Situated Conceptualization: Theory and Application

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In previous articles, the construct of situated conceptualization developed as an account of how simulations of conceptual knowledge become situated (Barsalou, 2003, 2005, 2008, 2009; Barsalou, Niedenthal, Barbey, & Ruppert, 2003; Yeh & Barsalou, 2006; also see Barsalou et al., 1993). Simulating conceptual knowledge about a bicycle, for example, doesn't simply represent a bicycle alone against an empty background. Instead, simulating a bicycle typically occurs in a background situation, such as riding cautiously along a busy street on the way to work (one of infinitely many situated conceptualizations associated with the category of bicycles). By simulating background situations this way, agents prepare themselves for situated action with the focal object or event. Simulating the ride to work, for example, generates useful inferences about the setting, relevant agents and objects likely to be encountered, relevant actions to perform, and mental states likely to result.

This chapter develops the construct of situated conceptualization beyond earlier treatments. After the first section establishes properties of situated conceptualization, the second demonstrates its applications to a variety of cognitive, affective, and behavioral abilities.

Situated Conceptualization: Theory

Concepts

Because situated conceptualization is a construct associated with conceptual processing, it is essential to define what is meant by a concept (also see Barsalou, 2012; Murphy, 2004). Following the account developed here, a concept is a dynamical distributed system in the brain that represents a category in the environment or experience, and that controls interactions with the category's instances (e.g., the concept of *bicycle* represents and controls interactions with bicycles). Within the human conceptual system, thousands of concepts represent diverse categories of settings, agents, objects, actions, mental states, properties, relations, and so forth.

Although many accounts of concepts exist, they generally assume that a given concept aggregates information across interactions with a category's members. The concept of *bicycle*, for example aggregates information accumulated across interactions with bicycles. Using selective attention to isolate information relevant to the concept (e.g., perceived bicycles), and then using integration mechanisms to integrate it with other bicycle information in memory, aggregate information for the category develops continually (Barsalou, 1999). Although learning plays central roles in establishing concepts, strong genetic constraints constrain the features that can be represented for a concept, and also their integration in the brain's association areas (Simmons & Barsalou, 2003).

Once the conceptual system is in place, it supports virtually all other forms of cognitive activity. During online interaction with the environment, concepts contribute to perception via inferences that support perceptual constancy, pattern completion, anticipatory movement, etc. Concepts enable categorization, making it possible to identify the objects, agents, actions, etc. currently present in a situation. Concepts support action via inferences that establish the affordances of objects, actions likely to be effective, and probable outcomes (e.g., affect, reward). In general, concepts make it possible to go beyond the information given, providing an agent with diverse forms of expertise about perceived category instances (Bruner, 1973).

Concepts also play central roles in offline processing when people represent non-present situations during memory, language and thought. As Donald (1993) reviews, humans, unlike other species, are prolific in representing and analyzing past situations, planning and coordinating future situations, and developing counterfactuals to current situations. Concepts provide the building blocks for representing and processing non-present situations. Without concepts, representing non-present situations wouldn't be possible.

Grounded Cognition

Because the construct of situated conceptualization draws heavily on the framework of grounded cognition, it is useful to place the construct within this framework. A natural way of doing so is to begin with the historical perspective. Since the cognitive revolution, the so-called *sandwich model* has dominated theories of cognition, viewing cognition as processes "sandwiched" between perception and action (Hurley, 2001). As a consequence, cognitive processes are often viewed as relatively modular, making it possible to study them without taking perception and action into account. By simply focusing on mechanisms associated with attention, working memory, long-term memory, language, and thought, it is possible to develop satisfactory accounts of cognition. Based on this assumption, paradigms for studying cognition—together with theories that explain results from these paradigms—typically ignore perceptual and motor processes.

From the perspective of grounded cognition, the sandwich model will never explain cognition successfully. Instead, proponents of grounded cognition argue that cognition will only be understood once the relevant domains of study are expanded significantly beyond classic cognitive mechanisms (Aydede & Robbins, 2009; Barsalou, 2008a, 2010; Clark, 2008). Only when these additional domains are included, will accounts of cognition be successful.

Across the literature on grounded cognition, researchers often argue that four additional domains beyond classic cognitive mechanisms must be included. First, researchers increasingly propose that cognition relies heavily on the modalities that constitute perception, action, and interoception. As described in the next section, the basic cognitive process of simulation utilizes mechanisms in the modalities. When conceptually representing the color of a non-present object, for example, the cognitive system utilizes simulations of color in the visual system (e.g., Hsu, Frankland, & Thompson-Schill, 2012; Simmons et al., 2007). Analogously, when conceptually representing how an object sounds, people do so with simulations of sounds in the auditory system (Kiefer, Sim, Herrnberger, Grothe, & Hoenig, 2008; Trumpp, Kliese, Hoenig, Haarmeier, & Kiefer, 2013).

Second, researchers increasingly propose that cognition often (but not necessarily) relies on bodily states and physical action (for reviews, see Barsalou et al., 2003; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005). On the one hand, cognitive states often produce related bodily states. When people perceive tools, for example, their motor systems anticipate the actions associated with object affordances (Caligiore, Borghi, Parisi, & Baldassarre, 2010; Tucker & Ellis, 1998). When people perceive the facial expressions of others, they sometimes mimic and embody them (e.g., Niedenthal, Mermillod, Maringer, & Hess, 2010). On the other hand, bodily states can influence cognitive states. When people experience physical warmth and cleanliness, for example, they may feel socially connected and psychologically cleansed, respectively (e.g., IJzerman & Semin, 2009; Lee & Schwarz, 2010).

Third, researchers propose that cognition depends on the physical environment. Since Gibson (1966, 1979), many researchers have argued that it is impossible to understand and study perception by only considering sensory systems. Because perception results from the coupling of sensory systems with the physical environment (together with the body), it is essential to include the physical environment in accounts of perception. More recently, researchers working from the perspectives of situated action and situated cognition have similarly argued that cognition cannot be explained without incorporating its coupling with physical environments (e.g., Aydede & Robbins, 2009; Clark, 1998, 2008). Because the brain establishes distributed patterns for processing familiar situations, taking the physical situations into account that produce and support these patterns is essential for satisfactory theories of cognition.

