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Moving beyond the distinction between concrete and abstract concepts

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From the perspective of the situated conceptualization framework, the primary purpose of concepts is for categorizing and integrating elements of situations to support goal-directed action (including communication and social interaction). To the extent that important situational elements are categorized and integrated properly, effective goal-directed action follows. Over time, frequent patterns of co-occurring concepts within situations become established in memory as situated conceptualizations, conditioning the conceptual system and producing habitual patterns of conceptual processing. As a consequence, individual concepts are most basically represented within patterns of concepts that become entrained with specific kinds of physical situations. In this framework, the concrete versus abstract distinction between concepts is no longer useful, with two other distinctions becoming important instead: (i) external versus internal situational elements, (ii) situational elements versus situational integrations. Whereas concepts for situational elements originate in distributed neural networks that provide continual feeds about components of situations, concepts for situational integrations originate in association areas that establish temporal co-occurrence relations between situational elements, both external and internal. We propose that studying concepts in the context of situated action is necessary for establishing complete accounts of them, and that continuing to study concepts in isolation is likely to provide relatively incomplete and distorted accounts.

This article is part of the theme issue 'Varieties of abstract concepts: development, use and representation in the brain'.

1. The importance of studying abstract concepts during situated action

Most typically, researchers study concepts in isolation. A word for a concept is presented (or sometimes a pictured instance), and the information that becomes active is assessed with behavioural and/or neural measures. From this perspective, a concept is simply the information that becomes active when processing cues for it. As a consequence, theories typically focus on the representational structures and processes that become active for concepts cued in isolation.

From the perspective of situated cognition, however, a concept supports the effective action of an embodied agent embedded in the physical and social environments [1–3]. To support situated action, a concept is typically coupled with its referents in the body and world, along with other concepts that represent additional situational elements and their integration—it doesn't operate in isolation. By situated action, we not only mean action *per se*, but all the cognition that supports it, including the comprehension of situations and the production of predictions that make human action possible (as discussed later in further detail; also see [4]).

If this account is correct, then what we learn from studying concepts in isolation is likely to be limited and perhaps distorted. Certainly, statistical regularities are associated with concepts that can be viewed as Bayesian priors [5]. Nevertheless, it can be argued that priors are never fully context-independent or fixed, instead reflecting the evolving contexts in which they are continually

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updated. Furthermore, priors are typically accompanied by significant amounts of potentially dominating, contextually relevant information. For these reasons, researchers argue increasingly that studying priors in isolation and reifying them into 'gold standard' conceptual cores is a misleading practice [5–8].

To develop more complete and powerful accounts of concepts, examining their use in situated action is necessary. The use of the Visual World Paradigm offers a compelling example [9–12]. Studying language embedded in visual worlds typically produces findings and conclusions that go beyond those established from studying language in isolation. Our theme here is that we will similarly establish a more complete understanding of concepts if we study them in the context of situated action. To the extent that we only study the information that becomes active for concepts from simple cues, our understanding will continue to be limited.

We further suggest that this conclusion is especially true for abstract concepts. As we will propose, the sophisticated situated action that humans perform is not possible without abstract concepts [4]. Abstract concepts integrate situations in ways that are essential for comprehending what is happening in a situation, making accurate predictions about what is likely to occur, and selecting actions that yield desirable outcomes.[1]

2. The situated conceptualization framework

The situated conceptualization framework offers one possible account of conceptual processing during situated action [13–17]. Its basic assumptions are as follows: first, the primary function of the conceptual system is to support situated action. To do so, it constructs a *situated conceptualization* to categorize and explain the current situation, to predict likely events in it, and to produce actions that yield desirable outcomes. Second, once a situated conceptualization is constructed to support situated action, it is superimposed on long-term memory, making it available for use in future situations. In this manner, habitual conceptual patterns for processing familiar situations become conditioned in the cognitive system. Third, as future situations are encountered, they activate relevant situated conceptualizations in memory that produce anticipatory inferences via multimodal simulation. As a consequence, past situational experiences play significant roles in situated action, especially in familiar situations. Finally, when people imagine situations that aren't present—recollecting the past, assessing counterfactuals to the present, projecting themselves into the future—they simulate these events as situated conceptualizations, again drawing on memories of past situational experiences.

(a) The Brain As a Situation Processing Architecture (BASPA)

Most basically, we define a situation as a setting where agents encounter other agents, objects and events, which activate goals, affect and bodily states, leading to actions and outcomes. Although other kinds of situations exist, we focus on these basic situations here.

From the situated conceptualization perspective, the brain's most basic function is to process situations, both in the present and when representing non-present situations. Because staying alive and being successful depend on comprehending perceived and simulated situations correctly, making accurate inferences about what is likely to happen, and acting effectively to produce desirable outcomes, the brain's architecture has evolved to support these essential functions. One hypothesis about this architecture is that it contains two basic kinds of neural systems: (i) systems that process the *elements* of situations, and (ii) systems that *integrate* these elements into broader patterns—situated conceptualizations—to support comprehension, prediction and action.[2]

