Religion and Embodied Cognition

with Fraser Watts, "Embodied Cognition and Religion"; John A. Teske, "From Embodied to Extended Cognition"; Daniel H. Weiss, "Embodied Cognition in Classical Rabbinic Literature"; Léon Turner, "Individuality in Theological Anthropology and Theories of Embodied Cognition"; and Warren S. Brown and Kevin S. Reimer, "Embodied Cognition, Character Formation, and Virtue."

FROM EMBODIED TO EXTENDED COGNITION

by John A. Teske

Abstract. Embodied cognitive science holds that cognitive processes are deeply and inescapably rooted in our bodily interactions with the world. Our finite, contingent, and mortal embodiment may be not only supportive, but in some cases even constitutive of emotions, thoughts, and experiences. My discussion here will work outward from the neuroanatomy and neurophysiology of the brain to a nervous system which extends to the boundaries of the body. It will extend to nonneural aspects of embodiment and even beyond the boundaries of the body to prosthetics of various kinds, including symbioses with a broad array of cultural artifacts, our symbolic niche, and our relationships with other embodied human beings. While cognition may not always be situated, its origins are embedded in temporally and spatially limited activities. Cognitive work also can be off-loaded to the body and to the environment in service of action, tool use, group cognition, and social coordination. This can blur the boundaries between brain areas, brain and body, and body and environment, transforming our understanding of mind and personhood to provide a different grounding for faith traditions in general, and of the historically dualist Christian tradition in particular.

Keywords: cognition; embodiment; emotion; externality; mental representation; neurophysiology; self-boundaries; simulation; social interaction; symbolic

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> *The tender pragmatisms of flesh have poetries no enigma–human or divine–can diminish or demean. Indeed, it can only cause them, and then walk out.*
> John Fowles (1974, 244)

We live in a world which is increasingly troubled by the very real spiritual difficulties produced by disconnection, dissociation, fragmentation, and

John A. Teske is a professor of psychology at Elizabethtown College, Elizabethtown, PA 17022, USA; e-mail: teskja@etown.edu.

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disembodiment. In his book *The Science of Evil,* Simon Baron-Cohen (2011) points out that it is often our failures in emotional empathy that are behind our capacities for cruelty. Not only are such failures made increasingly likely by the attenuations of electronic communication, but by a plethora of beliefs and practices which encourage us to treat ourselves as disembodied. It always delights me to remember Willem Drees's (1996) dedication of *Religion, Science and Naturalism* to his wife Zwanet: "I believe that her love and support is not less real for being embodied" (xvi). I believe that the love and support we give each other is *less real* when it is *not* embodied, the sin referred to by Gabriel Marcel as *desincarné.*

There is more to the human person than the physical body, but this need not entail any kind of dualism, nor the addition of anything with causal significance separable from, independent of, or unmediated by, our bodies. We need not be "nothing but" our physical nature to be "necessarily also" dependent upon that nature. Even "nonreductive physicalism" (Brown et al. 1998), or a more robust "emergentism" (Clayton and Davies 2006) make no claim for the emergence of a mind independent of body and brain. Fraser Watts (Watts 2013) pointed out that the contemporary theological view of the human person does not assume a separation of body and mind. Happily, what developments in contemporary cognitive science have begun to show is that cognition not only requires a brain, but is grounded more fully, not only in the body, but in the marriage of a whole person with the world, quite consistent even with Christian theological positions of a generation ago, like that of Karl Rahner (1978), and recently carried forth even more forcefully by Stanley Grenz (2001). A view from cognitive science includes minds that are extended into a world from which they are not clearly bounded, including a social world of similarly embodied fellow travelers, our knowledge being intersubjective, composed by knowing each other.

Our bodies include not only brains, but nervous systems coextensive with our bodies, of which the brain is a proper part. Similarly, as will become clearer below with our discussion of externalism and relationality, it may make a great deal of both conceptual and empirical sense, to think of the *body as a proper part of the mind.* I think this particular assumption not only makes better sense of the research data, but eliminates a whole range of confusions produced by talk of causal relations between minds and their physical substrate, "top down" or otherwise. It is consistent not only with Arthur Peacocke's notions of "whole-part constraint," but even with Roger Sperry's own exposition of "top-down causation" (1988, 1993). Fraser Watts also warns about the atomistic strain in contemporary culture, urging us to remember that it is neither minds nor brains that make decisions or take actions. "*We* make decisions and act in the world. We do so as creatures who are physically embodied and socially embedded." As we shall see, there may be good reasons, both scientific and theological, to take this point even further, and warn that it is the alienated nature of the contemporary "mythic reality of the autonomous individual" (Teske 2011) that may need redemption.

Disembodied Cognition

Now "traditional" cognitivist views have assumed an understanding of cognition as *computation upon mental representations* as nigh-definitive. Such views have tended to assume the presence of distinct and bounded internal representations, operated upon by highly specified functional mechanisms instantiated in the brain. These views have been influential throughout the cognitive sciences, from the initial meeting of the Cognitive Science Society (Teske and Pea 1981), to the more recent emergence of the Cognitive Neurosciences, and its attention to those instantiations, aided in the last generation by the availability of *in vitro* (even if motionless in a claustrophobic tube) brain scanning technologies like the fMRI. These views have been committed both to individualism and internalism, the claim that cognition is supervenient on the neurophysiology of the cognizer. What this has entailed is that anything outside the brain has little theoretical interest other than as providing sensory input and motor output, taking the form of what Susan Hurley (1998) called the "classical sandwich model" where the "meat" is in cognition segregated from the "bread" of lower-level sensory and motor processing. The *disembodiment thesis,* that cognitive processing is not only central, but largely modularized and specialized, and computationally context-independent, essentially independent of motor planning and execution, has been called into question by research on embodied experience (Barsalou 2008; Chemero 2009; Wilson 2004). While it may be true that some cognition is more embodied than others, and that less embodied forms may play an important role in specifically human capacities, this view would have us drop the *disembodiment thesis* entirely.

Embodied cognitive science has gone further to include, within a wider understanding of cognition, dynamic interactions between neural and non-neural processes, without clear boundaries between cognition, bodily function, and real-life situations, and as necessarily characterized on the scale and in terms of the behavior of bodily action in the world. Cognition is viewed not as operations upon internal representation, but as distributed, with dynamic function rather than operational mechanism. How the body constrains, regulates, or even distributes cognitive function is the focus of much research, and raises the prospect that cognition itself may be neither bounded by the brain, or even the skin. I will go so far as to suggest that it may also be deeply rooted in historical and social relationships, despite possibilities for disengagement, severance, and alienation.

Cognition in the Brain

A first step is to understand some things about the localization of cognitive functions in particular areas of the brain. As Watts indicated, much in the history of recent biology suggests that it is quite clearly moving away from a highly reductionistic phase toward the exploration of interacting systems. Epigenetics is only one example, but in the case of the kind of complex systems theory increasingly necessary for understanding neural function, it is even more compelling, not only in terms of the dynamics of what occurs inside the brain, but the causally relevant interactions with what the brain, and ultimately even the body, are themselves inside. Historically, the mind (or the soul) was thought to be composed of distinct faculties, like judgment, reason, and memory (Leahy 2000). By the late nineteenth century, Franz Gall thought each of these could be located in a specific area of the brain, as shown in phrenological diagrams at the time. Even contemporary cognitive science has tended to treat cognitive abilities as separable, with researchers specializing in attention, say, rather than memory or thought. Fodor's (1983) *modularity of mind thesis* suggests even that many of these could be treated as functionally separate and autonomous subsystems, and though Fodor himself has continued to raise questions about the extent of general and nonmodular functions (2000), evolutionary psychologists like Cosmides and Tooby (1992) posit a "massive modularity" of evolutionarily selected functions operating under different kinds of selection pressures. Cognitive neuroscientists have used neuroimaging technologies to identify the brain areas thought to be active for different faculties.

Embodied cognition argues that other things beyond central cortical processing might be required to explain cognition. As we will see later, neural aspects of motor control, and even nonneural aspects of body and environment might not only have causal effects upon such cognitive processes, but actually play sufficiently important roles as to either be necessarily coupled with such processes, or, to be component parts. Empirical research shows a role of motor control in language processing (Glenberg and Kaschak 2003), shows body sensations, or even actions such as extending a finger, affecting interpersonal judgment (Chandler and Schwartz 2009), shows manipulations of external resources playing causal parts of cognitive processes (Clark and Chalmers 1998), and shows effects of coordination dynamics on perception, action, and cognition (Chemero 2009). What this research renders problematic is both the localization of cognitive processes to particular brain areas and even the identification of separate cognitive faculties (especially if they readily reuse other neural tissues in their operation). This ultimately renders a separation of cognition from perception, action, and even social interaction difficult, if not indeterminate.

Neural populations are composed of semiautonomous, independent elements, each of which has weak interactions with many others, with nonlinear input-output relations, producing an *open system* (like social organizations or weather systems), in which the microscopic elements are constrained by the ensembles in which they are embedded. Neurodynamics are built out of activity patterns determined by the populations, not the individuals (Freeman 2001). For example, oscillatory patterns can become semiautonomous, self-sustaining, and self-organized. In this way mesoscopic patterns are formed by the interaction of neurons on a grand scale, in the same way that molecules form liquids and people form societies. The huge number of synaptic connections to each neuron, and the extensive branching of dendritic trees, on the order of thousands per cell, even more in the case of the huge dendritic trees of the Purkinje cells in the cerebellum, give us pause to consider the sort of mesoscopic behavior patterns that might be produced by populations of neurons so connected. It is even more amazing to realize that each individual neuron, generally minding its cellular business, is acting on hints and nudges from thousands of others.

Cognition is part of a system fitted to action in particular situations, its neural niche located in the constraints and opportunities provided by such action. One of the basic assumptions is that limited resources, to be used efficiently, are going to be reassembled, reconfigured, and reused in support of newer cognitive capacities. Neural circuits originally evolved for one purpose will be used in developing new functions. Much of the research I will sample below was conducted to find relationships between specific kinds of tasks, rooting them in bodily engagement with the world. Functional collections of neural circuits for accomplishing more recently evolved cognitive domains turn out to include more widely scattered circuitry than older domains specific to vision and motor control (Anderson 2007, 2008). Differences in cognitive domains are themselves less likely to involve different circuitry, and more likely to involve different patterns of cooperation with mostly shared circuitry (Anderson 2008). A meta-analysis of 1,469 fMRI experiments in eleven task domains (e.g., attention, emotion, language, memory) shows that a typical anatomical region is involved in supporting multiple tasks over nine separate cognitive domains, even small portions (equivalent to 1/1,000 of the brain) normally support tasks across more than four of these domains (Anderson 2010).

