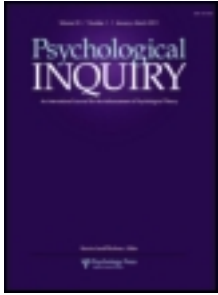


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Connectionism and Self: James, Mead, and the Stream of Enculturated Consciousness

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TARGET ARTICLE

Connectionism and Self: James, Mead, and the Stream of Enculturated Consciousness

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William James conceptualized I, the self as subject as a stream of consciousness. When this conception is augmented with George Herbert Mead's view of self as a radically socialized and enculturated process, a result is the James-Mead model of dynamic self as a stream of enculturated consciousness. In this paper, we argue that connectionism is best suited to theorize this challenging notion. Based on the view that a connectionist model should describe psychological processes that carry out psychological functions grounded in a biological living system, we propose the I-SELF (Imitative and Sequence Learning Functional) model, which is designed to capture the temporal dynamics of a stream of consciousness whose content can be acquired via symbolically mediated social interaction with others in society. We identify four implications of the James-Mead model of dynamic self (embodiment, narrative and self, individual and collective self, and culture and self), and report computer simulations to show the utility of I-SELF in conceptualizing the dynamic self-processes in the contemporary social psychological literature. Theoretical and metatheoretical implications of the connectionist approach to self are discussed.

Key words: connectionism, self, consciousness, culture, imitation, embodiment, cultural dynamics.

The first fact . . . is that thinking of some sort goes on.

William James (1890, p. 224, original emphasis)

More than a century on, William James remains one of the most fertile intellectual resources for psychologists. Particularly pertinent is his conceptualization of self. In *The Principles of Psychology*, James (1890, p. 225) listed five characteristics of the stream of thought, the first three of which are listed below (original emphasis):

1. Every thought tends to be part of a *personal* consciousness.
2. Within each personal consciousness thought is always changing.
3. Within each personal consciousness thought is sensibly continuous.

The first statement is about the personal nature of the stream of thought, thus, linking thought to self. The other two characterized thought as a changing and yet continuous process. Indeed, so interwoven were thought and self in his theorizing, James largely equated the two, declaring that the thinker, which James called *I*, the agent engaged in the process of thinking, is in fact the very process of thinking itself (James, 1890, p. 401). For James, then, thought and self are one and the same dynamic process, an intensely personal, constantly changing, and yet seamlessly continuous *stream*.

The Jamesian dynamic self, however, represents a challenge to contemporary self-psychology: how can a contemporary social psychology provide a theoretically principled description of such dynamic processes? We contend that much of the dynamism in James' model is missing from more contemporary attempts at theorizing *I*, self as a thinker (for reviews, see Greenwald & Pratkanis, 1984; Kihlstrom, Beer, &

Klein, 2003). There are two critical issues. The first is the inherent *temporality* of the dynamic processes. James's stream of thought is a flow of psychological events over time; a model of this process requires a mechanism to learn and reproduce a *sequence* of cognitive events. Much of social cognition is silent on this critical topic. More generally, it seems fair to say that social cognition has largely neglected the temporality of human action. Clearly, social events and actions occur in time. With some notable exceptions (e.g., Newton, 1973), however, social cognitive research has not dealt adequately with how we perceive, interpret, and participate in the stream of social interaction unfolding in time. The recent work on narrative thought (e.g., Bruner, 1990; Schank & Abelson, 1995; Wyer, 2004) speaks to this issue. Temporality is inherent in narrative (Ricoeur, 1984), which describes how events and actions unfold over time. A significant proportion of the dynamic Jamesian self may be narratively structured cognition unfolding in the stream of thought (e.g., Hermans, Kempen, & Van Loon, 1992; Nelson, 2003).

Nonetheless, James's conception is not quite enough in the contemporary perspective on the socio-cultural genesis of self. James's view is well known, which states, "a man (sic) has as many social selves as there are individuals who recognize him (1890, p. 294)". He clearly noticed the significance of the social. Yet, he fell short of recognizing the fundamentally socio-cultural nature of the stream of consciousness. To put it bluntly, James did not theorize fully where the bulk of its content and process come from. Another Pragmatist philosopher, social psychologist, George Herbert Mead (1934) augmented the Jamesian self by providing an answer to the question. The Meadean self is inherently *social*: a human individual's sense of self emerges from his or her on-going social interaction with others. Furthermore, to Mead, human social interaction is inherently *cultural*. That is, individuals interact with others using what he called *significant symbols*, those semiotic entities that give rise to similar responses in those who use them and those who receive them. In our current terminology, they are closely aligned with what we roughly call culture, a collection of meaning shared among people in a society (for a recent overview of symbolic interactionist approaches to self, see Smith-Lovin, 2002).

More specifically, in Mead's theorizing, self emerges in a sequence of cognitive events. When an action directed to others is initiated, a cluster of responses arises in the actor's mind in anticipated reaction to the initiated action. These responses are attributed to *Me*, or the generalized other. By observing how other social agents have responded to the actor's or others' similar actions in the past, and *by taking the role of those responding agents*, their responses and their implications are learned. In other words, *Me* is a memory of the implications of those social actions that other

people performed in similar circumstances in the past. In reaction to *Me*'s responses, the individual regulates his or her action. Here arises *I*, in Mead's theory. It is the regulator of one's social action in reaction to, and in internal dialogue with, *Me*, which resulted from the learning of structured social interaction patterns within the society.

Mead (1934, pp. 175–176) used a ball game to illustrate this point. Presuming that he had baseball in mind, here is our paraphrasing of what we think he meant. You catch the ball around the second base, and the player who hit the ball is dashing towards the first base. A cluster of organized responses arises in your consciousness in a split second. They may include a variety of responses that you learned from others in the past: others' expectations (or even verbal instructions) that you throw the ball to the first base player, fleeting images of the motor movements of someone demonstrating the throw of the ball, etc. Mead calls these responses *Me*. What you do in response to *Me* is your *I*'s doing. You throw the ball. Mead reminds us what your *I* does is not necessarily right—after all, you may make an error in throwing the ball. *I* is uncertain, novel, and shows some initiative, and therefore *I* is free. Mead's *I* is a well of individual agency, from which the spontaneous action springs. In short, *I* is a reactive agent that responds to *Me*; *Me* demands *I* to throw the ball, and *I* does so—perhaps with or without success.

The internal dialogue between *Me* and *I* as Mead described it seems but one instance of the content and process of the Jamesian self. Mead's *I* is James's *I*; Mead's *Me* is some of the antecedent thoughts that appear in James's stream of consciousness. What is noteworthy in Mead's theorizing is the hypothesized process by which *Me* arises. To use the ball game example again, imagine that you caught the ball for the first time in your life. You had never played a ball game before, but seen others play plenty of times. The *Me* that demands you to throw the ball is learned on the basis of your observations of other people's behaviors in similar situations in the past. By *taking the role* of other players, coaches, and spectators, you learn their words and deeds towards the second base (or short stop) players in baseball games you have seen in the past; these learned responses emerge as the cluster of organized "attitudes" that prompts you to throw the ball—the *I*'s doing. The role taking that Mead described is akin to *imitation* (also see James's imitation instinct). By imitation, we mean the acquisition of a new behavior that is not already in the imitating individual's behavior repertoire (e.g., Byrne & Russon, 1998). Mead's is not a simple, mindless imitationism, as Allport (1954) noted; it occurs within the organization of behaviors among multiple actors in society, which may be called a set of social roles. Nonetheless, it is in the tradition of theories (e.g., those of Bagefoot, Tarde, and Baldwin) that sought in imitation a principle to explain what

Allport (1954, p. 28) called “the overwhelming fact of social conformity in human behavior.” The contemporary social psychology has also come to see imitation as playing a significant role in socio-cultural processes (e.g., Dijksterhuis, 2005).

Thus, when James’s dynamic self is augmented by Mead’s socio-cultural self, a result is the *James-Mead model of dynamic self*, a conception of self that takes seriously the temporality, sociality, and cultural embeddedness of selfhood—one’s experience of oneself. A series of social events and actions may unfold over time in a stream of consciousness; a symbolic representation of such an event sequence may be coded into a narrative form; and an internal dialogue between *Me* and *I* may be based on dialogically patterned interaction sequences of the past. Thus, the dynamic stream of enculturated consciousness may be narratively get structured (e.g., Hermans, 1996; McAdams, 2001) and dialogically informed cognition (e.g., Hermans, 1996, 2002), strongly shaped by the stories and discourse available in one’s socio-cultural environment. How can such a vision be actualized within a contemporary theoretical framework? We believe connectionism provides one answer (also see Mischel & Morf, 2003). Critically following in James’s and Mead’s footsteps, we describe a connectionist approach that accords well with their dynamic conception of self, and argue that connectionism provides a suitable formal mechanism and conceptual apparatus with which to theorize it.

Four Implications of the James-Mead Model of Dynamic Self

In this paper, we present the I-SELF (*I*mitative and *S*equences *L*earning *F*unctional) model, a connectionist implementation of the James-Mead model of dynamic self, which addresses its temporality and socio-cultural embeddedness. We explore four of its implications, starting with a micro-level implication, namely, symbol grounding and embodiment, through its mezzo-level implications for narrative and self, and individual and collective self, and finally an implication in culture and self at a macro-level of cross-cultural difference in self-processes. Likewise, we report four simulation experiments, each addressing each implication, showing the utility of the I-SELF in simulating a broad range of psychological phenomena of interest to self-research.

First, Simulation 1 will demonstrate that the I-SELF is capable of imitation and sequence learning, the two functions that the model is designed to perform. In particular, the I-SELF will be trained to reproduce a sequence of simple behaviors performed by different agents including itself, and we show that it can learn the association between a motor behavior (e.g., clapping hands) and its symbolic description (e.g., “Clap hands.”). In doing so, we address one critical issue per-

taining to the socio-culturally embedded self, which Harnad (1990) called *symbol grounding*. It is a truism to say symbolically mediated social interaction, which Mead took to be his starting point of inquiry, requires that the interactants share an understanding of cultural symbols. For instance, a word or a phrase is a cultural symbol, and its meaning needs to be understood similarly by those who engage in an interaction using the symbol. At the very least, the interactants must have a shared understanding that a given cultural symbol refers to a certain object or object type. This sense of meaning is called referential meaning (there is another sense of meaning, but we will not address it directly here), and it is critical that a socio-culturally embedded self is capable of learning a referential meaning. Without this capacity, an agent has a symbolically constructed world disconnected from any concrete objects and events in the world. In particular, it is critical that a cultural symbol that refers to a human action is connected to the actual human bodily movement. Without this capacity, symbol-using creatures would not be able to describe each other’s action; this means they could not teach or instruct others what to do. Imagine the case where the fledgling second base player in the baseball example did not know what “Throw the ball!” meant. How would a coach instruct the player? The acquisition of referential meaning for objects and actions is at the heart of what a cognitive scientist, Barsalou, 1999; Barsalou, Niedenthal, Barbey, & Ruppert, 2003) called a perceptual symbol system and embodiment.