(b) Situational elements

First, consider systems that process the elements of situations in BASPA. What might these elements be? Decades of research on thematic roles in language [19,20] and frame structure in cognitive science [21–25] suggest the following kinds of situational elements (indicated next in italics): typically, situations occur in a physical *setting*, with *agents* present (at least oneself and often others), performing *action*s on *objects* (including people) to produce desired *outcomes*. Not only does the physical world contribute elements to a situation, so does the rich milieu of internal experience, including *self-relevance* (e.g. goals, values, norms, identities), which initiates *emotion* and *motivation*, often accompanied by various forms of *mentalizing* (e.g. evaluation, prediction). These internal states are central to situations, providing the personal meaning that makes them significant. Viewing situated action as only the external elements of situations misses the important contributions from internal states that drive situated action and make it meaningful. Basic elements of internal experience—self-relevance, emotion, motivation and mentalizing—complement external situational elements—settings, agents, actions, objects and outcomes.[3]

Besides emerging repeatedly as basic building blocks across the cognitive sciences, these situational elements are also likely to reflect well-established networks in the brain. Much evidence demonstrates, for example, that the brain contains distributed networks for processing: (i) an agent's current *setting* (parietal lobe, parahippocampal gyrus, retrosplenial cortex), (ii) *objects* in the setting (the ventral stream), (iii) *other agents* who are present (temporal poles, FFA, mPFC, PCC, STG, EBA), (iv) *self-relevance* (mPFC, PCC), (v) *physical actions* in the environment (motor and somatosensory cortices, cerebellum, basal ganglia), and (vi) a wide variety of internal responses to physical situations, including emotion, motivation and mentalizing (mPFC, OFC, lPFC, ACC, insula, amygdala, PCC).

From the BASPA perspective, this collective set of networks constitutes an architecture for continuously processing the elements of current situations. As situations come and go over time, each of these networks produces a continuous stream of perceptual experiences (qualia) for its respective situational content, along with corresponding conceptual interpretations of this content (categorizations). The network that processes settings, for example, produces a continuous stream of perceptual and conceptual information about current settings. Analogously, the networks that process objects, self-relevance and emotion produce continuous streams of perceptual and conceptual information about the objects present, their self-relevance, and the emotion experienced in response to them. Over time, each of these systems provides a continuous informational 'feed'—both perceptual and

conceptual—about its respective situational elements. In a similar manner, simulations of non-present situations are re-enacted within the same situation processing architecture.[4]

Finally, we assume that BASPA feeds are processed in two manners [15,16]. First, BASPA feeds enter consciousness and working memory where they are integrated into a coherent perceptual state of the current situation, along with a conceptual interpretation of it. Second, BASPA feeds function as cues to activate situational patterns in long-term memory that help process the current situation. As a situational memory becomes active, it in turn becomes implemented as a simulation in the BASPA architecture, perhaps being superimposed on the current situation.

(c) Integrating situational elements into meaningful configurations

As just described, BASPA produces a collective conceptualization of the elements present either in the current situation or in the simulation of a non-present situation. Without integrating these elements relationally, however, relatively little understanding of the situation is achieved. If, for example, a muffin is perceived in a coffeehouse, preceded by hunger and followed by consumption, no understanding exists of why hunger and consumption co-occurred with the muffin.

To establish more complete understanding, it is obviously necessary to relate situational elements to one another meaningfully. As we suggest later, the human ability to establish meaningful relations between situational elements is so flexible, productive, and open that it may be difficult, if not impossible, to characterize it fully. Essentially any combination of situational elements could potentially be integrated. Nevertheless, it is perhaps useful to note basic forms of relational integration that occur during the conceptual processing that support situated action.

Arguably, the relational structure of *goal-directed action* may be the most basic way that organisms (not only humans) organize situational experience. Such structure has played central roles across disciplines for decades, including theories of conditioning, problem solving and narrative [28–32]. As an example, imagine seeing food, activating the goal to consume it and becoming motivated by desire to do so, followed by eating the food and feeling satisfied. In this situation, its elements include an object, an agent, a goal, a motivation, an action and an outcome, all categorized by the respective distributed networks for processing situational elements. An underlying relational structure makes this set of elements coherent and meaningful, including: (i) the relation between the object (food) and a goal that comes to mind (to consume the food), (ii) the relation between the goal and the motivation to act that follows (desire), (iii) the relation between the motivation and the action that it produces (eating), and (iv) the relation between the action and the outcome that follows (satisfaction). In general, consumption situations of all sorts can be viewed as organizing relevant situational elements around basic relations associated with goal-directed action, as can many kinds of situations associated with other kinds of situated action.

Causal chains offer another basic kind of relational structure in situations. When too much rain falls, this can cause rivers and lakes to flood, which can cause streets, houses and schools to be under water, which can cause structural damage. *Speech acts* offer further basic forms of relational structure in human language situations [33–35]. In a request, for example, a speaker holds a mental state about a desired outcome, and produces an utterance that hopefully motivates a listener to act on the speaker's behalf. Should the listener be willing, the desired outcome is achieved. In this kind of situation, the relevant relations include the speaker and listener holding various mental states, the speaker making an utterance, the listener comprehending it, the listener acting, and an outcome resulting. In all these cases, situations become coherent and meaningful as the result of agents superimposing relational structure on relevant situational elements.

3. Concepts for situational elements versus situational integrations

From the perspective just described, two important kinds of concepts emerge to support situated action: (i) concepts that *represent* situational elements, (ii) concepts that *integrate* situational elements [15,18].