Fourth, researchers propose that cognition depends on the social environment. As evolutionary theories often argue, increasingly powerful social cognition constituted the primary adaptions of cognition in humans (e.g., Donald, 1993; Tomasello, 2009). Related to action, humans developed increasingly sophisticated representations of agency and self, together with increasingly powerful abilities for social mirroring, imitation, and cooperative action. Related to theory of mind, humans developed the abilities to establish joint attention and represent the minds of others. Related to communication, humans developed remarkable new abilities to use language, establish social groups, create culture, and archive cultural bodies of knowledge. For all these reasons, understanding human cognition successfully requires understanding its coupling to the social environment. Analogous to understanding how the physical environment shapes and supports cognition, it is essential to understand how the social environment shapes it as well.

Thus, from the grounded perspective, cognition doesn't simply reside in a set of cognitive mechanisms. Instead, cognition emerges from these mechanisms as they interact with sensory-motor systems, the body, the physical environment, and the social environment. Rather than being a module in the brain, cognition is an emergent set of phenomena that depend critically on all these domains, being distributed across them (e.g., Barsalou, Breazeal, & Smith, 2007; Clark, 1998, 2008).

Finally, referring to this perspective as "embodied cognition" is relatively narrow (Barsalou, 2008a, 2010). Certainly, cognition depends on the body in critical ways. Nevertheless, it also depends on sensory-motor systems, the physical environment, and the social environment. The classic way of describing this perspective as "grounded cognition" acknowledges all the domains in which cognition is grounded and from which it emerges (e.g., Pecher & Zwaan, 2005; Searle, 1980). As we will see shortly, the construct of situated conceptualization integrates cognition across these domains.

Simulation

As we will also see shortly, the construct of simulation plays central roles in situated conceptualizations (Barsalou, 1999, 2008a, 2009). Most basically, a simulation reenacts the kind of brain state that occurs while interacting with a category's members. When simulating a bicycle, for example, the brain reenacts the kind of brain state that occurs while experiencing bicycles. As we will see, simulations play diverse roles in representing a category, producing a variety of situated predictions and controlling action.

For simulation to occur, experiences of actual category members must become established in long-term memory. Consider experiencing instances of the category *hammers*. As people experience hammers, brain areas that process their properties become active and associated together (Martin, 2007). Specifically, distributed associative patterns are likely to become established across fusiform gyrus (shape), premotor cortex (action), inferior parietal cortex (spatial trajectory), and posterior temporal gyrus (visual motion). Following many learning episodes, an increasingly entrenched associative network reflects the aggregate effects of neural processing distributed across these areas. From the perspective developed here, this entrenched network represents the concept of *hammer*, given that it contains aggregate information about its respective category (elsewhere these distributed networks have been referred to as *simulators*; e.g., Barsalou, 1999, 2009). For a similar perspective, see the chapter in this volume by Brunel, Vallet, Riou, Rey, and Versace (also see Versace, Labeye, Badard, & Rose, 2009; Versace, Vallet, Brunel, Riou, Leosourd, & Labeye, 2014).

Once a concept has become established in memory, it produces specific simulations of the category dynamically. On experiencing a hammer (or hearing the word "hammer"), a subset of the hammer network becomes active to simulate the processing of a hammer in one of infinitely many ways. Typically, these simulations remain unconscious, at least to a large extent, while causally influencing cognition and action. To the extent that part of a simulation becomes conscious, mental imagery is experienced. Such simulations need not provide complete or accurate representations, but are likely to be incomplete and distorted in many ways, representing abstractions, caricatures, and ideals, as well as specific learning episodes.

In a Bayesian manner, the hammer simulated on a given occasion reflects aspects of hammers experienced frequently in the past, together with aspects that are contextually relevant (Barsalou, 2011). In other words, the underlying network generates one of infinitely many hammer simulations dynamically, each adapted to the current situation. Once this simulation exists, it represents a hammer temporarily in working memory, producing, for example, anticipatory inferences about the object's affordances.

As Barsalou (2008a) reviews, simulation appears to be basic computational mechanism in the brain. Not only is it central for conceptual processing, it also plays important roles across the spectrum of cognitive processes, from perception to social cognition. By no means, however, is simulation the only representational process in the brain. Instead, other important representational mechanisms work together with it to produce cognition, especially linguistic forms and perhaps various forms of amodal symbols, including conjunctive neurons in association areas (e.g., Barsalou, Santos, Simmons, & Wilson, 2008; Simmons & Barsalou, 2003).

Situatedness

When a simulation is constructed to represent a category, it is not constructed in a vacuum. Instead, much evidence suggests that simulations are situated (e.g., Barsalou & Wiemer-Hastings, 2005; Wu & Barsalou, 2009; for a review, see Yeh & Barsalou, 2006). When representing the category of chairs, for example, a simulated chair is likely to be embedded in a background setting, together with agents and objects likely to be present, and also with actions, events, and mental states likely to occur. By representing a category in a relevant situation, useful inferences about it support effective interaction (e.g., Barsalou, 2003b, 2009). Simulating a chair on a jet, for example, produces inferences about the specific structural properties of these chairs, how to operate them, what it feels like to sit in them, and the affect likely to result.

From this perspective, a category is typically simulated in diverse situations. Depending on the situation currently relevant, a different situated simulation is produced. A chair, for example, might also be simulated in a kitchen, living room, classroom, theater, ski lift, etc. In each case, the simulation is tailored to the situation, providing relevant inferences about the category in that context. As a consequence, no single abstraction covers the category. Instead, a large collection of situated simulations represents the category in the spirit of exemplar theories (Medin & Schaffer, 1978; Nosofksy, 2011), with local abstractions being constructed dynamically as needed (e.g., Barsalou, 2003a).

