

Biosymbols: Symbols in Life and Mind

Liz Stillwaggon Swan · Louis J. Goldberg

Received: 12 September 2009 / Accepted: 10 November 2009 /

Published online: 5 December 2009

© Springer Science+Business Media B.V. 2009

Abstract The *strong continuity thesis* postulates that the properties of mind are an enriched version of the properties of life, and thus that life and mind differ in degree and not kind. A philosophical problem for this view is the ostensive *discontinuity* between humans and other animals in virtue of our use of symbols—particularly the presumption that the symbolic nature of human cognition bears no relation to the basic properties of life. In this paper, we make the case that a genuine account of strong continuity requires the identification of some sort of correlate of symbol-use in basic life properties. Our strategy is three-fold: 1) we argue that examples of proto-symbolism in simple living systems would be consistent with an evolutionary trajectory that ultimately produced symbolic cognition in humans; 2) we introduce Gordon Tomkins' biological notion of 'symbol' as something that represents to the organism a feature of its environment that is significant to its survival; and 3) we employ this biological understanding of symbol-use to suggest that the symbolic nature of human cognition can be understood as an enriched version of the basic symbolic properties of life, thus preserving life-mind continuity in this context.

Keywords Strong continuity thesis · Life-mind continuity · Symbol-use · Symbolic communication

L. S. Swan (✉)

Department of Philosophy, University of Colorado, Denver, Campus Box 179, P. O. Box 173364,
Denver, CO 80217-3364, USA
e-mail: liz.swan@ucdenver.edu

L. J. Goldberg

Department of Oral Diagnostic Sciences, School of Dental Medicine, and Ontology Research Group
Center of Excellence in Bioinformatics & Life Sciences, State University of New York at Buffalo,
Buffalo, NY 14214, USA
e-mail: goldberg@buffalo.edu

Philosophical Foundations of the Strong Continuity Thesis

The *strong continuity thesis* (SCT) was formally introduced by that name into the philosophical literature on natural cognition (Godfrey-Smith 1996a). The thesis was simply explained as follows: the functional properties of mind are an enriched version of the functional properties of life, thus the difference between life and mind is one of degree and not kind. Furthermore, since life and mind have in common an abstract pattern or set of organizational properties, “mind is literally life-like” (Godfrey-Smith 1996b), which is to say that mind functions in a way that is fundamentally similar to how life functions. Since on this view mind cannot occur without life and in fact emerges out of (particular organizations of) life, the two phenomena are conceptualized as being *continuous*. Three features of SCT are especially important to note.

- 1) In the original formulation of SCT, weak and strong versions of continuity are delineated. The thesis of *weak continuity* makes the modest claim that everything that has a mind is alive, which entails that cognition is an activity of living systems only. The thesis of *strong continuity* makes the bolder claim that life and mind share a common fundamental pattern or set of (organizational or functional) properties. Strong continuity implies weak continuity because anything that is minded would necessarily have a lot of what it takes to be alive.
- 2) The basic theoretical tenets of SCT suggest a fundamental principle that has both ontological and methodological significance, with the latter implied by the former, namely: since life and mind share the same fundamental nature, our efforts to understand the nature of mind should be continuous with our efforts to understand the nature of life. The practical implication of this claim for the mind sciences is that cognition should be investigated in the context of living systems and not as an abstract, disembodied phenomenon which has been the tradition for much philosophy of mind and cognitive science.
- 3) The initial introduction of SCT did not at all address the fact that while life and mind are continuous in the way described, they are also different in important ways.¹ Biology is informative on the continuity in structure and function of all organisms including humans, but this biological fact fails to address the philosophical concern over the apparent discontinuity therein. While we are essentially the same, biologically speaking, as other organisms, we enjoy additional ways of interacting with and manipulating the world that other organisms seemingly do not. The next section of this paper is concerned with the issue of presumed discontinuity between animals and humans in virtue of our use of symbols.

Cognitive scientist Andy Clark has noted that perhaps the most difficult task in naturalizing the mind in the way prescribed by SCT is in finding a balance between the explanatory needs of seeing continuity in nature while somehow still recognizing that the mind is special. One possible way to satisfy this desideratum would be to provide an account of mind that draws on the known components of living systems

¹ Though Michael Wheeler notes in his 1997 paper that SCT is not meant to imply that life and mind are the *same*, since what we are after is “continuity and not equivalence”.

yet has them interacting in novel ways. Such a view would explain mind as a further function borne out by the same essential components involved in basic life processes. Clark seems to have something like this in mind when he explains that, “the thesis of strong continuity would be true if, for example, the basic concepts needed to understand the organization of life turned out to be...*those very same concepts and constructs*...central to a proper scientific understanding of mind” (Clark 2001, italics in original). The philosophical challenge encapsulated by SCT is thus to identify precisely what those concepts and constructs are within an account that is consistent with the natural history of mind.