(a) Concepts for situational elements

Again, from the BASPA perspective, the brain contains networks that process the elements of situations, with the feed from each network including perceptual qualia about its elements and conceptualizations of them. We propose that concepts for situational elements constitute the conceptual output of these networks. The setting network, for example, produces conceptualizations of settings, such as home, office and street. Similarly, the object network produces conceptualizations of objects, such as sofa, computer and car; the action network produces conceptualizations of actions, such as sit, search and drive. Networks that process internal states similarly produce streams of concepts on their feeds. The self-relevance network, for example, produces conceptualizations of goals (e.g. satiation, warmth, safety), along with conceptualizations of values, norms and identities (e.g. honest, friendly, helpful). For every network in BASPA that processes a kind of situational element, concepts develop within the network to categorize instances of the element.

(b) Concepts for situational integrations

Conversely, concepts for situational integrations develop to inter-relate situational elements relevant to comprehending situations, predicting likely events, and acting effectively to produce desired outcomes. Because so many kinds of integrations are possible, many different kinds of situational integrations develop (as discussed in more detail later). As also argued later, establishing concepts for situational integrations provides agents with leverage in situated action, supporting successful goal achievement. For decades, researchers have noted the importance of relational concepts in human cognition, similar to our notion of integrative concepts here [19,21–23]. The importance of thematic associates for abstract concepts is also consistent with our proposal that many abstract concepts integrate the elements of situations [9,36].

(c) Concrete and abstract content in situational integrations

Interestingly, situational integrations appear to range from being relatively 'concrete' to relatively 'abstract'. Even the more concrete integrations, however, often exhibit

considerable abstractness. Consider the situational integration associated with *dining*, which typically integrates a dining setting (e.g. kitchen, cafe) with relevant objects (food, dishware, cutlery) and relevant actions (e.g. eating, drinking). Notably, however, *dining* also integrates a variety of internal states including goals (e.g. become satiated), values (e.g. support sustainability), norms (e.g. politeness), motivation (e.g. hunger) and emotion (e.g. pleasure). When the social element of dining is further considered, the abstract side of these situations becomes still more pronounced, integrating the mental states of others, together with communication and other forms of social interaction.

Even what might seem like a completely 'concrete' situational integration can easily become 'abstract'. Consider *hammering*. Although this might appear to be a very concrete activity (e.g. integrating a swinging motion, a hammer, a nail and two boards), it typically includes a goal (e.g. attach something to a wall) and could easily include emotion (e.g. senses of accomplishment and power, fear of smashing one's finger) and social interaction (e.g. guilt at annoying one's neighbours with the racket).

Conversely, some situational integrations might seem almost completely abstract, but nevertheless actually be quite concrete as well. Consider the sense of *truth* associated with producing accurate statements about the world [26]. Imagine that someone claims it's snowing outside on a late summer day, and another person who just came in from outside confirms, 'That's the truth!' Here, *truth* refers to the first speaker's claim being an accurate representation of the world. Although *truth* might seem relatively abstract, it links together many concrete aspects of the situation, including a speaker's utterance embedded in a social interaction, along with reference to a perceived physical situation that matches the utterance's mentally represented meaning.

Emotion concepts similarly integrate both abstract and concrete situational content. On the one hand, they often seem relatively abstract, referring to internal mental states, such as love or fear. On the other, they typically integrate mental states with emotion-eliciting stimuli in the world (e.g. babies, spiders), along with physical actions and outcomes (e.g. approach, avoidance, reward, harm) and bodily states (e.g. arousal, hyperventilation). Not only has this mixture of abstract and concrete content been demonstrated frequently in specific experiments [18,37], it is also commonly documented in meta-analyses of neural activity during emotion [38–40].

As all these examples illustrate, close examination of just about any situational integration reveals both concrete and abstract content. Concrete content generally comes from the external elements of situations, including settings, objects, physical agents, physical actions and physical outcomes. Indeed, when abstract concepts are processed in the context of visual scenes, more activations can occur in visual and other sensory-motor areas than for concrete concepts processed in the same scenes [41]. In contrast, abstract content generally comes from processing the internal elements of situations, including self-relevance, emotion, motivation and mentalizing. Additionally, abstract content emerges from the relations that integrate situational elements, both external and internal.

(d) Revisiting the concrete versus abstract distinction

In the literature, a concept is typically categorized as 'concrete' if its referents are bounded physical entities perceptible in the external world, such as dogs, apples and chairs [42,43]. Operationally, concrete concepts are usually defined as being above some threshold on a self-report scale of 'concreteness', as just defined theoretically (e.g. the MRC psycholinguistic database; [44,45], but see [43]). In contrast to concrete concepts, abstract concepts are usually defined negatively as *not* being bounded physical entities perceptible in the external world, and respectively, as being *below* some scale-threshold for concreteness. Notably, these definitions actually do not offer much insight into the nature of concrete versus abstract concepts. In particular, the negative definition of abstract concepts only describes what they are not—it says nothing about what they are. For the purpose of the discussion to follow, we will refer to these standard definitions of concrete and abstract concepts in the literature as *concrete-LIT* and *abstract-LIT*.

From the perspective of situated conceptualization, the traditional distinction between concrete-LIT and abstract-LIT concepts is not particularly useful. Part of the problem, again, is the implicit assumption that all we need to understand about concepts is what becomes active when they are cued in isolation. From this limited perspective, concrete-LIT and abstract-LIT concepts simply activate different kinds of information in the cognitive system (e.g. perceptual versus non-perceptual).