Second, symbol-using creatures construct a symbolically mediated world. Narrative is one of the most ubiquitous and universal examples of symbolic constructions (e.g., Lonner, 1980). A growing number of research programs have addressed the role that narrative plays in social psychological processes (e.g., Adaval & Wyer, 1998; Bruner, 1990; Green & Brock, 2000; Kashima, 1997; Lyons & Kashima, 2003; Pennington & Hastie, 1986; Schank & Abelson, 1995; Wyer, 2004). As we noted earlier, narrative is inherently temporal; partly for this reason, it is a medium that is suitable for symbolically capturing the temporality of social interaction, the fact that social interaction unfolds over time. In turn, narrative informs selfhood. Polkinghorne (1988), Gergen and Gergen (1988), Hermans and his colleagues (e.g., Hermans, 1996, 2002; Hermans Kempen, & van Loon, 1992), and McAdams and his colleagues (e.g., McAdams, 2001; McAdams, Diamond, Aubin, & Mansfield, 1997; McAdams & Bowman, 2001) have suggested that people’s conceptualizations about themselves and their lives often take a narrative form. In Simulation 2, we show that the I-SELF can learn a simple narrative sequence constructed on the basis of Greimas’s (1966) structural model of narrative. Once a narrative is learned by the I-SELF, the protagonist of the story may be substituted by a pronoun that refers to self, *I*

in English, and yet, it would reproduce the story with *I* as its main protagonist. To put it differently, we aim to show the close link between narrative and self by showing that the I-SELF appropriates a well learned story to construct one's own self-narrative.

Third, self-narrative is not always about *I*, the first person singular, but also about *We*, the first person plural. There are stories about an individual and stories about a collective. A collective narrative is often a story about a people (e.g., Bhabha, 1990; Feldman, 2001; Wertsch, 1998, 2002), for instance, their struggle and glory of emancipation against oppressive enemies, their ascent in status and recognition among the world's nations, and the celebration of their past achievements and hope for future. In Simulation 3, we explore how the I-SELF represents an individual and a collective narrative, or an *I*- and *We*-narrative, and how they relate to the individual and collective self. A number of research traditions have distinguished these two types of self-concepts. To name but a few, both the social identity tradition (e.g., Brewer & Gardner, 1996; Turner, 1987) and the culture and self research (e.g., Triandis, 1989; Markus & Kitayama, 1991) drew a distinction between self as an individual and self as a member of a group. In Simulation 3, we examine how the two kinds of selves may be represented in a connectionist model, and how pronouns, *I* and *We*, may prime those representations (Brewer & Gardner 1996), again producing a stream of the Jamesian self in which the I-SELF appropriates the individual and collective self-narrative.

Finally, we examine the implications of the James-Mead model of dynamic self, and its connectionist implementation, the I-SELF, in particular, within the contemporary research context of culture and self. One of the obvious implications of the current approach is that people should develop different streams of thought, or James's *I*, depending on the social information that they encounter in their environment. More specifically, the *prevalence* of different types of symbolic representations—including narratives and other types of representations—should have a critical effect on self. Triandis (1989) pointed out symbolic representations that imply different self-conceptions are more or less prevalent in different cultures, and that the more prevalent are symbolic representations, the more likely they are to be sampled or accessed. Markus and Kitayama (1991) suggested that a critical cultural difference lies in the extent of self-other differentiation, namely, the extent to which a person is construed to be separate from others (independent self-construal) or connected to others (interdependent self-construal). In Simulation 4, we suggest that pronoun use is one of the ways in which the self-other differentiation is symbolically constructed. Kashima and Kashima's (e.g., Kashima & Kashima, 1998; Kashima & Kashima, 2003) research suggest that pronoun drop—whether

people speak a language in which a personal pronoun such as *I*, *you*, and the like can be dropped grammatically when it is the subject of a sentence—is highly correlated with cultural variation such as Hofstede's (1980) individualism. In this simulation, we examine the relations between pronoun use and self-other differentiation developed in the I-SELF.

In the end, we hope not so much to convert self-researchers to connectionist modelers, but to provide a *new metaphor* for conceptualizing self-processes—the metaphor of self that is at once dynamic and structured, a kind of dynamic configuration, which is embodied and socio-culturally embedded. To be sure, theoretical frameworks (e.g., Hannover & Kühnen, 2004; Kihlstrom et al., 2003; Greenwald et al., 1984) exist that have given conceptual underpinnings to the voluminous literature on self. Nonetheless, our contention is that these models fall short in providing theoretical imaginations to capture the richness, complexity, and dynamism of self-processes, which the contemporary literature on self has begun to examine. A connectionist framework can supply a much-needed metaphor that we can live by.

A Connectionist Approach to Self

Connectionism is a broad conceptual framework within which to theorize a psychological phenomenon. Its basic theoretical impetus comes from the brain metaphor of cognition as attested by its alternative name, artificial neural networks. Biological human brains process information through neurons and their connections; likewise, in connectionism, a complex information processor that consists of myriad neuron-like units is hypothesized to generate human cognition. Unlike the Central Processing Unit (CPU) in the von Neumann type serial computers, each individual unit in neural networks follows a simple rule of receiving inputs from other units and producing an output, often following a simple nonlinear function. However, when a number of units process information in parallel, they can collectively produce unexpectedly complex phenomena. By now, its basic idea and operating mechanisms would be well known. Rumelhart, McClelland, and their colleagues' two volumes (Rumelhart, McClelland, and PDP Research Group, 1986) are classic. In social psychology, a broad introduction is available in Smith (1996) and Read, Vanman, and Miller (1996).

More specific applications of connectionism in social psychology have focused on such diverse social cognitive processes as causal attribution and explanation (e.g., Read & Marcus-Newhall, 1993; Read & Montoya, 1999; Van Overwalle, 1998), person and group impression formation and change (e.g., Fiedler, 1996; Kashima & Kerekes, 1994; Kashima,

Woolcock, & Kashima, 2000; Smith & DeCoster, 1998; Van Overwalle & Labiouse, 2004; Van Rooy, Van Overwalle, Vanhoomissen, Labiouse, & French, 2003), cognitive dissonance (e.g., Van Overwalle & Jordens, 2002; Schultz & Lepper, 1996), and attitude formation and change (e.g., Eiser, Fazio, Stafford, & Prescott, 2003; Van Overwalle & Siebler, 2005), resulting in a sizable literature of some complexity and subtlety. Some researchers have begun to use connectionism or other related theoretical frameworks to address self-processes. Smith, Coats, and Walling (1999) and Nowak, Vallacher, Tesser, and Borkowski (2000) used a connectionist or closely related dynamic model to explore self-dynamics. Mischel and Morf (2003) suggested that the self may be modeled within the CAPS (Cognitive Affective Personality System) model (Mischel & Shoda, 1995).

However, these models (as well as other non-connectionist models) are ill equipped to handle the James-Mead model of dynamic self because they do not model the two psychological functions that are critical to their conceptualizations, namely, temporality and imitative learning. We present a connectionist architecture, the I-SELF, that can do just that. We hasten to add that this is not an attempt to present large-scale simulations of realistic social psychological processes; we only show that the proposed architecture, or its variants, is *in principle* capable of modeling self-related phenomena. What follows is an existential proof that a physical mechanism akin to our connectionist architecture could model the James-Mead dynamic self. First, we present the architecture while outlining the general principles that we followed in constructing it. Second, we present four simulation experiments, which are designed to demonstrate the model's utility in shedding light on the four implications of the James-Mead model of dynamic self: symbol grounding, narrative and self, individual and collective self, and culture and self.

Functional Artificial Neural Network System

The current modeling approach has two main concerns. First, we wished to develop a *social psychological model*. Processes such as modality specific perceptions, motor behaviors, and language comprehension using syntactic, semantic, and pragmatic knowledge are assumed to occur, rather than modeled explicitly. Second, we wished to use an artificial neural network architecture that is informed by the current knowledge of biological neural information processing. To achieve these ends, we followed three principles:

1. self-processes are conceptualized in terms of *psychological functions*;
2. there should be known *neural mechanisms* that are capable of performing these psychological functions;

3. *artificial neural network architectures* should be able to carry out those psychological functions.

We call Functional Artificial Neural Network Systems those artificial neural networks that carry out psychological functions that have known neural underpinnings. This modeling approach is generally compatible with Marr's (1982) conceptualization of cognitive models: psychological functions are at his computational level; the neural mechanisms are at his implementational level; and we attempt to model at the algorithmic level, which describes how certain psychological functions are carried out. However, Marr's argument has historically been used as a justification for dissociating the three levels of analysis, so that investigations can proceed at the three levels independently of (or ignoring) each other. Instead, we acknowledge the importance of each level of research informing each other, and attempt to make use of the knowledge gained at the implementational level (neuroscience) to inform our theorizing at other levels. Other researchers presented similar views about neural network modeling (e.g., Elman, Bates, Johnson, Karmiloff-Smith, Parisi, & Plunkett, 1996; Lieberman, 2002).

In this paper, we attempt to model two psychological functions: *sequencing* and *imitation*. Sequencing, the learning and reproduction of sequences, is critical for the handling of the temporality of the Jamesian dynamic self. Recent research suggests that there are several brain regions that are involved in the processing of sequence information, including the prefrontal cortex, parietal cortex (e.g., DeRenzi & Lucchelli, 1988), cerebellum, and basal ganglia (e.g., Hikosaka et al., 1999). In particular, Grafman (2002) proposed that the prefrontal cortex is centrally involved in the representation of a structured sequence of goal-oriented events, which he called structured event complexes. Suggesting the critical importance of sequencing in narrative, Mar's (2004) review argued that the lateral prefrontal cortex is likely involved in the processing of sequence information in narrative as well. For instance, Crozier et al.'s (1999) fMRI study found that large areas of prefrontal cortex (as well as parietal and temporal cortices) are implicated in the processing of both a routine event sequence (script) and a sequence of words in sentences. These include the premotor area (Brodmann's area, BA6), the posterior part of the middle frontal gyrus (BA8), the inferior frontal gyrus (BA 44), the anterior and posterior parts of the superior temporal sulcus (BA22), and the supramarginalis gyrus (BA 40).

Imitation is a psychological function central to the socio-cultural shaping of self-processes. In order to imitate, or to reproduce the behavior of another individual, the observer must first transform a series of observed actions in allocentric space (i.e., space whose center is located in the other individual) into an executable motor program in egocentric space (i.e., space that is

defined in terms of the observer's own coordinates). Recent research suggests that this transformation may be instantiated in the so-called, 'mirror neuron system.' Mirror neurons possess the unique property of responding when an individual performs a particular action, as well as when the individual simply observes that action being performed (Rizzolatti & Craighero, 2004). In humans, the network of mirror neurons formed by the caudal part of the inferior frontal gyrus (BA 44, 45) and rostral part of the inferior parietal lobule forms the basis of an observation-execution matching system, through which we are able to mentally simulate the actions of others. This mirror neuron system plays a critical role, not only in the imitation of actions within the observer's own motor repertoire, but also in facilitating imitation learning. For example, neuroimaging data suggest that the mirror system recognizes and segments observed movements into discrete elements within the observer's motor repertoire (e.g., Buccino et al. 2004), and subsequently re-assembles these elements into a novel and complete motor action. The capacity of mirror neurons to match observed and executed actions therefore allows the actions of the observer and the actor to be encoded in a common neural format, and suggests an intimate relationship between self and other (Gallese, 2003).

