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Natika Newton

# Representation in Theories of Embodied Cognition

## Abstract

This paper looks at a central issue with embodiment theories of cognition: the role, if any, they provide for mental representation. Thelen and Smith (1994) hold that the concept of representations is either vacuous or misapplied in such systems. Others maintain a place for representations (e.g. Clark 1996), but are imprecise about their nature and role. It is difficult to understand what those could be if representations are understood in the same sense as that used by computationalists: fixed or long-lasting neural structures that represent the sensory stimuli that caused them (e.g. neural response patterns in the visual cortex), or whose "meaning" is fixed innately or in early development for particular functions (e.g. the body schemas of Meltzoff and Gopnik 1993). The paper proposes a distinction between, on the one hand, neural patterns, traces of sensory activation that while not in themselves representations are available for representational activity, and on the other the act of representing, which is what gives representational content to neural patterns.

## I. Embodied Cognition

A growing movement in cognitive science views consciousness and cognition as self-organizing systems involving emotion and sensory-motor agency (e.g. Damasio 1994, 1999; Clark 1996; Glenberg, 1997; Hurley 1998). The view that cognition is best understood as embodied is replacing models involving amodal symbol systems like the arbitrary, intrinsically meaningless symbol manipulation of computer programs, which notoriously fail to explain common-sense reasoning and consciousness. The embodied-cognition approach sees such behavior as extensions of the animal's value-laden interaction with its environment. On the model of embodied action, cognitive activity at all levels of abstraction and complexity, from infant exploratory behavior to calculation in mathematics and logic, can be explained within a single framework. This framework, unlike the computationalist model, can explain intentional features of human cognition as well as the functional ones; it can also offer an intuitively plausible account of the understanding of meaning (Newton 1996; Glenberg 1997). The model is fully compatible with known brain mechanisms of motor behavior, cognition and language, and is capable of generating empirical predictions. It is also compatible with naturalistic approaches to consciousness, although not all embodiment theorists incorporate consciousness into their theories.

It is possible to develop limited but useful theories of embodied cognition without considering consciousness. This approach is taken by dynamical systems theorists such as Thelen and Smith (1994) and Port and Van Gelder (1995). In a recent article, Thelen et al. (2001) argue that a well-known cognitive phenomenon in infants (the A-not-B error) can be best explained in terms of the dynamics of embodiment. They define their approach this way:

> We offer a formal dynamic theory and model based on cognitive embodiment that both simulates the A-not-B effects and offers novel predictions that match new experimental results. The demonstration supports an embodied view by casting the mental events involved in perception, planning, deciding, and remembering in the same analogic dynamic language as that used to describe bodily movement, so that they may be continuously meshed. We maintain that this mesh is a pre-eminently cognitive act of "knowing" not only in infancy but also in everyday activities throughout the life span. (Thelen et al. 2001, p. 1.)

The model offered does provide a plausible approach to infant learning, although it has its critics (see Commentary in Thelen et al., 2001). One common criticism of Thelen's work is that she denies a role for conscious mental representation in embodied cognition. While I shall argue that this denial is mistaken, it is an important sign of the value of the embodiment approach in general that it lends itself to use by representationalists and nonrepresentationalists alike. It is both theoretically robust and intuitively plausible, to such an extent that it can be bent and shaped in a variety of ways without succumbing to incoherence. I will argue, nevertheless, that theories of embodied cognition need an account of conscious mental representation if they are to explain the full repertoire of human behavior.

What kinds of behavior must a complete theory of cognition explain? It must explain infant conceptual learning as well as skill learning; it must explain the source of the traditional "folk psychology" concepts of belief and desire (whether or not these are retained in the theory); it must explain sophisticated cognitive skills including natural language and abstract reasoning; and finally it must explain phenomenal consciousness, for the following reasons. Conscious experience is obviously of emotional significance to human beings, and phenomenologically consciousness manifests our awareness of our own embodied interactions with our environment. Whatever the full functional role of consciousness may be, it is clear that it has an important role in our commonsense scheme of beliefs and values. Many important insights that led to the theory of embodied cognition were derived from phenomenological study of conscious experience (e.g. Merleau-Ponty 1962, 1963; Husserl 1966). A fully developed theory must address and account for these facts, and it must also acknowledge and explain the nature of conscious experience in some way or other (see Ellis 1995, Ellis and Newton, 1998, and Newton 2001 for recent attempts to do that). One virtue of the embodiment approach is that it unifies the various aspects and abilities of intelligent animals, and clarifies their position on a continuum with other animals. A full account of consciousness would allow us to see its place in this continuum.

