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# Can Cognition Be Reduced to Action?

## Processes That Mediate Stimuli and Responses Make Human Action Possible

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**Abstract**

After treating action as peripheral for decades, cognitive scientists increasingly appreciate the fundamental roles it plays throughout cognition. Because action shapes cognitive processes pervasively, some theorists propose that cognition can be reduced to action. This chapter proposes that the central roles of action in human cognition depend on important processes that mediate between stimuli and responses. From this perspective, the unique features of human cognition reflect not only a remarkable potential for action, but also powerful abilities that mediate action in response to the environment. Sophisticated action results from sophisticated mediation; in particular, from mediating processes associated with representation, conceptualization, internal state attribution, affect, and self-regulation. Integrated with action systems, these mediating processes endow humans with unusually flexible and powerful means of shaping their physical and social environments. Without taking these mediating processes into account, it may be difficult, if not impossible, to explain human action. It may also be difficult to explain basic cognitive phenomena associated with memory, concepts, categorization, symbolic operations, language, problem solving, decision making, motivation, emotion, reward, self, mentalizing, and social cognition. Instead of reducing cognition to action, an alternative is to develop a viable theory that does justice to the importance of action in cognition, while integrating mediating processes that complement it.

## Introduction

Peripheralizing action is undoubtedly one of the great distortions of traditional cognitive science. Although for decades it has been argued that action is central

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to cognition, many researchers still view action as little more than making responses, as indicated by the almost complete omission of action from modern cognition texts. Many researchers do not consider action to be a significant factor when theorizing about phenomena of interest or when developing experiments to test their theories. Often the biggest concerns about action are how to counterbalance response handedness and trim reaction time distributions.

A complementary distortion has been to view cognition as an information storage system, which Clark (1998) referred to as the "filing cabinet" metaphor. Accordingly, the primary purpose of the cognitive system is to develop accurate models that represent the world, and then to use these models in reasoning effectively during language and thought. From this perspective, it seems reasonable that the motor system would not play central roles in cognition, but would instead serve primarily to output information as needed, either from the storage system or from operations that act upon it.

Corrective steps have increasingly remedied these distortions. An initial step was the insight that timing mechanisms in the motor system play central roles in cognition (Ivry and Keele 1989). Another was the increasing realization that action is central to cognition (e.g., Glenberg 1997; Hommel et al. 2001; Prinz 1997), as are bodily states (Barsalou et al. 2003) and embeddedness in situations (e.g., Aydede and Robbins 2009; Barsalou 2003; Clark 2008). In addition, researchers have increasingly realized that anticipated action shapes perception and learning ubiquitously (e.g., Clark 2013b; Engel et al. 2013; Friston 2010). Reflecting these trends in the literature, researchers are becoming aware that action is central to cognition. As the title of Engel et al.'s (2013) article states, a "pragmatic turn" is occurring.

Engel et al. (2013), however, argue for a stronger reductive position, suggesting that cognition can be reduced to action (see also O'Regan and Noë 2001). They state, for example, that "cognition is action" and advocate that the field "transform the whole theory of cognition into a theory of action" (Engel et al. 2013:203, 207). They further argue that the construct of *representation* constitutes a further distortion in traditional theories and is unnecessary for explaining cognition. They propose that cognition can be fully explained with *directives*, which are "dispositions for action embodied in dynamic activity patterns" (Engel et al. 2013:206; see also the related construct of sensorimotor contingencies in O'Regan and Noë 2001).

If this account is correct, then the field should focus on action and move forward. Even if it is incorrect, it still might establish a useful dialectic, swinging the field in a much-needed direction before oscillating into a further evolved state. A similar debate occurred in the responses and excellent commentaries to O'Regan and Noë's (2001) target article. Some of the points presented there will be echoed here, but readers interested in these issues are encouraged to examine that discussion more closely.