I-Self (Imitative and Sequence Learning Functional Architecture)

In order to model the psychological functions of imitative and sequence learning, we developed the I-SELF, which stands for the *imitation and sequence/learning functional architecture*. A modeling of the James-Mead model of dynamic self requires a mechanism that can process a sequence of events, which is critical for the acquisition of narrative self; as well, the capacity to learn such information by imitation, from other social agents, is a central aspect of Mead's vision of socio-cultural self. Figure 1 presents a schematic representation of the architecture. It combines two well known connectionist architectures: One modeled the imitation function, that is, to imitate and learn an event representation at a time (*Feedforward Network* with one hidden layer: FN), and the other modeled the sequencing function, namely, to learn event sequence (*Simple Recurrent Network*: SRN, Elman 1990). We used the standard backpropagation algorithm for both. FN has been used in earlier social cognitive applications; a similar architecture has been used to model imitation elsewhere (e.g., Oztop, & Arbib, 2002; Tani, Ito, & Sugita, 2004). SRN is perhaps new to social psychology although it has been used to model language processing (e.g., Dell, Berger, & Svec,

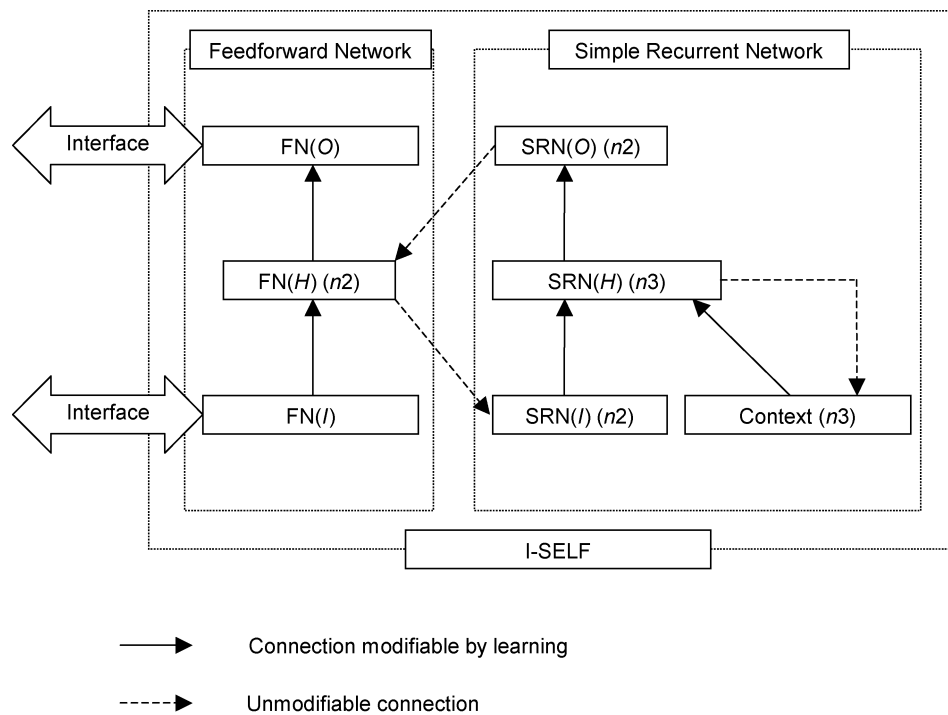


Figure 1. A schematic depiction of the I-SELF (Imitative and Sequence Learning Functional) architecture consisting of two functional neural network systems, Feedforward Network (FN) and Simple Recurrent Network (SRN). Note: FN stands for Feedforward Network; SRN stands for Simple Recurrent Network; I, O, and H in the parentheses indicate input, output, and hidden layers; $n1$, $n2$, and $n3$ stand for the numbers of units in each layer.

1997; Elman, 1990) and routine motor action (e.g., Botvinick & Plaut, 2004).

FN is an imitator, which basically takes in other agents' behaviors and other verbal behaviors into the system, and learns to reproduce them. FN consists of one input layer, FN(I), one hidden layer, FN(H), and one output layer, FN(O). The number of units in FN(I) and FN(O) is n_1 ; FN(H) has n_2 units. Each unit of the FN(I) layer is connected to each unit in the FN(H) layer, which is in turn connected to each unit in FN(O); the connection strength is modified in accordance with the learning algorithm. n_2 is set at $n_1/2$; when n_1 is an odd number, $n_2 = (n_1 - 1)/2$. FN encodes inputs into internal representations, which are then decoded into the output. FN(I) therefore represents the allocentric spatial and movement information, where an observed agent's action is encoded; FN(O) produces the network's egocentric spatial and movement information, in which the actor's own action is generated. The internal representations are then fed into SRN.

SRN is a sequence learning mechanism, which learns which input is followed by what input in the FN. SRN has an input layer, SRN(I), a context layer, SRN(C), a hidden layer, SRN(H), and an output layer, SRN(O). The number of units in SRN(I) is n_2 , the same as that of FN(H), because SRN(I) receives the output from FN(H). For the reason to be explained later, SRN(I) and SRN(O) have the same number of units; SRN(C) and SRN(H) too have the same number of units, which is n_3 . We set n_3 to be twice as many as n_2 . Note that the connections of FN(H) with SRN(I) and SRN(O) are not modifiable and remain at unity; likewise, neither are the connections between SRN(C) and SRN(H).

Each unit is the standard processing unit with a sigmoid activation function: when a certain amount of activation is received by the unit, it is activated at a level defined by the following equation: $\text{output} = 1 / (1 + \text{Exp}[-\text{input}])$, where "input" is the total amount of activation that the unit has received. An output from a unit then spreads to a connected unit, which receives an input that is a linear function of the product of the output and the connection strength. The receiving unit then sums all the inputs from the connected units, which then is the total input into this unit. Its activation is again determined by the above equation.

This architecture learns a stimulus sequence (i.e., a series of temporally ordered stimuli) in two cycles, one for FN and the other for SRN. First, a first stimulus is presented to FN(I). Each unit's activation spreads to connected units in FN(H), whose activations are fed forward to FN(O). Each unit's activation level is then determined. The discrepancy between the initial activation and this updated activation for each unit is used to modify the connections between the FN(I) and FN(H) and those between FN(H) and FN(O) in accordance with the standard backpropagation algorithm. A second stimulus is then presented to FN(I), and the process recurs.

Second, the spreading activations from FN(H) to SRN(I) initiate the cycle for the sequence learning in SRN. The activations in SRN(I) and those in SRN(C) spread to SRN(H), whose activations cascade to SRN(O). SRN(H) activations also spread to SRN(C) to function as the context for the next stimulus. At this point, the outputs in SRN(O) are compared to the activations in FN(H) for the next stimulus. The discrepancy between them is used to modify the connection strengths in SRN. Table 1 describes the processes.

Table 1. *Simulation Steps for Learning*

	Feedforward network	Simple recurrent network
1	FN(I) activations for stimulus t	
2	FN(I) activations spread to FN(H)	
3	FN(H) activations	
4	FN(H) activations spread to FN(O)	FN(H) activations spread to SRN(I)
5	FN(O) activations from FN(H)	SRN(I) activations from FN(H) SRN(C) activations
6	Compare activations in FN(I) (step 1) and activations in FN(O) (step 5)	SRN(I) & SRN(C) activations spread to SRN(H)
7	Modify connection strengths	
8	<i>FN(I) activations for stimulus $t+1$</i>	SRN(H) activations
9	<i>FN(I) activations spread to FN(H)</i>	SRN(H) activations spread to SRN(O) and to SRN(C)
10	<i>FN(H) activations</i>	SRN(O) activations
11	<i>FN(H) activations spread to FN(O)</i>	Compare activations in SRN(O) and FN(H) for stimulus $t+1$ and modify connection strengths
		<i>FN(H) activations spread to SRN(I)</i>
12	<i>FN(O) activations from FN(H)</i>	SRN(I) activations from FN(H) SRN(C) activations from SRN(H)
13	<i>Compare activations in FN(I) (step 8) and activations in FN(O) (step 12)</i>	SRN(I) & SRN(C) activations spread to SRN(H)
14	<i>Modify connection strengths</i>	–

Note: For the auto-associator, the steps from 1 to 7 constitute one cycle; for the simple recurrent network, the steps from 4 to 11 constitute one cycle.

In sum, FN learns to imitate each input stimulus accurately and produces an internal representation in the process, and SRN learns the order in which these internal representations were processed. FN constitutes a mechanism for imitation, whereas SRN is a mechanism for sequence learning. In combination, they are capable of learning event and action sequences and narratively structured symbolic representations of such event sequences by imitation. What follows is a demonstration that the I-SELF is indeed capable of doing what it is designed to do, and an exploration of the implications of this modeling approach to psychological inquiries into self-processes.

Simulation 1: Imitation, Sequence Learning, and Embodiment

In the first simulation, we demonstrate that the I-SELF can learn a sequence of social behaviors. Imagine a simple children's game. Several children sit around on the floor to form a circle. There is a leader (let's call her agent 1) who first performs a certain bodily movement (e.g., hand clapping) while describing the behavior verbally (e.g., "Clap hands"), other children each take turns (e.g., agent 2, agent 3, and so on) to imitate the behavior and the verbal description. Once all children perform the same behavior, the leader starts another round with a new behavior (e.g., ear pulling) and its verbal description. This game can be thought of as consisting of a sequence of events, in which each event involves both an agent's behavior (e.g., agent 1 performs certain hand movements) and its symbolic description (e.g., she claps hands). In as much as a child's play forms a basis for social self (e.g., Mead, 1934; Bretherton, 1984), it is perhaps fitting to show that the simulation architecture is capable of learning this type of simple sequence of events.

There are two additional purposes. First, we will show that the I-SELF can learn an association between a behavior and its symbolic description, so that the system can "call" a behavior by its appropriate symbolic code and produce the right behavior when its symbolic code is mentioned. In a sense, this implies that symbols are *embodied* (e.g., Barsalou et al., 2003; Niedenthal, Barsalou, Winkielman, Krauth-Gruber & Ric, 2005; Zwaan, 2004). To further demonstrate that embodiment is part and parcel of this architecture, we will show that the internal activation pattern for a behavior and that for its symbolic code are similar to each other; this is analogous to showing that similar regions of the brain are implicated for the processing of the behavior and its symbolic representation.

Second, we will show that the present architecture develops a "mirror" quality, in that the internal representation of other agents' behavior "mirrors" (or is similar to) that of the learning agent's own behavior.

As discussed earlier, both humans and some species of monkeys have a mirror-neuron system. This is operationally defined in neuroscience as the observation that a conspecific's and one's own behavior activate similar regions of the brain. Likewise, we show that the internal representation of one's own behavior is similar to the internal representation of others' same behavior.