If we assume instead that the fundamental purpose of concepts is to process situations in support of effective goal-directed action, then the distinction between concrete-LIT and abstract-LIT concepts becomes largely irrelevant. Concrete-LIT concepts no longer seem so concrete when viewed as elements of larger patterns that support situated action—situated conceptualizations—with these patterns typically including internal situational elements and relations between situational elements. Even the most concrete-LIT concepts, such as a chair, have an abstract character from the situated perspective, once internal aspects of typical chair situations are included in representing the concept. Because chairs are typically associated with goals (resting), motivation (fatigue), emotion (comfort) and mentalizing (mind wandering), they clearly have 'abstract' elements. Additionally, adding the relations that integrate the external and internal elements of chair situations makes them even more 'abstract'.

Conversely, abstract-LIT concepts no longer seem so abstract when viewed as parts of situated conceptualizations. As we saw earlier, abstract-LIT concepts such as truth and fear typically operate in the context of complex situations, contributing internal elements on the one hand, while integrating these internal elements with external elements on the other.

As these examples illustrate, the traditional concrete-LIT versus abstract-LIT distinction artificially divides situated cognition into idealized bits and pieces of each type, omitting the critical dependence each has upon the other. Rather than being processed in isolation, diverse concepts typically participate together in the representation and processing of complex situations. Furthermore, the negative definition of abstract-LIT concepts as *not* being bounded physical entities perceptible in the external world is again not as informative as a positive definition would be. Finally, the assumption that abstract-LIT concepts are not bound to perceptible entities is generally misleading, given that referents in the Visual World Paradigm can become more accessible when

cued by abstract-LIT than by concrete-LIT words [9]. We later address further cases of abstract-LIT words activating concrete content.

Thus, we propose an alternative account of concrete and abstract concepts from the perspective of the Situated Conceptualization framework, which we will refer to as the *concrete-SC* versus *abstract-SC* distinction. From this perspective, we will illustrate how viewing the brain as a situation processing architecture (BASPA) offers a different perspective on the concrete–abstract distinction. Not only does this account offer a theoretically motivated distinction between concrete-SC and abstract-SC concepts, it also offers a positive definition of abstract-SC concepts.

Specifically, we propose that concrete-SC concepts originate in BASPA's networks for processing external elements of situations, including settings, objects, agents, external actions and external outcomes. In each case, the respective concrete-SC concepts emerge from the continual feeds that relevant BASPA networks produce as they process and conceptualize the elements of external situations.

Conversely, we propose that abstract-SC concepts originate in two ways: first, one kind of abstract-SC concept emerges from BASPA's networks for processing internal elements of situations, including emotion, motivation, mentalizing and self-relevance (e.g. goals, values, norms, identity). As situations are processed, these concepts emerge from the continual feeds that relevant BASPA networks produce while processing elements of an individual's internal milieu.

The second kind of abstract-SC concept is one that *integrates* situation elements, both external and internal. We assume that the relational structure integrating situational elements is relatively abstract, not concrete, being represented internally, not externally. Specifically, the relations integrating situations only exist internally as constructions in working and long-term memory, rather than as physical entities in the world. As situational elements are processed together in working memory, representations of these processing episodes become increasingly established in long-term memory. As a consequence, entrenched integrations of familiar situations result. Later we offer a tentative account of how this integrative structure might emerge within the BASPA framework, using the brain's association areas.

As we just saw, it's possible to distinguish concrete-SC and abstract-SC concepts within the situated conceptualization framework. Nevertheless, we increasingly doubt whether terms like 'concrete' and 'abstract' are ultimately useful and informative in describing concepts. We further worry that such a distinction leads to the over-simplification associated with the concrete-LIT versus abstract-LIT distinction described earlier. For these reasons, we think that it might be advantageous to distinguish concepts in other ways that avoid these problems, and that instead are theoretically-motivated, providing mechanistic accounts of how different kinds of concepts originate.

Specifically, we suggest replacing the traditional concrete-LIT versus abstract-LIT distinction with two other distinctions central to the situated conceptualization framework: (i) the distinction between *external* versus *internal* elements of situations, (ii) the distinction between situation *elements* versus situation *integrations*. A further corollary is that external situational elements, internal situational elements and situation integrations are rarely processed in isolation under ecological conditions, but instead are typically processed together to support situated action. As a result, concepts become integrated into large conceptual patterns—situated conceptualizations—that support the processing of familiar situations.

Clearly, major differences between different kinds of concepts still remain within this framework. At a broad level, the concepts that represent external situation elements, internal situation elements, and situational integrations must vary considerably. Furthermore, major differences obviously exist within each of these general domains as well. For external situational elements, concepts for settings, objects, agents, physical actions and physical outcomes differ widely, as do emotions, motivations, mentalizing and self-relevance for internal situational elements. And as described later, the diversity of situational integrations is limited only by the combinations of situational elements that can be inter-related. Most importantly, the research orientation for understanding different concepts from this perspective does not revolve around whether they are concrete or abstract, but instead depends on the specific roles they play in processing present and non-present situations. Additionally, each kind of situational element, both external and internal, must be understood in its own right, as must concepts for situational integration.