An even larger debate has addressed the question of whether cognition can be reduced to *sensorimotor* systems in the brain (with reduction to action being

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a special case). More broadly, can cognition be reduced to *modal* systems, including systems for perception, action, and internal states (e.g., interoception, emotion, reward, motivation, proprioception, taste)? Conversely, this question can be asked in a somewhat different way: Are *amodal systems* necessary for cognition, with modal systems being insufficient?

Here I focus on three topics that may be useful to consider when addressing this family of questions. First, what is the nature of representation, and can reductionist programs afford to dismiss it? Of particular interest are caricatures of representation often used to discredit the construct, together with a modern account better suited for current research. Second, what phenomena must any reductive approach to cognition explain? What do we mean by *cognition*? Of particular interest are the extensive roles that representation has traditionally played in understanding cognitive phenomena. Third, what other basic building blocks besides action might be necessary to create cognition as we currently understand it? Of particular interest are powerful processes in humans that mediate between stimuli and responses.

## Misrepresenting and Representing Representation

In many theories, representation is assumed to play fundamental roles throughout cognition. Conversely, representation is often criticized on numerous grounds and is sometimes dismissed as having nothing to do with cognition. Can these perspectives be reconciled?

### Caricatures of Representation

One important problem in this ongoing debate is that critics often caricature representation. In perception, representation is sometimes cast as a picture in the head, or as a complete three-dimensional model, viewed by a homunculus. In memory and conceptualization, representation is often cast as a static structure built of amodal symbols residing in a disembodied storage system (e.g., a predicate, frame). Such accounts of representation—associated with traditional and increasingly outdated accounts of cognition—appear unlikely. Indeed, many proponents of representation readily dismiss such accounts and focus on more promising alternatives. Further, proponents note that representation is often dismissed unfairly because of its exclusive association with older accounts.

### Broad Views of Representation

At least since Dretske (1995), representation has been defined in ways that make it a broader construct than the narrow subclass that critics often target. Within the broad class of representational systems, traditional representations occupy a relatively narrow corner. Many other more biologically and

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cognitively plausible forms of representation exist. For example, modern accounts establish representation in neural nets, neural circuits, dynamical systems, situated action, grounded cognition, and so on (e.g., Bechtel 2008; Markman and Dietrich 2000a, b; Prinz and Barsalou 2000; Ramsey 2007; Rupert 2011; Vosgerau 2010). From this perspective, Rupert refers to cognition and the brain as "massively representational."

A simplified form of these technical accounts specifies that A represents B when two conditions are met:

1. A possesses information about B, such that utilizing A makes it possible to interact effectively with B in some way.
2. A was established for the purpose of providing information about B in the service of achieving a goal (e.g., via neural architecture, evolutionary selection, etc.).

Thus, an analog thermometer represents temperature because the mercury level (A) carries information about temperature (B) and was designed to do so. In contrast, a footprint carries information about the size, shape, and identity of a person's foot, but it is not a representation because it was not created for this purpose and serves no goal. Interestingly, sensorimotor contingencies (O'Regan and Noë 2001) and directives (Engel et al. 2013) are representations under this definition (cf. commentary by Scholl and Simons 2001).

Thus, a representation does *not* require the stereotypical properties associated with traditional theories of cognition: It need not contain a complete detailed account of what it represents, nor be a picture in the head, a three-dimensional model, or a predicate calculus structure. It need not contain amodal symbols, reside statically and unchanging in long-term memory, or be viewed by a homunculus.

Consider an example of what might constitute a more plausible form of representation. As people experience hammers, brain areas that process their multimodal aspects become active and associated together (Martin 2007). Specifically, distributed associative patterns become established across fusiform gyrus (shape), premotor cortex (action), inferior parietal cortex (spatial trajectory), and posterior temporal gyrus (visual motion). Following many learning episodes with hammers, an increasingly entrenched associative network reflects the aggregate effects of neural processing in these areas. Based on the definition of representation above, this sloppy, difficult-to-localize network constitutes a representation because it carries information about hammers that can be used to perform situated action with them later (reflecting an evolutionary function for brains to operate in this manner).