Neither science nor philosophy has come up with a definition of *mind* to which all can assent, and we do not endeavor in this paper to provide one. The plethora of proposed definitions and possible understandings of the human mind found in the philosophy of mind, cognitive science, artificial intelligence and other fields are too numerous even to provide a survey herein. For the purposes of this paper, we steer clear of adopting (much less advocating) one particular definition of mind, and instead invoke insights from biosemiotics to begin to formulate a naturalistic understanding of human mindedness.

Now that we have a working understanding of the important themes of SCT, we will take a look, in “[Life-Mind Discontinuity](#)”, at some philosophical concerns about life-mind *discontinuity* that stem from the presumption that humans are unique in their symbol-use. In “[Symbolic Communication in Organic Life](#)”, we argue that Gordon Tomkins’ biological notion of symbol-use constitutes an organismic analog to human symbol-use, thus preserving life-mind continuity in this context. In the fourth and final section of the paper, we conclude that the naturalistic account of symbol-use required by SCT motivates a new interpretation of what, precisely, is unique about human symbol-use, and we speculate on the novel challenge this insight poses to the collective philosophical effort to naturalize human mindedness.

Life-Mind Discontinuity?

An early proponent of the worry over discontinuity was John Dewey who (according to Godfrey-Smith’s account, 1996a) was committed only to the thesis of weak continuity (i.e., mind is a feature of living systems only) and not strong continuity (i.e., life and mind share the same fundamental properties). Dewey allowed that there were similarities between the patterns in life and mind but maintained that one of the fundamental properties of cognition—its symbolic nature—had no correlate in basic life properties. An unfortunate consequence of this view is that non-symbol-using animals—which presumably means all animals except humans—cannot think because they do not use symbols. Though this dubious conclusion may have met with less resistance a century ago, it is hard to take seriously today given what we know about the biology and behavior of animals from contemporary research in cognitive ethology² among other fields. The identification of thinking with symbol-use is an odd move for a philosopher who endorses naturalistic resolutions to philosophical

² An exemplar of which is Donald R. Griffin’s 1991 book, *Cognitive Ethology: the minds of other animals*.

problems precisely because this identification seems to deny the possibility of an evolutionary history of mind and thus of any promise of genuine life-mind continuity. But it is nevertheless a conclusion that garners general philosophical sympathy because we quite naturally presume that there is something unique about human cognition.

A more contemporary version of the worry over discontinuity is expressed by Godfrey-Smith who writes the following [note that in this context: 1) “life” denotes non-human life; and 2) it is a given that humans have language]:

I take all views on which having a language is necessary for thought to be views which deny strong continuity between life and mind (unless a very unusual view of the nature of life is taken). According to the strong continuity thesis, life is ‘proto-cognitive’ or ‘proto-mental’. But life is *not* ‘proto-linguistic’, (Godfrey-Smith 1996b, italics in original).

The reasoning behind the first statement in the passage is presumably as follows:

- a) View A claims that thought requires having a language
- b) Non-human animals do not have language, so
- c) Non-human animals do not have thought (i.e., they cannot think)
- d) And since thought is the function of mind,
- e) Non-humans animals do not have mind (and humans do have mind)
- f) Therefore, View A denies strong continuity between life and mind

Dewey held a view like View A, summarized by Godfrey-Smith as follows: “Only a communicating system in a social environment can literally think, because thinking is symbolic and symbolism is social” (Godfrey-Smith 1996b). Dewey’s view and others like it identify symbolic communication as the point of incongruence between life and mind. The underlying presumption is that non-human animals do not engage in symbolic communication, and humans do, so there is a disconnect between life and mind. Such views lead to the problematic conclusion that *humans alone can think* which has all sorts of undesirable implications³ that are difficult to justify on grounds other than philosophical a priori arguments.

The second claim in the passage above—that according to SCT life is proto-mental or proto-cognitive but not proto-linguistic—raises an interesting problem. We can infer from the context of the passage that ‘proto-linguistic’ means, roughly, foreshadowing of language. According to this understanding, the import of the claim is that while we may be able to account for how human cognition emerged out of life processes, telling a comparable story for the emergence of human language is not possible. Language, it seems, is an anomaly in the natural world. According to this reasoning, though we are justified in anticipating certain proto-cognitive correlates in non-human life, we should not expect to find proto-linguistic correlates since language is a categorically human phenomenon.

