activate brain areas associated with reward and cravings in problematic drinkers (e.g., Myrick et al., 2004; Schacht et al., 2011). In cue-reactivity studies, addicts' physiological responses to cues that are associated with drug use (including alcohol, nicotine, and cocaine) are very similar to the effects actually produced by taking the drug, such as increased heart rate and sweat gland activity (see Carter & Tiffany, 1999, for a meta-analysis). This suggests that exposure to drug-related cues triggers embodied simulations of drug use that produce physiological changes associated with actually using it. Studies using placebo designs have similarly shown that the mere expectancy of drinking alcohol can lead to physiological changes as if participants were actually drinking alcohol, such as impaired motor performance (Vuchinich & Sobell, 1978), increased male sexual arousal (Terence & Lawson, 1976), and reduced arousal during an anxiety-provoking interaction (Wilson & Abrams, 1977; for a meta-analysis, see Mckay & Schare, 1999). Across studies, the effects of expecting to drink alcohol are strongest in research settings imitating natural drinking environment, compared to lab settings (Mckay & Schare, 1999), which supports the important role of contextual cues in producing simulations of drinking experiences. Thus, when one is reminded of drinking or expecting to drink alcohol, cognitive, affective, and behavioral effects result as if one were indeed drinking. Furthermore, these simulations become increasingly likely as more alcohol-related contextual cues are present, thereby increasing the likelihood of retrieving a situated conceptualization of an earlier alcohol experience.

Together, these findings support our theoretical account that situated conceptualizations, pattern completion inferences, and simulations play central roles in the desire for alcohol. Additionally, these situated conceptualizations appear to be grounded in bodily systems, such that they can trigger compelling embodied simulations of drinking and its consequences.

Implications and Final Thoughts

Relations to Dual-Process Theories and Habits

We believe that the basic mechanisms in our theory underlie both the impulsive and reflective processes that are widely viewed as producing desire and its regulation (e.g., Hofmann, Friese, & Wiers, 2008; Metcalfe & Mischel, 1999; Strack & Deutsch, 2004), as well as the processes that lead to habitual behavior and to potential habit change (e.g., Aarts & Dijksterhuis, 2000; Ouellette & Wood, 1998). From our perspective, an impulse or a habitual response is activated when a situational cue triggers a situated conceptualization that has become well entrenched in memory. Because the situated conceptualization is highly learned, relatively little processing may be required to activate it, such that it becomes active quickly, intrusively, and/or unconsciously (cf. Moors & De Houwer, 2006). Situated conceptualizations supporting successful self-regulation may become active in equally automatic ways, if they have been stored in memory from earlier behavior. When a situated conceptualization of consuming chips on the couch becomes activated, for example, this may for some people activate long-term goals that one has often pursued in such situations, such as dieting, along with associated behaviors, such as grabbing an apple or hopping on the treadmill. The activation of such strategies is especially likely if a person has successfully pursued a such a long-term goal in similar situations (Fishbach et al., 2003; Papies, Stroebe, & Aarts, 2008), so that situated conceptualizations of pursuing the dieting goal in tempting situations have been stored in memory, and can easily be retrieved as healthy habits in response to attractive food cues.

Self-regulation can further occur when the executive system searches memory for situated conceptualizations that constitute alternatives to situated conceptualization activated initially as impulses or habits (cf. Barrett, Wilson-Mendenhall, & Barsalou's, in press, account of emotion regulation). When in a tempting eating situation, for example, memory may be searched for alternative ways of handling the situation. Situated conceptualizations of alternative behaviors could have been stored, for example, from planning healthy behavior (e.g., with situation-specific implementation intentions, Gollwitzer & Sheeran, 2006) or from health education, and may later be retrieved and implemented in a deliberate, effortful way. Thus, we assume that situated conceptualizations can become activated and implemented in very different manners, thereby affecting behavior either impulsively or reflectively, producing successful as well as unsuccessful self-regulation. Clearly, however, our accounts of habits, impulse, and regulation require further theoretical development, together with careful empirical testing.

