pitched at the functional/informational level. This is unfortunate and unnecessary given that much of the theory relies on very specific mechanisms for motor control and perspective taking that are precisely defined and empirically supported. Hence, the model could have been aimed at a functional neuroanatomical level, which would have made it more specific and more accurate.

The model also seems both underspecified and overspecified. In places where the literature is most agnostic on how certain processes work, Hurley is also agnostic. For example, the model intermixes concrete and abstract concepts (such as "targets," which can be either motor goals or life plans) without specifying whether we use the same neural processes for both, or just use analogous processes when planning to reach for a cup or to overthrow the government. In contrast, the formulation of the model into five discrete layers seems ill-fated, limiting the ability of the model to accord with the structure and functions of the nervous system. For example, layers 1 and 2 likely overlap a great deal in the brain because both require the cerebellum and act in concert to control action (cf. Wolpert et al. 1998). Conversely, there is no reason from phylogeny or ontogeny to assume that these two layers of control are primary to or evolved before the mirroring mechanisms of layer 3. Layer 2 focuses on visual and tactile feedback from the periphery, which are actually slow forms of feedback that forward models were designed to surpass. Layer 4 focuses almost entirely on "monitored inhibition" to segregate activation related to self and other, but it is unclear which type of inhibition is inculcated here (spinal, brain stem, frontal?), and there are many other ways in which self and other activation can be differentiated. Thus, it seems that there are ambiguities and inconsistencies in the model that could have been rectified by making more specific reference to the existing data on how the brain processes information.

Our lab seeks to understand the ways in which people process and understand the emotions of others. Like Hurley, we believe that basic emotion processing and related intersubjective phenomena, such as empathy, rely on an evolutionary conserved and basic perception-action mechanism (PAM) whereby perception of the emotional state of another automatically activates one's own representations for the state and situation (Preston & de Waal 2002).

Supporting Hurley's general rejection of the sandwich model, functional imaging work on empathy has found overlap between self and other processes in regions associated with subjective feeling states (Jackson et al. 2006; Lamm et al. 2007; Preston et al. 2007; in preparation b; Singer et al. 2004; 2006). Further supporting Hurley's application of perception-action processes to simulation, we have also found almost complete overlap in the neural substrates associated with imagining a personal past emotional experience and "trying on" the experience of another subject; however, we also found differences in self and other processes, which would not be predicted by the SCM, but are explicit in the PAM (Preston et al. 2007). In this study, the overall level of brain activation and autonomic arousal were much higher in the self-condition than the other-condition, and subjects recruited additional regions of visual association cortex when imagining another's scenario. These data suggest that online simulation of actual, personal events can differ in both quality and quantity from that of hypothetical events. Importantly, however, we found these differences between self and other only when subjects *could not* relate well to the situation of the other; there were no differences in neural patterns or autonomic arousal when subjects selected scenarios to which they could relate strongly (Preston et al. 2007).

This latter interaction reflects an important and overlooked point about the processing of other's actions and states: Perception-action mechanisms *require* that the subject have an existing representation for the action or state of the other. Thus, monkeys do not have mirror neurons for hand manipulations they do not understand, babies do not imitate gestures that they cannot make, and people cannot resonate with an unfamiliar emotional state and cannot predict your response to a truly novel situation.

We have striking pilot data to support this emphasis on personal representations, as individuals with depression perceive and respond to the distress of others differently than their non-depressed counterparts – they are less personally distressed by the sadness and hopelessness of hospital patients, and they are more likely to feel empathy and offer help to patients with particularly high need (Preston et al., in preparation a).

In another behavioral study, we have found that the mere perception of an emotional facial expression not only activates mirroring in a subject's facial muscles (cf. Dimberg & Oehman 1996), and primes the same valence in the subject (cf. Murphy & Zajonc 1993), but also rapidly activates the *semantic-level* representation for the *specific* emotion (e.g., "fear") (Preston & Stansfield, in press) – this finding is not predicted by models that exclusively rely on motor-based, facial feedback, or mirroring of emotion processing, but it is obvious from basic facts about how information is processed from perception to concept retrieval.

It is exciting and promising to have many researchers agreeing on some basic tenants about how behavior is instantiated – however, as with all complex problems, the devil is in the details. In order to make additional headway from here on out, we must look to the data.

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In search of a conceptual location to share cognition

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Abstract: It is argued that the multilayered model offered by the shared circuits model (SCM) falls short of capturing an essential aspect of social cognition, namely, its distributed nature. The SCM therefore falls short of modeling emergent social cognition and behavior.

Disciplinary perspectives cut the same realities in different ways, and so it is with philosophy, psychology, neuroscience, inter alia. At times, these disciplined languages cross their linguistic barriers and reach out to systematize knowledge at a level that supersedes the specific limitations imposed by their indigenous language and competence. And, even then, the particular slice of reality that we focus upon is conditioned by presuppositions about the nature of the beast we are examining.

The shared circuits model (SCM) provides a tour de force of portraying a multilayered account of *social cognition*, which is somewhat specifically grounded on imitation, whereby imitative learning is seen as a sophisticated form of social cognition. While *social* cognition appears to be a central construct for the SCM, the entire model is focused on an analysis at the *individual* level. It is this aspect of the SCM that we intend to complement in our commentary by drawing attention to the importance of distributed processes taking place between two or more individuals and the emergent quality of *social* cognition. Indeed, much of what is presented with the SCM has convergences with a social cognition model we advanced (Semin & Cacioppo, in press a; in press b), although the social cognition model we have advanced is cast in a different mold, in particular with respect to the distributed processes taking place between two or more individuals.