The overall point of this excursion into neurodynamics is to provide a framework in which we understand that the functional dynamics of the brain may be *interaction-dominant* (Kelso 2009) cognitive functions supported by temporary coalitions of neural circuitry to support specific tasks. At minimum, this lends serious doubt to the existence of modularity, at least of any anatomic kind, and suggests few natural joints between cognitive faculties which share a pool of components not restricted by domain. Hence, the entire explanatory procedure is likely not to be mechanical and reductive, but systemic, interactive, and dynamic, less mechanical and more explicitly goal-directed, even if that governance can be described entirely in physically causal language.

Embodied Cognition I: Simulation Theory

Simulation involves the reenactment of perception, action, and even interior states resulting from our embodied experience with the world and ourselves. The mind still mediates between sensory stimulus and motor response, but mental representations are *modal*, tied to particular sensory and motoric cortical functions. The classic example of such mechanisms would be the use of visual simulations in working memory during imaging tasks (Kosslyn 1994), where characteristics like visual size and distance have measurable effects on processing speed and for which there is overwhelming neural evidence (Kosslyn et al. 2006). Despite cognition being *grounded* by the perceptual and motor engagements, such a collection of simulation mechanisms is still at its core a kind of *computational* system, and could share a common, if multimodal, representational system, being reactivated by cognitive functions to simulate the experiences associated with them (Barsalou 2008; Goldman 2006). Note that this approach does not imply that bodily states themselves are necessary for cognition, which can be independent of the body. Simulations rarely regenerate entire experiences, bodily states, or actions, but are partial and can therefore include bias and error (Barsalou 1999). They can include symbolic operations implemented as simulators and go beyond the information given via a pattern completion inference mechanism. In some cases, like dreams, there may be specific mechanisms to attenuate sensory input, or eliminate motor output. There is certainly room for understanding how "some cognition is more embodied than others," to which Watts directs our attention, without falling into any reliance on "a propositional, nonembodied mode of cognition." Indeed, there is a more radical embodied cognitive science (Chemero 2009) which would have us largely replace the latter with increasingly wider consideration of embodied context.

Perception. The empirical evidence is accumulating that simulations, situations, and even bodily states play ubiquitous roles in perception. (1) We simulate the visual trajectory of an object and falsely remember anticipated motion (Freyd 1987). (2) Preparatory simulation of a grasping action under perception of a cup affects motor response on an unrelated task (Tucker and Ellis 1998). (3) Such simulations occur even when an object is merely named ("grape," Tucker and Ellis 2004), and fMRI evidence shows grasping circuit activation (Chao and Martin 2000). (4) Being tired from a run makes a hill look steeper; carrying a heavy pack makes a path look longer (Proffitt 2006). (5) Finally, people's perception of near space extends further outward as arm length increases (Longo and Laurenco 2007), an effect sustained after arm-length is extended artificially with a tool (like underestimating walking distance for roads we have driven).

Memory. (1) If memory's role is in service of situated action, then it should include bodily actions and their mesh with situations, triggering Gibsonian "affordances" for action (Glenberg 1997). (2) Just as reasoning about future action should require suppressing current perception (Glenberg et al. 1998), averting the gaze disengages the environment and facilitates memory. (3) *Working memory* consists of neurons in the frontal cortex sustaining simulations of absent stimuli in the original modal system, and different regions maintain different modal content, including objects, spatial locations, motion in different directions, and different spatial frequencies (Pasternak and Greenlee 2005). (4) The neural pattern associated with studying faces reappears when remembering them (Polyn et al. 2005). (5) Actions relevant to visual imagery are also simulated, bodily constraints shaping visual rotation (Parsons 1987), which is accompanied by motor area simulation (Richter et al. 2000).

Language. (1) It appears that readers will not only *confuse pictures with text* (Intraub and Hoffman 1992), but that sentence processing is not disrupted by replacing words with pictures (Potter et al. 1986). (2) Verb retrieval activates motor control areas and nouns activate visual areas (Damasio et al. 1996; Martin et al. 2000; Pulvermüller 2005). (3) Perceiving manipulable objects, or even just seeing their names, activates brain regions for grasping (Chao and Martin 2000) and manipulating objects can improve reading comprehension in schoolchildren (Glenberg at al. 2007). (4) *Attentional orientation* is also affected by the valence of words (positive/up vs. negative/down; Meier and Robinson 2004). (5) Most interestingly, the *gestures* that accompany speech may have cognitive functions (McNeill 2005). Gestures help speakers retrieve related words (Krauss 1998), help listeners comprehend the speaker (Alibali et al. 2001), and help children learn words (Goldin-Meadow 2003; Kelly 2001).

Thought. (1) Simulations play important roles in *physical reasoning,* about a static configuration of gears, a configuration of pulleys, or the tipping of a glass, which can also produce associated gestures (Hegarty 2004). (2) The time to make an inference may be correlated to an event's duration (Schwartz and Black 1996) and carrying out an action can improve inference (Schwartz 1999). (3) Even more abstractly, people use spatial metaphors to reason about *time* (Boroditsky 2000), and one's actual spatial trajectory can influence the interpretation of sentences like "Next Wednesday's meeting has been moved forward two days." (4) Abstract planning can activate motor areas even when the task involves no motor activity (Dagher et al. 1999). (5) Number processing appears to involve the circuits for hand motion (Andres et al. 2007; Zago et al. 2001).

Social Cognition. Traditional cognitivism presumes that our understanding of the internal states of others depends upon a *theory of mind* (Premack and Woodruff 1978). Simulation theory proposes that we simulate our own minds to understand those of others, particularly their interior states, their pleasures and pains, their emotions, and their intentions (Goldman 2006). (1) Neuroscience may be more consistent with seeing social cognition as a form of sensorimotor simulation in which intersubjectivity is built from felt bodily states (Gallese and Goldman 1998; Oberman and Ramachandran 2007; Umiltá et al. 2001). (2). Social simulation theories are supported heavily by the existence and use of *mirror neurons.* Such neurons, a subset of the circuits for manipulating objects, are also active when observing someone else perform a goal-directed action (Rizzolatti and Craighero 2004), giving them a role in the perception of intent. Such neurons represent a general mechanism for understanding the mental states of another, including emotional responses, via simulating our own feelings under similar motions (Gallese et al. 2004). (3) Certainly *bodily states* can be effects of social cognitions; for example, as activating an "elderly" stereotype can result in slower pace and slower lexical decisions (Dijksterhuis and Bargh 2001). (4) Bodily states can also have causal effects of their own. Engaging smiling musculature can produce positive affect (e.g., Strack et al. 1988; pencil in teeth does a better job than pencil in lips), slumping negative (Stepper and Strack 1993). Nodding produces positive affect (Wells and Petty 1980), pushing away negative (Cacioppo et al. 1993).

Individual differences in abilities to simulate the mental states of others (like pain) correlate with differences in capacities for empathy (e.g., Jackson et al. 2005). Indeed, such differences are behind Simon Baron-Cohen's newest work (2011) on *The Science of Evil,* though our capacities to respond more strongly to immediate others may actually produce difficulties in moral decision-making affecting larger populations and less immediate events (cf. Staub 2012). Directing this attention to wider social contexts, and to human persons who are not intimates or nearby neighbors, is certainly one of the important functions that religious traditions may perform.

Modal simulations can implement core cognitive operations like type-token binding, inference, productivity, recursion, and propositions, whose existence is not in question (Barsalou 1999). It is not clear how the brain actually does the job. Simulations and embodiments do play causal rather than simply epiphenomenal roles, as the effect of manipulations on motor areas show, as do the effects of bodily manipulations upon social cognition. Unlike amodal representations, such simulations are not autonomous from perceptual systems, bodily action, or their operational details, and meanings are not restricted to their connections to internal symbols. Such motor programs are not separate and independent from cognition, but are part of its composition, with cognitive activity reusing the processes and operations used in perceiving and acting. Such grounding is central to language comprehension, and even abstract concepts seem to depend upon situations and situated action. Moreover, the evidence from embodied cognitive science suggests that nonneural structures are not merely peripheral, but actually contribute, cause, and even constitute the development of specific cognitive capacities, including those necessary for language use. Finally the pervasiveness of a system of mirror neurons may be behind the perception of intentions, the mimicry of action, and inferences about mental states, though it is not clear how human abilities so surpass those of other primates, nor how the compromise of such a system may lead to psychopathologies born from a lack of intersubjectivity. Nevertheless, it is readily apparent why religious practices and traditions which specifically underpin bodily engagement and intersubjectivity may be important to the development of cognitive and moral capacities, as well as to healing social relationships and institutions.

Embodied Cognition II: Cognition in the Flesh

It is true that we do not always need to be present in a situation to think about it (or simulate it). Indeed, this is part of the power of language and symbolic representation in general that we can think about objects and events far distant in space and time. Organism-environment interaction alone cannot account for anticipation and planning, which require factors beyond the immediate constraints of the environment, particularly in the case of reasoning about absent, nonexistent, or counterfactual events. But this carries no necessary implication that such representations are *in the brain,* nor does it have straightforward implications as to how the brain, the rest of the nervous system, nonneural bodily tissue, or even our technical and symbolic prosthetics actually accomplish this, with or without environmental embedding, at whatever time scale. Nevertheless, it remains true to date that while there is little actual empirical evidence for amodal representations, a subject's performance can be accommodated by both modal and amodal explanations (Machery 2007; Rupert 2006).