A second form of representation results from activating small varying subsets of this distributed network on specific occasions. Upon seeing a hammer (or hearing the word "hammer"), a subset of the hammer network becomes active to represent or "simulate" the processing of a hammer in one of infinitely many ways (Barsalou 1999). Typically, these simulations remain unconscious,

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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 simulations of a hammer 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 (e.g., Barsalou 2009; Vosgerau 2010). When the simulation dissipates, this particular act of representation ends.

These two forms of representation diverge considerably from classic accounts in the following ways:

1. There is no permanent static representation of hammers in long-term memory, built from amodal symbols, that is loaded into working memory identically across different occasions.
2. The representation that does reside in long-term memory results from superimposed effects of associative learning distributed across relevant sensorimotor systems, with the resultant network changing constantly after every learning episode (and overlapping considerably with networks for other categories).
3. When this distributed network is accessed, it produces one of infinitely many hammer representations dynamically.
4. These representations serve temporary representational functions by providing useful inferences in specific situations.

## What about Cognition Must a Reductive Theory Explain?

Providing a complete account of cognition is *not* the goal of this discussion. Instead, the goal is to describe phenomena that reductive accounts of cognition probably need to explain. As will be seen, representation is traditionally assumed to play a central role in these phenomena. Thus, any theory which aims to explain these phenomena without representation must offer compelling alternative accounts.

### Memory

In many memory phenomena, a cognitive/brain state provides information about a situation that is not present. Typically, researchers assume that

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information about a past event resides in memory, which later becomes active to represent it currently. Often the activation of a memory is assumed to motivate and guide subsequent action, but not necessarily (it could simply evoke emotion).

During explicit memory, recollection of a previous episode becomes conscious, including information about when and where the episode occurred (Squire et al. 2004). Medial temporal structures, such as the hippocampus, integrate memory elements for people, objects, settings, actions, events, self-relevance, and affect (distributed across multimodal brain areas). Not only are these distributed neural patterns often viewed as representations of past situations, the act of conscious recollection is typically viewed as a representational activity. Retrieving a memory provides information about an event that has passed (and thus is not present), representing what the event was like (not necessarily accurately). An explicit memory can similarly provide information about what a similar future event might be like, supporting future action.

During working memory, frontal areas maintain neural activity in posterior sensorimotor areas that became active while processing a stimulus that is no longer present (Levy and Goldman-Rakic 2000). Typically, these distributed representations are viewed as representing the recent stimulus for the purpose of performing a subsequent task effectively (e.g., *n*-back recall). In mental imagery, multimodal states activated in working memory are often viewed as consciously representing something that is not present, such as an object or event, again potentially supporting future action.

For both explicit and working memory, adopting classic forms of representation is not necessary, such as static amodal data structures. Instead, many modern researchers assume that memories result from the dynamic activation of distributed and constantly varying information in neural networks.

## Concepts and Categorization

Conceptual knowledge constitutes another fundamental form of memory, often referred to as *semantic memory* (Barsalou 2012). Rather than representing specific events, however, conceptual knowledge represents categories in the world and in experience (e.g., objects, events, settings, mental states, bodily states). Conceptual knowledge is often viewed as representational in several ways. First, the concept that becomes established for a category (e.g., hammers) aggregates information acquired while processing category exemplars, thereby representing information about the category as a whole (e.g., their shape, function, motion). Second, a specific state can be constructed in working memory that represents the category temporarily. Third, these temporary states can be used to perform representational acts, such as imagining what a category exemplar might be like when one is not present or drawing anticipatory inferences about one that is. As described earlier, the representational processes

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underlying conceptual processing emerge naturally across distributed neural networks that function dynamically.