4. Using concepts for situational integration to leverage situated action

Because the basic function of situational integration is to interrelate situational elements, it's not clear how much can be learned from studying concepts for situational integration in isolation. If no situational elements are present to integrate, it's not clear what would become active for these concepts and how they would be processed. Instead, concepts for situational integration may only become fully engaged when at least some elements of a relevant situation are present, such that something exists to integrate. Consistent with this conclusion, abstract-LIT concepts are processed more effectively when relevant contexts are present than when they're not [46]. Furthermore, the brain areas that become active for abstract-LIT concepts change dramatically when processed deeply in relevant contexts [41]. Similar to language processing in the Visual World Paradigm, conceptual processing changes significantly when coupled with relevant situations.

To the extent that this account is correct, what are the functions of conceptual integration, as concepts for situational integration engage with the external and internal elements of situations? In general, we suggest that this engagement provides significant leverage on performing situated action effectively. Specifically, we propose that engaging concepts for situational integration supports three important functions: (i) comprehending situations, (ii) predicting events, and (iii) performing appropriate actions that produce desirable outcomes. We address each role of situational integration in turn.

First consider the comprehension of situations. Understanding what is happening currently in a situation is the first step towards predicting what could happen later and acting effectively. To the extent that perceivers can integrate the perceived external and internal elements of a situation into a meaningful pattern, they can comprehend it. On

seeing people sitting around a table with food on it, for example, perceivers can comprehend the situation if they integrate its elements using integrative concepts for eating, dining, etc. Similarly, on seeing someone standing next to a sink by a stack of dirty dishes with the water running, perceivers can comprehend the situation if they integrate its elements using integrative concepts for washing, cleaning up, etc. Understanding all these everyday situations requires integrating their situational elements. In many situations, integration is likely to revolve around basic goal-directed action, where situational elements trigger goals, values, norms and identities from which motivation, action and outcomes follow. Similarly, in social situations, integration is likely to revolve around basic interactive patterns, such conveying information, making requests, demonstrating procedures, showing affection, etc. As people become increasingly expert in social, professional and recreational domains, their ability to comprehend them grows as a function of the concepts they possess for integrating their elements (e.g. understanding dating rituals, grasping a trial lawyer's strategy, watching a baseball game).

The situational patterns that support comprehension also support prediction. Perhaps the primary difference is that comprehension typically involves integrating perceived situational elements (both external and internal), whereas prediction involves inferring the likely later presence of situational elements not yet perceived. On seeing pizza at a party, for example, perceivers can predict how it is likely to taste, and how enjoyable eating it would be. On seeing someone down several drinks quickly at a bar, perceivers might predict that intoxicated speech and uninhibited behaviour will follow. Within the situated conceptualization framework, pattern completion inferences underlie these predictions. As some external and internal elements of a situation are perceived, they activate relevant situated conceptualizations in memory whose integrative concepts have integrated similar situations in the past. Once active, a situated conceptualization is superimposed on the current situation via multimodal simulation, within the same situation processing architecture used to process the current situation. To the extent that this superimposition includes simulations of situational elements not yet present, it predicts their possible occurrence.

Effective situated action similarly results from pattern completion inferences. Besides predicting situational elements not yet present, situated conceptualizations that become active suggest and implement actions likely to be appropriate and effective in the current situation. On seeing pizza at a party, for example, inferences about eating the pizza become relevant, which may then be executed. Similarly, on watching someone become intoxicated at a bar, inferences about their mental state and subsequent behaviour may implement relevant actions, such as joining in or staying clear. To the extent that perceivers have acquired concepts that integrate a situation's elements, they can comprehend and predict situations accurately, and produce effective actions yielding desirable outcomes. In these ways, concepts for situational integration provide leverage in handling situations successfully.

More generally, developing expertise in a domain may typically only be possible once agents possess a sophisticated and relatively complete set of situationally-relevant integrative concepts that support comprehension, prediction and action. Consider the concepts necessary for being a successful trial lawyer. To comprehend what is occurring in a trial situation, a lawyer must know concepts for prosecute, defend, law, felony, among many others. To predict what will happen, a lawyer must also know how various concepts are related, such as that the evidence determines the verdict, and in turn, the verdict predicts the sentence. To act appropriately in a trial situation, lawyers and judges must understand concepts like objection, sustain and overrule, and then be able to carry out the associated actions correctly. As these examples illustrate, knowing the relevant integrative concepts in a domain and how to apply them appropriately in relevant situations is essential for successful comprehension, prediction and action. Doing so provides leverage in performing effective situated action. Without integrative concepts, sophisticated action would not be possible.

Again, simply studying concepts for situational integration in isolation, as cued by their linguistic labels, doesn't allow them to fully manifest themselves. Only when these concepts are engaged with the elements of relevant situations—providing leverage for situated action—do they become fully revealed.

5. Grounding the relations that integrate situational elements

A key issue for this account concerns the relations in abstract-SC concepts that integrate situational elements. Are these relations represented in some kind of amodal symbolic manner, such as argument-value structures in linguistic syntax, predicate calculus expressions in logic, or frames in programming languages? Or might they arise in a more grounded way? If so, what is the nature of this grounding?

(a) Grounding integrative relations in temporal co-occurrence

Our hypothesis is that the relations underlying integrative concepts both result from and represent co-occurrences between situational elements. Because many co-occurrences exist between pairs of situational elements, various factors may contribute to making certain important co-occurrences salient [47]. Biological influences, for example, could naturally draw attention to certain kinds of temporal co-occurrences that have been evolutionarily significant. Or certain kinds of co-occurrences could occur more frequently than others, leading to increased attention. Finally, language, culture and social interaction may orient attention to culturally relevant co-occurrences, thereby making them salient.