Cognition is considered "embodied" when it is dependent on features of an agent's body which are beyond the brain, but having reciprocal causal relationships between bodies and brains does not necessarily challenge traditional views that the body is peripheral to understanding cognition. Many theorists (e.g., Barsalou 2008) sustain what looks like standard computational and representational theories of the mind (even if the nature of the representation is understood to be substantially more modal), including the idea that the mind is realized in the brain. However, it is also possible to understand structures and processes *beyond the brain* as not merely stimulating or influencing brain-based cognition, abstracted from sensory mechanism and motor control, but as actually playing a role in realizing or constituting the cognitions themselves. This might extend from relatively simple features like *morphological computation* (MacIver 2009), wherein aspects of anatomy (like the shapes of bats' ears) may play a computational role in a cognitive process, to direct uses of body parts, like counting on fingers, to further uses of external material, like doing multidigit addition on paper, or with a calculator. A tighter coupling of brain based guidance systems and bodily actions, including their feedback, is likely to be required by activities for which split-second timing is crucial, and the body is integral to feedback-driven online control of the cognition itself, for example, in the case of balancing and negotiating a turn, under slick conditions, among competitors, during motorcycle racing.

Intelligence without Representation. In robotics Rodney Brooks (1991) proposed an embodied approach, which he characterized as "intelligence without representation," which, instead of heavily computation- and representation-based systems, builds robots in which control is bottom-up, governed by behavioral engagement with the world rather than by complicated internal algorithms. Andy Clark (1997) provided a theoretical integration for work on embodiment in cognitive science which argues that minds are not centrally "thinking things," but are primarily in service of *doing things in the world in real time.* This idea has become central to embodied cognition, and a growing understanding of cognition as *scaffolded*, *embedded*, and *extended.* Robotics research continues to offer a fascinating area in which these insights are actually being used to construct robots which accomplish tasks in real time, and which can also be used to explore human reactivity, for example, by experimentally separating behavioral components which would be more difficult to tease apart in human beings, especially socially interacting ones (cf. Breazeal 2002 on designing sociable robots).

Neural Correlates of Consciousness. Even in the case of human beings, the relationship between conscious experience and neural processes is controversial, despite the neural correlates of such experiences (Noë and Thompson 2004). Particular experiences may be *multiply realizable*, even within the same person. As I happily understood from Nancey Murphy (1998), different contexts might mean the same brain state might constitute multiple mental states; we will return to the argument for externalism and extended cognition later. Even if one assumes that such brain states provide a minimal substrate for a conscious experience, it is not clear whether the neural contents match the content of conscious experience, since they appear to be incommensurable. Unlike the properties of a neural system, experiential content always has a point of view and is active and attentional, able to be revealed and explored via movements of head and body. Noë (2004) argues that the sense of our conscious experience depends on our mastery of sensorimotor contingencies, and is therefore a temporary pattern of skilled activity, something we *do* rather than something we *contain.* Even a neuroscientist like Antonio Damasio (1994) presents evidence that our consciousness consists in *somatic marking,* experiences being tied to bodily sensation.

Motor Control. Several experimental findings show surprising limits to our explicit memory which are consistent with more embodied views: (1) *change-blindness* to repeated presentations of a visual scene (originally during visual saccades, Levin and Simons 1997) and (2) *inattentional blindness*, when even rather large changes to a scene during attention-intensive tasks go unreported (such as a dancing gorilla appearing in the middle of a scene; Mack and Rock 1998; Simons and Chabris 1999). Both suggest that vision is not about the construction of a mental representation, but a skill of an agent whose temporally extended movements of eyes, head, and body are part of the experience, necessary to direct attention to the environment. If nonneural substrates are necessary for the enactment of a conscious state, then consciousness is bodily distributed. This also means that the same brain states could constitute different experiences in differing contexts (*multiple constitutability*), and that a brain without a body ("a brain in a vat") would not have such conscious experience. It also suggests that our sensorimotor coupling with the environment is crucial, as it also provides the proprioceptive and kinesthetic feedback that "somatically marks" an experience as our own. We experience the feeling of our own bodies in action by feeling the moment-by-moment control of our actions, including the feedback from touching and being touched by external objects and events. Our agency originates in our sensorimotor engagements with the environment, the "neural signature" of our bodily self-consciousness (Tsakiris et al. 2007). Conscious intention may be a form of motor cognition (Haggard 2005), motor awareness and motor control share the same neuroanatomy (Berti et al. 2005) and are the neural correlates of experiencing oneself versus another person as the cause of an action (Farrer and Frith 2002; Farrer et al. 2003).

Multiple realizability is also shown in evidence that the construction of concepts is context-dependent, varying across individuals, and within individuals across different occasions (Medin and Shoben 1988; Solomon and Barsalou 2001). Only 44% of the features in one person's definition, even of simple categories like bird and chair, are found in that of another, and there is even within-individual flexibility across a period as short as two weeks (Barsalou 1993). Patterns of interaction with particular objects can produce distinct patterns of categorization with different kinds of expertise, and in ways different from nonspecialists (Medin et al. 1997).

Bodily Memory. Empirical evidence suggests that the retrieval of memories is not independent from sensorimotor mechanisms. For example, in the case of remembering the tools and ingredients for baking a cake, the kitchen location can serve as an external aid to memory, and imagining embodied actions affords the retrieval of information (Cole et al. 1997). The imagined spatial layout with reference to the observer's body has been shown to affect the recall time (Bryant and Wright 1999; Waller et al. 2002, 2008). Memory traces also include body posture (Barsalou et al. 2003). The body itself appears to contain autobiographical links, as memories of past experiences are facilitated if the body posture is reassumed (Dijkstra et al. 2007). The most fascinating evidence of a direct bodily role in memory is provided in a study by Presson and Montello (1994) in which blindfolded subjects could readily point to the location of objects in a room; no deficit in performance was produced by subjects actual rotation of 90°, but an *imagined* rotation produced slow and inaccurate performance. Sadly, the literature on trauma amply documents the existence of trauma-related sensorimotor connections experienced involuntarily, and producing traumatic responses in the present (Herman 1992; Van der Kolk 1994, 1996). Successful therapeutic treatment is greatly facilitated by directly addressing and manipulating sensorimotor states of the body, including agency (Ogden et al. 2006).

Social Interaction. Paula Niedenthal (2007) summarizes the evidence on embodied emotion, suggesting that perceiving and thinking about emotion involves a reexperiencing of perceptual, somatovisceral, and motoric responses. Our mimicry of other's facial expressions, for example, may be what enables us to share feelings and to experience and understand what someone else is experiencing. The tendency to mimic facial expressions has been documented widely (Bush et al. 1989; Dimberg 1982). As Ohman and Mineka (2001) show, some of this facial processing occurs at sufficiently early stages of limbic system processing that it can have its bodily effects even when our ability to identify both facial identity and emotional response has been masked by subsequent stimuli; people even mimic faces presented subliminally (Dimberg et al. 2000). Across a number of levels of analysis mimicry helps interlocutors to establish rapport, empathy, and cooperation (Berneiri 1988; LaFrance 1985). Even neonate movement is synchronized with adult speech (Condon and Sander 1974), and adult rapport is tied to postural synchrony (LaFrance and Mayo 1978).

There is a further paradigm here, summarized by De Jaegher et al. (2010) which argues that social interaction may actually *constitute* social cognition. Empirical results do imply that social cognition is not reducible to the cognitive mechanisms of individuals, and that interaction is more than a context, but may complement and even replace individual mechanisms. The notion of *engagement* is used to capture the qualitative aspect of a social interaction in a complex coregulated pattern once it takes on a "life of its own." An example is the case of Murray and Trevarthen's (1985) study in which infants and mothers interact via a television link. When presented with a recorded (rather than "live") display of their mothers, infants disengage, become distracted and upset. This could be because of an individual mechanism that, via relative timing of actions, might distinguish contingency and noncontingency. However, research suggests an enabling role for prior engagement (DiPaolo et al. 2008). Nadel et al. (1999) fail to replicate the results of Murray and Trevarthen when mothers and infants are not allowed to develop sufficient engagement *before* the recording is presented, suggesting that the *enabling condition* is prior engagement, not merely contingency.

Social interaction is not merely enabling but a *constitutive element* in an experiment by Auvray et al. (2009). Subjects attempt to detect each other's movable sensor on a virtual line where there is also a static object and a "shadow" object copying the movements of the sensor at a fixed distance, of which subjects are unaware. Subjects do learn to concentrate their mouse clicks on each other's sensors rather than the shadow (66% vs. 23%). But this is not based on contingency; individuals cannot distinguish between detecting the others sensor or the shadow. They use back and forth patterns to help distinguish moving from nonmoving objects, but the situation only stabilizes when they scan each other's sensors, scanning the others shadow is a disengaged one-way coupling, and the other participant will move away because she is still searching. Hence the stability of sensor detection is produced by the stability of the coupling and not to individual strategies. The interaction process is *constitutive*; the detection task could not be accomplished otherwise. Characteristics of social interactions external to individual participants play explanatory roles in a cognitive task.

Moral Cognition. Kohlberg's developmental work on moral reasoning (1969) remains the gold standard, but not until recently has it asked questions about embodiment. The work of Jonathan Haidt and others (Greene and Haidt 2002; Haidt 2010; Haidt et al. 1993) has been challenging this view, and his research suggests that moral judgment may be driven by bodily affect, the rational tail being wagged by the emotional dog. Harmless actions which produce strong affect (eating a dead pet, incest between consenting adults) are often judged to be morally wrong; subjects provide justifications based on nonexistent harms, rationalizations after the fact which may mask the affective origins of the judgment. There is a relationship between moral cognition and disgust (Wheatley and Haidt 2005), disgust also being an emotion of social rejection (Niedenthal et al.

2005). Feelings of disgust induced by exposure to a bad smell or a dirty room can make moral judgments more severe (Schnall et al. 2008a), and subjects given a cleanliness manipulation find certain immoral actions to be less wrong (Schnall et al. 2008b). All in all, we see an essential role for the embodied aspects of cognition in much of moral judgment (Haidt 2010).

The research literature suggests that social and moral cognition may be guided or constrained by specific bodily and affective reactions, and states of bodily excitation readily transfer across situations (Bryant and Miron 2003). Damasio's *somatic marker hypothesis* (1994, 1999) suggests that the reenaction of bodily states triggered during emotional experiences provides a source of information centrally important to prioritizing in decision-making, and organizing our courses of action. When the capacity to integrate such feelings with one's knowledge is compromised, as it is in patients with damage to the ventro-medial prefrontal cortex (e.g., *Phineas Gage*), their decision-making is impaired. Missing an embodied state, like a galvanic skin response in anticipation of possible loss, such patients miss information essential to making a less risky choice (Bechara et al. 1994). This suggests that affective and bodily feedback is a necessary part of the normal physical implementation for realizing cognitive processes.