Categorization constitutes one of the most basic processes that organisms perform. As objects and events are perceived, they are mapped to concepts in the brain, thereby producing rich inferences from associated conceptual knowledge to support situated action (e.g., perceiving an object, categorizing it as a hammer, and inferring that it can be used to connect two boards with a nail). Once a type-token binding becomes established between an exemplar and a concept during categorization, the concept interprets the exemplar in one of infinitely many ways, given that an infinite number of concepts can be used to categorize any given exemplar (e.g., a hammer could be categorized as a tool, paperweight, or political symbol). Notably, such processing goes significantly beyond simple stimulus-response approaches that lack mechanisms for stimulus interpretation. A perceived hammer is not just a sensory state. When reading a manuscript outside on a windy day, a nearby hammer could be interpreted as a paperweight instead of a tool. Typically, stimulus interpretation is viewed as a representational process, with a concept projecting relevant interpretive inferences onto a stimulus once it has been categorized in some way.

## Conceptual Operations

For decades researchers have assumed that basic conceptual operations underlie cognition (e.g., Pylyshyn 1973). As just discussed, categorization implements the basic conceptual operation of type-token binding. Although type-token binding could be implemented using amodal symbols in a predicate-inspired formalism, many more cognitively and neurally plausible implementations have been suggested as well (e.g., Barsalou 1999; Pothos and Wills 2011; Smolensky 1990). It is reasonable to assume that conceptual operations exist in any species that performs categorization.

Constructing relational structures is another basic conceptual operation. For example, organisms construct relational structures to represent part-whole relations in objects (e.g., eyes as parts of faces), and to represent relations between agents, goals, actions, objects, and outcomes in events (e.g., people eat soup with spoons). Once a relational structure has been constructed, it is generally assumed to temporarily represent a corresponding configuration of referents in the world, categorizing them via a type-token relation. Across diverse theoretical perspectives, relational structures are assumed to have important computational properties, such as productivity (e.g., Barsalou 1999; Fodor and Pylyshyn 1988). Again, relational structures offer infinite construals about a situation, produce powerful inferences that support situated action, and are likely to arise in any species that recognizes relations between stimuli, goals, actions, and outcomes.

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## Language

In humans, language offers an unusually powerful means of representing and conveying conceptual knowledge during communication and social coordination. Across diverse sociocultural activities, speakers attempt to convey conceptual representations through language to listeners, who attempt to reconstruct the intended meanings of these utterances. When comprehension occurs successfully, it establishes co-reference to relevant referents in the world and interprets them conceptually via lexical meanings and relational structures.

Similar to memory and conceptual knowledge, language offers another powerful means of representing objects and events not present. Especially important is the ability to represent situations that have never been experienced, or that may even be impossible to experience. Entertaining and working with such possibilities probably requires language and may be argued to be responsible for much of human culture and technology.

## Problem Solving and Decision Making

During problem solving, agents attempt to construct a not-yet-realized plan for achieving a goal (e.g., how to paint a room). Often, different plans are formulated before one is executed, so that the possibilities can be evaluated, compared, and tweaked. During the planning process, each plan entertained is typically assumed to represent a possible action sequence in the world, together with outcomes that could result from performing it.

Similarly, in decision making, possible choices are evaluated based on temporarily constructed representations of them (e.g., when purchasing a product or choosing how to act in a social situation). By assessing represented choices before one is selected, their relative merits can be assessed, thereby attempting to optimize desirable outcomes.

## Affect

Organisms experience a wide variety of affective states, including core affect, emotion, motivation, and reward. Interestingly, affective states are often associated with salient qualia (at least in humans), implicating their significant status in human consciousness. Indeed, "hot" affective states often trump "cold" cognitive states in many decision-making contexts. How people feel is central to how they act.

Action often originates in affective states (Frijda 1986). Arguably, affective states evolved because of their importance in signaling the necessity of action in certain situations and motivating its successful execution. Can affective states, however, be reduced to action?

An affective state can include activity in the cardiovascular, respiratory, autonomic, endocrine, and immune systems as well as in the musculature.

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In general, these states are assumed to result from conceptually appraising an object or event as significant for oneself in some way. For example, appraising an object as "threatening" triggers bodily states that signal danger. Analogously, appraising an object as a "tasty food" triggers bodily states that motivate consumption. As these examples illustrate, an affective state can be viewed as saliently representing the significance of an object or event for oneself.