How are situated simulations of categories constructed? One proposal is that the brain is a situation processing architecture whose primary function is to capture and later simulate *situated conceptualizations* (Barsalou, 2003b; Lebois, Wilson-Mendenhall, Simmons, Barrett, & Barsalou, 2014; Wilson-Mendenhall, Barrett, Simmons, & Barsalou, 2011; Yeh & Barsalou, 2006). According to this proposal, a person's current situation engages the brain's situation processing architecture, coupling the brain, the modalities, and the body with the physical and social environments. As a person perceives, cognizes, and acts in a situation, multiple neural systems in this architecture process different situational elements in parallel, generating complementary streams of information. Specifically, different neural systems process the current setting (parietal lobe, parahippocampal gyrus, retrosplenial cortex), objects in the setting (the ventral stream), other agents who are present (temporal poles, mPFC, FFA, STG), self relevance (mPFC, PCC), physical actions in the environment (motor and somatosensory cortices, cerebellum, basal ganglia), and a wide variety of cognitive, affective, and interoceptive responses to the situation (lPFC, ACC, mPFC, PCC, OFC, basal ganglia, amygdala, insula).

Over time, each of these neural systems produces a continuous stream of perceptual information about its respective situational content, along with corresponding conceptual interpretations. If you are reading this article in a café, for example, the neural system that processes space produces a continuous stream of perceptual experience about space surrounding you, together with conceptual information that categorizes the space as a café. Simultaneously, two other neural systems produce streams of perceptual experience and categorizations about objects in the space and other agents present. Similarly, the self system continually establishes the self-relevance of objects and events in the situation, reflecting your goals, values, and identity. Still other neural systems control actions in the situation, including eye movements, hand actions, body locomotion, and communication, while incorporating perceptual feedback about action effectiveness and adjustment. Finally, other neural systems that process internal states continuously produce perceptual and conceptual streams of information about motivation, affect, interoception, and reward.

At the perceptual level, the local streams of perceptual input from the individual networks are integrated into a coherent perceptual experience. Rather than perceiving elements of the situation individually, they are experienced globally as a coherent conscious state.

Local vs. Global Conceptualization

As each system in the situation processing architecture categorizes its respective situational information, it produces "local" conceptualizations of its content. As an agent moves through various settings, for example, the system that processes space continually categorizes the current space, thereby conceptualizing where the agent is. Analogously, other systems analogously produce "local" conceptualizations of the objects and agents present, the actions being performed, the internal states being experienced, and so forth. At any given point of time, all these systems together produce a collection of the local elements characterizing the situation. As the situation changes, so does the collection of local conceptualizations currently active.

At a higher level of conceptual analysis, conceptual relations continually integrate local conceptualizations. If, for example, a waiter in the café serves food to the table, conceptual knowledge about serving integrates relevant local elements of the situation into a coherent event. Similarly, once the agent begins eating the food, conceptual knowledge about eating integrates relevant local elements into a subsequent coherent event. Over time, the sequence of global conceptualizations captures what is happening within the situation across relevant local elements.

We refer to the combined local and global conceptualizations of a situation as a *situated conceptualization.* At a given point in time, the current situated conceptualization interprets what is occurring in the situation across both the local and global levels of analysis.

Exemplars vs. Abstractions

As a situated conceptualization is constructed, associative mechanisms establish a statistical trace of it in long-term memory. Not only does a situated conceptualization interpret a current situation, it becomes available in long-term memory for processing similar situations on later occasions. Thus, the construct of *situated conceptualization* has two senses, first, as the interpretation of a current situation, and second, as a record of a past situation stored in memory.

To the extent that a particular type of situation occurs repeatedly, situated conceptualizations constructed for it accumulate in memory. If, for example, you read articles while having lunch in a café on many occasions, a category of situated conceptualizations for this repeated situational experience develops in memory.

A key issue is understanding how closely related situated conceptualizations for the same type of event become integrated in memory. One possibility is that each situated conceptualization for a type of situation is stored as a relatively independent trace in memory, as in exemplar theories of categorization (cf. Medin & Schaffer, 1978; Nosofsky, 2011). As a consequence, a collection of situated conceptualizations becomes stored to represent the situation. On later occasions in the same situation, these memories can be activated as a set or individually to generate predictions and control action (e.g., Hintzman, 1986; Ross, 1987). Brunel et al. (this volume) offer a similar account of situated memory traces (also see Versace et al., 2009, 2014).

Another possibility is that a frame or schema is abstracted across the situated conceptualizations constructed for each kind of situation (e.g., Barsalou, 1992, 1999, 2003a). Within the frame, local outputs of the situation processing architecture constitute slots/variables (e.g., setting, agent, object, action, etc.), with the global relations integrating slots in a predicate-like manner. Interestingly, the individual networks comprising the situation processing architecture are reminiscent of the classic types of slots found in frames and related linguistic structures (for processing setting, agent, object, action, etc.).

Still another possibility is that the situated conceptualizations for a type of situation are superimposed onto a common network, such that their aggregate effects on network weights represent the category. To the extent that the network includes hidden units for capturing correlations between local situation elements, it becomes possible to statistically maintain information about specific exemplars (e.g., McClelland & Rumelhart, 1985). Whereas a network attractor functions as an implicit abstraction about the situation, information about specific instances of the situation also reside in the network as well.

Because so much empirical evidence demonstrates that detailed exemplar information supports categorization (e.g., Nosofsky, 2011), accounts that incorporate this information are likely to be most useful in developing computational models of situated conceptualization. Importantly, however, exemplar information need not arise from the storage of independent situated conceptualizations, but could reflect superimpositions of situated conceptualizations onto a network capable of capturing details of specific situations (Barsalou, 1990).

An attractive feature of the situated conceptualization framework is that it offers a natural account of individual differences (e.g., Papies, Pronk, Keesman, & Barsalou, 2014; Wilson-Mendenhall et al., 2011). To the extent that different individuals experience different kinds of situations, different populations of situated conceptualizations accrue in their respective memories. If, for example, different individuals experience different kinds of eating situations, they accumulate different populations of situated conceptualizations in memory for them. As a consequence, these different populations produce different anticipatory responses to food on later occasions (as described shortly for pattern completion inferences). Similarly, if different individuals accumulate different populations of situated conceptualizations in fear situations, they will later become anxious about different kinds of things.