Breaking down Boundaries. Organism-environment couplings can be described by dynamic systems theory rather than broken down into stimulus inputs and internal computations. States of such systems are coupled to reflect *interaction-dominant dynamics* between each other, with the environment, or with each other, in the couplings between perception and action. One particular program of research in nonlinear dynamic modeling has shown that *1/f noise (*sometimes called "pink noise" or "long memory;" intermediate between white noise, with no correlation in time $S(f) = k$, and random walk *Brownian motion* with no correlation between increments $S(f) = 1/f^2$) is ubiquitous in cognitive activity. This shows that the connections among the cognitive system's components are highly nonlinear, which indicates that they are not modular (Holden et al. 2009; Van Orden et al. 2003, 2005), since the operations of nonlinear systems are not easily localizable but distributed. "Parts" of the system cannot be treated as functionally or structurally separate: they are *synergies.* Van Orden et al. (2003) argue that this is a signature of a *soft assembly*, sustained not by component-dominant dynamics, but interaction-dominant dynamics (where parts alter the dynamics of other parts, with complex interactions extending to the body's periphery). Soft assembly, as the product of strongly nonlinear interactions can account for the 1/f character of behavioral data; assembly by virtue of components with predetermined roles and communications cannot. Interaction-dominant systems cannot be modular (Anderson et al. 2012).

This might all seem rather arcane, except that 1/f noise is found in a lot of cognitive and behavioral tasks (Van Orden et al. 2009), showing that task-specific, softly assembled systems *including brain and body* were responsible for performance. Hence, even in tasks like tapping, key pressing, word naming and others, the cognitive system is not encapsulated in the brain, and includes the motor component of the body itself, though 1/f noise is also found in purely cognitive phenomena, modeling insight in problem solving. Stephen et al. (2009) found that finding a new strategy for problem solving coincides with the appearance of 1/f noise in eye-movements, suggesting that eye-movements are part of the cognition.

As Watts pointed out, the Judeo-Christian tradition has taken a renewed emphasis on the importance of embodiment, the Hebrew Bible viewing the human person as an "ensouled body," St. Paul being better understood as assuming a complex, nondualist view of the person, and Aquinas seeing the soul as the form of the body. But whether a religious tradition refers to the resurrection of the body, or to its reincarnation, the belief from the book of Job that "in my flesh shall I see God," receives direct empirical support from research on cognition in the flesh; without my flesh I cannot see anything at all. What it suggests is that while flesh alone may be insufficient to see God, it is a necessary mediator. Processes beyond the brain and even the nervous system are involved in the guidance of bodily action, in intelligence, in the "somatic marking" of consciousness, in bodily memory, in moral judgment, and even in social engagement, in ways that may even step beyond the individual body, emerging from the interaction between embodied persons.

Embodied Cognition III: Extended Cognition

There are also data that the extension of the cognitive system does not stop at body boundaries. Dotov et al. (in press) induce and then disrupt an extended cognitive system. Subjects control an object on the computer screen with a mouse, but the connection is disrupted, and then restored. 1/f noise is found at the hand-mouse interface, but not during the interruption, suggesting that the mouse is part of a smoothly functioning interaction-dominant system, synergy including a nonbiological part, interrupted during perturbation. Perhaps such extended cognitive systems are fairly common.

Coordinated Movement. If the boundary between the cognitive agent and her environment is malleable, blurry, or indeterminate, so might cognition be extended to the inclusion of other human agents. The belief (at least in this culture) that individuals are independent, functionally autonomous, and bounded from each other is often accepted as self-evident. But there are research examples in which this is belied.

(1) The rhythmic movement coordination of two interacting individuals is unintentionally and spontaneously constrained to an inphase or antiphase relationship. The inphase is more stable, but stability is lessened by increases in either the movement frequencies themselves, or the degree of difference between the natural frequencies of components. The stability and patterning of the coordination doesn't depend upon the specific movements or parts involved, but on the strength of the (visual or auditory coupling) between the two. The same dynamics occur in intrapersonal interlimb coordinations of finger, wrist, arm, leg, torso, or even the interpersonal coordination of two individuals in rocking chairs. The order and regularity depends more on the nonlinear relations that couple the movements than any part of the human perceptual-motor system, a soft-assembled synergy (Richardson et al. 2008).

(2) Research by Harrison and Richardson (2009) provides a compelling example. Pairs of subjects are instructed to walk and jog together tethered by a 75 cm long foam pole. As in the previous research, the leg movements became spontaneously phase-locked. Surprisingly, they also exhibited a preference for particular four-legged gait patterns, like pace or trot, preferences determined by differences in gait stability. Apparently stable, multilegged patterns can emerge without direct neuromuscular coupling, showing that the organization of stable interpersonal motor control need not require any centralized mental or neural structure.

(3) Other research also shows the formation of coherent perception-action synergies, Chang et al. (2009) showed that the perception of the passability of an opening by an adult perceiver with a child companion was perceived on the basis of body-scaled information defined by the dyad rather than by either alone. Isenhower et al. (2010) showed similar findings for paired subjects in a graduated plank-lifting task, showing that the transition from solo to joint activity bifurcated at a ratio of their collective action capabilities, a point of transition dependent on their previous history, transitioning later from joint to solo lifting when the pair began with descending presentation rather than ascending. (This is called *hysteresis,* a dynamic "memory" process inherent to interaction-dominant, softly assembled system), implicitly committing to being a "plural subject" when beginning together, a decision to cooperate made without planning or prior expectation occurring as a dynamic response.

(4) Roberts and Goldstone (2009) provide a more traditionally cognitive example of a social system that is softly assembled and interaction-dominant. An Internet connected group was to guess a randomly generated number over a series of rounds, summing the group members' responses and giving feedback on whether their number was too high or too low. Groups took fewer rounds to reach the target across a series of games. But the reactive strategies taken by members of the group spontaneously differentiated into the role of reactors (always decreasing or increasing estimates)

or nonreactors. The faster this differentiation occurred, the more successful was the group, a success not reducible to any member, or the result of a steady state for any individual. The group itself exhibited cognition by being temporarily constrained to act as a synergy, which was softly assembled and exhibited interaction-dominant dynamics.

Embodied cognition is actually a subset of a broader set of approaches to *situated cognition* (for which there is a whole *Cambridge Handbook*), first stepping beyond the brain to other aspects of an agent's body, including those involved in sensory and motor systems in particular (which arguably give thoughts their *content*), then to its *embedding* in a natural and social environment, where cognitive activity *in the wild,* to use the title of Hutchins's 1995 book on navigation, may be distributed across the agent-environment systems, including social ones. The core of the embodied science community still holds most of the nonneural cognitive resources to be bounded by the skin. Nevertheless, research on group-level effects, like Hutchins (1995), and the research summarized above from the tradition of ecological psychology (Anderson et al. 2012), suggest that the expansion of the cognitive system need not stop at the boundaries of the biological body, and that even the boundaries between individuals may open in different ways under interaction-dominant dynamics, and be replaced by varying levels of synergy. *Extended* cognition stipulates that external features are more than distributive, but may actually *constitute* a broader cognitive system (Clark 2008; Clark and Chalmers 1998; Wilson 2004). Might some of our cognitive tasks, including even remembering, involve off-loading some of their components not only to our bodies, but even to the external world? Is it even possible, as Merlin Donald (1991, 2001) suggests, that we live in an era where our externalization of memory has made it all the more obvious that the nature of human beings is as *symbolic symbionts*? And if we are symbolic symbionts, are not the most important of those symbioses found in diachronic relationalities with other human beings? Here, of course, the argument becomes more philosophical, but I think this is the direction to which embodied cognitive science is going to be inexorably drawn.

Externalism. Until quite recently, our conceptions of mind, self, and soul have held these to be internal to the central nervous system of our biological organism, an internal/external boundary which has roots as far back as the early modern emergence of science. Rejecting both the individual possession and locational internalism of Descartes, there is a growing externalism within scientific and philosophical studies of mind which view it as embodied, enactive, encultured, and interwoven with a social and technical web, and as a construction not limited to the boundaries of the individual organism (Wilson 2004). Originating a generation ago in the *content externalism* of Hilary Putnam (1975) and Tyler Burge

(1986), that the semantic content of mental states (seeing vs. hallucinating a tree) is often dependent on factors external to the subject (the actual presence or absence of a tree), the last decades have seen the emergence of a substantially stronger *process* or *vehicle externalism,* that the structures or mechanisms making various mental states possible may themselves extend beyond the skin (e.g., Clark and Chalmers 1998; Hurley 1998; cf. Teske 2011 for a review of these varieties). Many of our mental states are hybrids, spread across internal and external materials, biological or not.

Externalism is, quite simply, the view that "the mind ain't in the head." It is the claim that the mind is constituted by the mechanisms and resources that we use to think. It asserts that the constitution of thoughts, beliefs, and desires often includes, even requires, states and processes external to our biological organism. This is not unlike the *extended phenotype* of evolutionary biology. In the case of human beings, our cognitive niche includes many things by which we extend our minds into the environment, like imitation and symbol use, as well as external artifacts, and even social practices and structures, from which emerge the possibilities of distributing cognitive tasks across individuals or accumulating knowledge across generations. That does not mean that the mind's location is separate from heads and bodies, as these are proper parts of a mind (*mereological*, part-whole relationships). Mental phenomena are hybrids that couple events in the world to physical processes in the nervous system. According to Mark Rowlands (2003), this is the most important development in the philosophy of mind in the latter half of the twentieth century, rooted in the phenomenological philosophy of Husserl, the linguistic philosophy of Wittgenstein, and in the existentialism of Sartre.