Relations to the Elaborated Intrusion Theory of Desire

The theory that we develop here differs in important respects from Kavanagh et al.'s (2005) Elaborated Intrusion Theory. Most importantly, our account focuses on situated conceptualizations that originate during consumptive experiences, together with the pattern completion inferences and simulations that result from cuing them later. Therefore, our theory not only focuses on mechanisms underlying desire, but also on mechanisms that produce motivated behavior, together with the learning of these behavioral patterns. Furthermore, our account of simulation differs from Kavanagh et al.'s account of imagery in several ways. First, whereas they focus on sensory imagery, we focus more broadly on multimodal simulations that not only reenact sensory states, but also bodily states, motor behavior, settings, and various internal states, including reward, goals, emotions, thoughts, etc. Second, simulation in our account not only takes the form of conscious imagery, but also unconscious reenactment of perception, action, and various internal states. Third, Kavanagh et al. tend to assume that desire primarily results from conscious elaboration of associative intrusions, whereas we assume that desire can also result from automatic simulations that are not elaborated in working memory. Finally, neural mechanisms play central roles in our account, in contrast to the central role of conscious experience in Kavanagh et al.'s account. We hasten to add that both theories share the important assumption that representations of consumption can produce desire.

Learning and individual differences

Our grounded cognition approach to desire is essentially a learning theory of desire. As an individual has appetitive experiences, memories of these experiences are stored in memory as situated conceptualizations, constituting a form of learning. Because different individuals have different appetitive experiences, they have different learning histories, as different populations of situated conceptualizations accumulate in memory. On later occasions, different individuals may therefore respond to the same appetitive cues differently. Because appetitive cues are likely to retrieve different situated conceptualizations across different individuals, different pattern completion inferences follow, producing different simulations of craving (or not craving).

We believe that this learning account has much potential for explaining individual differences in desire and the motivated behavior that follows. Clearly, however, this account must be developed both theoretically and empirically before this potential can be realized.

Interventions to regulate desire effectively

It follows from our account that one approach to intervention aims at changing the population of situated conceptualizations that controls an individual's appetitive behavior. Effortful change of behavior may therefore eventually turn into healthy habits if the new behavior is repeated sufficiently often and in a sufficiently stable context (cf. Ouellette & Wood, 1998) to establish a new population of situated conceptualizations in memory (Papies & Barsalou, 2014). As a result, the pattern completion inferences that are triggered by relevant cues will change, thereby changing desire and the motivated behavior that follows.

Another approach to changing consumptive behavior is to control the cues that activate the situated conceptualizations stored in an individual's memory, for example by changing the environment to remove or avoid such cues. Indeed, strategies like making food less visible are effective for reducing unhealthy eating(e.g., Wansink, Painter, & Lee, 2006). However, our account predicts that a large number of very diverse cues may potentially be involved in triggering reward simulations, making this strategy difficult to put into practice. We further assume that these cues may often be difficult for an individual to identify, as situated conceptualizations typically do not reach conscious awareness. In addition, controlling one's environment such as to remove or avoid relevant cues may often simply not be possible.

Controlling the cues that activate situated conceptualizations in a less far-reaching way can be achieved by goal priming. By presenting cues in a person's environment that activate situated conceptualizations associated with specific goals (e.g., situated conceptualizations of behaviors to perform when one is dieting), behaviors that can facilitate pursuit of these goals are likely to occur as pattern completion inferences, but only among those individuals who have stored relevant situated conceptualizations from previous experiences (e.g., dieters). As a result, behaviors like buying and eating high-calorie foods will be less likely to occur after such primes, compared to behaviors like ordering a healthy salad (e.g., Anschutz, Van Strien, & Engels, 2008; Papies & Hamstra, 2010; Papies, Potjes, Keesman, Schwinghammer, & van Koningsbruggen, 2014; Papies & Veling, 2013).

Still another approach that has proven effective is to undermine the hedonic simulations that motivate appetitive behavior, for example by mindfulness (Jenkins & Tapper, in press; Papies et al., 2012) or reappraisal (e.g., Hofmann, Deutsch, Lancaster, & Banaji, 2010). Once a person recognizes the potential harm that these simulations can do in motivating unhealthy consumption, they can learn various strategies that make them less compelling. As a result, these simulations increasingly lose their control over behavior, such that they arise and dissipate with little effect.

Conclusion

In this chapter, we have introduced a novel theoretical framework for understanding desire and motivated behavior, based on a grounded cognition perspective. We have argued that this framework allows us to understand how desire arises from well-established mechanisms of grounded conceptual processing, and we have reviewed literature from diverse areas that can be interpreted and integrated by means of this theory. Our account suggests that even though the situated and grounded character of our cognitive systems typically helps us navigate a highly complex living environment in effective ways, it also increases our susceptibility to the myriad temptations that our living environments offer, generating various forms of desire. We hope that our analysis of desire and motivated behavior, utilizing the constructs of situated conceptualization, pattern completion inference, and simulation, will increase our understanding of how desire arises, how it affects behavior, and how situated processing mechanisms can be used to modulate these effects.

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