Emergence

Earlier, cognition from the grounded perspective was defined as a set of phenomena that emerge in a distributed manner across cognitive mechanisms, the modalities, the body, the physical environment, and the social environment. The construct of situated conceptualization epitomizes this emergence. As a person engages with a particular kind of physical/social situation, a coupling occurs between the environment, the modalities, cognitive mechanisms, and the body. In the process, a situated conceptualization emerges across domains to interpret the situation and guide action.

Thus, viewing a situated conceptualization as simply an internal representation is much too narrow. Instead, it links the cognitive system to the environment, while controlling perceptual processing in the modalities, bodily states, and action. Although a situated conceptualization serves to interpret a situation, it also plays broader roles in coupling the individual with their physical and social environment, managing the interface between them, and controlling their situated actions.

Pattern Completion Inferences

When a local or global element of a previous situation is reencountered on a later occasion, a situated conceptualization in memory containing that element may become active. In a Bayesian manner, the likelihood that a particular situated conceptualization becomes active reflects its past frequency of use and its similarity to the current situation (Barsalou, 2011; Clark, 2013). As the reencountered local or global element is perceived and categorized, it projects onto all situated conceptualizations in memory that share the same perceptual and conceptual content. Essentially, the brain is attempting to categorize the type of situation currently being experienced. When the best fitting situated conceptualization is found, it becomes active and categorizes the current situation as a similar type of situation. On many occasions, the best fitting situated conceptualization may come from a category for a familiar repeated situation; on others, it may come from a specific memory of a relatively unique situation. On rare occasions, no relevant situated conceptualization may be available in memory, and the situated conceptualization constructed to represent the current situation functions on its own.

When a stored situated conceptualization becomes active, it produces inferences about what is likely to happen in the current situation, based on the inferential process of pattern completion (Barsalou, 2009; Barsalou et al., 2003). Content in the activated situated conceptualization that has not yet been perceived is inferred as likely to occur. When you walk into the same café again, for example, a situated conceptualization from a previous visit may become active from the category for this repeated event, preparing you to order and eat what you had previously.

We further assume that simulation (as described earlier) underlies the process of pattern completion inference. When something in the current situation reactivates a situated conceptualization stored in memory, the pattern completion inferences that result are expressed as simulations. When entering the café again and expecting to have lunch and read an article, these pattern completion inferences are produced as simulated events. Anticipating lunch, for example, produces relevant simulations of eating, drinking, and reward. We further assume that these neural simulations often produce associated embodiments, such as anticipated feelings of arousal from consuming coffee, and positive affect about reading an article.

As anticipated earlier, pattern completion inferences are likely to exhibit large individual differences. If different individuals have stored different populations of situated conceptualizations for the same local or global cue, the pattern completion process will produce different inferences. If, for example, one individual has consistently experienced good food and service in a café, whereas another individual has experienced poor food and service, these two individuals will establish contrasting situated conceptualizations for the same café. As a consequence, later visiting the café (or thinking about it) will produce different pattern completion inferences. Each individual will simulate different anticipated experiences.

Finally, any element of a situated conceptualization can serve as a cue for activating it in memory, producing the rest of the situated conceptualization as inferences. In this way, a situated conceptualization offers a flexible means of activating relevant information in memory. Any element of situated conceptualizations associated with using a hammer, for example, can activate them, including associated objects, settings, individuals, etc. Because a variety of situational elements constitute a situated conceptualization, later encountering any one can activate it.

Subjective Realism

When pattern completion inferences about an anticipated experience are simulated, they often seem subjectively real, as if they were happening (Papies & Barsalou, in press; Papies, Barsalou, & Custers, 2012). Seeing a piece of chocolate cake, for example, activates situated conceptualizations of eating chocolate cake previously. In turn, pattern completion inferences simulate how delicious the cake would taste and how rewarding it would be to consume it. Because these situated inferences seem so real, they can produce salivation in anticipation of eating (e.g., Spence, 2011). Similarly, seeing an affective stimulus, such as a wasp, can produce pattern completion inferences that manifest as bodily responses in the cardiovascular, respiratory, electrodermal, neuroendocrine, and immune systems (e.g., Lench, Flores, & Bench, 2011). According to (Papies, Pronk, Keesman, & Barsalou, 2015), the realism of these simulated inferences plays important motivational roles, being so compelling that they can induce effective situated action, such as consuming attractive food or avoiding stinging insects.

What is it about these simulated inferences that make them so real? Although this issue has received little attention, several possible cognitive abilities could potentially contribute. One possibility is that the spatial and temporal qualities of a simulated experience are sufficiently compelling that they produce the experience of time travel. In these simulations, people have the sense of "being there," as they experience being at a time and place other than their current setting. Because the spatial and temporal qualities of the experience are simulated in such a realistic manner, it seems as if it were happening, at least to some extent.

Motor simulations may also contribute to the experience of subjective realism. As people imagine acting in another time and place, these simulated actions may further contribute to the sense of doing something other than what one is actually doing currently. Similarly, simulated affect and bodily responses in the imagined situation may further contribute to the feeling that it is actually happening. As someone imagines eating a piece of chocolate cake, for example, the anticipated taste and reward responses, together with a happy feeling, may contribute to the subjective realism of the experience. Finally, having the sense of a self acting in the situation who is experiencing affect and bodily responses may contribute further. Together, all of these factors, and probably others may contribute to making simulations seem sufficiently real that they influence affect and behavior.

Interestingly, it appears possible to remove the subjective realism from a simulation. One means of accomplishing this is to shift perspective on a thought. Rather than experiencing the thought as a subjectively real experience occurring at another place and time, the thought is experienced as a mental state constructed and dissipating in the current moment. In Buddhism, this shift in perspective is referred to as creating *emptiness,* or making the thought *empty* (Khenchen Thrangu Rinpoche, 2004). In psychotherapy, coming to see emotional mental states as thoughts to be worked on may similarly shift perspective (as in cognitive behavioral therapies, psychodynamic approaches, etc.). Additionally, many secular mindfulness practices may often produce benefits because of their ability to shift perspective on a thought from being viewed as subjectively real to a transitory mental state (e.g., Bishop et al., 2006; Kabat-Zinn, 1994; Papies et al., 2012, 2015).