The manipulation and exploitation of information-bearing structures is also likely to have been important in the historical development of some of the abilities which they make possible, as in code memorization, or the development of capacities for reading and writing. There is a huge difference in how our brains are shaped, and how we interact with the world, and how we use this important set of external memory structures. Indeed, as documented by Luria (1976) and Vygotsky (1978), many of our higher cognitive functions have been socially scaffolded in ways that are contingent on historical changes in social life and organization. We think of our higher cognitive functions as being produced by the basic equipment of the brain, but there are historical developments, learned though socialization, which are also necessary to make them possible. We are evolved to have remarkably plastic brains, which are what make us historical beings, including substantial changes in how our brains are shaped developmentally to do what we so take for granted as part of intellectual functioning. Such abilities have been so shaped by the symbolically rich environment around us that we cannot make a principled separation between our ability to remember and our ability to exploit ambient information. This includes the formalisms that reduce complicated arithmetic calculations to an iterated set of simpler steps, as well as the use of technological artifacts which we find increasingly indispensable.

The Parity Principle states that "if something plays a role in cognitive activity, such that, were it internal we would have no difficulty in concluding that it was part of the mind, it should be counted as part of the mind whether it is internal or not" (Clark and Chalmers 1998). If Inga and Otto both set out for the Museum of Modern Art, Inga by recalling its location on 53rd Street and the Alzheimer-suffering Otto by consulting his notebook, there is no reason to treat their memories differently, as both are just as accessible, reliable, and transparent in use. Even paradigmatically mental events, like biologically instantiated memory, are not constantly available, not always easily accessible, not automatically endorsed, and can be implicit or procedural. Why not also include the downloading to external artifacts which distributes the cognitive load of a task, from paper and pencil to the electronic prostheses of calculators or cell phones?

Parity may only be a special case of a much wider *complementarity principle* which argues, on grounds of both individual differences and historical variation that the advantages of external resources, both physical and symbolic, might not merely be in duplicating internal functions, but in developing capacities otherwise unavailable. Different cognitive artifacts do actually have different effects on our brains, as brain changes under literacy show (expansion of the *planum temporale)*, and historical and cultural differences in the uses of such artifacts suggest. As Clark (2008) points out, the questions about the range and variety of cognitive scaffolding and the different ways they can enhance (or damage) performance are empirical questions. The nonlinear, complex, and iterated couplings between the brain and the body, and between the brain and external resources, in which each may have effects on the other, render any boundaries highly permeable. Even the extent of context dependence varies widely over contexts and tasks. Such external couplings may be precisely what make us the kind of creatures we are, easily extending our minds onto the environment, including the shared social space with which we are so mimetically engulfed. Indeed, given the evolution of our extended childhoods (Konner 2010), and the extensive shaping of our neuroplasticity by socialization and enculturation, they may make human history and civilization possible.

Self, Identity, and Responsibility. If the mind is extended does the self follow? Much of what matters to our identity are our cognitive capacities, so this would seem to be a natural extension (Clark 2003). If so, this might have many implications, especially for autonomy and responsibility. Is violating someone's externalizations have comparable moral significance to violating one's body? Anyone who has felt her personal space violated, or been the victim of a theft, can feel invaded and vulnerable, so perhaps we already have a kind of sliding-scale of ownership and identification. Could a "frail control hypothesis," that external contingencies partially realize a behavior, mean that human beings have little control and no normative competence, or does it extend it? If agency is distributed, then how should punishment be applied? If agency is not restricted to neural circuits and bodily experience, don't we have to rethink ideas of normative competence, freedom, and personal identity? Or can we still appeal to a difference between agency, identified as the locus of control located in the agent's body, though we allow that cognitive systems can be extended, not unlike what we do when we distinguish between the biological boundaries of an organism, like a spider, and the extended biological system, which includes the webs they spin (Wilson 2004).

From my own religious tradition, there are explicit references to us all being parts of one body; as Paul puts it in his first epistle to the Corinthians: "But God has so composed the body, giving the greater honor to the inferior part, that there be no discord in the body, but that the members may have the same care for one another. If one member suffers, all suffer together; if one member is honored, all rejoice together" (*1 Cor. 12: 24–6*). Within the Buddhist tradition, the idea of "interdependent arising" may capture some of this same spirit, and this same kind of bodily grounding.

Relationality

Self-Boundaries. Personal identity is made possible by the evolution of a human neuropsychology that requires social interdependency for its development. Our neuroplasticity requires shaping over a lifetime, socially scaffolding our neuroregulation, including emotional attachments and dynamics. The evolutionary hypertrophy of our prefrontal cortex leads to a colonization of brain function making possible the social construction of virtual realities, novel forms of socially constituted experience, and the transforming effects of mythic, ideological, and religious systems (Teske 2001).

A neural affect system is shaped into emotional patterns by the social scripts laid down during our lengthy period of developmental dependency, including second-order emotions, the development of independence, autonomy, and relations of intimacy and power (Nathanson 1992; Tomkins 1979). Pride, guilt, and shame are generally thought to be emotions *about* other emotions, and involve experienced expansions and contractions of self-boundaries respectively (e.g., "hiding in shame"). While the affect systems are strictly biological, it is the production of regular patterns of emotion, and their recall, which produce the organizing scenes and scripts that are the basis of our personal dramas. These patterns will not only be heavily dependent upon the domestic or family dynamics of a particular moment in history and culture, but are likely to shape, and necessarily so, our extremely plastic and immature nervous systems during the course of development, in ways that may often be irrevocable (Teske 2006).

Relational Externalism. If our neuroplasticity makes it possible for us to be "natural-born cyborgs" (Clark 2003) one of the crucial lessons of our extended developmental dependency (Konner 2010) must certainly be how much our externalism is rooted in biologically embodied relationships with other human beings. We offload memory anytime we ask someone to remind us of something, and we even make "mind" distributed when we distribute memories socially, as when couples specialize, for example, where one remembers birthdays on both sides of the family, the other remembers vacation locales. The externalist position being put forth here is that mental life is both embodied and embedded in the world, not just located within the nervous system: the nervous system is a necessary part, but it is only a part, not the whole construction.

Empathy and Intersubjectivity. Research on empathy and on the neurophysiology of social interconnectedness suggests the existence of a primary intersubjectivity, out of which experiences of separate autonomies need to be differentiated. There are contemporary cognitive and neuropsychological views that self and other have no independent existence, no intrinsic identity, and our subjectivity is preceded by an intersubjectivity produced by empathies running deeply beneath our embodied and interdependent biological lives (Thompson 2005, 2007). Empathy exists in our involuntary and sensorimotor coupling, mediated by "mirror neurons" (Iacoboni 2008) which respond similarly whether preparing one's own or observing the movements of another. There is also an affective resonance resulting from our capacity to read and mimic facial expressions automatically, and by which we feel what someone else feels. The measurable nonverbal duet in empathy includes matched patterns of arousal and even complimentary breathing (Goleman 2006). Higher levels of empathy include the imaginary transposition to the place of another, and a mutual self and other understanding which involves a reiterated experience of seeing each other as experienced empathically by the other. This is how we come to experience our bodies as objects belonging to an intersubjective world. "In this way, my sense of self-identity in the world, even at the basic level of embodied agency, is inseparable from recognition by another, and from the ability to grasp that recognition empathically" (Thompson 2005, 268). Human subjectivity is intersubjectivity from the outset, developing from it, "configured by the distributed cognitive web of symbolic culture" (382).

Freedom, Vulnerability, and Intimacy. We establish our autonomy, our freedom, and our identity, finally, only on the fragile and vulnerable ground of our intimate interdependencies (Winter 2011). While there are dangers when our self-boundaries are overwhelmed, intimacy requires us not only to guard them less zealously, but to open them, both to another, and to ourselves, as the only way we can ever transcend ourselves is by going beyond them. Self-transcendence is driven by our longing for the *kenosis* of pouring ourselves into things greater than ourselves. Perhaps we too easily forget the ones closest to us, those who know us best, and in whom we may find the only others who really matter, and with whom we might find the other within, in our anxiety and vulnerability, to step outside of ourselves and genuinely love.

Religious and Theological Implications

Teed Rockwell (2009), drawing on the hypothesis of extended cognition, has explicitly endorsed a nondualist model, arguing that even if the brain has enduring substance, the mind itself is a conventional rather than a natural kind, and there is not sharp border between mind and world. Evan Thompson's Buddhist view is that it is the egocentric attachment to a mentally imputed self that is the source of all suffering, and suggests ethical practices of empathic imagination, to open oneself to a primary intersubjectivity prior to the imputation of "self" and "other" (Thompson 2007).

There are deep and historical contributions of Christianity to the understanding of interiority as separate, individuated, and bodily restricted, and of redemption as a private, individual relationship with the sacred. There are, nevertheless, contemporary theological resources for an externalist view, including Karl Barth's (1958) conception of the *imago Dei* as existing not in individuals but in relationship itself and Karl Rahner's (1978) anti-Platonist view that the substantial unity of the human person is not merely *in praesanti statu vitae* but that we are wedded to the world, for better or worse, as "one flesh," that we do not part even in death, that we are inescapably material and related to matter. Death is a fulfillment of what we have made of ourselves in life, which comes into being *through* death, not *after* it, not leaving the world, but entering more fully into it. Stanley Grenz's encyclopedic work, *The Social God and the Relational Self* (2001), sees a person not as a static entity, determined by its boundaries, but as a drive toward both integration and self-transcendence, so that we are ourselves only in communion. What we are *about* is outside ourselves, is *other.* What we *are,* even as individual selves are not internal spaces, connected to each other, but literally, and externally, composed of each other. We redeem each other *bodily.* The *imago Dei*, in our quest for loving relationality in our communal life, is at historical tension with the postmodern isolation of the individual, the fragmentation of self and meaning, to which ideas of disembodied souls, of minds separated from the body and from the world, can only have contributed.

The present exploration, from embodied to extended cognition, presses us to take the idea of being wedded to the world, literally of one flesh with it, ever more seriously. We are not only *cyborg* selves, incorporating our technologies, particularly extensive informational technologies, into our empirical self-experience, but, in the extensive exteriorization of higher cognitive abilities, and even memory, we are truly *symbionts* with a symbolic material culture. Moreover, in the ways in which our memories, and the externalizations of them, can be involved in the highest levels, not only of cognition but of empathy, inclusive of our histories and our stories, our marriage with the world is also a marriage to time, it is diachronic. Preeminent among the externalities from which our selves are composed are our relationships with other human beings, particularly those with whom we have deep and lengthy intimacies, but necessarily, and also, with those we do not, but with whom we share an increasingly interdependent planetary ecology. If religion teaches anything it is to model the latter upon the former, to love thy neighbor as oneself; if an extended and relational cognitive science teaches us anything it is that we only learn about ourselves, and how to love ourselves, from the love we have been shown. It is in gratitude for this love that we can show it to others, even strangers, in our bodies and theirs, even unto death. Hence, to see our own hearts beating in the neck of the other; perhaps also to see our own blood flowing in our streams and rivers, our bodies broken with a planet of which we are part.

