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THEMATIC ISSUE ARTICLE: CULTURAL NICHE CONSTRUCTION

Cultural Niche Construction and Human Learning Environments: Investigating Sociocultural Perspectives

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Abstract Niche construction theory (NCT) can be applied to examine the influence of culturally constructed learning environments on the acquisition and retention of beliefs, values, role expectations, and skills. Thus, NCT provides a quantitative framework to account for cultural-historical contingency affecting development and cultural evolution. Learning in a culturally constructed environment is of central concern to many sociologists, cognitive scientists, and sociocultural anthropologists, albeit often from different perspectives. This article summarizes four pertinent theories from these fields—*situated learning*, *activity theory*, *practice theory,* and *distributed cognition.* As a basis for interdisciplinary investigation, the article considers how these theories may be addressed using a cultural niche-construction framework, including the utility of an embedded model that explicitly accounts for effects of the constructed learning environment on within-individual learning dynamics in an evolutionary framework.

Keywords Activity theory · Distributed cognition · Niche construction · Practice theory · Situated learning · Cultural evolution

Niche construction theory (NCT) asserts that behavior can alter the environment in ways that affect selection on heritable information (Odling-Smee et al. 1996, 2003). Although NCT was originally specified by investigating how organisms' effects on the environment might influence natural selection on a gene pool, the theory is applicable to any form of heritable information, including epigenetic subcellular structures, socially learned patterns of behavior, and forms of symbolic representation (Odling-Smee et al. 2003; Jablonka and Lamb 2005).

Cultural niche construction refers to the special case that is common, but not exclusive, to humans, where culturally derived behaviors modify an environment. This can have evolutionary consequences. For instance, rice farming in the Neolithic may have contributed to selection of the copy number of gene AMY1, responsible for salivary amylase, which breaks down starch into simple sugars (Perry et al. 2007; Laland et al. 2010). In contrast, the contemporary Balinese cultural practice of irrigation systems used in rice farming provides a selective environment affecting cultural change in self-governing assemblies and religious beliefs (Lansing and Fox 2011).

Thus, cultural NCT can be applied to the context of cultural evolution, which seeks to explain population-level patterns of ideas, behaviors, and customs for which there is measurable variation and that is subject to various forms of social transmission, selection, and drift (Cavalli-Sforza and Feldman 1981; Boyd and Richerson 1985; Feldman 2008; Laland and O'Brien 2012; Mesoudi 2011). In some cases, these traits will coevolve with genetic evolution, but in others, genetic variation may not influence cultural change. The latter may occur if cultural and biological evolution are occurring at different time scales (Odling-Smee et al. 2003), and thus if cultural change is either not explained by observed genetic variation or occurs in the absence of genetic variation relating to the trait in question and for the time scale under consideration.

In cases where genetic causation of cultural variation can be discounted, cultural variation may still be subject to selection as a result of differential survival and reproduction—*demic selection*—or as a result of differential trait

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adoption and abandonment rates—*cultural selection* (Cavalli-Sforza and Feldman 1981; Feldman 2008). This paper focuses on the effect of niche construction of the learning environment on *cultural selection*. The constructed learning environment can provide a source of selection on information variants by differentially affecting their probability of acquisition and retention over time.

Among non-biologists, an evolutionary account of human behavior is often equated with biological causation. However, niche-construction theorists have argued that incorporating cultural niche construction and ecological inheritance (Laland and O'Brien 2012, this issue) into cultural-evolutionary models provides a quantitative framework to account for historical contingency on patterns of cultural change. The current literature consists of only a few examples, reflecting the infancy of this approach (e.g., Feldman 2008).

Psychologist Mary Gauvain (2000, p. 153) commented in support of Laland et al.'s (2000) niche-construction review but warned that integration of biological and human social sciences "will not be met unless the biological and evolutionary approaches are better integrated with theory and research in human psychological development." Of the latter, she argued that the "remarkable coordination between basic biological capabilities and the social and cultural context of development is essential to survival, and it is far from coincidental" and that the "key question that arises from this is: How, over the course of human development, does culture become part of individual functioning?" In this regard, Gauvain finds Laland et al.'s account of human psychological development to be underspecified, requiring "the critical examination and incorporation of … the mind as a symbol generating, meaning-making, artifact-devising, socially transmitting system that is simultaneously an individual, social, and historical (cross-generational) phenomenon." If this challenge is to be taken seriously, there are important links to be made between NCT and those disciplines that examine the interplay between the construction of the sociocultural environment and human development.

This article makes a start by summarizing four pertinent theories developed by sociologists, cognitive scientists, and sociocultural anthropologists: *situated learning*, *activity theory*, *practice theory*, and *distributed cognition*. Each is introduced and points that are particularly relevant to a cultural niche-construction approach are highlighted before bringing the theories together in terms of Gauvain's *cognitive developmental niche*.