How do people know that these simulated experiences aren't real? One possibility is that only real experiences typically engage bottom-up input channels into the brain. A person knows that an eating simulation, for example, isn't real because bottom-up gustatory input doesn't occur. Although taste inferences in the gustatory system become active, these don't engage the neural pathways that become active when actually tasting something.

Thus, subjective realism can be viewed as lying on a continuum. A simulated event can seem somewhat real because it engages some of the same systems associated with real events (e.g., systems that process space, time, action, affect, bodily responses, self). By assessing whether certain bottom-up sources of input and feedback are occurring, however, it can be determined that a simulated event is only imagined. Conversely, when these bottom-up sources of input are present, a higher degree of subjective realism is experienced, suggesting that the event is actually occurring.

More generally, actual events are typically associated with "closed loop" sensory-motor processing, as captured in work on sensory-motor contingencies and predictive coding (e.g., Clark, 2013; Engel, Maye, Kurthen, & König, 2013; Friston, 2010; O'Regan & Noë, 2001; Pickering & Garrod, 2013). In contrast, imagined events constitute "open loop" processing, with simulations producing anticipatory inferences *not* complemented with bottom-up feedback. As a result, imagined events don't seem as real as actual events for which such feedback occurs.

Situated Conceptualization: Application

The framework for situated conceptualization just described offers a general account of diverse phenomena throughout cognition, not only in conceptual processing. As described next, pattern completion inferences within situated conceptualizations (PCIwSC) potentially support diverse forms of intelligent activity in perception and action, cognition, social cognition, affective processing, and appetitive processing. As we will see, PCIwSC also offers a natural means of explaining individual differences across these areas. Although only a few illustrative phenomena are described for each area, it is likely that PCIwSC supports many other phenomena in them as well.

Perception and Action

PCIwSC offers a natural account of many phenomena associated with perception and action. Two examples are described next: object affordances and effects of top-down expectation on perception.

Object affordances. As people use an object (e.g., a hammer), situated conceptualizations become established that integrate the object with the setting, associated objects, actions, and internal states. On later seeing another instance of the object, it activates situated conceptualizations containing it, which produce simulated actions as pattern completion inferences. Consistent with much evidence, object affordances utilize the motor system (e.g., Caligiore et al., 2010; Chao & Martin, 2000; Lewis, 2006; Tucker & Ellis, 1998). The PCIwSC perspective naturally explains how affordances originate in situational experience and are later triggered via pattern completion inferences when perceiving relevant objects.

The PCIwSC perspective further explains expertise effects that arise as a function of individual differences in using an object (Bril, Rein, Nonaka, Wenban-Smith, & Dietrich, 2010). When someone has had no experience using a tool, for example, they shouldn't generate affordances on seeing it, given that no situated conceptualizations exist in memory. Conversely, an expert should simulate detailed motor performance, given their extensive situated experience using the tool.

Top-down effects of expectation on perception. In general, context facilitates a wide variety of perceptual processes through top-down processing. Objects are perceived worse in isolation than in familiar scenes (e.g., Biederman, Rabinowitz, Glass, & Webb, 1974; Chun & Jiang, 1998; Palmer, 1975). Words are perceived worse in isolation than in sentences (e.g., Marslen-Wilson & Tyler, 1980). Emotional expressions on faces are categorized worse in isolation than in emotional situations (e.g., Barrett, Mesquita, & Gendron, 2011).

In all these cases, contexts can be viewed as activating situated conceptualizations that facilitate the processing of objects, words, or facial expressions. On seeing a kitchen scene, for example, a skillet is recognized faster than when it is perceived in isolation, because seeing a kitchen activates situated conceptualizations established in kitchens, which activate associated objects as pattern completion inferences. As these pattern completion inferences become active, they facilitate processing relevant objects currently perceived. Consistent with interactive activation and predictive coding models, the activation of contextual knowledge supports processing of related information by generating predictions about what is likely to be present currently (e.g., Clark, 2013; Friston, 2010; McClelland & Rumelhart, 1981; Rumelhart & McClelland, 1982). Situated conceptualizations offer a natural account of this contextual knowledge, with pattern completion inference offering a natural account of its activation and top-down influence on perception.

Cognition

PCIwSC similarly offers a natural account of many phenomena associated with cognition. Three examples are described next: the cuing of episodic memories, comprehension inferences, and reasoning.

Episodic memories. Many studies demonstrate that autobiographical memories become activate on encountering a wide variety of cues. Simply hearing a word that describes some part of a situation experienced in the past can retrieve a life memory associated with it (e.g., Rubin, 2002). Intuitively, we all have the experience of encountering an object, person, smell, location, feeling, etc. that reminds us of a previous event. PCIwSC offers a natural account of these reminding phenomena. When an episodic memory is encoded, it is established as a situated conceptualization, with medial temporal structures integrating its elements (e.g., Squire, Stark, & Clark, 2004). Later encoding something related to the memory activates its situated conceptualization, which is re-experienced as a simulation via pattern completion inference (e.g., Buckner & Wheeler, 2001; Rubin, 2006).

Much laboratory research further demonstrates roles of spontaneous episodic reminding in a variety of cognitive tasks (e.g., Jacoby & Wahlheim, 2013; Ross, 1987; Weymar, Bradley, El-Hinnawi, & Lang, 2013). Interestingly, as contextual variability increases across repetitions of the same stimulus, the stimulus becomes easier to remember, relative to when contextual variability is low (e.g., Berntsen, Staugaard, & Sørensen, 2013; Wahlheim, Maddox, & Jacoby, 2014). This robust finding suggests that situational information is stored on each repetition of the stimulus, with greater variability establishing more diverse situational information. On a later memory test, retrieving larger amounts of previous situational information increases the likelihood of recognizing the stimulus. From the PCIwSC perspective, greater contextual variability when learning a stimulus establishes an increasingly diverse set of situated conceptualizations in memory. On later encountering the stimulus, diverse pattern completion inferences result, producing contextual information that facilitates recollection.