It does seem that genuine life-mind continuity would demand that thought not require language because although non-human animals do not use language we have

³ For example, a proponent of View A could argue that because non-human animals cannot think they are no different from inanimate objects and thus are not deserving of any sort of moral consideration.

good reason to believe that they are nevertheless capable of *thought* (or at least sentience) and thus continuous with human life on more fundamental grounds. But it is important to note here that the question of whether thought *requires* language is a controversial and complex one; in fact, it is not even clear at this point whether this question is an empirical or a philosophical one. What is uncontroversial, however, is that symbolic communication is a key feature of human cognition. We use symbols to understand the world and communicate with each other about the world. Acknowledging that humans, who engage in symbolic communication, evolved along the same evolutionary trajectory that produced all life motivates a naturalistic understanding of human language not as an anomaly in nature but rather as one particular example of organismic, symbolic communication.

We recognize the futility of trying to identify *language* correlates in non-human life,⁴ precisely because we understand human language as a sophisticated form of symbolic communication that is unique to humans, and not because it is a true anomaly in the natural world. Human language is no more an anomaly in the natural world than is whalesong or birdsong—each a particular kind of symbolic communication that is unique to a particular biological family. We believe it is a mistake to identify language as a rogue ability that sets humans apart from the rest of the natural world because this move denies the biological fact of group-specific communication and thus creates an artificial problem of *discontinuity* between life and mind. We instead propose a more modest desideratum: to identify correlates of symbolism in simple living systems that we understand as biological precursors to the symbol-use characteristic of human cognition.⁵

In the next section, we explore Gordon Tomkins' biological account of how cells use molecular symbols to recognize important features of their environments and communicate with one another. His work on biological symbols provides an example of proto-symbolism in simple living systems that we argue comprises an essential part of the biological substrate for the enriched version of symbol-use that is unique to humans.

Symbolic Communication in Organic Life

So far we have explored the basic theoretical tenets underlying SCT and have questioned the presumption of a disconnect between life and mind in virtue of human symbol-use. We proposed that human symbolic communication be recognized as an enriched version of organismic symbol-use, a move that motivates the identification of symbolic properties in non-human life. The essence of our argument thus far is that if we want to take SCT seriously, then even the particular brand of symbol-use that is unique to humans must be an enriched version of some more basic life properties, and that the identification of such properties will inform our understanding of both the nature of life and the nature of mind.

Before getting into the details of Gordon Tomkins' account of molecular symbols, we offer the following general conceptualization of the role of symbols in organic systems that emerges from Tomkins' analysis of what he identifies as the *metabolic*

⁴ And here we distinguish human *language* from the various forms of animal *communication*.

⁵ See [Appendix](#).

code. By ‘symbol’ we mean an entity inside an organism that stands for (or represents) some feature of the environment outside the organism. The feature of the environment that is represented by the symbol normally has great significance with respect to the survival of the organism; this fact accounts for why the organism has evolved the capacity to detect the feature and symbolize it internally. Symbol production inside an organism, evoked by the presence of a significant environmental feature, leads to an action taken by the organism that is adaptive with respect to its survival (see Fig. 1).

Why ‘Symbols’ and Not ‘Signals’?

The term ‘symbol’ generally refers to elements that map signifiers to that which they signify (Deacon 1997). This mapping can be understood as either arbitrary or transparent. If the mapping is arbitrary, a code is needed to *understand* the logic that makes the mapping meaningful. Words are signifiers that are symbols because that which they signify, or refer to, is given by convention. This is a fundamentally different situation from mappings that are transparent. A transparent signifier is often referred to as an icon. Iconic signs are, for example, “linked by resemblance to the things they are signs of—a picture of a zebra is an iconic sign” (of a zebra) (Noble and Davidson 1996). In the transparent condition the mapping is not arbitrary, or constructed by convention, thus no code is needed.

Signals, on the other hand, are generally considered to be transparent signifiers that merely make physical or mechanical connections to other objects. Deacon gives the following example of a signal: “a light on a dashboard of a car might be a signal that the engine is low on oil by virtue of its being electrically linked with an oil pressure sensor” (Deacon 1997). The light is a signifier that is physically connected to an oil pressure sensor. The signifier (the light) points to that which is signified (the state of the oil pressure sensor).