In this simulation, we train an agent with a sequence of behaviors in which four agents (Agent 1 to Agent 4), one of which is the learning agent itself take turns to perform four different behaviors (behavior 1 to behavior 4). We assume that the learning agent is Agent 2, the second agent to participate in this sequence, and that the behaviors are coded symbolically by linguistic phrases. For the purpose of simulation, what they are called does not matter because symbolic coding is arbitrary, but we give them labels for ease of communication, *hand clapping*, *ear pulling*, *lap slapping*, and *head touching*. Furthermore, we assume that each agent is referred to by a pronoun from the learning agent's perspective. Agents 1, 3, and 4 are referred to by a third person pronoun, *s/he*, in this simulation; Agent 2 is referred to by the English first person singular pronoun, *I*. Each event consists of an agent's behavior (e.g., Agent 1 behavior 1) and its symbolic coding (e.g., *s/he* clap hands). To simplify the simulation, we will not follow the English syntax perfectly (for instance, we will describe, "*s/he* clap hands" instead of "*s/he* claps hands," without following the rule of subject-verb agreement).

Method and Results

The simulation code was written in *Mathematica* adapting Freeman's (1994) codes. The learning rate for the FN system was set high at 2 and that for the SRN was set low at 0.5. One sequence of behaviors is listed in Table 2. In this simulation, 4 agents, 4

Table 2. *Event Sequence Used in Simulation 1*

Behavior		Symbolic code	
A1	b1	s/he	hand clapping
A2	b1	I	hand clapping
A3	b1	s/he	hand clapping
A4	b1	s/he	hand clapping
A1	b2	s/he	ear pulling
A2	b2	I	ear pulling
A3	b2	s/he	ear pulling
A4	b2	s/he	ear pulling
A1	b3	s/he	lap slapping
A2	b3	I	lap slapping
A3	b3	s/he	lap slapping
A4	b3	s/he	lap slapping
A1	b4	s/he	head tapping
A2	b4	I	head tapping
A3	b4	s/he	head tapping
A4	b4	s/he	head tapping

behaviors, 2 pronouns (I and s/he), and 4 symbolic codes (hand clapping, etc.) were involved, and one unit in the input layer was dedicated for each of these. For instance, one unit represented “I”, another unit represented “Agent2”, still another unit represented “hand clapping”, etc.; the total of 14 units (4 + 4 + 2 + 4 = 14) was included in the input layer of the FN system.

First, we examined how many times the sequence needed to be presented for the network to learn the sequence. In the learning phase, the sequence was presented 50, 100, and 150 times or epochs; in the test phase, we fixed the connection weights and observed whether the correct sequence was reproduced in the output layer when the first input was presented in the input layer. We defined a correct response as the case in which only the correct unit was activated in FN(O) at 0.5 and above. Even if the correct unit gained the highest activation, or if it did not reach 0.5, we defined it to be incorrect. By this definition, if more than one units were activated, the output was deemed incorrect. We followed the same procedure in all simulations throughout. In all cases, the correct sequence was reproduced; the system could learn the simple sequence of events: namely, who does what in what order.

Next, we repeated 20 times the same procedure with 50 epochs of learning. For all simulation runs, the correct sequence was reproduced. In addition, in the test phase of each simulation run, we examined whether this architecture has learned the association between a behavior and its symbolic code. In each simulation run, we activated a behavior (e.g., behavior 1) in the input layer and observed whether the corresponding symbolic code (e.g., hand clapping) was activated in the output layer; we also activated a symbolic code and observed whether the corresponding behavior was activated in the output layer. In all simulation runs for all behaviors and symbolic codes, this correspondence

was observed, clearly showing that the system is capable of learning the behavior-symbol association.

We also examined whether the system exhibits the mirror and embodiment properties by adopting the following procedure. In the test phase of each simulation run, we activated an input for one’s own behavior (e.g., Agent 2 behavior 1), other agents’ same behavior (e.g., Agent 3 behavior 1), and the symbolic code of one’s own behavior (e.g., I clap hands), and recorded the corresponding hidden layer activation pattern, FN(H). We then examined (a) the similarity between the activation patterns (mathematically treated as vectors) representing one’s own behavior and symbolic codes, and (b) the similarity between the activation patterns representing one’s own behavior and others’ behaviors. Similarity was indexed by computing a normalized dot product (i.e., the sum of the cross-products divided by each vector’s length), which (a) is used to examine embodiment, and (b) to examine the network’s mirror property.

The index (a) showed a clear pattern of embodiment. The activation pattern for a symbolic representation of a behavior was very similar to that for the same *matched* behavior ($M = 0.996$, where the maximum value was 1), but it was much less similar to that for other *unmatched* behaviors ($M = 0.847$). Table 3 reports the mean similarities of a symbolic representation with the matched and unmatched behaviors. A planned contrast comparing the mean index (a) of matched and unmatched behaviors was highly significant (see Table 3). To put it differently, the internal representation of a symbolic representation of a behavior was very similar to that of the behavior itself, suggesting the embodied symbolic representations.

Likewise, the index (b) suggested a mirror property of the internal representations developed in this connectionist system. The activation pattern for one’s own

Table 3. Mean Dot Products (Similarities) of the Hidden Layer Activation Patterns of a Self’s Behaviors to Matched and Unmatched Symbolic Representation (Index A: Embodiment) and Others’ Behaviors (Index B: Mirror Property)

	Hand clap	Ear pull	Self’s own behavior		F(1,19)
			Lap slap	Head tap	
Symbolic representations					
Symbolic hand clapping	0.999	0.852	0.844	0.846	389.94
Symbolic ear pulling	0.855	0.999	0.846	0.840	347.92
Symbolic lap slapping	0.846	0.846	0.999	0.850	340.54
Symbolic head tapping	0.849	0.844	0.851	0.987	.85.58
Others’ behaviors					
Others’ hand clapping	0.901	0.745	0.739	0.742	339.23
Others’ ear pulling	0.750	0.901	0.742	0.736	375.60
Others’ lap slapping	0.736	0.736	0.900	0.743	435.40
Others’ head tapping	0.743	0.739	0.745	0.892	205.85

Note: The bold figures indicate the mean dot products for matched behaviors; all F-tests are significant at 0.0001 level.

behavior was highly similar to that for other agents' same (matched) behavior ($M = 0.899$), but it was less similar to that for other agents' unmatched behaviors ($M = 0.741$). Again, Table 3 reports the mean similarities of self's behavior with others' matched and unmatched behaviors. A planned contrast comparing the mean index (b) of matched and unmatched behaviors was highly significant (see Table 3). The hidden layer units reacted to a behavior similarly regardless of whether it was executed by the self or others, exhibiting a property akin to the mirror-neuron systems found in monkeys and humans.

Discussion

This simulation showed that in principle the I-SELF could learn embodied symbols by imitating others' behaviors. In doing so, it learns the association between symbols and their referents. Furthermore, because of its imitation function, it develops a mirror-quality, that is, the tendency to generate similar internal activation patterns for its own execution of a behavior and observations of others' performance of the same behavior. In other words, the model develops an internal representation of a behavior that is involved in its execution, observation, and symbolic representation such as language. This simulation result is in line with ideomotor theory of action that was suggested by William James (1890) among others, and resurrected in contemporary theories of volitional action (e.g., Greenwald, 1970; Prinz, 1997). Namely, the mental representation and the execution of an action involve the activation of the same internal representation. Furthermore, the I-SELF suggests that these internal representations of motor actions may be closely associated with, or involve the same neural circuits as, their symbolic and linguistic representations. Indeed, some (e.g., Arbib, 2005; Rizzolatti & Craighero, 2004) have even argued that the mirror system formed the foundation of humans' linguistic (and presumably symbolic) capacity. This is partly based on the observation that monkey mirror neuron areas are homologous to human language areas.

The I-SELF's property—the acquisition of an internal representation of a behavior that binds the observation, enactment, and symbolic representation of the behavior—provides an explanation for the recent research on automatic mimicry (for a recent review, see Chartrand, Muddox, & Lakin, 2005). A series of studies have shown that in interpersonal contexts, the mere perception of others' actions increases the likelihood of the performance of those same actions by the perceiver. For example, Chartrand and Bargh (1999) demonstrated that participants automatically mimicked the specific gestures of a confederate, such as rubbing one's face or shaking one's leg, without any awareness of having done so (also see Brass, Bekkering, & Pinz, 2001; Craighero, Bello, Fadiga, & Rizzolatti, 2002;

Kilner, Paulignan, & Blakemore, 2003). In addition, other studies showed that the activation of symbolic representations, such as linguistically coded personality traits and stereotypes, which are associated with specific behaviors, could automatically activate the corresponding behavior. In studies where participants were primed with certain traits while engaging in an unrelated task, they were more likely to demonstrate the behavior consistent with the primed trait (Bargh, Chen, & Borrows, 1996; Epley & Gilovich, 1999; Macrae & Johnston, 1998). For example, Bargh, et al. (1996, Experiment 1) showed that participants primed with traits related to "rudeness" (or politeness) responded more rudely (or politely) than a control group: namely, it took them shorter (or longer) to interrupt a conversation, respectively. Similarly, other studies have shown that those who perceived a member of a stereotyped group were more likely to engage in the behavior associated with the stereotype. The activation of the stereotypes of the elderly resulted in younger adults behaving in the way consistent with the elderly stereotype, for example, responding more slowly in a lexical decision task (Dijksterhuis, Spears, & Lepinasse, 2001), walking more slowly down a corridor (Bargh, et al., 1996, Experiment 2), and performing worse on a memory task (Dijksterhuis, Aarts, Bargh, & van Knippenberg, 2000). Likewise, when participants were exposed to male African American faces, they expressed greater hostility after provocation, in line with the stereotype of male African Americans being hostile (Bargh et al., 1996, Experiment 3). Dijksterhuis and van Knippenberg (1998) even showed that when participants were asked to think about college professors, who are generally associated with 'intelligence,' they performed better on a general knowledge test than the control group. Conversely, when participants were asked to think about soccer hooligans, generally associated with 'stupidity' they performed worse on the general knowledge test compared to the control group.

A neural network that can construct internal representations that align the observation, execution, and symbolic representation of a motor action is highly functional for a species that engages in a culturally mediated social living. This is not only because one can learn adaptive behavior from other conspecifics, but also because one can be instructed to perform a behavior by symbolic means. Just like what Mead called significant symbols, a symbolic representation (e.g., linguistic labels of a behavior, such as "Clap hands") learned in association with an observed and executed action acquires a capacity to invoke in the agents such internal representations that can give rise to similar images of the observed and executed action. By producing such a symbolic representation (e.g., saying "Clap hands"), one can instruct others to perform what one simulates in one's mind. This way, symbolic representations acquire the capacity to socially regulate

others' behaviors. The I-SELF is an instance of an artificial neural network capable of achieving the alignment among the physical, mental, and symbolic representations of a sequence of human actions.

Nonetheless, simply mimicking others' behaviors presents problems for social coordination, and indiscriminately doing what has been told to do has obvious problems. We discuss these issues in the final section of the paper.