## II. Representation

In its current incarnation, the theory of embodied cognition can be seen as emerging from two major predecessors: computationalism and phenomenology, both of which essentially include mental representations. In positive terms, embodiment theory owes more to the latter than to the former: much of the descriptive language of embodiment discussion is the language of Husserl, Merleau-Ponty, Sartre, among others. But the theory is dependent upon computationalism as well, because that research program, which was dominant for thirty years ("It's the only game in town," Fodor remarked in 1981) defined the problems that contemporary embodiment theory seeks to solve. Computationalism sought to explain the mechanisms of cognition in such a way that (1) they could in principle be implemented in a computer, and (2) they could be mapped onto actual brain mechanisms. Traditional phenomenology had a different goal: it sought to explore the phenomenal field for its own sake, to map the terrain for the purpose of developing a new science of conscious experience with its own terminology and laws. The insights that were developed in this effort have shaped theories of embodied cognition, but those theories share the aims of computationalism more than those of pure traditional phenomenology: the goal is to develop a science of cognition that is continuous with biological science, and that can be modeled in dynamical systems theories. Throughout this transition the general concept of intentional mental representations has survived from its original definition (as "ideas") by Brentano, through the abstract symbol-systems of computationalism, to most but not all contem-

What is this concept? Brentano's account of the relevant kind of intentionality is reference or "direction upon something": we can think of something by having it "before the mind" or "present to consciousness," (Brentano, 1960). He did not use the term "representation," but his "ideas" represent or "present" the things that the thoughts are "about." These ideas are objects of judgments (propositional attitudes) and mental states such as love or hate.

Jumping ahead to Fodor, we are told that Brentano's ideas are *symbols*. Fodor summarizes his Representational Theory of Mind as follows:

(a) Propositional attitude states are relational.
(b) Among the relata are mental representations (often called "Ideas" in the older literature).
(c) Mental representation [sic] are symbols: they have both formal and semantic properties.
(d) Mental representations have their causal roles in virtue of their formal properties.
(e) Propositional attitudes inherit their semantic properties from those of the mental representations that function as their objects. (Fodor 1981, p. 27)

Fodor's mental representations are just like the symbol-strings manipulated by computer programs; hence the "computational theory of mind."

This theory no longer enjoys wide, uncritical acceptance; too many insoluble problems with it have been discovered. But the notion of mental representations that it adopted has not been replaced by one more appropriate to an embodiment approach to cognition. The problem is that representations are still viewed by most writers as static, semi-permanent symbol strings, now in the form of groups of neurons that are linked together by experiential training (via mechanisms such as Hebbian synapses) and trigger each other to fire in response to appropriate input. Such neural groups, just like symbol-strings in computers or strings of letters in the words of a natural language, carry content in themselves (either actually, with "intrinsic intentionality," (Haugeland, 1985) or potentially, waiting to be employed by a user (Dennett, 1987)). Whichever view is taken, the neural groups are themselves the representations, and it is they that bear the intentional content, if any, of a thought. (It is true that Dennett, along with Millikan, 1984, holds that the user determines the content of the representation. But for them the content imbued by the user is fixed by evolution: the content of the representation is that which the representational mechanisms have evolved to bear by their "proper function." Novel intentions emerging from spontaneous creative acts of users, which are central to human cognition, are not part of such accounts.)

This notion of representation is common in neuroscientific writing. Consider a recent example from an article describing studies of 'canonical' neurons (which respond to visual aspects of three-dimensional objects') and 'mirror' neurons (active both during the performance of an action and when seeing a conspecific performing the same action) in the preventral motor area (PMv):

> Canonical neurons were largely found in the portion of the PMv that is buried in the back of the arcuate sulcus. Mirror neurons are active when a monkey executes a specific action and when the monkey watches someone else perform a similar action. These neurons were largely found in the portion of the PMv that is on the cortical surface caudal to the arcuate sulcus. The presence of mirror and canonical neurons, along with the extrinsic coding that we found, suggests that the PMv may contain a spatial representation of actions. (Kakei et al., 2001)

The above usage of 'representation' is compatible with the view that representations are groups of neurons that are more or less stably linked together and available for use by an organism in various activities. The representational neurons are causal intermediaries between stimulus and response, in most views: they are caused by external events that stimulate sensory mechanisms or by internal events that leave traces of their patterns (as with motor representations), and in turn they play a causal role in behavior, providing patterns that guide the organism in action planning and execution. The representations referred to in the above article are deeply embedded in such a causal mechanism, as are many other representations both earlier and later in the sequence of events between input and output.