However, the SCM relies on *reception*, namely, the construction of inner neural representations based on observed behavior. Second, social cognition is restricted to a *reproduction metaphor* (e.g., empathy, resonance, imitation, shared representations, or mindreading). Finally, the model attempts to provide an answer as to how intersubjectivity is achieved. However, the model remains at a purely representational level, neglecting the reciprocal nature and co-regulation of social behavior. The three R's (reception, reproduction, and representation) are conceptual consequences of relying on an individual-centered paradigm. There is a problem when social cognition, especially social cognition that emphasizes imitation, is centered on the individual, however. Cognition evolved for the control of adaptive *action*, and social cognition evolved for the control of adaptive interaction in response to evolutionary demands for the organism's survival and reproduction, which for humans always takes place in a social context (Caporael 1997; Fiske 1992), and involves the *co-regulation of action*. Imitation of a parent by an infant is not a solitary event in the service of social cognition. Instead, the infant's imitative behavior elicits an imitative or nurturant response by the parent, which not only reinforces the infant's imitative response but also establishes a connection and constitutes a co-regulation of action by the parent and infant. Any depiction of the social cognition of imitation that ignores the interaction and emergent information between individuals is incomplete.

Thus, social cognition is not driven entirely by inner processes and representations as the SCM suggests, but relies on resources that are distributed across neural, bodily, and environmental features (e.g., Agre 1997; Brooks 1999; Hutchins 1995; Kirsch 1995) with the social and physical environment supporting social action and interaction (Smith & Semin 2004). As this example illustrates, two or more individuals are capable of (a) joint work to perform a feat that supersedes their individual capabilities, and (b) co-cogitation and co-regulation to achieve this joint feat. Co-regulation encompasses qualitatively different forms of co-action. The first is *entrainment* and is exemplified by periodic co-action and occurs in cycles. This can be illustrated with the example of rhythmic clapping (e.g., Neda et al. 2000). The second form is non-periodic co-action illustrated by *mimicry* or imitation (e.g., Chartrand & Bargh 1999). The third case is exemplified when people have to perform a complex task requiring interfacing each other's actions (as in open-heart surgery or playing tennis). The third case entails the execution of complementary actions, namely *coordination*, in the pursuit of accomplishing a task (e.g., successful surgery, winning in tennis).

Entrainment, mimicry, and coordination can obviously all occur simultaneously and to different degrees during social interaction. Take, for instance, a dialogue. Any dialogue features a variety of instances of multimodal coordination, entrainment, and mimicry. A dialogue can simultaneously manifest *coordination* as in the case of turn taking in a conversation (e.g., Sachs et al. 1974), or introducing a new topic, at a syntactic level (e.g., syntactic priming; Bock 1986; 1989; Bock & Loebell 1990) or at an affective level (e.g., mood contagion; Neumann & Strack 2000). Simultaneously, it is possible to see cyclically occurring instances of affective facial expressions (e.g., Dimberg et al. 2000) and breathing movements (e.g., Furuyama et al. 2005). Coordination and entrainment can converge when joint behavior is goal driven (e.g., playing tennis versus choral singing): It can be consciously accessible or escape conscious access (two people moving a heavy object versus emotional contagion), or a combination of both.

If the aim of the SCM is to fully understand the bases of emergent social cognition and behavior, then it has to incorporate a level of analysis of interacting dyads and beyond.

Goals are not implied by actions, but inferred from actions and contexts

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Abstract: People cannot understand intentions behind observed actions by direct simulation, because goal inference is highly context dependent. Context dependency is a major source of computational intractability in traditional information-processing models. An embodied embedded view of cognition may be able to overcome this problem, but then the problem needs recognition and explication within the context of the new, layered cognitive architecture.

Susan Hurley proposes a layered cognitive architecture to model, among other things, the human capacity for understanding people's actions. We applaud the effort because we believe cognitive science can benefit from pursuing alternatives to the traditional cognitive-sandwich account, especially when it comes to higher cognition (Haselager et al. 2003; van Rooij et al. 2002). We do see one potential problem with Hurley's conception of how layers 3 and 4 of the shared circuits model (SCM) implement our ability to understand the goals that drive people's actions.

According to the SCM, people understand why people act by "mirroring" the "means/ends structure of observed actions" (sect. 4, para. 5 [*layer 3*]). From reading the target article, it is less than clear what mechanism underlies the activity of mirroring, but Hurley seems to have in mind a non-inferential mechanism in which goals and actions are directly coupled. According to Hurley, this is made possible by the fact that humans can reverse the direction of the goal – action associations generated by their own goal-directed actions. As a result, Hurley argues, "observing movements generates motor signals in the observer that tend to cause similar movements" (sect. 4, para. 5 [*layer 3*]). When the motor outputs are inhibited to prevent overt copying, then the system is able to engage in a form of "mirroring [that] simulates in the observer the causes of observed action" (sect. 3.4, para. 5, layer 4 of the SCM).

This conception of inferred goals and their relationship to observed actions is not unproblematic. It seems implausible that a simple one-to-one association between action and goal can account for the intelligent ways in which humans infer goals from observed actions. Research shows that the goals that people infer depend in complex ways on the context in which the actions are observed. For example, the action "pushing a button with one's head" can suggest the goal "that the button be pushed" (e.g., when the person's hands are occupied holding a towel), or the goal "that the button be pushed with the head" (when the hands are free to do the pushing as well). Even infants are sensitive to such contextual factors, leading them to push the button with their hands after seeing an adult push it with her head while holding a towel in her hands, but pushing the button with their heads when the adult's hands were free during the action (Gergely et al. 2002). These observations underscore the problematic nature of Hurley's idea that "observing movements generates motor signals in the observer that tend to cause similar movements" (sect. 4, para. 5 [*layer 3*]). From the perspective of motor plans, after all, pushing a