Communication among cells in biological systems is traditionally conceived as occurring by means of signals. It is well recognized that the very existence of multicellular organisms is dependent on communication systems that support the cooperative interactions of ensembles of millions of cells. The manner by which such cooperation is accomplished is elaborated in great detail in modern molecular biological texts. According to molecular biologists, the communication among cells

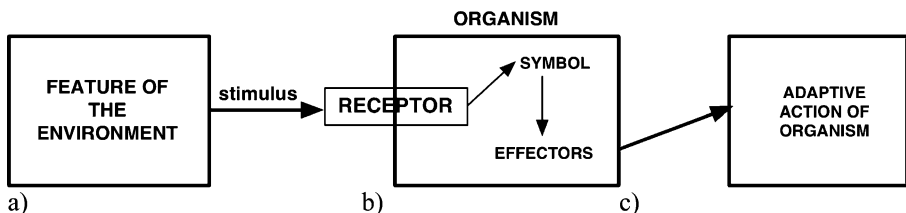


Fig. 1 The general process by which features of the environment evoke adaptive responses in organisms: [a→b] the environmental features become stimuli by virtue of receptors that evolved in the organism to detect the features; b) the stimuli activate receptors which initiate symbol formation within the organism; [b→c] symbols induce effector-processes within the organism that result in actions that are adaptive with respect to the nature of the environmental feature that initiated the process

that support such cooperation is accomplished by signals that pass from cell to cell (Alberts et al. 2002). The term, symbol, is never used. This deliberate choice reflects the standard view in biology that communication among cells is simply a physical, transparent, form of mapping. Tomkins, however, took a radically novel approach, arguing for an understanding of cellular communication as *symbolic*; in the next few sections, we take a look at exactly what this means, and the implications.

Gordon Tomkins' Molecular and Hormonal View of Symbols

In 1975, molecular biologist Gordon Tomkins presented a paper in which he attempted “to understand regulation in complicated multicellular organisms in terms of the evolution and function of seemingly comparable processes which occur in much simpler systems” (Tomkins 1975). For Tomkins, the notion of there being any biological discontinuity between simple organisms and more complex organisms including humans does not conform to the facts of biology. Simple organisms such as bacteria must self-regulate using intracellular molecules to represent environmental conditions, and complex organisms such as humans are composed of cells which self-regulate in this same way.

Tomkins proposed three evolutionary stages in the development of symbolic communication in organisms. The first stage emerged in primitive free-living prokaryotic cells. The second stage occurred with the evolution of multicellular organisms. The third stage emerged with the evolution of central nervous systems in multicellular organisms. Below we take a look at the significant developments of each evolutionary stage.

Stage 1: The free-living cell.

Free-living, prokaryotic cells, of which bacteria are living examples, appeared approximately 4 billion years ago. Tomkins proposed that such free-living cells use specific molecular symbols to represent within the cell specific environmental conditions outside of the cell. In his words: “Since a particular environmental condition is correlated with a corresponding intracellular symbol, the relationship between the extra- and intracellular events may be considered as a ‘metabolic code’ in which a specific symbol represents a unique state of the environment” (Tomkins 1975).

He further explains that, “The term ‘symbol’ refers to a specific intracellular effector molecule which accumulates when a cell is exposed to a particular environment” (Tomkins 1975). For example, cells need to live in an environment that includes the presence of a carbon-source such as glucose and thus have receptors in their membranes for glucose molecules. In a low-glucose environment, the decreased activity at the cellular receptor sites leads to the accumulation of cyclic AMP in the cell. And the increased concentration of cyclic AMP represents within the cell a carbon-depleted environment outside the cell. Note that cyclic AMP and glucose are two distinct molecules, different in shape and molecular binding characteristics. Yet the varying concentrations of the one *represent* to the cell the varying concentrations of the other and effect particular survival strategies. For example, an increased intracellular concentration of cyclic AMP in some cells causes the formation of flagella that permit cellular motility, thus increasing the cell's chances of finding a glucose-rich environment.

The molecular symbol system described by Tomkins is essential for cell survival and has been conserved and continues to be used by all prokaryotic cells, and by the eukaryotic cells that comprise the basic structural and functional units of all multicellular organisms. Tomkins views this continued use of molecular symbols in complex organisms as a demonstration of the conservation and continuity of molecular-based regulatory symbol systems over evolutionary time.

Stage 2: Intercellular communication in multicellular organisms.

Eukaryotic cells, also free-living but containing nuclei and organelles, evolved from prokaryotic precursors approximately 2.5 billion years ago; paramecia and yeasts are existent exemplars. Sponges, which evolved approximately 500 million years ago, were the first multicellular organisms composed of cooperative ensembles of eukaryotic cells.

Tomkins explains that the use of intracellular symbols was necessarily expanded with the evolution of multicellular organisms to include the addition of *extracellular* molecular symbols that are referred to as hormones. Cells began to synthesize and secrete into the extracellular environment hormones that acted as metabolic symbols to distant cells. Tomkins explains:

“[Hormones] carry information from ‘sensor’ cells in direct contact with the environmental signals, to more sequestered responder cells. Specifically, the metabolic state of a sensor cell, represented by the levels of its intracellular symbols, is ‘encoded’ by the synthesis and secretion of corresponding levels of hormones. When the hormones reach responder cells, the metabolic message is ‘decoded’ into corresponding primary intracellular symbols. Thus, hormones apprise responder cells of the concentrations of intracellular symbols in the sensor cells, allowing relatively protected internal organs to respond coordinately to external perturbations’ (Tomkins 1975).