Simulation 2: Narrative and Self

An agent that can learn a sequence of embodied symbolic representations of actions would be able to learn narrative, which is after all a symbolically constructed action sequence. Labov (1972) defined a minimal narrative as two temporally ordered clauses in the past tense. When an extended sequence of such temporally ordered clauses, which describe a number of social actions, is strung together, it would surely be a good candidate of a story (though it may not be a *good* story). Although theorists define narrative variously, there is typically one element in common. Narrative involves a goal-directed action sequence (e.g., Burke, 1969; Greimas, 1966). Narrative, then, can be construed as a symbolic representation about self-regulation, providing an example of what goal to pursue and how to pursue it (or what *not* to pursue and how *not* to pursue it, for that matter). If appropriated, narrative may provide people with guidance for construing themselves. For instance, a retired African American police chief may narrate his life story as one of redemption, where his encounter with Reverend King turned his frustrated ambition into a successful police career (McAdams & Bowman, 2001). Likewise, a school headmaster may tell his students how he redeemed his life by turning his wasted youth into a devotion to the next generation. In a story of redemption, the self is the protagonist in pursuit of a good life. If the goal is to have a good life, the hard work and struggle is the means to achieve it. A redemptive story has a generative process and a happy ending. Understandably, those with redemptive self-narratives tend to have high levels of well-being (McAdams, Reynolds, Lewis, Patten, & Bowman, 2001).

Although a well learned story may act as a self-regulatory guideline in general, transportation (e.g., Green, 2005; Green & Brock, 2000) is a factor (among a number of other factors; e.g., Feldman, 2001) that may affect the degree to which one appropriates a story, which in turn influences one's self in particular. Transportation is the experience of being carried away (or transported) into the world of a narrative—the people, objects, and events in the world that are symbolically constructed by the story. Green and Brock (2000) showed that when transported into a narrative world, people are influenced by the story through a

psychological mechanism distinct from cognitive elaboration of a persuasive argument. Although the exact mechanisms underlying narrative social influence are unclear at this stage, one of the processes involved in the transporting experience is a reader's identification with the protagonist of the story. In this simulation, we examine whether the I-SELF can learn a simple narrative, appropriate it, and simulate the effect of transportation.

Method and Results

We constructed a simulation stimulus following Greimas (1966), who proposed a structural model of narrative on the basis of Propp's (1968) analysis of Russian folktales. According to Greimas, a narrative typically involves three thematic axes, each of which connects two central roles in a story. There is the axis of desire, which links *Subject* with *Object*. It captures the theme of how the protagonist of the story (Subject) pursues the goal (Object). The axis of conflict captures the conflict between people, objects, and events that help the protagonist to pursue the goal (*Helper*) and their opponents that hinder the protagonist's goal pursuit (*Opponent*). Finally, the axis of communication describes the transfer of an object to a recipient, or from *Sender* to *Receiver*. We beg the reader's forgiveness for the following rather androcentric example, but it serves the purpose of illustration. In a fairytale of a prince who rescues a princess, Subject is the prince, Object, the princess. Helper may be a dragon slaying sword, and Opponent may be the evil dragon. In this tale, Sender is perhaps the king, the father of the rescued princess, who transfers the object of desire, the princess, to Receiver, who in this instance is the rescuing prince. In Greimas's scheme, a story describes a sequence of events that lead up to either euphoric (Subject attaining Object) or disphoric (Subject not attaining Object) end.

A simple skeletal story was constructed on the basis of Greimas's model. It consisted of a sequence of nine inputs, each of which was meant to describe an episode in a story. Table 4 lists the sequence. The I-SELF was trained to reproduce this story. In the network input layer, FN(I), there were 14 units: one unit for the English first person singular pronoun, *I*, and one unit for each word in the second column of Table 4 (13 words in total, which were Subject, Object, Helper, Opponent, Sender, have, want, approach, prevent, avoid, help, defeat, and give). Although a pre-test showed that it was possible to do so after 50 epochs, we exposed a network to the story 500 times to ensure that the story was well learned. In this experiment, we repeated the simulation ten times and every time, it could reproduce the correct sequence. That is, when input 1 was presented to the network, it was able to reproduce the correct input 2; the correct input 3 for input 2, and so on.

Table 4. *A Story Sequence Used for Simulation Experiment 2*

Narrative structure	Example
1 Sender have Obj	A king has a beautiful princess.
2 Sbj want Obj	A prince falls in love with the princess.
3 Sbj approach Obj	The prince serenades the princess.
4 Op prevent Sbj	A rival prince blocks the prince's advance.
5 Sbj avoid Op	The prince avoids confrontation with the rival.
6 H help Sbj	The prince's friend helps him.
7 Sbj defeat Op	The prince defeats the rival in a contest.
8 Sender give Sbj Obj	The king allows the princess to wed the prince.
9 Sbj have Obj	The prince marries the princess.

Note: the verb inflections in the second column are ignored; Sbj = Subject; Obj = Object; Op = Opponent; H = Helper.

In order to examine the effect of a well-learned narrative on self-processes, we tested a trained network by activating the *I* unit instead of the Subject unit. Metaphorically, this can be construed as self's, or *I*'s, appropriation of the narrative. For instance, input 2 in Table 4 would be coded as [I want Obj] instead of [Sbj want Obj]. In order to simulate the degree of transportation, we tested this in two conditions. In the non-transported condition, a test was done with the same inputs as the training set with the modifications specified above. In the transported condition, input 1 was the same as in the non-transported condition, but the subsequent inputs were the outputs produced by the network, again with the modifications. In other words, the output produced by the network, when the first input was activated in the input layer was then modified by activating the *I* unit to the maximum level; and setting the activation level for the Sbj unit at the minimum, and this modified output was used as the next input. This process was repeated for the next output, and continued for the subsequent outputs until the last output in the story was produced. To put it differently, in the latter transported condition, *I* was inserted into the stream of outputs (stream of thought) whereas in the former non-transported condition, each step of the story was activated with *I* as the protagonist. The use of the network's own outputs in the transported condition was intended to signify that the agent was transported into the stream of events depicted in the story.

Each time when the network was trained, we tested it with the transported and non-transported testing conditions. When the transported test stimuli were used, the network was able to reproduce the correct sequence perfectly 100% of the time, ten times out of ten simulations. Even when the non-transported stimuli were used, it could reproduce the correct sequence 50% of the time, five out of 10. On the average, 7.2 out of eight sentences were accurately reproduced. The differences in the numbers of accurately reproduced sentences be-

tween the two test conditions were computed, and averaged to see if this statistically differed from zero. A *t*-test showed that it was significant, $t(9) = 2.45$, $p = 0.037$. A well-learned narrative became a self-narrative especially when the agent was transported into the world of the narrative.

Discussion

Narrative constitutes a symbolically constructed world of people and objects interacting with each other and events and actions unfolding over time. It is one of the most prevalent and universal forms of human communication. As a goal-directed event sequence, it can be construed as a cultural medium for self-regulation—it can provide guidance for what goals to pursue and how to pursue them. Nonetheless, symbolic representations such as a story may enter into social reality through our appropriations of them, namely, when people liken themselves with the protagonist of the story, identify with them, and regard it as an appropriate description their own self and use it as guidance. The I-SELF can simulate an aspect of the complex process of psychological appropriation of cultural products. Without a doubt, what is presented here is not the whole story—or not even a major part of the phenomenon. However, the simulation showed that the psychological functions modeled by the I-SELF enable us to begin to theorize a mechanism to carry out this cultural mediation process, a critical one for humans as symbol using cultural animals.

Simulation 3: Individual and Collective Self

Culturally available narratives are not always about an individual as the protagonist. More often than not, cultural narratives are about a collective. Collective narratives—stories in which the protagonist is a group of people—are a significant source of a collective identity (e.g., Ashmore, Deaux, & McLughlin-Volpe, 2004; Jacobs, 2002; Wertsch, 1998, 2002). A collective narrative often serves the function of making sense of and legitimizing the past, present, and potential future courses of action of a collective such as a nation state (e.g., Wertsch, 1998, 2002; White, 1980–1981). For instance, American college students often construe the history of the United States as a story of a “quest for freedom,” according to Wertsch (1998). Starting with the Pilgrims' quest for a religious freedom in the New World, the 13 states' fight for political freedom in the Independence War, and so on, the recurrent theme in the students' narration about their own country was the story in which the White Americans as the collective were portrayed as the protagonist that struggled for (and won) freedom. Somewhat more pejoratively, Feldman (2001) suggests that what Engelhardt (1995)

called *triumphalism* is an American national narrative. It is a recurrent theme in the American movies and stories about cavalries and Indians, the World War II, and the like, in which Americans (typically White Americans) are portrayed as the main characters morally wronged by an opponent (Indians and enemies), who is eventually annihilated by the morally superior protagonist. The eventual triumph marks a moral victory. A collective narrative is a symbolic medium by which the moral and historical meaning of the collective is constructed and conveyed through public discourse (e.g., Bhabha, 1990; Liu & Hilton, 2005; Solomon, 2004).

Collective narratives are significantly connected with collective selves, those aspects of self-representations that define oneself as a member of social groups. A number of researchers have suggested that collective narratives often shape the individual self-narratives of those who strongly identify with the collective (Ashmore et al., 2004; Feldman, 2001). Indeed, the past research has shown significant connections between collective narratives and collective self-concepts. Trafimow, Goto, and Triandis (2001) had their participants read a story in which an individual or a collective (family) was the protagonist. Those who read the collective story mentioned a greater proportion of items that related to collective self (e.g., social identity, family role) than those who read the individual story. In this simulation, we explored how the I-SELF may learn and represent individual and collective narratives, and how they may be accessed and activated through the priming of personal pronouns, *I* and *We*. We had the network learn two kinds of stories, one that involves *I* individual self as Subject, and the other that involves *We* collective self as Subject. We then primed the network with the person pronouns, *I* and *We*, to show that the results can be interpreted to parallel Brewer and Gardner's (1996) priming experiments, in which they showed that, by having people read a story in which *I* or *We* is the protagonist, personal or collective aspects of oneself became more salient as measured by a variety of cognitive tasks.

Method and Results

We simulated the acquisition of an individual story in which a single person, who takes the first person singular perspective, *I*, and the learning of an analogous collective story in which a collective, *We*, becomes the protagonist of the story. There were 20 units in the input layer of the network, FN(I): the same 13 units as in Simulation 2, two units for *I* and *We*, and five units for Agents 1 through 5. We used the same story sequence as in Simulation 2; however, we modified the inputs so that in one story sequence (I-story), the *I* unit was activated, and in the other story sequence (We-story), the

We unit was activated instead. When the *I* unit was activated, the input unit signifying Agent 1 (A1) was also activated, signaling that Agent 1 is *I*; likewise, when *We*-unit was activated, the input unit signifying Agents 1, 2, and 3 (A1, A2, and A3) were also activated, signaling that "We" referred to these three agents, but not the other two agents, Agents 4 and 5. In the training phase of the simulation, one training block consisted of one sequence of I-story and one sequence of We-story. The order of the two stories was randomly varied. Each network was exposed to a training block 600 times. To test each network, we followed the procedure we used for the transported condition in Simulation 2. Namely, the first input in each of the I- and We-story was activated in FN(I), the output in FN(O) was then activated in the input layer, FN(I), the next output in FN(O) was then fed into FN(I), and so on. We trained and tested 10 networks this way, and in every network, the story reproduction was perfect.

In order to examine the internal representations acquired within networks, we recorded the SRN(H) for each input in the I- and We-stories, and conducted a multidimensional scaling analyses. A typical MDS solution is displayed in Figure 2. In this instance, a two dimensional solution was a good fit with a normalized raw stress value of .01 and Tucker's coefficient of congruence of .99. Each story is represented in the multidimensional space as a trajectory: the I-loop represents a movement of the activation from the first input in the individual story (I1) to the last input (I8), and the We-loop represents an analogous movement in the collective story. It is interesting to note that the two story trajectories are similar, but different. It is as if one segment of the stream of thought is represented by a trajectory of the activations. When one's stream of thought enters into the I-story (i.e., I1), it carries itself through to its endpoint (i.e., I8); when the We-story takes over, the stream of thought takes one to the endpoint of the We-story (i.e., We8), which is somewhat different to that of the I-story.