How is the content of these representations determined? On most accounts, external objects, the perception of which causes the formation of these neural groups, are what is represented. Thus, in the visual cortex various neural patterns are said to represent external visual objects in many different ways: early ones represent, e.g., stimulus shape and location, and later ones represent familiar objects in association with other objects. Bodily input also forms representations (which may also be innate): "body maps" in various locations such as the parietal cortex represent various aspects of the subject's body for purposes of orientation, action preparation, and maintenance of physical well-being. Content is also determined by what the representations can cause: a motor pattern that when activated causes a particular action is said to represent that action (Jeannerod 1998).

There is enormous difficulty in giving an exact account of the content of representations conceived as static, enduring neural groups. One famous problem

' According to Rizzolati et al., 2000, "3D objects ... are identified and differentiated not in relation to their mere physical appearance, but in relation to the effect of the interaction with an acting agent. ... F5 neurons [in the ventral premotor cortex] become active only if a particular type of action (e.g. grasp, hold, etc.) is executed to achieve a particular type of goal (e.g. to take possession of a piece of food, to throw away an object, etc)".

concerns misrepresentation: if the patterns represent their causes, how could an activated pattern ever misrepresent its cause? Problems like this lead some researchers, such as Thelen, to reject talk of representations altogether:

> Representations in their strongest, original and most meaningful sense are symbols that stand for what is represented and are distinct from the computational forces that operate on them. By this original definition, sensorimotor processes are decidedly not representations. More recently, however, the range of internal events considered to be representations has expanded. In this newer view, any dynamic internal event that is causally related to behavior is a representation. This is fine by us. If we all agree that there is only process, and if we reject the dualist partition of knowledge distinct from process, then we are happily representationalists. But notice such a move takes all meaning from the term: a hurting knee becomes a representation of the fall that gave rise to it. It hardly seems worthwhile to ask whether a theory posits representations or not. (Thelen et al. 2001)

Thelen is right that indiscriminately labeling any causal component of a perception-behavior sequence is pointless. And she is also right to reject representations as symbols that stand for what is represented, and are distinct from cognitive processes. But there is an essential role for mental representations nevertheless. In what follows I first discuss two serious problems with viewing representations as fixed neural structures. I then explore the notion of representation as a mental activity. The term 'mental activity' is significant here: it is not synonymous with 'mental state'; it refers to an intentional action, similar to motor action except for being covert, and controlled by the same brain structures (the cerebellum, the motor cortex) as those involved in overt activity. In general, thinking is acting in this sense.

## III. Representations as Vehicles with Fixed Content: Two Problems

There are (at least) two problems with viewing representations as brain structures (vehicles) whose content is determined locally via the history and/or causal relations of those structures. The first is that embodiment theories make sense primarily as metaphorical extensions of our concepts of bodily activity, and there is no suitable bodily analog for representations as fixed neural patterns. This fact makes modeling difficult. Bodily activity is driven by needs and motives of the whole organism, and it is aimed at environmental features that satisfy them. These features, in most theories, are given in the perception of the environment directly as "affordances" - they have no prior "objective" meaningful content for the embodied subject, and they acquire content only through this interaction.

If we think of cognition as an extension of this activity, and at the same time posit stored neural patterns as possessing meaningful content even when not "in use," then we will need two distinct theories of content. One theory will explain how content is created by the emotionally-driven activities of an organism as it seeks to satisfy its needs through the available features of the environment. This theory will have to show how, just as we can ask about an animal that is performing a natural behavior what it is "trying to do," so we can ask about a person who forms sensory imagery in the course of planning an action or solving a problem what she "means by" the imagery. Say that her imagery is an activated memory trace of seeing the ocean at Fire Island last August. It is not enough to say that her imagery "means" the ocean as it appeared to her last August. It has been activated in order to play a role in her current cognitive activity - e.g. trying to decide whether to rent a summer cottage next year on Lake Michigan. In this role, the memory traces have entirely new content: they represent future possibilities that now carry emotional and other features completely foreign to the original memories.

The other theory will explain how the neural traces can bear content "intrinsically," even when stored and inactive. (This idea is caricatured in the old notion of the "grandmother neuron"). Below we examine the problems with this theory. Even without them, however, it seems unnecessarily unparsimonious, as well as confusing, for a general theory of cognition to require two quite different types of representation.