Figure 2 illustrates this phenomenon.

Stage 3: Multicellular organisms with central nervous systems.

The evolution of organisms with central nervous systems marks a significant advance in molecular symbol-use: the primitive virtual hormonal pathways that linked environmental features and organismic response now become actual structural pathways in the brain. It is Tomkins’ view that with the evolution of organisms with central nervous systems, the use of the metabolic code was further expanded to include neurotransmitters that allowed for intercellular communication within the brain. Neurons have evolved into cells that generally have long, output structures (axons) and shorter input structures (dendrites) that permit extensive neuron-to-neuron communication between distant cells: the sending cell (the presynaptic neuron) secretes a neurotransmitter that acts as a metabolic symbol for conditions in the external environment of the receiving cell (the postsynaptic neuron). This system allows for the elaboration of brain pathways in which symbolic communication can occur rapidly over great distances. The communication between neurons remains hormonal in the Tomkinsonian sense—it depends on the release of a molecule synthesized in the sending neuron that activates receptors in the receiving neuron. This results in both rapid and focused symbolic communication.

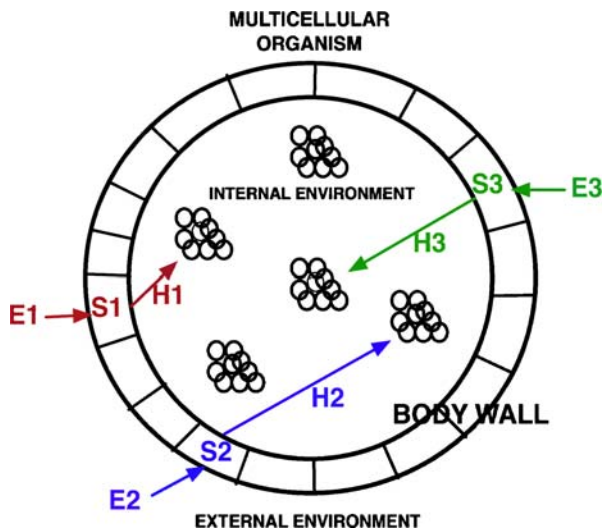


Fig. 2 Multicellular organisms use hormones for intercellular communication. Environmental conditions (E1, E2, and E3) activate particular sensory cells (S1, S2, and S3) on the cell membrane that then induce the production of the corresponding hormone (H1, H2, or H3) that symbolizes for the internally isolated receiving cell that particular environmental condition. The arrows indicate receptor site affinity of cellular clusters for particular hormones. A set of virtual pathways is formed in which different environmental stimuli elicit correspondingly different responses from the organism

All three stages (reviewed above) in the evolution of molecular symbols have been conserved and are concurrently active in all existent animals including humans. Each individual cell in a human uses intracellular symbols to regulate its metabolic processes. In the cooperative ensemble of cells that characterizes multicellular organisms, hormones play an essential role in coordinating the activity of cells that are distributed throughout various locations in the organism. And, finally, in organisms with central nervous systems, neurotransmitters play an essential role in controlling and coordinating the activity of large neuronal ensembles that in turn coordinate all the organism's behaviors.

A Current Perspective on Tomkins' Views on Metabolic Coding Systems

The use of the word 'symbol' in descriptions of mechanisms of cell communication was not subsequently adopted by molecular biologists. In the authoritative text, *Molecular Biology of the Cell* (Alberts et al. 2002) the word 'symbol' does not appear in the index. Cellular communication is prominently featured in the book but the more neutral word 'signal' is used to describe how such communication is accomplished.

In the more than thirty years since Tomkins' metabolic code paper was published, considerable detail has been added to our knowledge of the molecular biology of cell function. Yet the fundamental principles elaborated in Tomkins' paper remain operant. For example, consider this recent account of the means by which a cell responds to a feature of its environment:

"Signals received at the surface of a cell by...receptors are relayed into the cell interior by a combination of small and large *intracellular signaling molecules*."

The resulting train of intracellular signaling events ultimately alters *target proteins*, and these altered target proteins are responsible for modifying the behavior of the cell” (Alberts et al. 2002, italics in original).

Molecules in the environment act as *signals* in virtue of receptors on the cell surface that are designed specifically to respond to their presence. The functional description of these intracellular signaling molecules is identical to that of Tomkins’ *symbols* in the metabolic code in that they initiate a train of events that results in activating target effector proteins that modify cell behavior.