To see these possibilities, consider some examples. On perceiving certain stimuli, a sense of self-relevance subsequently becomes active, such as a goal, value, norm or identity. Seeing pizza at a party, for example, might activate the goal of consuming it. Or seeing someone steal jewellery in a store might cause values and norms associated with honesty and theft to become salient. Or hearing music from one's adolescence might activate a sense of cultural identity. In each case, an associative relation develops between a stimulus and a sense of self-relevance that later causes perception of the stimulus to activate self-relevance as a pattern completion inference.

A wide variety of other important integrative relations in situations could emerge similarly. Consider, for example,

relations between self-relevance and subsequent emotion and motivation. On seeing someone steal jewellery from a store, activating the norm that stealing is bad could initiate anger and other negative emotions. Similarly, seeing pizza and activating the potential goal of eating it could initiate a motivational state of desire, or perhaps the motivational state to restrain eating for the sake of health.

In the same manner, relations between motivations and actions, and between actions and outcomes could be captured via temporal co-occurrences. To the extent that specific actions, such as eating or dieting, follow from particular motivational states, the actions come to be viewed as resulting from the respective motivational states. Similarly, to the extent that specific outcomes, such as satiation and good health, follow from particular actions, these outcomes come to be viewed as resulting from the respective actions.

Notably, these relations may typically remain relatively implicit, not being labelled or represented explicitly (although they could be). By virtue of simply attending to situation elements that co-occur temporally, an implicit relation becomes constructed between them in memory. On later occasions, perceiving one element activates the other, via the associative relation that has been established between them. Rather than explicitly labelling the conceptual content of these relations as 'self-relevance' or 'motivation', their content remains implicit. Self-relevance, for example, is represented implicitly when an external stimulus activates a personally relevant goal (e.g. seeing a chair activates the goal of sitting). Similarly, motivation is represented implicitly when certain internal states activate instrumental actions (e.g. feeling hungry and eating a sandwich).

In general, temporal co-occurrence, together with other factors that make co-occurrences salient, could potentially ground the relations that integrate situational elements. As particular pairs of situational elements are perceived as co-occurring during comprehension, prediction and action, they become established as integrative relations in the respective situated conceptualizations. To the extent that the same general kinds of relations become important across many situated conceptualizations, they could develop increased in importance across domains of situated action.

Rather than assuming that amodal structures represent these relations, qualia associated with the respective situational elements becoming active together represent them. Because these temporal co-occurrence qualia are perceived, they offer grounding for the underlying relations. In other words, relations between situational elements are represented by internal perceptions of their temporally dependent co-occurrence. We further assume that different kinds of co-occurrence relations reflect the different kinds of situational elements they integrate, producing diverse relations in the process (e.g. relations between stimuli and self-relevance, relations between motivations and actions, relations between actions and outcomes). Finally, this approach explains why it is so difficult to establish a fixed set of relations. Because perceiving co-occurrence between so many different kinds of situational elements is possible, an indefinitely large set of co-occurrence relations exists.[5]

(b) The neural substrates of integrative relations

If the temporal co-occurrence hypothesis has merit, it would further require a plausible neural basis. One possibility is that the brain's association areas support this function, with different association areas coding different types of co-occurrence relations [47–49]. Consider again co-occurrence relations between stimuli and self-relevance. It has become increasingly well established that the perception of objects in the ventral stream triggers predictions about the value of these objects in orbitofrontal cortex [50,51]. One possibility is that association areas in the anterior temporal lobes and/or in medial prefrontal cortex integrate the temporal co-occurrence of object and value representations. Similarly, medial prefrontal cortex could further mediate the co-occurrence of object and value representations with action representations in motor areas, as could mid-cingulate cortex. Association areas along the cortical midline and in the angular gyrus could further integrate self-relevance with settings and outcomes. Similarly, association areas in the supramarginal gyrus of the parietal lobe could link objects with the actions used to manipulate them along particular spatial trajectories. Finally, middle temporal areas could link auditory word forms with their multimodal semantic representations.

Similar to the proposal that association areas contain conjunctive neurons [47,48,52], the idea here is that conjunctive neurons come to encode the temporal co-occurrence of situational elements processed in adjoining networks. Thus, when one element in a relation becomes active (e.g. an object), it activates a temporal co-occurrence relation in a relevant association area (e.g. anterior temporal lobe), which in turn activates other elements in the relation (e.g. a goal). To the extent that these latter elements participate in further relations mediated by other association areas, they in turn activate additional situational elements. In this manner, perceiving one element of a situated conceptualization could activate an entire situated conceptualization distributed across the brain. On seeing pizza, for example, the initial visual representation could activate reward prediction areas in orbitofrontal cortex via association areas in the anterior temporal lobe, which in turn activate action representations via association areas in medial prefrontal areas and mid-cingulate gyrus, which in turn activate spatial and motion elements via supramarginal gyrus.

In essence, this account assumes that the 'skeleton' of an abstract-SC concept for situational integration contains a collection of implicit temporal-occurrence relations in relevant association areas. Consider an example. For the integrative concept, *prosecute*, a collection of implicit relations in association areas points to systems that process relevant situational elements (e.g. court room, lawyer, defendant, crime, evidence, etc.). When the word 'prosecute' is encountered in isolation, it begins to activate the variety of implicit relations associated with it in association areas. If a relevant situation is not present, only implicit representations of these relations become active not bound to (associated with) active situational elements. If, however, a situation with relevant situation elements is already present, this constrains the activation of implicit relations to those that bind these elements, thereby facilitating processing.