Note

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References

Alibali, Martha W., Dana C. Heath, and Heather J. Meyers. 2001. "Effects of Visibility between Speaker and Listener on Gesture Production." *Journal of Memory and Language* 44:169–88.

Anderson, Michael L. 2007. "Evolution of Cognitive Function via Redeployment of Brain Areas." *The Neuroscientist* 13:13–21.

———. 2008. "Circuit Sharing and the Implementation of Intelligent Systems." *Connection Science* 20:239–51.

———. 2010. "Neural Re-Use as a Fundamental Organizational Principle of the Brain." *Behavioral and Brain Sciences* 33:245–313.

Anderson, Michael L., Michael J. Richardson, and Anthony Chemero. 2012. "Eroding the Boundaries of Cognition: Implications of Embodiment." *Topics in Cognitive Sciences* 4:1–14.

Andres, Michael, Xavier Seron, and Etienne Oliver. 2007. "Contribution of Hand Motor Circuits to Counting." *Journal of Cognitive Neuroscience* 19:563–73.

Auvray, Malika, Charles Lenay, and John Stewart. 2009. "Perceptual Interactions in a Minimalist Virtual Environment." *New Ideas in Psychology* 27:32–47.

Baron-Cohen, Simon. 2011. *The Science of Evil: On Empathy and the Origins of Cruelty*. New York: Basic Books.

Barsalou, Lawrence W. 1993. "Flexibility, Structure, and Linguistic Vagary in Concepts: Manifestations of a Compositional System of Perceptual Symbols." In *Theories of Memory*, ed. A. C. Collins, S. E. Gathercole, and M. A. Conway, 29–101. Hillsdale, NJ: Lawrence Erlbaum.
———. 1999. "Perceptual Symbol Systems." *Behavioral and Brain Sciences* 22:577–660.
———. 2008. "Grounded Cognition." *Annual Review of Psychology* 59:617–45.
Barsalou, Lawrence W., W. Kyle Simmons, Aron K. Barbey, and Christine D. Wilson. 2003. "Grounding Conceptual Knowledge in Modality-Specific Systems." *Trends in Cognitive Sciences* 7:84–91.
Barth, Karl. 1958. *Church Dogmatics*. Edinburgh: T&T Clark.
Bechara, Antoine, Antonio R. Damasio, Hanna Damasio, and S. W. Anderson. 1994. "Insensitivity to Future Consequences Following Damage to Human Prefrontal Cortex." *Cognition* 50:7–15.
Berneiri, Frank. 1988. "Coordinated Movement and Rapport in Teacher-Student Interactions." *Journal of Nonverbal Behavior* 12:120–38.
Berti, Anna, Gabriela Bottini, M. Gandola, Lorenzo Pia, Nicola Smania, A. Stracciari, Isabella Castiglioni, Guiseppe Vallar, and Eraldo Paulesu. 2005. "Shared Cortical Anatomy for Motor Awareness and Motor Control." *Science* 309:488–91.
Boroditsky, Lera. 2000. "Metaphoric Structuring: Understanding Time through Spatial Metaphors." *Cognition* 75:1–28.
Breazeal, Cynthia. 2002. *Designing Sociable Robots*. Cambridge, MA: MIT Press.
Brooks, Rodney. 1991. "Intelligence without Representation." *Artificial Intelligence* 47:139–59.
Brown, Warren S., Nancey Murphy, and H. Newton Malony. 1998. *Whatever Happened to the Soul? Scientific and Theological Portraits of Human Nature*. Minneapolis, MN: Fortress Press.
Bryant, David, and W. Geoffrey Wright. 1999. "How Body Asymmetries Determine Accessibility in Spatial Function." *Quarterly Journal of Experimental Psychology* 52:487–508.
Bryant, Jennings, and Dorina Miron. 2003. "Excitation Transfer Theory." In *Communication and Emotion: Essays in Honor of Dolf Zillman*, eds. by J. Bryant, D. Roskos, E. Woldsen, and J. Cantor, 31–59. Mahwah, NJ: Lawrence Erlbaum.
Burge, Tyler. 1986. "Individualism and Psychology." *The Philosophical Review* 95:3–45.
Bush, Lauren K., Carol L. Barr, Gregory J. McHugo, and John T. Lanzetta. 1989. "The Effects of Facial Control and Facial Mimicry on Subjective Reactions to Comedy Routines." *Motivation and Emotion* 13:31–52.
Cacioppo, John T., Joseph R. Priester, and Gregory G. Berntson. 1993. "Rudimentary Determination of Attitudes: II. Arm Flexion and Extension Have Differential Effects on Attitudes." *Journal of Personality and Social Psychology* 65:5–17.
Chandler, Jesse, and Norbert Schwartz. 2009. "How Extending Your Middle Finger Affects Your Perception of Others." *Journal of Experimental Social Psychology* 45:123–28.
Chang, Chih-hui, Michael G. Wade, and Thomas A. Stoffregen. 2009. "Perceiving Affordances for Aperture Passing in an Environment-Person-Person System." *Journal of Motor Behavior* 41:495–500.
Chao, Linda L., and Alex Martin. 2000. "Representation of Manipulable Man-Made Objects in the Dorsal Stream." *NeuroImage* 12:478–84.
Chemero, Antony. 2009. *Radical Embodied Cognitive Science*. Cambridge, MA: MIT Press.
Clark, Andy. 1997. *Being There: Putting Mind, Body, and World Together Again*. Cambridge, MA: MIT Press.
———. 2003. *Natural-Born Cyborgs: Minds, Technologies, and the Future of Human Intelligence*. New York: Oxford University Press.
———. 2008. *Supersizing the Mind: Embodiment, Action, and Cognitive Extension*. New York: Oxford University Press.
Clark, Andrew, and David Chalmers. 1998. "The Extended Mind." *Analysis* 58:10–23.
Clayton, Philip, and Paul Davies, eds. 2006. *The Re-Emergence of Emergence: The Emergence Hypothesis in Science and Religion*. New York: Oxford University Press.
Cole, Michael, Lois Hood, and Ray McDermott. 1997. "Concepts of Ecological Validity: Their Differing Implications for Comparative Cognition." In *Mind, Culture, and Activity*, ed. M. Cole and Y. Engestroem, 48–58. New York: Cambridge University Press.
Condon, William S., and Louis W. Sander. 1974. "Neonate Movement Is Synchronized with Adult Speech." *Science* 183:99–101.

Cosmides, Leda, and John Tooby. 1992. "Cognitive Adaptations for Social Exchange." In *The Adapted Mind: Evolutionary Psychology and the Generation of Culture*, ed. J. H. Barkow, L. Cosmides, and J. Tooby, 163–228. New York: Oxford University Press.

Dagher, Alain, Adrian Owen, Henning Boecker, and David Brooks. 1999. "Mapping the Network for Planning." *Brain* 122:1973–87.

Damasio, Antonio R. 1994. *Descartes' Error: Emotion, Reason, and the Human Brain*. New York: Grosset/Putnam.

———. 1999. *The Feeling of What Happens: Body and Emotion in the Making of Consciousness*. New York: Harcourt Brace.

Damasio, Hanna, Thomas J. Grabowski, Daniel Tranel, Richard Hichwa, and Antonio R. Damasio. 1996. "A Neural Basis for Lexical Retrieval." *Nature* 380:499–505.

De Jaegher, Hanne, Ezequiel Di Paoulo, and Shaun Gallagher. 2010. "Can Social Interaction Constitute Social Cognition?" *Trends in Cognitive Sciences* 14:441–47.

Dijksterhuis, Ap, and John A. Bargh. 2001. "The Perception-Behavior Expressway: Automatic Effects of Social Perception on Social Behavior." In *Advances in Experimental Social Psychology*, Vol. 23, ed. Mark P. Zanna, 10–40. San Diego, CA: Academic Press.

Dijkstra, Katinka, Michale P. Kaschak, and Rolf A. Zwaan. 2007. "Body Posture Facilitates Retrieval of Autobiographical Memories." *Cognition* 102:139–49.

Dimberg, Ulf. 1982. "Facial Reactions to Facial Expressions." *Psychophysiology* 19:643–47.

Dimberg, Ulf, Monika Thunberg, and Kurt Elmehed. 2000. "Unconscious Facial Reactions to Emotional Facial Expressions." *Psychological Science* 11:86–89.

DiPaulo, Ezequiel, Marieke Rohde, and H. Iizulla. 2008. "Sensitivity to Social Contingency of Stability of Interaction? Modeling the Dynamics of Perceptual Crossing." *New Ideas in Psychology* 26:278–94.

Donald, Merlin. 1991. *Origins of the Modern Mind: Three Stages in the Evolution of Culture and Cognition*. Cambridge, MA: Harvard University Press.

———. 2001. *A Mind So Rare: The Evolution of Human Consciousness*. New York: W. W. Norton.

Dotov, Dobromir, Lin Nie, and Anthony Chemero. In Press. "Readiness-to-Hand, Unreadiness-to-Hand, and Multifractality." *Journal of Mind and Behavior*.

Drees, Willem B. 1996. *Religion, Science and Naturalism*. New York: Cambridge University Press.

Farrer, Chloe, Nicolas Franck, Nicolas Georgieff, Christopher D. Frith, Jean Decety, and Marc Jeannerod. 2003. "Modulating the Experience of Agency: A Positron Emission Tomography Study." *NeuroImage* 18:324–33.

Farrer, Chloe, and Christopher D. Frith. 2002. "Experiencing Oneself vs Another Person as Being the Cause of an Action: The Neural Correlates of the Experience of Agency." *NeuroImage* 15:596–603.

Fodor, Jerry. 1983. *The Modularity of Mind*. Cambridge, MA: MIT Press.