Furthermore, the current view of the molecular mechanisms underlying the function of hormones and neurotransmitters in intercellular communication is the same as that elaborated by Tomkins. Endocrine cells secrete “signal molecules, called **hormones** into the blood stream, which carry the signal to target cells distributed widely throughout the body”. Neurons in the brain “secrete a chemical signal called a **neurotransmitter**” at the terminals of their axons. “These signals are secreted at specialized nerve junctions called *chemical synapses*, which are designed to ensure that the neurotransmitter is delivered specifically to the postsynaptic target cell.” These are the molecular “mechanisms that allow endocrine and nerve cells to coordinate cell behavior in animals...” (Alberts et al. 2002, bold and italics in original).

Tomkins was a leader in the field of biochemistry and molecular biology until his untimely death in 1975. Tomkins had a reputation as a creative thinker who was interested in the broad implications of molecular biology for the evolution and functioning of complex life forms. As stated in a paper celebrating his life’s work, Tomkins

“established a fresh view of the evolutionary importance of intracellular compounds which encode the metabolic status of a cell. From this followed the notion that hormones and neural transmitters arose to extend similar symbolism to communication *between* cells. Clearly, the capability for such communication was crucial to the evolution and survival of multicellular organisms. Thus, this unifying hypothesis, the metabolic code, brings together a vast number of seemingly unrelated observations in endocrinology, developmental and molecular biology, neurobiology and genetics” (Ames 1977).

The significance of Tomkins’ “unifying hypothesis” in the context of this paper resides in his giving the important designation of ‘symbol’ to the molecular entities which mediate communication between a cell and its particular environment, as well as mediating communication among the cooperative ensemble of cells within the confines of the body of a multicellular organism.

Continuity in Symbolic Communication

What precisely does it mean to say that communication in biological entities is symbolic or representational? In the case of cells, an environmental condition such as the concentration of glucose molecules cannot be allowed to directly affect the internal conditions of the cell in a way that would destabilize those conditions and

lead to cell death. But the cell, as a living entity, needs to be aware of the presence or absence of, for example, food in its environment. It has to be able to sense the environment without being overwhelmed by it. It does this through the mechanism of intracellular molecules, the concentrations of which *represent*, in this example, levels of glucose concentration outside the cell. The membrane does not permit glucose to freely enter the cell; instead, receptors for glucose on the cell membrane ‘sense’ the presence of glucose and initiate production of the intracellular symbol for glucose, cyclic AMP (more if glucose levels are low; less if they are high).

The basic survival principle for multicellular organisms is as follows: the survival of any organism depends on the survival of the cells of which it is composed; cellular survival depends on effective intercellular communication; and effective intercellular communication depends on representation through the medium of molecular symbols. Because this basic principle of the nature of communication between environment and cell remains in effect for all complex organisms including humans, we argue that it satisfies the desideratum posed by Andy Clark regarding a full account of SCT—namely that concepts or constructs be identified which inform our understanding of both life and mind.

It is a philosophical tradition to conceptualize symbols as things out there in the world, waiting for our interpretation and utilization. But Tomkins’ account instead explains symbols as internal representations of features of the organism’s environment that permit those features to be perceived by the organism. In addition, the symbol also works internally to activate effectors that drive the organism’s response to the perceived environmental feature. Letters, signs, numbers, and statues are inanimate features of the (human) environment until they are registered in a human’s brain; this is, we propose, when their representations actually become *symbols*. Environmental features of this kind (letters, signs, etc.) are physical entities, the meaning of which is established throughout the entire process (outlined in Fig. 1) of their being recognized and registered in the brain of the organism, and then acted on or reacted to with respect to the feature’s significance to the organism’s wellbeing.

Naturalizing Symbol-Use

Dewey was right, in a sense, to believe that symbolism is social since there must be a sender and a receiver of the symbol for it to have any meaning and effectiveness at all. But cellular communication is at least ‘proto-social’. Tomkins argued that symbol-use is necessary for the intercellular communication systems that support the social (cooperative) behavior of cells in multicellular organisms. Thinking may be symbolic, but proto-social interactions among cells and social interactions among organisms are symbolic as well.

Tomkins’ views on the symbolic nature of intercellular communication were used in a paper focusing on the evolution of the complex movement capabilities needed for the production of human speech. It was hypothesized that molecular symbols are essential for the “internal communication necessary for the control of animal movement and for the coordination of actions among organisms” (Bellman and Goldberg 1984).

A theory of the evolutionarily-based continuity of human language with biological precursors was elaborated by the biological anthropologist, Terrance Deacon, in his book, *The Symbolic Species*. Deacon disagrees with claims that there is a discontinuity between human language and other biological phenomena. He writes that, “Interpreting...discontinuity between linguistic and nonlinguistic communication as an essential distinction between humans and nonhumans...has led to an...exaggerated and untenable interpretation of language origins... it also assumes an essential biological discontinuity. In other words that language is somehow separate from the rest of our biology and neurology” (Deacon 1997).