Once an affective state exists, it often motivates action aimed at resolving the object or event that has destabilized homeostasis. In addition to energizing the motor system, an affective state may initiate a wide variety of actions associated with approach, avoidance, consumption, and so forth, all designed to create change in some (hopefully) useful way. Thus, an affective state, besides representing self-relevance, can be viewed as representing a desire to effect self-relevant change. Because affective states are so salient subjectively, what they represent often comes to dominate the choice of actions, and the intensity with which actions are pursued. Although affect and action are often closely related, affect appears to complement and coordinate action in various ways, rather than being reducible to it.

## Self and Mentalizing

What is the nature of the self system that detects self-relevance and initiates relevant actions? Increasingly, self is viewed as taking multiple forms that serve multiple purposes (Damasio 2000; Gallagher 2013). For example, a conceptual form of self is often viewed as representing the identity that one would like (or ought) to be (e.g., traits, roles, values, goals, norms). An experiential form of self is often viewed as representing who someone is at the current moment (e.g., bodily states, affect, thoughts). Clearly, these different forms of self evolve through situated experience of action and play central roles in motivating action. Nevertheless, they also seem to have a representational function of defining how one conceptualizes and experiences oneself.

Just as the importance of the default mode network in the brain has become increasingly apparent, so too has the constant mentalizing and mind wandering that it produces (e.g., Buckner et al. 2008; Gerlach et al. 2014; Smallwood and Schooler 2015). When people are not performing a focused task, they often appear to mentalize about themselves, social connections, daily activities, long-term goals, emotional events, appetitive stimuli, and so forth. Not surprisingly, brain areas that implement mentalizing overlap extensively with areas that process self-relevance (Northoff et al. 2006).

Typically, researchers assume that mentalizing serves a representational function. While mentalizing, for example, one might imagine various forms of one's actual and desired selves. Similarly, one might ruminate about various events and interactions that have implications for oneself. In many cases,

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representing nonpresent situations in their absence makes it possible to increase understanding of their self-relevance, to regulate affective reactions, and to perform effective future action.

### Social Cognition

Humans are adept at representing others as well as themselves. Indeed, many proposals about the evolution of human cognition suggest that its primary adaptations supported revolutionary advances in social cognition, interaction, and communication (Donald 1993; Tomasello 2009). Thus, to understand human cognition, it is essential to understand its social character.

Considerable literature demonstrates that social interaction revolves around attributions about the cognitive and affective states of others. Similar to how individuals represent their own senses of self, they similarly try to represent other people's sense of self conceptually and experientially. In the process, perceivers represent a wide variety of cognitive, affective, and bodily states, as they attempt to explain and predict what people are thinking and feeling, and why they act as they do.

## Which Underlying Capabilities Enable Human Cognition?

If we ask ourselves what makes humans so remarkable as a species, would we say that it is simply our ability to act? Certainly, we act in ways that are unique and powerful (at times frighteningly). However, are there other remarkable abilities, that make our actions possible, which cannot be reduced to action in a compelling way?

If one asked cognitive psychologists to provide a value for X in "Cognition is X," what would be their response? I'm betting that many would reply "memory." Arguably, a sensory or motor process becomes cognitive once memory in some form contributes to it through top-down processing. Many cognitive psychologists might also include attention as a key capability. Memory and attention are critical for cognition, not only in humans, but across species, along with sensation and perception (especially in grounded approaches that emphasize the importance of sensorimotor systems in higher cognition). I suspect that most modern researchers would not be comfortable defining cognition solely as action without including these other basic systems. Without them, even simple actions cannot occur, much less sophisticated ones.

In addition to these basic processes shared across species, are there other important capabilities that make the unique and powerful character of human cognition possible? In general, capabilities that mediate sensation and action seem like a good place to look, given that humans are typically viewed as excelling in this regard. Perhaps humans have capabilities, not best understood as action, that explain why human action is so remarkable. Characterizing such

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capabilities accurately and optimally may require postulating mechanisms beyond those associated with action per se.