This simulation reproduced the well-replicated pronoun priming effect (e.g., Brewer & Gardner, 1996), in which the salience of the first person singular or plural pronouns (*I* or *we*) has been found to affect cognitive processes. This empirical finding can be understood as a consequence of the activation of the *I* or *We* unit. In particular, when the *I* unit is activated in the input layer (i.e., *I* is primed), the *I*-unit and the associated agent units, namely, the unit for Agent 1, should be activated in the output layer. Likewise, the activation of the *We* unit (priming of *We*) in the input layer should activate the *We*-unit and the associated agent units, namely the units for Agents 1, 2, and 3, in the output layer. However, other units should not show a systematic pattern of variation. To test this, for each trained network, we activated the *I* or *We* unit in the input layer, FN(I), and observed the activation levels of the units in the

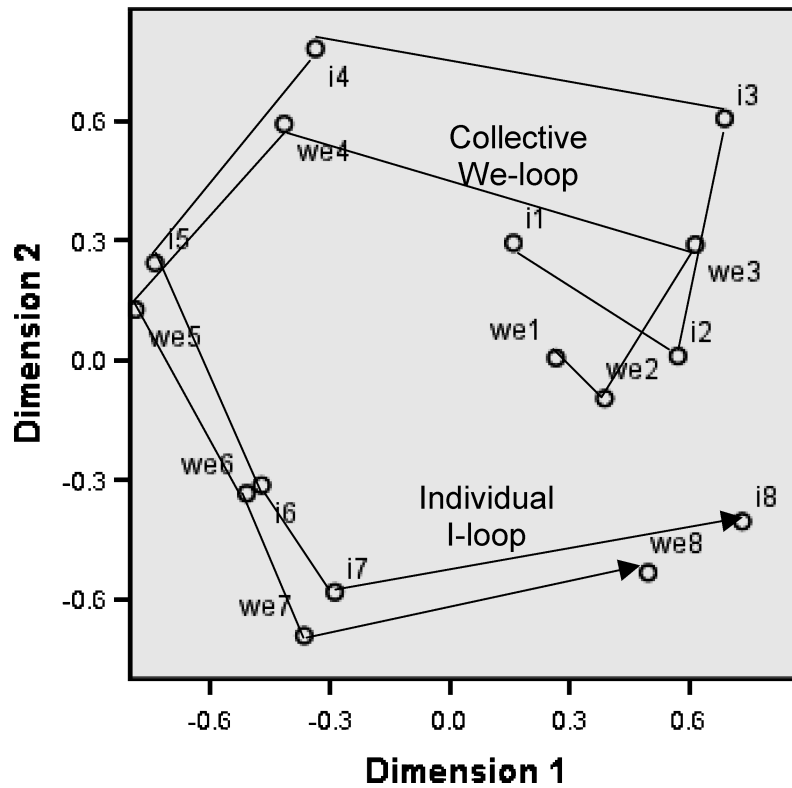


Figure 2. Trajectories of activation patterns for the I-story and We-story in the multidimensional space of the hidden layer activation patterns in Simple Recurrent Network (SRN). Note: The $i1$ to $i8$ are the points indicated by the vector that represents the activation pattern for inputs from 1 to 8 in the I-story. The $we1$ to $we8$ represent the analogous points for the We-story.

output layer, FN(O). The results conformed to our expectations. Figure 3 displays the mean activation levels of the relevant output layer units as a function of the priming conditions. The average activation levels in the units for I, We, Agent 2, and Agent 3 differed between the I- and We-priming conditions, $t(9) = 5.93, 6.35, 6.35,$ and 6.35 , respectively, $p < 0.001$ for all. The activation levels of the units for Agent 1, Agent 4, and Agent

5 did not differ between the priming conditions, $t(9) = 1.56, 1.93,$ and 0.51 , respectively, $p > 0.05$.

Discussion

The I-SELF represents a narrative as a trajectory in the multidimensional space defined by the activation levels of the hidden layer units. In the current framework, the Jamesian dynamic self can be construed as moving from one point to another in the space, where every point in this space represents a pattern of activation of the hidden units. When the same narrative sequence is learned with the individual or the collective as the protagonist, the I-SELF reproduces the narrative as somewhat different stories; however, their trajectories are similar, suggesting the possibility that one may slip in and out of an individual or a collective narrative as one appropriates those stories as one or the other is cued by some environmental stimuli. Indeed, one of the most potent symbolic representations that cue an individual or a collective narrative may be singular and plural first person personal pronouns, *I* and *We*. When *I* is activated, the James-Mead dynamic self appropriates the individual story; when *We* is made salient, it takes on the role of Subject in a collective narrative, regarding oneself as a member of the collective entity (Turner, 1987).

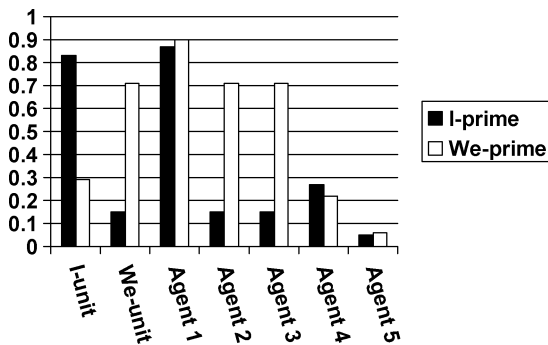


Figure 3. The mean activation levels of the units signifying I, We, Agents 1 through 5 as a function of the priming conditions. Note: *I* = first person singular pronoun; *we* = first person plural pronoun; Agent 1 = agent that *I* refers to; Agents 1–3 = agents that *We* refers to; Agent 4 = opponent agent; Agent 5 = sender agent.

Simulation 4: Culture and Self

Both James and Mead regarded the personal pronouns, *I* and *Me*, as metaphors of their theorizing of the dynamic self. The linguistically codified difference between *I* and *We* may represent a significant symbolic means of social regulation involving individual and collective identities, and therefore individual and collective social action. Had these theorists known some other non-Western European languages, they would have noticed another significant symbolic cue that may invite people to construe themselves differently. That is the phenomenon of pronoun drop (Kashima & Kashima, 1998; Kashima & Kashima, 2003). In English, for instance, a personal pronoun such as *I* is uttered explicitly when it appears as the subject of a sentence. In many non-Western European languages, people more often drop their pronouns than they utter them explicitly. Generally, it is ungrammatical to drop a personal pronoun when it is used as the subject of a sentence in languages spoken in individualistic cultures by Hofstede's (1980) index (no pro drop languages), whereas languages used in less individualistic cultures tend to permit pronoun drops (pro drop languages). Kashima and Kashima (1998) reported a correlation of 0.75 between Hofstede's individualism and the linguistic practice of not dropping pronouns, suggesting that the tendency to drop personal pronouns may relate to cultural differences in self-conceptions.

Drawing on Langacker's (1987) cognitive linguistics, Kashima and Kashima (1997, 1998) suggested that the explicit utterance of a personal pronoun highlights and profiles the person to whom the personal pronoun refers; in contrast, dropping the pronoun contextualizes the person, reducing the prominence of the person against the background of the speech context. Generally, the explicit utterance of personal pronouns symbolically signifies a clear self-other separation, whereas the dropping of personal pronouns reduces the self-other separation. A cross-cultural study of pronoun drop in social interaction found the pattern of pronoun use that is consistent with this line of reasoning. Kashima and Kashima (1997) found that Japanese conversations tended to drop both first and second person pronouns (i.e., Japanese equivalents of *I* and *you*, though there are multiple first and second person pronouns in Japanese) more than English conversations. In fact, a cultural difference in the use of *you* was dramatic: there was no drop of *you* in English conversations, whereas second person pronouns were always dropped in Japanese. Furthermore, the tendency to drop first person pronouns differed between conversations among friends and acquaintances in Japan: pronouns were dropped more often in conversations between friends (87%) than those between strangers (53%). However, there was little contextual variation in English conversations; in their study, there was no

occasion in which the first person pronoun was dropped in either friends' or acquaintances' conversations. The less frequent utterances of first person pronouns in friends' conversations relative to strangers' conversations suggest that the self-other differentiation was symbolically and linguistically regulated by pronoun drop, with pronoun drop decreasing the self-other distance.

Psychological consequences of such pronoun use can be explored by simulating pronoun drop with the I-SELF. We expected that internal representations of self and others developed in the hidden layers of the I-SELF would differ between the condition in which personal pronouns were always explicitly used (no pronoun drop) and the other condition in which they were dropped more often than not dropped (pronoun drop; see Kashima & Kashima, 1999, for a related simulation). More specifically, the internal representations for *I* would vary more in the pronoun drop condition than in the no pronoun drop condition. If this expectation is supported by the simulation, there is in fact empirical evidence consistent with this expectation, which links pronoun drop and variability of self-representations: those who speak pronoun drop languages have more variable self-representations than those who speak no pronoun drop languages. Kanagawa, Cross, and Markus (2001) found that Japanese self-representations (pronoun drop) changed more across different social contexts than American self-representations (no pronoun drop). Likewise, Suh (2002) found a comparable difference between Koreans (pronoun drop) and Americans. Kashima et al. (2004) also reported a greater variability in self-representations among Japanese than English-speaking Australians and Britons as well as Germans.¹

To examine the expected link between pronoun use and self-representations across cultures, we simulated the learning of self-other representations in the pronoun drop and no pronoun drop conditions with the I-SELF.

Method and Results

The network was trained with the sequence of events used in Simulation 1 in two different ways. In the no drop condition, each behavior was symbolically coded with the corresponding pronoun, either *s/he* or *I*, and symbolic code for the behavior. In the pro drop condition, each behavior was coded in the same way as in the no drop condition 40% of the time; however, in 60% of the time, each behavior was coded without the pronoun. In other words, we tried to simulate the statistical

¹ Although Korean self-representations significantly less variable than Japanese self-representations in their study, this may be due to the limited social contexts that were used to examine self-representations.

characteristic of many East Asian cultures in the pro drop condition, where the self and other are explicitly referred to in only a minority of social contexts. To simulate this in the experiment, we constructed two kinds of training sets. The *no drop training set* consisted of five repeats of the Simulation 1 sequence, where the pronouns I and s/he were always activated explicitly. The *pro drop training set*, again, had five repeats repeated the same sequence; however, the pronouns, s/he and I, were used explicitly in only two repeats, but in the other three repeats, the pronouns were dropped. The pro drop repeats were placed randomly in each sequence of five repeats. In the no drop condition, we trained the network with the no drop training set for 150 epochs, fixed the connection weights, and then have the network reproduce the sequence in the test phase. For each input in the test phase, we recorded the hidden layer activation pattern in the simple recurrent network, SRN(H). We followed the same procedure for the pro drop training set for the pro drop condition.