Biologist Gerard Edelman has also long been a strong proponent of the biologically-based evolution of complex organisms including humans and human linguistic systems. He believes that, “We must incorporate biology into our theories of knowledge and language. To accomplish this we must develop what I have called a biologically based epistemology—an account of how we know and how we are aware in light of the facts of evolution and developmental biology” (Edelman 1992).

Tomkins’ paper makes several notable contributions in support of SCT’s main claim that life and mind share the same fundamental nature, against the opposing view that mind is sustained by the unique linguistic symbol-system of human language, a symbol-system that presumably has no correlate in the biological processes that sustain life. In the first place, Tomkins’ account is intensely cell-centered, with a particular focus on the means by which cells engage with the world surrounding them. It proposes an evolution-based theory of the methods of communication between living cells and their external environments, as well as intercellular communication among the cooperative ensemble of cells within a single organism.

Of special significance is Tomkins’ proposal that intercellular communication in multicellular organisms is accomplished via a symbol-based messaging system. The only way in which cells can communicate is through the medium of specific molecules they themselves synthesize through metabolic means, which are then delivered to the membranes of other cells for reception and interpretation. The appellation of ‘the metabolic code’ reflects the fact that every step in these processes is grounded in molecular, metabolic actions directed by the encoding and decoding of symbols. Tomkins shows that this intercellular communication system evolved as an extension of the intracellular system by which early single cells came to internally symbolize important features of their surrounding environment.

The retention of the independent nature of cells in multicellular organisms has been commented on by others such as the neurologist Antonio Damasio who writes that, “sensing environmental conditions, holding know-how in dispositions, and acting on the basis of those dispositions are already present in single-cell creatures before they were part of any multicellular organisms, let alone multicellular organisms *with* brains” (Damasio 1999). And the philosopher Ralph Pred considers individual neurons in organisms with brains to be cells whose “regulatory networks” give them the independent capacity to “detect, interpret, and respond to changes in their environments” (Pred 2005).

What is Unique About Human Symbol-Use?

We propose symbol-use as one of the main constructs that Clark postulates will be central to a comprehensive understanding of life-mind continuity. Symbolic

cognition and communication in humans is not discontinuous from the symbol-use that is fundamental to all living systems, including that which occurs in the individual cells and systems of cells that populate the interior of humans. Though we do not present an explicit argument for the origin of language in this paper, we believe our account is consistent with the notion that the evolution and use of human language is necessarily dependent upon the processes underlying intercellular communication in multicellular organisms as discussed above. We believe that the evidence from evolutionary biology strongly suggests that human symbol-use, including language, is an enriched version of more basic forms of symbol-use that have existed in the natural world for billions of years; and biologically-based support for the view that human symbol-use has emerged, evolutionarily, from the underlying structural and functional background of biological precursors has been presented.

So what, if anything, is unique to human symbol-use? We contend that the uniqueness of human symbol-use lies in the particular nature of the symbols themselves. As Tomkins makes clear, the symbols employed in cellular communication are molecules that move from place to place within the internal space of the organism. But the symbols employed in human communication are not molecular. Granted, the production of any human symbol, e.g., through speech or writing, is accomplished by the integrated action of millions of cells within the neuromuscular system. The necessary coordinated contraction of thousands of striated muscle cells of the respiratory muscles, vocal cords, tongue and lips to produce speech is produced by the integrated activity of countless neurons in the brain. And the communication among cells necessary to produce speech is accomplished via Tomkins' molecular symbols. But the symbols of speech *themselves* are not molecular; instead, they are social constructions, tokens, features of our particular, human environment.

Many multicellular organisms also communicate using auditory or visual signals, but humans are unique in their ability to produce tokens which become features of the environment that have consistent meaning for human observers. Every token is an object that can be observed: heard (speech), read (writing), or felt (braille). Sensory receptor cells in the human observer must be activated in the observation process. The excitation of receptor cells leads to a cascade of molecular symbol communication among neurons in the brain of the observer. In some way, not yet understood, the token must be represented isomorphically within the material of the brain. In other words, the representation of the token must take the form of a brain-symbol that maintains the fidelity of the token it represents. In this way tokens that are objective features of the environment become symbols in the brain that represent with fidelity the tokens that are not part of the human, but a component of the human's physical environment.