## Representing Nonpresent States

People represent nonpresent states frequently in episodic memory, working memory, imagery, problem solving, decision making, mind wandering, and social cognition. Donald (1993) argued that humans excel in their ability to represent nonpresent states in the past and future, whereas most other species are largely locked into the present moment, with modest exceptions (see also Prinz and Barsalou 2000). By representing nonpresent situations, humans evolved to achieve diverse goals beyond the reach of other species. From this theoretical perspective, a central computational strength of human intelligence is its ability to represent nonpresent situations.

Again, this ability need not imply static amodal representations in long-term memory. Instead, dynamic multimodal representations temporarily constructed in working memory may typically represent nonpresent situations. Consistent with this perspective, Donald (1993) argued that human fitness increased significantly when written language made it possible to represent conceptual understandings indefinitely, archiving them in a stable and precise manner across generations. On one hand, the value of written records reflects the vagaries of dynamic neural representations that are imprecise and unstable; on the other, it reflects the utility of developing stable representations that are useful.

Representing nonpresent situations appears central to expanding the action repertoire of humans. By examining a represented situation from novel perspectives, diverse actions can be generated creatively that exceed stimulus-response conditioning (see commentaries by Pylyshyn 2001; Van Gulick 2001). By representing geography with maps, navigational capability expands significantly beyond action-based route navigation (Spelke and Lee 2012). The ventral stream represents objects and space in ways that can transcend action (Milner and Goodale 1995). Representing stable objects in perception appears to support effective eye scanning (see commentaries by De Graef et al. 2001; Tatler 2001) and may underlie shape and color constancy. Similarly, representing intended actions perceptually as forward models makes the tracking and successful execution of action possible (see commentary by Gallese and Keysers 2001). It seems difficult to explain how processing false beliefs and counterfactuals, together with the actions they enable (e.g., deception), could occur without representation (Wellman et al. 2001). Finally, establishing principles of the physical world scientifically, not just in human minds but in written records, has led to a spectacular expansion of human action. It's difficult to imagine how modern engineering, technology, and medicine could have developed without explicit attempts to represent scientific principles cognitively during their discovery, documentation, and application.

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In general, the utility of representing nonpresent states is consistent with the principle that distinguishing data from process is computationally useful. In a completely compiled procedure, no flexibility exists—data embedded in the procedure always operate under a single task-specific interpretation. In contrast, when data are represented independently, they can be processed more flexibly, allowing novel affordances to be exploited at later times as they become apparent and needed. Because systematic procedures can extract these affordances from data, homunculi are not necessary. Arguably, human cognition capitalized on this computational principle by evolving prolific abilities to represent nonpresent situations. Cognition built solely on action would be much less flexible and adaptive.

## Conceptualization under Linguistic Control

Humans excel in their ability to interpret the world conceptually in creative ways that support novel and powerful action. For example, humans develop scientific taxonomies to conceptualize, organize, and categorize domains of experience (Malt 1995). Where would chemistry and biology be without taxonomic classifications of elements and species? On a daily basis, humans perform diverse forms of goal-directed categorization that enable mundane but still impressive forms of action (Barsalou 1991; 2003). By conceptualizing foods as containing calories, fats, and nutrients, for example, it becomes possible to categorize them as healthy and unhealthy, thereby controlling one's weight and longevity. By reappraising a situation as affording a challenge instead of a threat, people can change their emotional reaction from fear to excitement, in turn, changing their action from avoidance to approach.

Representation appears central to the conceptualization of nonpresent objects and events dynamically, creatively, and effectively in the service of goal pursuit. Developing conceptual knowledge about categories enables humans to represent them offline, while trying to understand their nature and select actions for interacting with them effectively in future online situations. In particular, the possibilities entertained, evaluated, and manipulated during planning, decision making, and mind wandering originate in conceptual knowledge that represents the world and human action in it.

Language appears central to people's impressive conceptual abilities. The productive and quasi-compositional structure of linguistic forms is likely to play central roles in manipulating conceptual structures creatively, as people attempt to understand and manipulate the physical world, and to coordinate action within social groups. As a consequence, various forms of abstract thought arise, enabling actions that would not be possible without them (as in science, government, and business).