In both conditions, the network could reproduce the sequence accurately. We recorded 16 hidden layer activation patterns (i.e., vectors) for each of the five repeats. We regarded each repeat of the training sequence as a specific context. Therefore, the activation pattern for every input that included the self as the agent was taken to represent a context-specific self. Within each repeat, then, there were four different context-specific selves for the four different behaviors. Likewise, there were 12 different context-specific others, including three other representations for each of the four different behaviors. We computed the average vector for each behavior, collapsing across the three other-representations involving the same behavior. This then resulted in four other-representations within each context (i.e., repeat). All together, 40 vectors (4 self- and 4 other-representations in each of the five contexts) were analyzed by a Euclidean-distance ordinal MDS analysis: a two dimensional model showed an excellent fit (Stress = 0.10; $R^2 = 0.96$). The upper panel of Fig. 4 displays the configuration of the self and other representations. We followed an analogous procedure in the pro drop condition as well, generating 40 context-specific self and other-representations. Again, a Euclidean-distance ordinal MDS model was fit to the data, and a two dimensional model showed an adequate fit (Stress = 0.19; $R^2 = 0.84$). This is nonetheless somewhat worse than the fit for the no drop condition, suggesting a greater complexity of the self-other representations in the pro drop condition. The lower panel of Fig. 4 displays the self and other representations for the pro drop condition.

The two figures cannot be directly compared because the scales are different. However, general impressions of the self- and other-representations can be gained from them. Note that the points in the two dimensional space indicates the representations: the

points that share the same numbers are the representations for the same behaviors, whereas the points that share the same alphabets are the representations for the same contexts. In the no drop condition, self-representations for the same behaviors cluster together tightly without much contextual variability; the distance between self- and other-representations seem fairly stable for the same behaviors. On the other hand, in the pro drop condition, self-representations for the same behaviors vary across contexts; the self-other distance appears to show a greater cross-context variability, so that in some contexts, the self-other distance seem much greater than in other contexts.

Although these impressions are consistent with the prior expectations, we conducted the following quantitative analysis to further examine the context-variability of self-representations and self-other differentiation. First, we computed the average vectors representing the self and other within each context, resulting in five context-specific self-representations and five context-specific other-representations. We then computed the pair-wise Euclidean distances among self-representations ($5 \times 4/2 = 10$ self-self distances) and the pair-wise Euclidean distances between self- and other-representations ($5 \times 5 = 25$ self-other distances), with the former indexing the context-variability of self-representations and the latter, that of self-other differentiation.

We first compared the variances and means of the self-self distances between the no drop and pro drop conditions (Table 5). Levine's test for equality of variance showed that the variance in the pro drop condition was significantly greater than that in the no drop condition. A *t*-test adjusted for the violation of the equality of variance assumption showed that the mean self-self distance in the pro drop condition was significantly greater than that in the no drop condition. Consistent with our hypothesis, the self-representations were more context-variable in the pro drop condition than in the no drop condition.

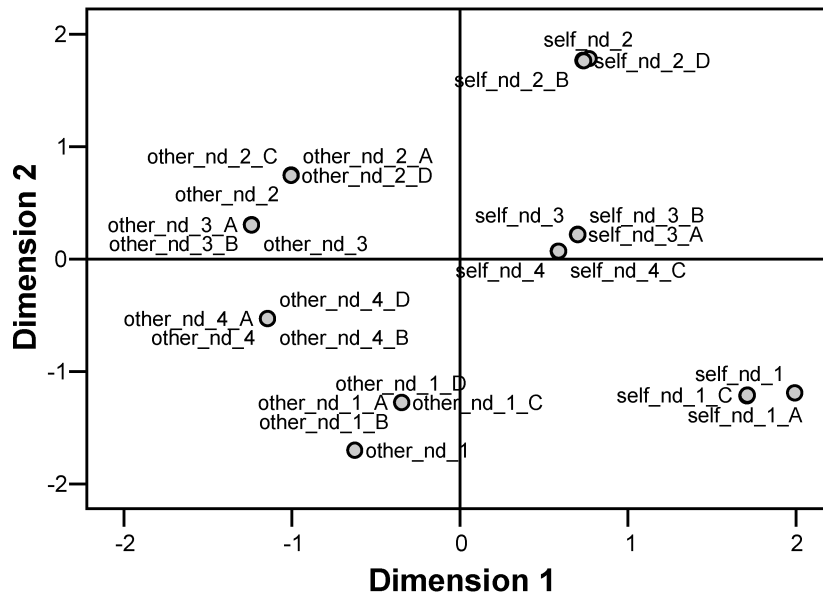
Next, we compared the variances and means of the self-other distances between the two conditions (Table 5). Levine's test again showed that the self-other distances were more variable in the pro drop condition

Table 5. *The Means and Standard Deviations of Self-Self Distances and Self-Other Distances in the No Drop and Pro Drop Conditions*

	Self-Self		Self-Other	
	Mean	SD	Mean	SD
No Drop	0.033	0.043	1.013	.007
Pro Drop	0.271	0.302	1.051	.136
Levine's F		122.51**		39.55**
<i>t</i> -test	$t(9.357) = 2.47^*$		$t(24.118) = 1.37$	

Note: * $p < 0.05$, ** $p < 0.0001$.

No Drop Condition



Pro Drop Condition

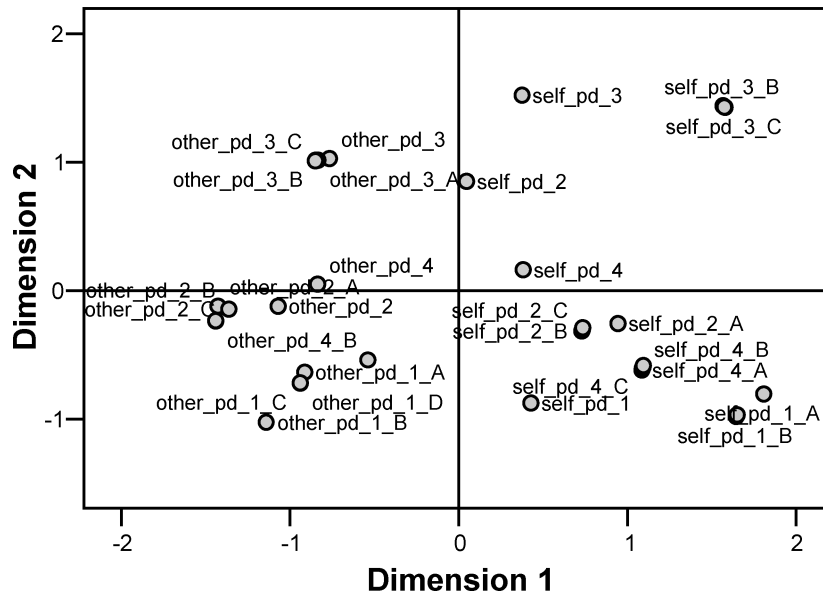


Figure 4. The hidden layer activation patterns within Simple Recurrent Network (SRN) for the pro drop and non pro drop conditions.

than in the no drop condition. Interestingly, there was no mean difference in self-other distance between the two conditions. The mean self-other distances were very similar in the two conditions.

Discussion

The simulation results confirmed the expectation that in cultures where their languages permit pronoun

drop (e.g., East Asian cultures), self-representations are likely more variable than in cultures where pronouns are not dropped. As noted earlier, this expectation derived from the simulation is in fact supported by the empirical research in variability of self-representations across cultures (Australia, Germany, the UK, and the USA for no drop and Japan and Korea for pronoun drop). On the other hand, it is intriguing that the overall self-other differentiation may not

differ between these two types of cultures; what differs is the context-variability of self-other differentiation. In pronoun drop cultures, self-other differentiation may be stronger when personal pronouns such as *I* and *you* are explicitly used, signaling the social distance between self and other. However, when pronouns are dropped, self-other differentiation may be much more reduced, so that self- and other-representations are more similar.

These results are intriguing in the context of the recent critical scrutiny of the individualism-collectivism constructs and independent and interdependent self-construals in the cultural psychological literature (e.g., Oyserman, Kimmelmeier, & Coon, 2002; Schimack, Oishi, & Diener, 2005). Markus and Kitayama (1991), in their influential distinction between independent and interdependent self-construal, suggested that the fundamental difference among world cultures lies in the extent to which the self and other representations are clearly separated.² In independent self-construals, the self is clearly separated from others; in interdependent self-construals, the self and other are connected (Markus & Kitayama, 1991, p. 226). In this formulation, the theoretical meaning of self-other separation (or self-other overlap) has remained largely metaphorical and psychological processes involving self-construals have remained unspecified (cf. Smith, Coats, & Walling, 1999). The I-SELF may shed light on this conceptual problem by offering a more principled interpretation of self-other separation (or overlap). In this system, leaning is generally exemplar-based, and so is a representation of self and "other." For each context-specific self-other interaction, a self-representation and a representation of that particular "other" involved in that particular context are formed as patterns of activation of the units in a distributed representational system. Here, self-other separation can be understood as the extent to which the pattern of activation for a particular context-specific event involving oneself (self-representation) is in some sense *different* from the pattern of activation for a particular context-specific event involving the other person. In other words, within the current theoretical framework, independent self-construal (specifically interpreted as separation of self and other) implies that self- and other-representations are different from each other, whereas interdependent (or connected) self-construal means that self- and other-representations are similar to each other.

²The meaning of "other" was ambiguous in Markus and Kitayama's (1991) original writing. However, subsequent research suggested that there are two senses of "other": one involving particular individuals such as parents, children, partner, etc. and the second sense involving groups such as family and work group, and collectives such as social categories based on ethnicity and gender (e.g., Brewer & Gardener, 1996; Kashima et al., 1995; Kashima & Hardie, 2000).

Finally, it is interesting to point out the connection between self-other differentiation and mimicry across cultures. Decety and Sommerville (2003) suggested that self-other differentiation may be implicated in the inhibition of mimicry. If mimicry is automatic, it requires some control mechanism that inhibits it so as to stop people from mimicking each other all the time. One of the mechanisms involved in this may be self-other differentiation. To the extent that one's self is clearly differentiated from others, this separation may be somehow used to inhibit mimicry. In line with this, van Baaren, Maddux, Chartrand, de Bouter, and van Kippenberg (2003) showed that when the concepts of independence or interdependence were made salient by having participants complete sentences with words that imply these concepts (e.g., alone, individual vs. cooperate, group), people mimicked more when independence was primed than when interdependence was primed. Furthermore, American and Japanese students in the USA were observed for their tendencies to mimic, the Japanese were more likely to mimic than the Americans. The Japanese self-other differentiation was presumably less than the Americans' in the experimental context. It is possible that there are other circumstances in which East Asians mimic less than Westerners when the context widens the symbolic distance between self and other (e.g., formal setting).

General Discussion

In the current literature of self and identity, William James and George Herbert Mead often provide a historical background, the intellectual forerunners of the contemporary knowledge, the past figures that legitimize our current interests in self-processes. However, the dynamic conception of self captured by James's stream of consciousness and Mead's symbolic interactionism has largely been lost. Our objective was to recapture their visionary dynamism in a connectionist framework without sacrificing the richness and complexity of selfhood in the contemporary theoretical context. We described the I-SELF model, which was designed to learn by imitation a sequence of inputs as configurations of the perceived events, actions, and objects in the world and their symbolic representations. First, we showed that the I-SELF can perform the imitation learning of sequences, as it was designed to do. In addition, the model was capable of learning the association between the objects and actions on the one hand and their symbolic representations on the other, exhibiting the symbol grounding capability. Furthermore, it showed a mirror-property, responding similarly to both one's own and other agents' action representations.