Knowledge-based inference during language comprehension. PCIwSC offers a plausible account of many inferences made during language comprehension, especially those associated with meaning elaboration and prediction, with others, such as anaphora, requiring additional cognitive and linguistic mechanisms (cf. Singer & Lea, 2012). Consider the classic example of reading about a surgeon and her effectiveness in the operating room. As much work shows, the social role of a surgeon immediately activates stereotypical knowledge that the surgeon is a man, such that readers are surprised when she turns out to be a woman (e.g., Garnham, Oakhill, & Reynolds, 2002; Reynolds, Garnham, & Oakhill, 2006). Such inferences can be viewed as the result of PCIwSC. Because males are typically encoded into SCs associated with surgery, cues that activate these SCs produce simulations of male surgeons as inferences.

PCIwSC further explains inferring an event and its situational elements from encountering one of these elements (e.g., Hare, Jones, Thomson, Kelly, & McRae, 2009; McRae, Hare, Elman, & Ferretti, 2005; Metusalem et al., 2012). Reading about a location, for example, activates the people, objects, and events likely to occur in it. Analogously, reading about an object is likely to produce inferences about its location, agents, and events (also see Papies, 2013; Wu & Barsalou, 2009). In general, such inferences can be viewed as beginning with the construction of situated conceptualizations that integrate these situational elements together. On later occasions, when one of these elements is encountered, it activates the others via pattern completion inference.

PCIwSC also explains a wide variety of simulation-based inferences (e.g., Glenberg & Gallese, 2012; Zwaan, 2004; Zwaan & Madden, 2005). When reading about pounding a nail into a wall, for example, readers visually anticipate a horizontal nail. Similarly, when reading about opening a drawer, readers motorically anticipate a pulling action. Again, such inferences can be explained as occurring when a text activates relevant situated conceptualizations that produce modality-specific simulations as inferences. Consistent with this account, Richter, Zwaan, and Hoever (2009) demonstrate the role of learning episodes in simulation inferences.

Human reasoning. Finally, PCIwSC offers a basic set of mechanisms on which human reasoning processes might be grounded. Consider the basic reasoning pattern of modus ponens. According to this pattern, if X then Y is true, then when X is true, Y must be true as well. Intuitively and roughly speaking, this is the essence of pattern completion inference: X→Y is the pattern, X is the cue, and Y is the pattern completion inference. Certainly, there is more to modus ponens than pattern completion. Arguably, however, the additional logical structure required for modus ponens is built upon the pattern completion process. Importantly, modus ponens is an intuitive, natural, and ubiquitous inference, occurring robustly across tasks and individuals (e.g., Evans, 2002). Perhaps modus ponens is so intuitive and obvious because it is built upon PCIwSC.

Conversely, the inference pattern of modus tollens is much less intuitive. According to this pattern, if X→Y is true, then when not-Y is true, not-X must be true as well. Often people fail to note the importance of this logical pattern when it occurs in abstract logical arguments (e.g., Evans, 2002). From the perspective of PCIwSC, modus tollens may not be obvious in abstract arguments because the absence of something is typically not a cue that can effectively retrieve situated conceptualizations. As a result, inferring the absence of X takes sophistication and effort to conclude.

Interestingly, however, when modus tollens applies to a familiar situation, it is more likely to be salient and recognized as important. As many researchers have argued, knowledge about familiar situations is responsible for this improvement. From the perspective of PCIwSC, not-Y is now represented as a familiar situational element that can activate relevant situated conceptualizations and produce inferences about not-X. Imagine, for example, that if someone is 18 (X), then they can legally drink alcohol (Y). From much experience of knowing that individuals younger than 18 cannot drink, situated conceptualizations of young people not drinking become stored in memory. On later occasions, hearing that someone can't drink (not-Y) activates these situated conceptualizations, producing the pattern completion inference that this individual must be under 18 (not-X).

Social Cognition

Three examples demonstrating how PCIwSC

has been applied to social cognition are described next: social embodiment, social priming, and social mirroring.

Social embodiment. Much work shows that experiencing a particular state of the body activates associated social states, especially states associated with affect and evaluation (for reviews, see Barsalou et al., 2003; Niedenthal et al., 2005). Consider some examples. Surreptitiously configuring someone's face into a smile produces positive affect and evaluation, whereas configuring their face into a frown produces negative affect and evaluation. Similarly, a wide variety of other bodily states produce associated affect and evaluation, including head motion, arm motion, body motion, and body posture. Barsalou et al. (2003) used PCIwSC to explain this general class of effects. In general, a particular state of the body activates a situated conceptualization in memory containing it, thereby producing simulated affect and evaluation as pattern completion inferences. Slumping, for example, activates situated conceptualizations containing it that typically include negative affect and evaluation. As these situated conceptualizations become active, they produce the affect and evaluation contained in them as pattern completion inferences.

Social priming. Social embodiment can be viewed as a special case of the more general process of social priming. As many researchers have shown, just about any element of a social situation can prime affect and evaluation, including temperature, weight, cleanliness, color, shape, age, social role, and so forth (for recent work, see the supplemental 2014 issue of *Social Cognition* on social priming). Although some social priming effects don't always replicate, there is no doubt that they occur ubiquitously. Again, just about any element of a social situation can prime other aspects of social situations, ranging from affect and evaluation to beliefs and behavior.

PCIwSC offers a natural account of social priming and its ubiquitous character. As social situations are experienced, situated conceptualizations are constructed. As these situated conceptualizations accumulate in memory, they offer extensive sources of pattern completion inferences on subsequent occasions. When one of their elements is encountered (e.g., temperature, weight, cleanliness), it activates a relevant situated conceptualization containing it, producing remaining elements as pattern completion inferences, including affect, evaluation, and action. Because any aspect of these situated conceptualizations can trigger this process, social priming takes infinitely many forms.