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## Internal State Attributions

Attributing internal states to objects and people appears to be an especially important conceptual ability in humans. People naturally attribute essences to objects even when they do not exist (Gelman 2003). Similarly, people attribute internal traits to themselves and others which arguably do not exist (Mischel 1968). Not only do lay people attribute internal states informally, scientists attribute them formally (e.g., the attribution of atomic structure to chemical substances, energy and force to objects, and genetic structures to organisms).

In all cases, attribution of internal states supports action. By attributing traits to people, we can predict their behavior. By attributing atomic structure to chemical substances, we can predict how chemical compounds will react. By attributing self-concepts to individuals, social organizations develop the ability to regulate and coordinate individual action via roles and group identities. The ability to develop, represent, and manipulate conceptual structure—in this case about internal states—enables action which otherwise would not be possible.

## Rich Affective Experience

Humans appear to experience richer affective states than do other species. Not only are we motivated to eat, reproduce, and survive, we are motivated to develop artistic skills, become better people, improve our communities, and worship deities. Similarly, people do not only perceive pleasure and safety to be rewarding, they also find it rewarding to succeed professionally, to have others recognize their contributions, and to leave a legacy. Human emotional experience appears unusually rich: not only do people experience fear and disgust, they experience complex social emotions such as gay pride, guarded optimism, and civic responsibility.

From the perspective of appraisal and constructionist theories, these complex forms of affect reflect the impressive conceptual abilities of humans (e.g., Barrett 2006; Scherer 2001; Wilson-Mendenhall and Barsalou 2016). Specifically, the ability to construct complex conceptualizations of affective situations increases the richness of the affect experienced in them. In turn, rich affective states produce unusually complex and nuanced actions aimed at resolving the respective situations.

## Self-Regulation

For every cognitive or social ability that has ever been studied scientifically, a dual-process theory has probably been proposed to explain it (e.g., Sherman et al. 2014). Generally speaking, dual-process theories contrast cognitive processes that are relatively fast, implicit, effortless, and habitual with cognitive processes that are relatively slow, explicit, effortful, and regulatory. Although

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the extent to which implicit habits govern daily life is impressive, so is the human regulatory capacity. Using an expanded executive system together with metacognition, humans regulate perception, conceptualization, affect, and action extensively, at least relative to other species.

Significantly, self-regulation can be viewed as internal action that regulates external action. Nevertheless, the executive system depends critically on representing situations in their absence, establishing conceptual structure that informs sophisticated goal-directed action, and assessing self-relevance and affect continuously. Without these complementary abilities, executive action could not function as effectively as it does in humans. All of these abilities work together, mediating sensation and physical action. In an integrated manner, these mediating abilities endow humans with unusually flexible and adaptive means of designing and selecting effective actions in their physical and social environments.

## Implications for Cognition and Action

Based on the mediating processes just reviewed, definitions of cognition and action follow that motivate the central role of action in cognition.

### Cognition

Imagine a system that maps sensed stimuli directly onto motor responses in a deterministic manner. Because this system has no processes that mediate between stimuli and responses, it cannot change its responses to a given stimulus adaptively.

Now imagine inserting the kinds of mediating processes just described between sensing a stimulus and responding to it. With mediating processes in place, it becomes possible to change responses to the same stimulus in ways that optimize outcomes for the system in its environment.

This perspective suggests that cognition can be defined as mediating processes between stimuli and responses that yield adaptive action. Under this definition, cognition evolved for the purpose of creating novel actions, selecting among actions, regulating actions, and so forth, thereby increasing the chances that relevant goals in the environment are achieved successfully. Importantly, cognition is not an end in itself, as is often assumed implicitly when its implications for action are minimized or ignored. Instead, cognition exists to support adaptive action.

### Action

In a system with no mediating processes, an action simply reflects the stimulus that triggered it. The action is evolution's solution to the stimulus, encoded into a hard-wired system. For all intents and purposes, the stimulus is the proximal

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cause of the action. In a system with mediating processes, however, the proximal cause of an action is one or more cognitive states, with any eliciting stimulus being a distal cause (except for reflexes). As a consequence, nonreflexive actions reflect contributions from mediating states.