The second problem is the number of intrinsic difficulties in giving an account of content in stored neural patterns. The difficulties are apparent in debates about linguistic content, because these neural patterns are seen as language-like. What gives content to linguistic symbols? Causal theories are notorious for problems in explaining misrepresentation. Causal theories, moreover, give no account of creative processes in which structures with fixed content acquire novel uses, an essential and ubiquitous feature of human cognition. And as Thelen et al. argue (see above), solving its problems in terms of causation results in an almost vacuous account: anything involved in a causal system is a representation.

Given the problems just discussed, I propose that we should seek an account of mental representation in which content arises only during actual cognitive activity. If we reserve the notion of content for active components of representational behavior, and treat stored patterns neutrally as traces of their causes, then these problems from traditional philosophy of language disappear. If what gives a symbol its content is the way it is used, then we should focus on the use. Representations arise when we actively represent. Content is provided by the context and goal of the representational activity; it is not ready-packaged in the neural patterns recruited in representational activity.

## IV. Representation in Action

The idea that representation arises in goal-directed action is far from novel. In addition to prefigurations in classical philosophy (such as Aristotle's "entelechy") and in the 19th century pragmatists such as Peirce, it is clearly stated in such writers as Polanyi:

> We may say in general that by acquiring a skill, whether muscular or intellectual, we achieve an understanding which we cannot put into words and which is continuous with the inarticulate faculties of animals.
> What I understand in this manner has meaning for me, and it has this meaning in itself, and not as a sign has a meaning when denoting an object. I have called this earlier on an existential meaning. (Polanyi 1958, p. 90.)

Performing a learned action is exercising one's understanding of the action: the action has meaning. What does one understand; what is the meaning? I would suggest that one understands what one is trying to do, or what the action is for. In other words, the meaning of the action is the goal of the action, which one at least tacitly understands in intentionally performing the action. Thus we might say that performing the action is itself the activity of representing the goal as a goal, the desired outcome of the action. The goal is not represented separately, in a static neural pattern, as a detachable component of the performance.

A similar view is taken by Merleau-Ponty. He rejects the idea of a "representation" as an independent component of a behavioral sequence; instead, he sees the action as a whole as having imminent meaning in the unification of its means and end. Unless the end and the means are internally related in the action, the action lacks meaning for the organism:

> ... as long as consciousness is defined by the possession of certain "representations,"
> ... then the consciousness of the act is necessarily reduced to representation of its goal on the one hand and possibly to that of the bodily mechanisms which assure its execution on the other. The relation of means to end can be only external under these conditions.
> But if ... representative consciousness is only one of the forms of consciousness and if this latter is defined more generally by reference to an object - whether it be willed, desired, loved or represented - the felt movements will be linked together by a practical intention which animates them, which makes of them a directed melody; and it becomes impossible to distinguish the goal and the means as separable elements, impossible to treat human action as another solution to the problems which instinct resolves: if the problems were *the same*, the solutions would be identical.

> An analysis of the imminent meaning of action and its internal structure is substituted for an analysis of the goals of action and their means. (Merleau-Ponty 1963, pp. 173-174.)

The action of working toward a goal is the action of representing the goal *as* the aim of the means. Independent of the means, the goal would not be a goal; independent of the goal, the means would be meaningless.

I am not arguing that there are no neural patterns that can be used representationally in goal-directed actions. Jeannerod (1998), for example, has argued persuasively that action imagery, laid down by previous performances of an action, is recruited in a new performance of that action type and plays a vital role in the initiation, control, and evaluation of the action. Action images *in use* can be said to represent the action that that they facilitate, because they are sensorimotor images of the unified performance, in which means and ends are blended and derive their significance from each other. But it is consistent with this fact to claim that they do so only when actually used for this purpose. Otherwise they are mere potential images, potential representations of actions. And when they are actualized in a performance, they represent the action token that they are currently facilitating; it is unnecessarily abstract and metaphysically confusing to claim that they represent action types. I propose the following definition for representations in action:

> R represents object O or state of affairs S *iff* because of some appropriate isomorphism or other feature of correspondence with O or S, R plays the role of O or S in a simulated action involving O or S.

R can be any component of an action image that is in use, when the imaged action is an interaction with an external object, that plays the role of the object; and the "isomorphism or other feature of correspondence" is indefinitely variable: any property of the image that would allow the interaction will serve (e.g. the image need offer only an appropriately imagined spatial relation).

If neural groups actually in use in an action image are to be allowed to represent objects involved in the relevant actions, then the action image as a whole would logically be expected to represent the action as a whole. This relation can also be defined:

> Image I represents Action token A *iff I* plays the role of A in any mental simulation activity involving evaluating, planning, activating, controlling, or completing A. However, when in the quiescent state, they represent only potentially; they do not actually represent until activated for that purpose.