———. 2000. *The Mind Doesn't Work That Way*. Cambridge, MA: MIT Press.

Fowles, John. 1974. *The Ebony Tower*. New York: Little Brown.

Freeman, Walter J. 2001. *How Brains Make Up Their Minds*. New York: Columbia University Press.

Freyd, Jennifer J. 1987. "Dynamic Mental Representations." *Psychological Review* 94:427–38.

Gallese, Vittorio, and Alvin Goldman. 1998. "Mirror Neurons and the Simulation Theory of Mind-Reading." *Trends in Cognitive Science* 12:493–501.

Gallese, Vittorio, Christian Keysers, and Giacomo Rizzolatti. 2004. "A Unifying View of the Basis of Social Cognition." *Trends in Cognitive Science* 8:396–403.

Glenberg, Arthur M. 1997. "What Memory Is For." *Behavioral and Brain Science* 20:1–55.

Glenberg, Arthur M., Megan Brown, and Joel R. Levin. 2007. "Enhancing Comprehension in Small Reading Groups Using a Manipulation Strategy." *Contemporary Educational Psychology* 32:389–99.

Glenberg, Arthur M., and M. P. Kaschak. 2003. "The Body's Contribution to Language." In *The Psychology of Learning and Motivation*, Vol. 43, ed. B. Ross, 93–126. New York: Academic Press.

Glenberg, Arthur M., Jennifer L. Schroeder, and David A. Robertson. 1998. "Averting the Gaze Disengages the Environment and Facilitates Memory." *Memory and Cognition* 26:651–58.

Goldin-Meadow, Susan. 2003. *Hearing Gesture: How Our Hands Help Us Think.* Cambridge, MA: Harvard University Press.

Goldman, Alvin. 2006. *Simulating Minds: The Philosophy, Psychology, and Neuroscience of Mind-reading*. New York: Oxford University Press.

Goleman, Daniel. 2006. *Social Intelligence: The New Science of Human Relationships*. New York: Bantam Books.

Greene, Joshua, and Jonathan Haidt. 2002. "How (and Where) Does Moral Judgment Work?" *Trends in Cognitive Sciences* 6:517–23.

Grenz, Stanley J. 2001. *The Social God and the Relational Self: A Trinitarian Theology of the Imago Dei*. Louisville, KY: Westminster John Knox Press.

Haggard, Paul. 2005. "Conscious Intention and Motor Cognition." *Trends in Cognitive Science* 9:290–95.

Haidt, Jonathan. 2010. *The Righteous Mind: Why Good People Are Divided by Politics and Religion*. New York: Pantheon.

Haidt, Jonathan, Silvia H. Koller, and Maria G. Dias. 1993. "Affect, Culture, and Morality, or Is It Wrong to Eat Your Dog." *Journal of Personality and Social Psychology* 65:613–28.

Harrison, Steven J., and Michael J. Richardson. 2009. "Horsing Around: Spontaneous Coordination of Four-Legged Coordination." *Journal of Motor Behavior* 41:519–24.

Hegarty, Mary. 2004. "Mechanical Reasoning by Mental Simulation." *Trends in Cognitive Science* 8:280–85.

Herman, Judith. 1992. *Trauma and Recovery*. New York: Basic Books.

Holden, John, Guy van Orden, and Michael T. Turvey. 2009. "Dispersion of Response Times Reveals Cognitive Dynamics." *Psychological Review* 116:318–24.

Hurley, Susan. 1998. *Consciousness in Action*. Cambridge, MA: Harvard University Press.

Hutchins, Edwin 1995. *Cognition in the Wild*. Cambridge, MA: MIT Press.

Iacoboni, Marco. 2008. *Mirroring People: The New Science of How We Connect with Others*. New York: Farrar, Straus and Giroux.

Intraub, Helene, and James E. Hoffman. 1992. "Reading and Visual Memory: Remembering Scenes that Were Never There." *American Journal of Psychology* 105:101–14.

Isenhower, Robert W., Michael J. Richardson, Claudia Carello, Reuben M. Baron, and Kerry L. Marsh. 2010. "Affording Cooperation: Embodied Constraints, Dynamics, and Action-Scale Invariance in Joint Lifting." *Psychonomic Bulletin and Review* 17:342–47.

Jackson, Philip L., Andrew N. Meltzoff, and Jean Decety. 2005. "How Do We Perceive the Pain of Others? A Window onto the Neural Processes Involved in Empathy." *NeuroImage* 24:771–79.

Kelly, Spencer D. 2001. "Broadening the Units of Analysis in Communication: Speech and Nonverbal Behaviors in Pragmatic Comprehension." *Journal of Child Language* 28:325–49.

Kelso, J. A. Scott 2009. "Synergies: Atoms of Brain and Behavior." In *Progress in Motor Control*, ed. D. Sternad, 83–91. New York: Springer.

Kohlberg, Lawrence. 1969. "Stage and Sequence: The Cognitive-Developmental Approach to Socialization." In *Handbook of Socialization Theory and Research*, ed. D. A. Goslin, 347–480. Chicago, IL: Rand McNally.

Konner, Melvin. 2010. *The Evolution of Childhood: Relationships, Emotion, Mind.* Cambridge, MA: Harvard University Press.

Kosslyn, Stephen M. 1994. *Image and Brain*. Cambridge, MA: MIT Press.

Kosslyn, Stephen M., William L. Thompson, and Giorgio Ganis. 2006. *The Case for Mental Imagery*. New York: Oxford University Press.

Krauss, Robert M. 1998. "Why Do We Gesture When We Speak?" *Current Directions in Psychological Science* 7:54–59.

LaFrance, Marianne. 1985. "Postural Mirroring and Intergroup Relations." *Personality and Social Psychology Bulletin* 11:207–17.

LaFrance, Marianne, and Clara Alexandra Weiss Mayo. 1978. *Moving Bodies: Nonverbal Communication in Social Interaction*. Belmont, CA: Wadsworth.

Leahy, Thomas Hardy. 2000. *A History of Psychology*, 5th ed. Upper Saddle River, NJ: Prentice Hall.

Levin, Daniel T., and Daniel J. Simons. 1997. "Failure to Detect Changes to Attended Objects in Motion Pictures." *Psychonomic Bulletin and Review* 4:501–06.

Longo, Matthew R., and Stella F. Laurenco. 2007. "Space Perception and Body Morphology: Extent of Near Space Scales with Arm Length." *Experimental Brain Research* 177: 285–90.

Luria, Alexander R. 1976. *Cognitive Development: Its Cultural and Social Foundations*. Cambridge, MA: Harvard University Press.
Machery, Edouard. 2007. "Concept Empiricism: A Methodological Critique." *Cognition* 104:19–46.
MacIver, Malcolm A. 2009. "Neuroethology: From Morphological Computation to Planning." In *The Cambridge Handbook of Situated Cognition*, ed. P. Robbins and M. Aydede, 480–504. New York: Cambridge University Press.
Mack, Arien, and Irvin Rock. 1998. *Inattentional Blindness*. Cambridge, MA: MIT Press.
Martin, Alex, Leslie G. Ungerleider, and James V. Haxby. 2000. "Category-Specificity and the Brain: The Sensory-Motor Model of Semantic Representations of Objects." In *Category Specificity and the Brain: The Sensory-Motor Model of Semantic Representations of Objects*, ed. M. S. Gazzaniga, 1023–36. Cambridge, MA: MIT Press.
McNeill, David. 2005. *Gesture and Thought*. Chicago, IL: University of Chicago Press.
Medin, Doug L., Elizabeth B. Lynch, and John D. Coley. 1997. "Categorization and Reasoning among Tree Experts: Do All Roads Lead to Rome?" *Cognitive Psychology* 32:49–96.
Medin, Doug L., and Edward Shoben. 1988. "Context and Structure in Conceptual Combination." *Cognitive Psychology* 20:158–90.
Meier, Brian P., and Michael D. Robinson. 2004. "Why the Sunny Side Is Up: Associations Between Affect and Vertical Position." *Psychological Science* 15:243–47.
Murphy, Nancey. 1998. "Nonreductive Physicalism: Philosophical Issues." In*Whatever Happened to the Soul? Scientific and Theological Portraits of Human Nature*, ed. Warren S. Brown, Nancey Murphy, and H. Newton Malony, 127–48. Minneapolis, MN: Fortress Press.
Murray, Lynn, and Colwyn Trevarthen. 1985. "Emotional Regulation of Interactions between 2-Month Olds and Their Mothers." In *Social Perception in Infants*, eds. T. M. Field and N. A. Fox, 177–97. New York: Ablex.
Nadel, Jacqueline, Isabelle Carchon, Claude Kervella, Daniel Marcelli, and Denis Réserbat-Platney. 1999. "Expectancies for Social Contingency in 2-Month Olds." *Developmental Science* 2:164–78.
Nathanson, Donald L. 1992. *Shame and Pride: Affect, Sex, and the Birth of the Self.* New York: Norton.
Niedenthal, Paula M. 2007. "Embodying Emotion." *Science* 316:1002–05.
Niedenthal, Paula M., Lawrence W. Barsalou, Piotr Winkielman, Silvia Krauth-Gruber, and François Ric. 2005. "Embodiment in Attitudes, Social Perception, and Emotion." *Personality and Social Psychology Review* 9:184–211.
Noë, Alva. 2004. *Action in Perception*. Cambridge, MA: MIT Press.
Noë, Alva, and E. Thompson. 2004. "Are There Neural Correlates of Consciousness?" *Journal of Consciousness Studies* 11:2–28.
Oberman, Lindsay M., and Vilayanur S. Ramachandran. 2007. "The Simulating Social Mind: The Role of the Mirror Neuron System and Simulation in the Social and Communicative Deficits of Autism Spectrum Disorders." *Psychological Bulletin* 133:310–27.
Ogden, Pat, Kekuni Minto, and Clare Pain. 2006. *Trauma and the Body: A Sensorimotor Approach to Psychotherapy*. New York: W. W. Norton.
Öhman, Arne, and Susan Mineka. 2001. "Fears, Phobias, and Preparedness: Toward an Evolved Module of Fear and Fear Learning." *Psychological Review* 108:483–522.
Parsons, Lawrence M. 1987. "Imagined Spatial Transformations of One's Body." *Journal of Experimental Psychology: General* 116:172–91.
Pasternak, Tatiana, and Mark W. Greenlee. 2005. "Working Memory in Primate Sensory Systems." *Nature Reviews Neuroscience* 6:97–107.
Polyn, Sean M., Vaidehi S. Natu, Jonathan D. Cohen, and Kenneth A. Norman. 2005. "Category-Specific Cortical Activity Precedes Retrieval Memory Search." *Science* 310:1963–66.
Potter, Mary C., Judith F. Kroll, Betsy Yachzel, Elisabeth Carpenter, and Janet Sherman. 1986. "Pictures in Sentences: Understanding without Words." *Journal of Experimental Psychology: General* 115:281–94.
Premack, David, and George Woodruff. 1978. "Does the Chimpanzee Have a Theory of Mind?" *Behavioral and Brain Science* 4:515–26.
Presson, Clark C., and Daniel R. Montello. 1994. "Updating after Rotational and Translational Body Movements: Coordinate Structure of Perspective Space." *Perception* 23: 1447–55.