Social mirroring. People often mirror the actions, emotions, speech, attention, postures, etc. of other perceived individuals, at least neurally, and sometimes bodily and behaviorally. These mirroring activities play important roles in individual cognition and social interaction, including action understanding, action preparation, social contagion, and learning via imitation. A standard account of mirroring is that it results from mirror neurons, namely, neurons that have both motor and perceptual tunings (e.g., Rizzolatti & Craighero, 2004). Mirror neurons not only become active when an action is performed, but also on perceiving it. Because these neurons become active during action perception, they ground action perception in motor simulation.

Following many similar proposals, PWIwSC offers an alternative learning account of social mirroring (e.g., Brass & Heyes, 2005; Cooper, Cook, Dickinson, & Heyes, 2013; Heyes, 2011; Hommel, 2013; Keysers & Perrett, 2004; Prinz, 1997; Shin, Proctor, & Capaldi, 2010; also see Pickering & Garrod, 2013). From this perspective, the perception of an action is typically associated with production of the action through a wide variety of learning processes (Ray & Heyes, 2011). Waving to someone, for example, becomes associated with seeing oneself and others wave. On later occasions, perceiving the action activates its stored association with the performed action, producing the performed action as an associative response.

From the PWIwSC perspective, the perception and production of an action become stored together in situated conceptualizations when both occur, with later perception of the action producing a motor simulation of it via pattern completion inference (Barsalou, 2013). From this perspective it also follows that performing the action produces a simulation of its perception again via the pattern completion process (i.e., forward models and corollary discharge; e.g., Clark, 2013; Pickering & Garrod, 2013). It further follows that perceiving any element of these situated conceptualizations could produce both the perception and the production of the action. In other words, mirroring is just one of many pattern completion processes possible from situated conceptualizations that include both the perception and performance of actions.

Affective Processes

Two examples next demonstrate how PCIwSC can be been applied to affective processes: emotion and conditioning.

Emotion. Genetically-endowed circuits are often assumed to produce discrete emotions such as fear, disgust, anger, sadness, happiness, etc. (e.g., Ekman, 1992). From this perspective, the circuit for a particular emotion responds to relevant stimuli in the environment by producing relatively fixed facial expressions, peripheral physiology, neural activity, actions, and subjective experience. Problematically, however, increasing evidence demonstrates considerable heterogeneity within an emotion across facial expression, peripheral physiology, neural activity, action, and subjective experience, together with much overlap across emotions (e.g., many different facial expressions occur for fear, which often occur for other emotions as well; for reviews, see Barrett, 2006a; Barrett et al., 2007).

In contrast, constructivist accounts naturally explain the heterogeneity and overlap that occur for emotions (Gendron & Barrett, 2009). From this perspective, a given instance of an emotion assembles processing resources throughout the brain and the body relevant for producing the emotion in the current situation, including perceptual, cognitive, physiological, and motor resources. Depending on the situation, different resources are assembled that are currently relevant for producing the emotion. Producing fear when one's life is threatened by an approaching car, for example, assembles different resources than producing fear when one unintentionally insults the boss at work. Across situations where fear is appropriate, different resources are assembled, such that heterogeneity across facial expression, peripheral physiology, neural activity, action, and subjective experience occurs. Furthermore, because the same resources are relevant for different emotions, overlap in the resources utilized across emotions occurs.

One way of thinking about emotion construction is that it results from the processes of constructing and using situated conceptualizations (e.g., Barrett, 2006b; Lebois et al., 2015; Wilson-Mendenhall et al., 2011). During an affective situation, a situated conceptualization is assembled to interpret and manage the situation. As in any situation, networks in the brain's situation processing architecture produce streams of perceptual experience and conceptual interpretation. Across different situations associated with a given emotion, different local and global conceptualizations are established, thereby producing the heterogeneity and overlap that characterizes the emotion.

PCIwSC also contributes to the process of constructing an emotion. As elements of a familiar affective situation are encoded, situated conceptualizations that contain them in long-term memory become active. In turn, these situated conceptualization produce pattern completion inferences in facial expression, peripheral physiology, neural activity, action, and subjective experience. In other words, these inferences reproduce the past emotion in the brain and the body. Generally speaking, much emotion probably results in this manner. As one encounters familiar affective stimuli, settings, and events (e.g., babies, cafés, and weddings), they activate situated conceptualizations of similar experiences, producing the associated affect in the brain and body via pattern completion inferences. Consistent with this account, a wide variety of emotional stimuli induce emotion, including faces, scenes, words, texts, videos, and smells (e.g., Coan & Allen, 2007; de Groot, Semin, & Smeets, 2014; Lench et al., 2011).

Conditioning. In classical conditioning, a conditioned stimulus becomes associated with an unconditioned stimulus, such that the conditioned stimulus produces an unconditioned response in the absence of the unconditioned stimulus (e.g., Domjan, 2014). Seeing a bag of potato chips, for example, becomes associated with eating them, such that just seeing the bag produces the salivation that normally occurs during actual consumption. From the perspective of PCIwSC, classical conditioning results from conditioned stimuli, unconditioned stimuli, and unconditioned responses co-occurring in the same situation, such that situated conceptualizations become established that integrate them together. On later occasions, when conditioned stimuli are perceived, they activated these situated conceptualizations, which produce unconditioned responses via pattern completion inferences.

Much work has reported that classical conditioning is highly sensitive to context (Bouton, 2010; Bouton & Todd, 2014; Gawronski & Cesario, 2013). As current contextual cues overlap increasingly with past learning contexts, the likelihood of a classically conditioned response increases, suggesting that relatively complete memories of previous situations mediate the production of conditioned responses. Additionally, the related processes of extinction and spontaneous recovery are also highly sensitive to context. The more an extinction situation varies from situations associated with classical conditioning, the faster extinction occurs. Following extinction, increasingly reinstating the original learning context augments the probability of spontaneous recovery. All these results implicate situated conceptualizations and pattern completion in classical conditioning, or at least processes like them.