These definitions allow action images to represent actions that they are currently facilitating, and they allow components of those images to represent components of the actions. They represent them in the classical sense of standing for them, or playing their functional roles, in a given mental simulation of an action. They do not, however, represent anything when in a quiescent state - e.g. when not activated for that purpose. Representation is an activity; it is not an external relation between two static objects.

Theories of embodied cognition cannot end with intentional representation on the level of basic action performance; complex cognitive behavior involves covert, abstract thought. How can abstract reasoning (e.g. logic and mathematics) make use of bodily action abilities? Many theorists argue that sensorimotor imagery, conscious or semiconscious activated memory traces of the experiences of performing basic actions, functions not only in action contemplation and planning but also in the mental manipulation of objects in abstract reasoning. Abstract thought builds on basic action schemas: bodies interacting with objects in space (e.g. Huttenlocher 1968; Newton 1996). While mental representations are involved here, these representations are in use in mental performances of imagined actions. Recent work on the cerebellum (Schmahmann, 1997) shows that this organ, traditionally known only for its role in the sequencing of specific action plans, is involved in abstract reasoning and problem solving as well. This finding is an exciting confirmation of the theory of embodied cognition (Newton et al., 2002).

Apart from the cerebellum work, most of the claims of the theory regarding representation in action imagery are now fully testable. To those claiming to lack such imagery, it can be argued that such images are not necessarily fully conscious, and brain imaging studies are now available that can decide such matters. But it is important to be clear on what is meant by the term 'image.' There is an entrenched tendency to think of all images as visual. But while that is the traditional meaning of 'image,' there is a very good reason to expand the term to include representations of all sensory, motor, proprioceptive and affective states, not just visual ones. The mechanisms of visual imagery, which include many areas also involved in visual perception, are completely analogous to those involved in reactivated experience in other modalities. Motor images, for example, appear to involve activity in the motor cortex identical to that present in actual motor behavior (Jeannerod 1998). In short, we can imagine anything we can experience, it appears, and imagining hearing, touching, tasting, feeling emotion, or performing specific motor actions, is entertaining images of those activities.

If it is indeed possible for us to form images in any modality, then many if not all of the traditional objections to an imagistic view of cognition collapse. Pylyshyn, for example, argued that mental representation is propositional, not imagistic, because we can represent relations that cannot be captured pictorially:

> ... while two visual images of a chessboard may be pictorially identical, the mental representation of one might contain the relation between two chess pieces which

> could be described by the phrase ‘being attacked by’ while the representation underlying the second image might not. ... For this reason, it would be reasonable to expect that the mental representation of a configuration of pieces on a chessboard would be much richer and highly structured for a chess master than for an inexperienced chess player. (Pylyshyn 1973, p. 11)

Pylyshyn is arguing that the relation is not part of the image, since that is available to both the master and the novice, but is contained in information represented in propositional form, available only to the master. But if we expand the notion of ‘image’ to encompass experiences in all modalities, including motor, proprioceptive, and emotional, then we can easily form an image of two chess pieces in the ‘attack’ relation. One way we can do this is to evoke sensorimotor imagery of the possible moves of the two pieces, combined with affective imagery of hypothetical “emotional states” of the two pieces: aggression in the one, fear or defensiveness in the other. This description may sound farfetched, but in fact is perfectly consistent with the language used by Pylyshyn to describe the relation: ‘being attacked by’ is a relation inherently associated with affect. To be attacked is to be in danger; to be in danger is bad. Chess is an abstract game, but unless abstractions are grounded in concrete states that we can understand from our own experience, they cannot be meaningful and hence useful to us.

These concrete states are representations of action, but always of action in a situational context that is wider than simply the motor movements of the body. Actions require, motivation. Even subtle actions such as covert attention shifts depend on emotional interests of the organism; subcortical structures such as the amygdala, hippocampus and the hypothalamus influence voluntary attention mechanisms in the anterior cingulate. Actions imagined but not performed are both activated and inhibited in the frontal lobes and motor cortex; inhibition, controlled in large part by the hypothalamus, allows action images to be consciously experienced (Jeannerod 1998) along with the emotional values associated with the actions as well as aspects of the material world upon which the action depends.

The theory of cognition as based in sensorimotor imagery - cognition as embodied - cannot be fully defended here. We have focused on the issue of representation, and argued that the concept is indispensable, but that it must be revised to fit the demands of embodiment as the basis of cognition. Much more work must be done, of course, to iron out remaining wrinkles in the account and establish it over its still powerful rival, the view that representations are static, semipermanent brain objects with fixed content.[2]

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