The cells of humans, over evolutionary and developmental time have developed the capacity to transcend the conditions and constraints of the molecular metabolic code which for billions of years was the fundamental communication mechanism for organisms. Although symbol-use in humans has emerged from the cooperative cellular ensembles that characterize multicellular organisms, it is not tied to the molecular imperative of hormonal communication nor the structural imperatives of fixed nuclei and pathways that are bound up in the complex, gross anatomical

structure of the human brain. Vilayanur Ramachandran's comment that the connection between neurons and meaning is the 'holy grail' of neuroscience⁶ resonates with the new challenge our current paper poses to the mind sciences: to understand how the unique form of symbol formation and symbol-use demonstrated in human cognition and language has emerged from the biological substrate of coordinated and cooperative symbolic communication at all composite levels of the human organism.

It is our contention that if we want to take SCT seriously—which we do—then we must do better than accept that the symbolic nature of human cognition is an anomaly in the natural world whose origins are presumed to be categorically different from the origins of life. We have shown that the presumption that humans are unique is their symbol-use is unfounded since symbol-use is ubiquitous in living systems from the simplest to the most complex. Based on this insight, we propose that if we recognize symbolic communication in humans as an enriched version of organismic symbol-use, then human symbol-use is not the roadblock to genuine life-mind continuity many have worried it is.

Appendix

Thus our working hypothesis is this: since evolution did in fact produce language-using organisms (us), and language is an enriched version of symbol-use, we should expect to find examples of proto-symbolism in simpler living systems. There is some evidence that Godfrey-Smith is amenable to such a hypothesis. He explains, "First, in humans we find not just first-order representation use, but a framework used to talk and think about representations. The empirical phenomenon of language and thought includes the existence of a framework that we use to describe, predict, influence, and manage the representation use of ourselves and others" (Godfrey-Smith 2006). This statement suggests that 'first-order representation use' is common to all life and that language is a unique human way of manipulating those (first-order) representations. Thus the use of first-order representation is important to many life forms including humans, and although humans may have a unique way of manipulating such representations, human language is not an anomaly in the natural world. And also: "The precursors of thought in non-human animals involve a low-level and comparatively "shallow" pattern of adjustment and transformation of environmental conditions. With the advent of language, the causal reach of these capacities is greatly extended and focused' (Godfrey-Smith 2006). Human language use is seen as an enriched version of the 'precursors of thought' found in all life, in that it enriches our interaction with the world in ways unavailable to non-human life. Although (in the passage quoted in "Life-Mind Discontinuity") Godfrey-Smith claims that life is "*not*" proto-linguistic (Godfrey-Smith 1996b), we read the set of quotations above as suggesting that in fact certain "proto-cognitive" features in non-human life are to be understood as the biological precursors to human language use.

⁶ The Science Network's interview with Dr. Vilayanur S. Ramachandran, Director of Brain and Cognition Institute at the University of California in San Diego: <http://www.youtube.com/watch?v=jTWmTJALe1w>

References

- Alberts, B., et al. (2002). *Molecular biology of the cell* (4th ed.). New York: Garland Science.
- Ames, B. N. (1977). Gordon M. Tomkins 1926–1975. In G. Litwack (Ed.), *Biochemical actions of hormones* (pp. xvii–xxxvi). New York: Academic.
- Bellman, K. L., & Goldberg, L. J. (1984). Common origin of linguistic and movement abilities. *American Journal of Physiology*, 246(Regulatory Integrative Comp. Physiol. 15), R915–R921.
- Clark, A. (2001). *Mindware*. New York: Oxford University Press.
- Damasio, A. R. (1999). *The feeling of what happens: Body and emotion in the making of consciousness*. Florida: Harcourt.
- Deacon, W. T. (1997). *The symbolic species: The co-evolution of language and the brain*. New York: W. Norton & Company, Inc.
- Edelman, G. M. (1992). *Bright air, brilliant fire: On the matter of the mind*. New York: Basic Books.
- Godfrey-Smith, P. (March 2006). Keynote address at the Harvard/MIT graduate philosophy conference.
- Godfrey-Smith, P. (1996a). *Complexity and the function of mind in nature*. New York: Cambridge University Press.
- Godfrey-Smith, P. (1996b). Spencer and Dewey on life and mind. In M. Boden (Ed.), *The philosophy of artificial life* (pp. 314–331). Oxford: Oxford University Press.
- Griffin, D. R. (1991). *Cognitive ethology: The minds of other animals*. New Jersey: Erlbaum.
- Noble, W., & Davidson, I. (1996). *Human evolution, language and mind: A psychological and archaeological inquiry*. Cambridge: Cambridge University Press.
- Pred, R. (2005). *Onflow: Dynamics of consciousness and experience*. Cambridge: MIT.
- Tomkins, G. M. (Sept 5, 1975). The metabolic code. *Science*, New Series, Vol 189, No 4205, pp 760–763.
- Wheeler, M. (1997). Cognition's coming home: The reunion of life and mind. In I. Harvey & P. Husbands (Eds.), *Proceedings of European conference on artificial life IV* (pp. 10–19). London: MIT.