Similarly, instrumental conditioning can be naturally incorporated into the situated conceptualization framework. During instrumental conditioning, a cue indicates that performing an instrumental response is likely to produce a reward (e.g., Domjan, 2014). From the situated conceptualization perspective, instrumental learning occurs in situations that include the cue, the instrumental behavior, and the reward outcome. As a consequence, situated conceptualizations become established in memory that link the elements of the conditioning process together. On later occasions when the cue is presented alone, it activates these situated conceptualizations, which in turn, produce the instrumental behavior, together with anticipated reward, as pattern completion inferences. Again, many aspects of instrumental conditioning exhibit strong sensitivity to contextual details, implicating the storage and use of situational information, as the situated conceptualization framework predicts.

Appetitive Processes

Finally, several examples demonstrate how PCIwSC can be been applied to appetitive processes: desire, habits, implementation intentions, and goal priming.

Desire. On encountering an appetitive stimulus, such as a pizza, people often experience desire to consume it. As Papies and Barsalou (in press) propose, PCIwSC offers a natural account of hedonic responses to appetitive objects. According to this account, situated conceptualizations of consumptive episodes become established in memory (e.g., eating pizza). On later occasions, when encountering an appetitive object, situated conceptualizations containing it become active to guide anticipations and actions in the current situation. As a consequence of the pattern completion process, simulations of consuming the appetitive object result, whose subjective realism is sufficiently compelling to produce desire and actual consumption (Papies et al., 2012, 2015; also see Kavanagh, Andrade, & May, 2005).

Consistent with this account, much work demonstrates that these pattern completion inferences activate simulations of consumptive behavior. When people perceive food cues, for example, they activate primary gustatory and food reward areas (e.g., Barros-Loscertales et al., 2011; Simmons, Martin, & Barsalou, 2005; van der Laan, de Ridder, Viergever, & Smeets, 2011). From the PCIwSC perspective, food cues activate situated conceptualizations of previously eating a cued food, which in turn produce taste and reward inferences about what it would be like to actually eat it.

More generally, PCIwSC offers an account of desire across appetitive domains, including food, alcohol, nicotine, sex, drugs, and so forth. Across domains, appetitive cues activate situated conceptualizations associated with past consumption, thereby producing pattern completions of simulated consumption that can be highly motivational. Furthermore, PCIwSC offers a natural account of individual differences in a given domain. Depending on a person's specific consumptive history, a unique population of situated conceptualizations for consumptive experiences develops in memory, which then controls subsequent consumptive behavior through pattern completion inferences.

Habits. To the extent that a person regularly performs a particular kind of consumptive behavior in a particular kind of situation, a well-entrenched set of situated conceptualizations should become established for it in memory. As a consequence, entering the situation should readily trigger the habit via pattern completion inferences, such that it runs relatively effortlessly and implicitly, without much conscious deliberation (e.g., Aarts & Custers, 2009; Aarts & Dijksterhuis, 2000; Ouellette & Wood, 1998; Sheeran et al., 2005; Wood, Quinn, & Kashy, 2002). Thus, PCIwSC provides a natural account of how habitual behavior becomes established in memory, and how it is later cued and controlled in relevant situations (Papies & Barsalou, in preparation).

Implementation intentions. When someone wants to change behavior, developing an implementation intention can be a useful strategy (e.g., Gollwitzer, 1999). Imagine, for example, wanting to eat salads when going out for lunch during the work week instead of sandwiches. To support this goal, one could create an implementation intention by imagining, as concretely as possible, a situation where you might eat salad, and then imagine ordering it off the menu. On later actually entering the imagined situation, you're reminded of the implementation intention, which (hopefully) produces your intended action.

From the PCIwSC perspective, envisioning future situations and planning actions in them can be viewed as constructing situated conceptualizations (Papies & Barsalou, in preparation). Furthermore, activating an implementation intention in a targeted situation can be viewed as activating the situated conceptualization constructed earlier, which in turn simulates the intended action via pattern completion inference. Consistent with this account, the more contextual detail and imagery included in an implementation intention, the more effective it is in producing the targeted behavior (e.g., Knäuper et al., 2011; Papies, Aarts, & de Vries, 2009).

Goal priming. When someone has pursued a goal in previous situations, encountering a relevant goal cue can activate the goal, such that it controls behavior in the current situation. When someone diets on a regular basis, for example, they pursue the dieting goal in many eating situations, establishing situated conceptualizations of them in memory. On later occasions, when a cue related to dieting is encountered, it activates these situated conceptualizations, producing the dieting goal and dieting behavior as pattern completion inferences (Papies & Hamstra, 2010; Papies, Potjes, Keesman, Schwinghammer, & van Koningsbruggen, 2014; Papies & Veling, 2013). As these studies further show, these pattern completion inferences do *not* occur for non-dieters, who have not established situated conceptualizations for dieting behavior.

Again the PCIwSC perspective naturally explains these findings (Papies & Barsalou, in preparation). Not only does it explain how situational cues can produce goal-directed behavior, it explains how individual differences in goal pursuit results from different situational behavior in the past. This approach further suggests that adding situated conceptualizations to memory while pursuing desirable new goals offers an approach for behavior change, establishing new habits that compete with old ones.

Conclusion

As the applications just reviewed suggest, the situated conceptualization framework is potentially relevant to diverse areas of human cognition and behavior. Across domains, people appear to store situated conceptualizations and later use them to guide future activity via pattern completion inference. Additionally, this framework offers a plausible account of intelligent behavior, not only in humans, but in others organisms as well (Barsalou, 2005a). The potential generality of this framework across domains and species suggests that its mechanisms are central to biological intelligence.

In laying out the case for this account, however, it has become increasingly clear, to me at least, how little we actually understand it, and how little direct evidence there is for it. Although much indirect evidence is consistent with this framework, little evidence bears directly on the construction of situated conceptualizations, their storage in memory, and their use during pattern completion inference. Clearly, further work is needed to establish whether the accounts of the phenomena just reviewed are correct, and if so, how they operate in detail.

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