Having shown that the I-SELF can develop embodied symbolic representations, we began to examine the I-SELF's capability to learn symbolically constructed

narratives, and to appropriate and activate them in association with its symbolic individual and collective representations of itself, *I* and *We*. In Simulation 2, it learned a simple narrative, so that it can accurately reproduce the sequence of events in the story. Furthermore, we showed that it was capable of appropriating the learned story when the original subject of the story was replaced by the pronoun *I*, the first person being singular. In Simulation 3, it learned individual and collective narratives of the same structure, and was primed to reproduce each version of the narrative by activating the *I* and *We*, the symbolic representations of the individual and collective selves. In Simulation 4, we showed that when a personal pronoun like *I* is dropped in some of the times, the I-SELF developed self and other representations that are more variable than when it is not dropped most of the time. This phenomenon—pronoun drop—is also empirically associated with cultural variations of lower individualism and greater variability in self-representations, suggesting that the I-SELF's simulations reflect the observed cultural difference in self-understandings. In all, the four simulations attempted to demonstrate the utility of modeling the James-Mead dynamic self in connectionist terms, while capturing the rich collection of self-related phenomena including narrative, individual and collective selves, and cultural variation in self-construal.

Theoretical Issues

Although the reported simulations go some way towards showing the utility of the framework, there are a number of theoretical issues left unanswered before the I-SELF can be regarded as a full fledged model of self-processes in socio-cultural context. One obvious limitation is its inability to *control* social action (on the significance of the role of self in control, see Baumeister 1998; Twenge & Baumeister, 2002). Imitation may indeed be a foundation of socio-cultural living; however, human sociality significantly involves *non*-imitation. In fact, most social co-ordination requires people not to mimic, and to execute a complementary action. Take an example of simple co-ordination of one person holding a box and the other person opening it; this requires an inhibition of automatic mimicry. Humans are obviously capable of such co-ordination, and yet, we have not explored how a model like the I-SELF can inhibit its automatic tendency to mimic (e.g., not to hold the box like the other person), and to execute a complementary action (e.g., to open the lid). More generally, the inhibition of mimicry and execution of alternatives are psychological functions necessary for activities that require complex social coordination, such as carrying out a conversation in a small group, making a plan for parents' and adolescent children's activities for the day, organizing an association, an institution, or even

a country and beyond. A more complete model of dynamic self needs to be able to perform such coordinated inhibition and execution of social actions.

As Decety and Sommerville (2003) noted, the learning of self-other differentiation may be a critical step towards a theorization about inhibitory and executive functions. The current implementation of the I-SELF learns the self-other differentiation through the differential association of one's and others' actions with different linguistic labels, namely, personal pronouns. Nonetheless, social coordination does not only require linguistic, but also motor behavioral synchronization and coordination of action (Semin, in press). A more *embodied* conceptualization of social coordination may be required to construct a model of human social coordination. Just as Mead (1934) noted long ago, and as developmental psychologists have examined more recently (e.g., Bretherton, 1984), children may learn self-other differentiation and social coordination through their symbolic play—a playful enactment of social roles in an imagined and symbolically constructed world. A next step towards developing a model of socio-culturally constitutive self may be to incorporate into the model and simulations a more sophisticated understanding of the processes of socialization and enculturation.

Another obvious limitation of the current simulations is their lack of ecological validity of a sort. The phenomena we simulated are simple, contrived, and small scale; they need to be “scaled up” at least in two ways. First, current simulations had only one network learn a stimulus sequence. Although the I-SELF has the capability to imitate each other, this capacity was not explored in the simulations reported in this paper. We have, however, conducted such simulations, and their results will be reported elsewhere. Second, simulation experiments need to have more verisimilitude, and need to explore more real-life like phenomena. The narrative used for the current simulation was a simple sequence of goal-directed actions and events; however, most contemporary real life stories have a more complex causal structure with a greater number of relevant actors, actions, and events, most notably including psychological events with what philosophers typically call *intentionality* such as beliefs, desires, emotions, and intentions. Such stories may help us use a sophisticated lay theory of the mind to understand human actions (e.g., Wellman, 1992).

Metatheoretical Issues

A connectionist approach to self, and more specifically, the I-SELF model, has some metatheoretical implications. First of all, it takes a clear stance about levels of theorizing in social psychology. Currently, there are two strong undercurrents that appear to be pulling social psychology in two directions: one that

directs us to neural processes and the other that takes us to socio-cultural processes. On the one hand, our approach may *appear* to be in agreement with some who have argued for the complete reduction of psychological theories to neural processes (e.g., Churchland, 1981). Often dubbed *eliminativism*, this stance argues for the elimination of such folk psychological concepts as beliefs, desires, and intentions from psychological theories. In this stance, self may also be regarded as one of those concepts that should be eliminated from psychological theorizing. Le Doux's (2003) attempt at reducing self to neural synaptic connections may be seen as an example. In the advent of social neuroscience, this may be one of the strong trends that we may experience in social psychology in near future.

On the other hand, our approach radically socializes and enculturates *I*, the self as the subject. Just like Mead (1934), the I-SELF reproduces what it has learned from others as its own by appropriating those others' actions in the past. In this sense, the self as the subject may be largely *reproductions*. This view of *I* is broadly congruent with Hermans's (2002) conception of dialogic self and in general agreement with Turner's (1987; see Onorato & Turner, 2002) conception of self-categories. Just as human psychological processes must be implementable in a biological system, they must enable our socio-cultural living. Some have argued that the human biological system is itself an evolutionary adaptation to the socio-cultural living that humans have adopted as a species (e.g., Brothers, 1997; Dunbar, 1996).

Nonetheless, we neither advocate a neural reductionism, nor a socio-cultural determinism, but do argue for an integration of the neural strata and the socio-cultural context into social psychological theorizing. Even Mead (1934) portrayed *I* as "a source of innovation, uncertainty, and unsocialized agency" (Humphreys & Kashima, 2002, p. 44). Likewise, it is possible that the I-SELF can produce a response that is hitherto unseen and novel, something akin to what Bourdieu (1977, p. 78) called "regulated improvisation". There remains the role of an individual person in social psychology. We remain convinced that we profitably theorize about psychological functions at the process level. What the current approach does is to connect the three levels of psychological functions, algorithmic processes, and neural implementations, and to ensure that our theorizing about the processes that serve psychological functions is grounded in the biological organism that carries them out. In the end, the current approach squarely locates self-processes at the intersection of neural and socio-cultural dynamics.

In so doing, the current approach has an implication for the conception of culture in psychology. Culture is often construed in two complementary ways in the current literature on culture and psychology (Kashima, 2000, 2001). One view is to regard culture as a meaning

system, which is relatively enduring, globally coherent, and attached to a group of people. The concepts of individualism and collectivism (e.g., Hofstede, 1980; Triandis, 1996) and independent and interdependent self-construals in Markus and Kitayama's 1991 paper seem in line with this conception of culture. A group of people (in Hofstede's case, typically a national group) is seen to have a culture that has certain cognitive, affective, behavioral, and institutional tendencies. The other conception regards culture as meaning making processes; individuals' concrete actions in particular contexts in interaction with each other are seen to generate culture and mind. Socio-historical view of culture inspired by Vygotsky and Bakhtin is an epitome of this view (e.g., Cole, 1996; Rogoff, 2003; Wertsch, 1998). In this view, culture is seen to be domain specific and constructed in situ. When Markus, Mullally, and Kitayama (1997) used the term *selfway* to characterize independent and interdependent self-construal, arguably they meant to capture this type of conception of culture. Kashima (2000, 2001) suggested that the systemic and process conceptions of culture are complementary, and that one of the central questions of cultural dynamics is how symbolically mediated social actions in situ can generate a global pattern that appears to be a stable system of meaning.

The current approach provides one answer to this metatheoretical question about conceptions of culture. We suggest that humans are enculturated through concrete *cultural practices* performed in social context. By a cultural practice, we mean a recurrent pattern of psycho-motor activities that are prevalent in a culture (e.g., Cole, 1996; Rogoff, 2003). Just as formal schooling and various cultural practices that go with the experience of being at school (e.g., learning decontextualized rules of inference, mathematical operations, etc.) can explain cultural differences in children's performances on intelligence tests (e.g., Rogoff & Chavajay, 1995, for a concise review), some cultural practices such as pronoun drop (also see Kashima, Kashima, Kim, & Gelfand, 2006) may give rise to relatively stable cultural differences such as differences in the variability of self-representations across contexts. More generally, human social actions are context-specific and context may play a large role in the generation of social action, resulting in an apparent lack of coherence in culture. However, context-specific variation may result in global coherence when aggregated across a number of contexts and numerous specific actions.

In this connection, it is intriguing to reflect on the theoretical significance of first person pronouns such as *I* and *We* in the symbolic construction of self (see Kashima & Kashima, 1999). A Swiss linguist, Ferdinand de Saussure (1959) differentiated language as a *system (langue)* and language as *speech (parole)*, a distinction analogous to the systemic and process conceptions of culture. Benveniste (1966/1971) suggested that

the linguistic phenomenon of deixis in which words such as *I, you, here, there*, etc. are used to refer to some concrete things at the moment of speech play an important role in bridging the gap between *langue* and *parole*:

[*I*] is linked to the *exercise* of language and announces the speaker as speaker. . . . Habit easily makes us unaware of this profound difference between language as a system of signs and language assumed into use by the individual. When the individual appropriates it, language is turned into instances of discourse, characterized by this system of internal references of which *I* is the key, and defining the individual by the particular linguistic construction he makes use of when he announces himself as the speaker. Thus the indicators *I* and *you* . . . exist only insofar as they are actualized in the instance of discourse, in which . . . they mark the process of appropriation by the speaker (Benveniste 1966/1971, p. 220).

Analogously, examination of the use (or non-use for that matter) of personal pronouns may help us further bridging the conceptual gap between culture as a meaning system and culture as meaning-making processes.

Concluding Comments

After all, self is a psychological phenomenon that is biologically enabled and socio-culturally constituted. In the on-going human historical process, self is, as Foucault (1971/1972) famously said at his Collège de France lecture, only “a slender gap.” However slender it may be, self is a dynamic process that participates in the biological and socio-cultural co-evolution, perhaps more like a link than a gap that connects the past to the future (for a brief review of the literature on history and self, see Kashima & Foddy, 2002). When self is construed in time, William James’s conception of self as a *stream* of consciousness seems an apt metaphor. If the gene-culture co-evolution is likened to a large river without a clear destination that has come from the past and continues into the future, self-processes may be regarded as streams that at times coalesce and at other times clash against each other to form the great flow of human history. It is in this sense that we believe the temporality and socio-cultural embeddedness of self-needs to be taken seriously. If our approach to self in general, and the I-SELF model in particular, provides an instance of such a vision that James and Mead embodied so well, our purpose has been served. It is about time for us to engage with other streams of consciousness.

Note

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