To the extent that this account is true, it further implicates internal states in the conceptual processing of situations, with constructed representations of temporal co-occurrences between situational elements becoming part of how situations are processed conceptually. By activating these co-occurrence relations as a situation is processed, agents perceive relations

between situational elements that originate in top–down knowledge, rather than in the bottom–up signal.

6. Implications of this account

In this section, we illustrate how the situated conceptualization framework described so far explains a variety of findings in the literature on concrete-LIT versus abstract-LIT concepts. Because the findings we address often adopted the traditional distinction between concrete-LIT versus abstract-LIT concepts, we'll use this distinction to describe them, while also using the concrete-SC versus abstract-SC distinction when presenting alternative accounts from our perspective.

(a) The importance of language for abstract-LIT concepts

Since Paivio's [53,54] Dual Code Theory, it has been clear that language is especially important for abstract-LIT concepts. Reviews of neuroimaging confirm this importance, showing that abstract-LIT concepts heavily use language areas in the brain (when processed in isolation; [55]). Recent reviews further document the important roles that language plays in abstract-LIT concepts [42,56,57].

From our perspective, language is important for abstract-LIT concepts because it is essential for specifying an abstract-LIT concept's referents. In contrast to concrete-LIT concepts, it's typically not possible to point to the referent of an abstract-LIT concept physically (e.g. as when pointing to referents of chairs). Because the referents of abstract-LIT concepts tend to be non-perceived, non-bounded and non-physical, pointing to them is not possible. Similarly, from the situated conceptualization perspective, abstract-SC concepts refer, first, to internal situational elements, and second, to the internal integration of external and internal situational elements, with neither being pointed to easily. Specifying them in some other way is required.

Language provides a natural means of doing so. Using language for propositional attitudes enables referring to internal situational elements, such as, 'I want to eat' (goal), 'I'm feeling happy' (emotion), 'I'm hungry' (motivation) and 'I'm thinking about taking a holiday' (mentalizing). Using relational forms of language further enables reference to integrated situational content, such as, 'I ate doughnuts at work to make myself feel happier, not because I was hungry', or 'What you said was true because it accurately described the state of the world'. Because of language's powerful ability to integrate situational elements with hierarchically-embedded argument-value structures, it becomes possible to specify the integrated situational elements to which a situated conceptualization refers.

Rather than pointing to the referents of abstract-SC concepts with their hands, people refer to them with linguistic expressions. Not only can these expressions point out internal referents that people experience—both elemental and integrative—they can be used to teach children abstract-SC concepts by specifying the relevant internal elements and integrated elements linguistically. As a consequence, language becomes highly associated with abstract-SC concepts, strongly engaging the brain's language system when they are processed.

Our approach also naturally explains how people learn abstract-SC concepts via language indirectly from other cultural members, rather than directly from experience [42,56,57]. Because language specifies the content and structure of abstract-SC concepts (both elemental and integrative), it can be used to define new concepts not yet experienced. A critical factor from our perspective, however, is that participants must be able to represent a non-present situation to which they can apply a new abstract-SC concept as it's defined for them via language. We assume that people activate situated conceptualizations from memory for this purpose, or construct novel ones needed under linguistic guidance. Once the respective situations are simulated, new internal elements and situational integrations can be defined with respect to them.

(b) The concreteness of abstract-SC concepts

Although language may be essential for learning and using abstract-SC concepts, it is not sufficient. As suggested earlier, abstract-SC concepts that implement situational integrations only become fully active when engaged with situations, integrating relevant situational elements, both external and internal. Consistent with this proposal, visual areas can become more active for abstract-LIT concepts than for concrete-LIT concepts, when both kinds of concepts are embedded in situations [41]. Other examples of abstract-LIT concepts engaging concrete-LIT information have also been reported [9,42,58].

As suggested earlier, abstract-SC concepts develop a concrete dimension after being applied to situations. Abstract-SC concepts for internal situational elements typically co-occur with concrete-SC concepts for external situational elements, which all become integrated via abstract-SC concepts for situation integration. As a consequence, situated conceptualizations containing all three types of concepts are constructed continuously to process current situations, becoming subsequently superimposed in memory. On later receiving a cue for an abstract-SC concept (either an internal situational element or a situational integration), a situated conceptualization may become active that includes external situational elements as pattern completion inferences. If so, then the abstract-SC concept develops a concrete dimension.

(c) Effects of context availability

The context availability hypothesis first proposes that context is important for processing both concrete-LIT and abstract-LIT concepts [42,46]. This basic assumption is highly consistent with our view that concepts of all kinds develop to support situated action, and operate together—not in isolation—to support comprehension, prediction and action in situations. The context availability hypothesis further proposes that context is especially relevant for abstract-LIT concepts, given that they tend to activate relevant situations less easily than do concrete-LIT concepts.

From our perspective, concrete-SC concepts are situational elements that often form highly predictable patterns for typical external situations, including settings, objects, agents and physical actions. Once one part of a pattern becomes active, it quickly activates other parts via pattern completion inference, thereby activating an external situation. Conversely, abstract-SC concepts only manifest themselves when relevant external elements of a situation are present.