Proffitt, Dennis R. 2006. "Embodied Perception and the Economy of Action." *Perspectives in Psychological Science* 1:110–22.
Pulvermüller, Friedemann 2005. "Brain Mechanisms Linking Language and Action." *Nature Reviews Neuroscience* 6:576–82.
Putnam, Hilary. 1975. "The Meaning of 'Meaning'." In *Language, Mind, and Knowledge: Minnesota Studies in the Philosophy of Science*, Vol. 7, ed. K. Gunderson. Minneapolis: University of Minnesota Press.
Rahner, Karl. 1978. *Foundations of Christian Faith*. New York: Seabury Press.
Richardson, Michael L., Brett R. Fajan, Kevin Shockley, Michael A. Riley, and Michael T. Turvey. 2008. "Ecological Psychology: Six Principles for an Embodied-Embedded Approach to Behavior." In *Handbook of Cognitive Science: An Embodied Approach*, eds. Paco Calvo and Toni Gomila, 161–97. New York: Elsevier.
Richter, Wolfgang, Ray Somorjai, Randy Summers, Mark Jarmasz, Ravi S. Menon, Joseph S. Gati, Apostolos P. Georgopoulos, Carola Tegeler, and Kamil Ugurbil. 2000. "Motor Area Activation during Mental Rotation Studied by Time-Resolved Single-Trial fMRI." *Journal of Cognitive Neuroscience* 12:310–20.
Rizzolatti, Giacomo, and Laila Craighero. 2004. "The Mirror-Neuron System." *Annual Review of Neuroscience* 27:169–92.
Roberts, Michael E., and Robert L. Goldstone. 2009. "Adaptive Group Coordination." *Proceedings of the Thirty-First Annual Conference of the Cognitive Science Society*, 2698–2704. Amsterdam: Cognitive Science Society.
Rockwell, Teed. 2009. "Minds, Intrinsic Properties, and Madhyamaka Buddhism." *Zygon: Journal of Religion and Science* 44:659–74.
Rowlands, Mark. 2003. *Externalism: Putting Mind and World Back Together Again*. Montreal: McGill-Queen's University Press.
Rupert, Robert. 2006. "Review of Raymond W. Gibbs, Jr., *Embodiment and Cognitive Science*." *Notre Dame Philosophical Reviews* 8. <http://ndpr.nd.edu/news/25099-embodiment-and-cognitive-science/>
Schnall, Simone, Jonathan Haidt, Gerald L. Clore, and Alexander H. Jordan. 2008a. "Disgust as Embodied Moral Judgment." *Personality and Social Psychology Bulletin* 34:1096–1109.
Schnall, Simone, Jennifer Benton, and Sophie Harvey. 2008b. "With a Clean Conscience. Cleanliness Reduces the Severity of Moral Judgments." *Psychological Science* 19: 1219–22.
Schwartz, Daniel L. 1999. "Physical Imagery: Kinematic vs Dynamic Models." *Cognitive Psychology* 38:433–64.
Schwartz, Daniel L., and John B. Black. 1996. "Analog Imagery in Mental Model Reasoning: Depictive Models." *Cognitive Psychology* 30:154–219.
Simons, Daniel J., and Christopher F. Chabris. 1999. "Gorillas in Our Midst: Sustained Inattentional Blindness for Dynamic Events." *Perception* 28:1059–74.
Solomon, Karen O., and Lawrence W. Barsalou. 2001. "Representing Properties Locally." *Cognitive Psychology* 43:129–69.
Sperry, Roger. 1988. "Psychology's Mentalist Paradigm and the Religion/Science Tension." *American Psychologist* 43:607–13.
———. 1993. "The Impact and Promise of the Cognitive Revolution." *American Psychologist* 48:878–85.
Staub, Ervin. 2012. "The Roots and Prevention of Genocide and Related Mass Violence." *Zygon: Journal of Religion and Science* 47:821–42.
Stephen, Damian G., James A. Dixon, and Robert W. Isenhower. 2009. "Dynamics of Representational Change: Entropy, Action, and Cognition." *Journal of Experimental Psychology: Human Perception and Performance* 35:1811–22.
Stepper, Sabine, and Fritz Strack. 1993. "Proprioceptive Determinants of Emotional and Non-Emotional Feelings." *Journal of Personality and Social Psychology* 64:211–20.
Strack, Fritz, Leonard L. Martin, and Sabine Stepper. 1988. "Inhibiting and Facilitating Conditions of the Human Smile: A Nonobtrusive Test of the Facial Feedback Hypothesis." *Journal of Personality and Social Psychology* 54:768–77.
Teske, John A. 2001. "The Genesis of Mind and Spirit." *Zygon: Journal of Religion and Science* 36:93–104.

———. 2006. "Neuromythology: Brains and Stories." *Zygon: Journal of Religion and Science* 41:169–96.

———. 2011. "Externalism, Relational Selves, and Redemptive Relationships."*Zygon: Journal of Religion and Science* 46:183–203.

Teske, John A., and Roy D. Pea. 1981. "Metatheoretical Issues in Cognitive Science." *The Journal of Mind and Behavior* 2:123–78.

Thompson, Evan. 2005. "Empathy and Human Experience." In *Science, Religion, and the Human Experience*, ed. James D. Proctor, 261–85. New York: Oxford University Press.

———. 2007. *Mind in Life: Biology, Phenomenology, and the Sciences of Mind*. Cambridge, MA: Harvard University Press.

Tomkins, Silvan. 1979. "Script Theory: Differential Magnification of Affects." In *Nebraska Symposium on Motivation, Vol. 26*, eds. H. E. Howe and R. A. Dienstbier, 21–36. Lincoln: University of Nebraska Press.

Tsakiris, Manos, Maike D. Hesse, Christian Boy, Patrick Haggard, and Gereon R. Fink. 2007. "Neural Signatures of Body Ownership: A Sensory Network for Bodily Self-Consciousness." *Cerebral Cortex* 17:2235–44.

Tucker, Mike, and Rob Ellis. 1998. "On the Relation between Seen Objects and Components of Potential Actions." *Journal of Experimental Psychology: Human Perception and Performance* 24:830–46.

———. 2004. "Action Priming by Briefly Presented Objects." *Acta Psychologica* 116:185–203.

Umiltà, M. Alessandra, Evelyne Kohler, Vittorio Gallese, Leonardo Fogassi, Luciano Fadiga, Christian Keysers, and Giacomo Rizzolatti. 2001. "I Know What You Are Doing: A Neurophysiological Study." *Neuron* 32:91–101.

Van der Kolk, Bessel A. 1994. "The Body Keeps the Score: Memory and the Evolving Psychobiology of Posttraumatic Stress." *Harvard Review of Psychiatry* 1:253–65.

———. 1996. "Trauma and Memory." In *Traumatic Stress: The Effects of Overwhelming Experience on Mind, Body, and Society*, ed. B. A. van der Kolk, A. C. MacFarlane, and L. Weisaeth, 182–213. New York: Guilford Press.

Van Orden, Guy C., John Holden, and Michael T. Turvey. 2003. "Self-Organization of Cognitive Performance." *Journal of Experimental Psychology: General* 132:331–51.

———. 2005. "Human Cognition and 1/f Scaling." *Journal of Experimental Psychology: General* 134:117–23.

Van Orden, Guy C., Heidi Kloos, and Sebastian Wallott. 2009. "Living in the Pink: Intentionality, Well-Being, Complexity." In *Handbook of the Philosophy of Science, Volume* 10*: Philosophy of Complex Systems*, ed. Cliff Hooker, 639–83. New York: Elsevier.

Vygotsky, Lev. S. 1978. *Mind in Society*. Cambridge, MA: Harvard University Press.

Waller, David, Yvonne Lippa, and Anthony E. Richardson. 2008. "Isolating Observer-Based Reference Directions in Human Spatial Memory: Head, Body, and the Self-to-Array Axis." *Cognition* 106:157–83.

Watts, Fraser. 2013. "Embodied Cognition and Religion." *Zygon: Journal of Religion and Science* 48:745–758.

Waller, David, Daniel R. Montello, Anthony E. Richardson, and Mary Hegarty. 2002. "Orientation Specificity and Spatial Updating of Memories for Layouts," *Journal of Experimental Psychology: Learning, Memory, and Cognition* 28:1051–63.

Wells, Gary L., and Richard F. Petty. 1980. "The Effects of Overt Head Movements on Persuasion: Compatibility and Incompatibility of Responses." *Basic and Applied Social Psychology* 1:219–30.

Wheatley, Thalia, and Jonathan Haidt. 2005. "Hypnotically Induced Disgust Makes Moral Judgments More Severe." *Psychological Science* 16:780–84.

Wilson, Robert A. 2004. *Boundaries of the Mind: The Individual in the Fragile Sciences*. New York: Cambridge University Press.

Winter, Steven L. 2011. "Reimagining Democratic Theory for Social Individuals." *Zygon: Journal of Religion and Science* 46:224–45.

Zago, Laure, Martino Pesenti, Emmanuel Mellett, Fabrice Crivello, Bernard Mazoyer, and Nathalie Tzourio-Mazoyer. 2001. "Neural Correlates of Simple and Complex Mental Calculation." *NeuroImage* 13:314–27.