Consider the action of donating to charity over the Internet. The distal stimulus for this action might be learning about a disaster somewhere in the world. Via mediating processes, the disaster activates conceptual knowledge and affect, which in turn motivates making a charitable donation. At the motor level, the act of donating might include eye movements associated with reading a computer screen and finger movements associated with operating a keyboard. At the level of mediating processes, however, the action provides resources to a charity for disaster relief. The important goal of this action is not to produce the supporting motor responses, but to produce sociocultural effects on the environment (i.e., to transfer funds from a person's bank account to a charity to aid victims of the disaster). A tremendous amount of conceptual knowledge about banking, social organizations, disasters, identity, and social responsibility makes this action possible, together with supporting emotion, motivation, and reward. Without these mediating processes, donating money to disaster relief would be incomprehensible, much less feasible. It is difficult to imagine such actions as simply the result of sensorimotor contingencies.

Important human actions generally appear to reflect mediating processes in this manner. Consider the actions that modern humans use to acquire physical resources, including food, shelter, and wealth. We do not simply pick food up off the ground and sleep in caves. Instead, we purchase food from stores, prepare food in kitchens, procure residences, and furnish them. We alter the physical environment extensively (arguably too much), clearing and farming land, damming rivers, and managing wildlife. While acquiring physical resources and altering the environment, we invent and use sophisticated artifacts, including machines, computers, and communication systems. Rather than performing these actions in isolation, we often coordinate them in social groups, relying heavily on language to do so. In performing sociocultural actions, we also rely heavily on institutions and cultural knowledge, including science, technology, ethics, and law.

In general, one can view this remarkable action repertoire as serving niche construction. Over the course of human evolution, we have created physical and social environments that have increased our fitness and, in turn, our ability to harvest environmental resources. Without this action repertoire, such niche construction would not have been possible.

It is difficult to imagine our action repertoire evolving without the kinds of mediating processes described earlier. Sophisticated conceptual understandings of the environment, social groups, tools, and ourselves are essential for formulating actions and representing their anticipated impact on niche construction. Similarly, our affective states, social awareness, communication skills, and regulatory capacities further contribute in myriad ways to our

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actions and their environmental impact. The mark of a sophisticated human action is the sophisticated cognition behind it.

Clearly, automatized expert performance in many domains benefits from the development of sensorimotor contingencies, making responses to relevant stimuli more efficient through learning. Nevertheless, it is difficult to imagine how the remarkable repertoire of human actions could have developed in the first place without sophisticated mediating processes. Similarly, it is difficult to imagine how we continue to regulate this action repertoire and develop it further without these processes. Even when we perform a relatively automatized action, mediating processes are often available to comprehend, support, and alter it adaptively, should doing so be useful.

## Conclusion

Increasingly, researchers appreciate the central roles that action plays throughout cognition. To understand any cognitive process, it is important to understand not only its constant entwinement with action, but also how action contributed to creating it.

Here I have proposed that mediating processes constitute human cognition, including representation, conceptualization, internal state attribution, affect, and self-regulation. Without these mediating processes, human action would not exhibit the remarkable and powerful forms it takes. Although I propose that these mediating processes cannot be reduced to action, I hasten to add that none of these mediating processes could develop without action. Action is necessary for these processes to develop during childhood and is deeply implicated in the forms they take. Furthermore, the expression of these mediating processes occurs through action.

Reducing cognition to action is not only an ambitious project, it is a provocative one. Undoubtedly we can learn much from it. Ultimately, the project could succeed, or at least contribute to dialectic change.

An alternative project might be to sketch the outline of a viable theory that does justice to the importance of action in human cognition, integrating it properly with the powerful processes that mediate sensation and action. No doubt, such integration must also take into account the physical and social situations in which human perception and cognition are embedded as well as the constant and constraining couplings between them all.

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