When an external situation isn't present, abstract-SC concepts don't become fully engaged and don't reveal themselves. This proposal appears especially true for abstract-SC concepts that integrate situations. Without external situational elements to integrate, these concepts don't have the input that they require to operate. As a consequence, these concepts' temporal co-occurrence relations don't become fully specified, such that they remain vague and not fully activated.

Concepts for internal situational elements may also typically require external situations for their operation, given that they often represent internal responses to external situations. When what produced an internal situational element is not known (e.g. for an emotion), the internal element processed in isolation may not make much sense, and so is only processed superficially. For these abstract-SC concepts, too, it appears essential to study them in the context of relevant situations.

(d) The activation of broad situational content for all kinds of concepts

Much work from the feature listing paradigm demonstrates that people generate broad situational content when producing features for specific concepts [59–63]. When people generate features for concrete-LIT concepts, such as chair, dog and banana, they typically generate diverse situational information that goes beyond simple features of the respective objects, including internal situational elements and situation integrations. Conversely, when people generate features of abstract-LIT concepts, they typically generate external elements of the situations to which they apply.

The situated conceptualization framework naturally explains these two findings. Because both concrete-LIT and abstract-LIT concepts are typically processed in situations, they become integrated in situated conceptualizations with other relevant elemental and integrative concepts. Later, when concrete-LIT and abstract-LIT concepts are cued, relevant situated conceptualizations become active, producing broad situational information as pattern completion inferences. In this manner, the situated conceptualization framework naturally explains the diverse situational information typically active for concepts, beyond the cues provided.

(e) Diverse kinds of abstract-SC concepts

It is a humbling exercise to enter a word database and extract all of the abstract-LIT concepts (e.g. going into the MRC database and filtering concepts below a particular concreteness threshold). The diversity of abstract-LIT concepts is truly remarkable, attesting to the vastness and power of the human conceptual system. Explaining this diversity constitutes an obvious challenge.

Our approach perhaps provides one modest insight into this diversity. Consider the subset of abstract-SC concepts that develop to integrate situational elements. Because so many types of situational elements exist, with a huge space of possible relations between them, many different configurations of integrated situational elements become possible. As a consequence, many different kinds abstract-SC concepts develop to perform diverse forms of situational integration. Certainly, there must be constraints, principles and biases associated with the situational integrations that these integrated concepts represent. If so, then one direction for future research is to begin establishing them.

7. Conclusion

Because concepts emerge from processing situations, they are best studied in the context of situations. Although we have focused on abstract-SC concepts here, we believe that the same is true of concrete-SC concepts. What we learn from studying both kinds of concepts in isolation—especially in shallow processing tasks such as lexical decision—is likely to be limited and possibly distorted (again, consider the Visual World paradigm). We will understand all kinds of concepts better when we study them in their natural operating environment—situations.

We further advocate abandoning the traditional distinction between concrete-LIT and abstract-LIT concepts. This distinction is overly simplistic, focusing on superficial (and problematic) differences in perceptual information, and only defining abstract-LIT concepts negatively and/or operationally. Furthermore, the concrete–abstract distinction assumes that all we need to know about concepts is what becomes active when they are cued, failing to consider the important roles of concepts in situated action. Because large amounts of situational information typically become active for concepts of all types, this suggests that they are typically co-active with broad collections of other concepts, both elemental and integrative, to support situated action. These patterns further suggest that, not only should we study concepts embedded in relevant situations, we also need to theoretically explain the broad situational information that typically becomes active for all concepts when processed deeply.

Finally, we propose that developing a new set of distinctions between concepts—based on situated action—may offer useful insights and constraints in understanding concepts as a whole. Specifically, we propose that establishing the basic elements of situations, both external and internal, will be central to understanding concepts, along with further establishing how these elements are integrated to support comprehension, prediction and action. We further suggest that distributed neural networks process these situational elements in parallel, and that association areas play central roles in integrating elements, perhaps via temporal co-occurrence relations (i.e. the BASPA framework). To the extent that this account has any merit, considerable work remains to establish situational elements at both the cognitive and neural levels, and to understand the association areas that integrate them.

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Endnotes

[1]Although we use the construct of abstract concepts in early sections of this article to make contact with current literature (and also the construct of concrete concepts), we drop the abstract-concrete distinction in §3d, arguing that it is no longer useful and should be replaced with more specific distinctions.

[2]We have previously referred to situational elements as 'local concepts', and to situational integrations as 'global concepts' [18]. Because the local–global distinction primarily conveys difference in resolution (high versus low), it misses the important functional distinction that we want to capture here, namely, the difference

between the elements of situations vs. integrations of these elements. Because integration will later play a central role in how situated conceptualizations provide leverage for effective situated action, we shift to this more transparent terminology.

[3]We acknowledge that our specific list of situational elements may require refinement and revision. The point here is simply that the situations constituting daily life are likely to contain elements along these lines.

[4]From the perspective of Perceptual Symbol Systems, perceptual states (and simulations) are processed within the same networks as conceptualizations. Whereas perceptual states and simulations are implemented as the specific states of a BASPA network, conceptualizations are implemented as simulators within the same network. Simulators develop initially from the bottom–up accrual of perceptual states (using association areas), and later implement specific perceptual states as top–down simulations [26,27].

[5]Additionally, there is the important issue of distinguishing mere temporal co-occurrence from causality and intentionality. Given consistent patterns of temporal precedence from one situational element to another, along with other potential mechanisms such as counterfactuals, it seems likely that integrative relations may often develop a causal character.

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