Situated Learning

Lave and Wenger (1991) describe situated learning as a process by which newcomers, through *legitimate peripheral participation*, become full participants in a *community of practice*, such as an apprenticeship into a particular trade, or participation in a religious community or a secular group such as Alcoholics Anonymous. A community of practice is a social formation of individuals engaged in a particular kind of activity. Legitimate peripheral participation refers to the idea that newcomers begin in a position that is not central to the learned practice within a community and yet their participation is legitimate, meaning that the newcomers take on established or recognized activity within the community during the learning process. The term *situated learning* both emphasizes learning in situ through participation and decentralizes common notions of mastery, pedagogy, and learning through instruction and replication. As Lave and Wenger (1991, p. 95) note, "Mastery resides not in the master but in the organization of the community of practice of which the master is part" and "moves the focus of analysis away from teaching and onto the intricate structuring of a community's learning resources." From a niche-construction perspective, the structured learning resources may be considered congruent with a constructed learning environment that affects cultural selection on learned variants through situated learning.

Situated learning emphasizes the importance of the interaction between the learner and the constructed learning environment (also see *situated action*; Lave 1988; Nardi 1996). Similarly, ecological psychologists use the notion of *affordance*, which is a measure of the properties of the environment relative to the learner (Gibson 1986). In NCT, this relational measure is characterized by the *niche*: the organism–environment relationship that is a function of both the state of the organism and the constructed, inherited (persisting) environment (Odling-Smee et al. 2003). In reference to biological evolution, *developmental systems theory* also recognizes the importance of this type of interaction, noting that "the unit of both development and evolution is the developmental system, the entire matrix of interactants involved in a life-cycle" (Griffiths and Gray 2001, p. 206).

Lave and Wenger (1991) emphasize the process of change in the nature of legitimate peripheral participation during learning, as the newcomer develops into a mature member of a community of practice. This change can be structured by tradition. For instance, a tailor apprenticeship typically starts legitimate peripheral participation with initial preparation work and finishing details on completed garments. Then, the apprentice slowly moves backwards through the production process as skills develop, before being given crucial cloth-cutting jobs (Lave and Wenger 1991). Thus, traditions concerning the apprenticeship structure result in a constructed learning environment (scaffolding learning) and affect the acquisition of the learned skills.

Consistent with the idea that instruction is not essential; the learning process such as an apprenticeship is assumed

to rely heavily on participation rather than just imitation of tasks. As a consequence, it is argued that the apprentice acquires a broad suite of values, normative expectations and behavior, in addition to technical skills, that are commonly held and practiced by the community in which the learner is participating. Analysis of the clustering and linkage between aspects of culturally transmitted traits is an understudied area in the quantitative analysis of cultural microevolution (but see Brown and Feldman 2009). Taking a cultural niche-construction perspective in the context of situated learning, the behavior of the community of practice provides the constructed learning environment, which affects, during legitimate peripheral participation, the cultural selection of normative expectations, habits, and values adopted by the learner.

Although situated learning is principally concerned with the developmental learning process, Lave and Wenger (1991) situate their descriptive model within what is the equivalent of an evolutionary context. The idea of ecological inheritance of an environment modified by niche construction is inferred by their observation that "reproduction cycles … leave a historical trace of artifacts—physical, linguistic, and symbolic—and of social structures, which constitute and reconstitute the practice over time" (Lave and Wenger 1991, p. 59), resulting in the "continuity of roles while displacement of individuals"—something they refer to as a "continuity-displacement contradiction." However, they also recognize the potential for the evolution of novel behavior and change in the community of practice over time—something they refer to as "developmental cycles of communities of practice" (p. 121). They note that this can result from a conflict of interest between master and apprentice, and a change in resources such as the technology used in a particular trade [e.g., dairy farming technology in French Alpine villages (Layton 2000)].

The situated-learning perspective of the evolution of a community of practice would appear consistent with that of NCT and developmental systems theory. The latter argues that

> … evolution is change in the nature of populations of developmental systems. This change is driven both endogenously, by the modification by each generation of developmental systems of the resources inherited by future generations, and exogenously, by modifications of these resources by factors outside the developmental system. (Griffiths and Gray 2001, p. 207)

Activity Theory

An area of psychology closely related to situated learning is cultural-historical activity theory. This theory, originating with the Russian psychologist Lev Vygotsky, focuses on the effect of the constructed learning environment on the learner. Shotter (1993, p. 111) notes that consistent with a Marxist perspective, "Vygotsky is concerned to study how people, through the use of their own social activities, by changing their own conditions of existence, can change themselves."

The effect of niche construction on learning can be found in what Vygotsky called a *mediational triangle* to express the effects of tools and artifacts in the environment on the activity of the subject in relation to an object that is being worked on (Fig. 1). Mediation through cultural practices alters what Vygotsky referred to as the *intramental plane*, that is the subject's internalized relationship with the object.

According to activity theory, the subject then contributes to shaping the collective understanding of the object. An example of cultural (and historical) mediation of the intramental plane used by Leont'ev is the difference in the way traders and geologists learn to view gemstones: "Each group would see different meanings held in the stones and the social practices of the activity system would differ accordingly" (Edwards 2005, p. 4). A niche-construction approach may contribute to activity theorists' cultural and historical analysis of the feedback between mediation and understanding over time.

Vygotsky's work is particularly useful for empirical scientists, as he attempted to develop measurable concepts to capture the effect of mediation on learning. Specifically, his "zone of proximal development" is defined as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky 1978, p. 86). The intention was that this concept could apply to learning across a wide variety of subject matters, would be relevant to learning in a social environment, and would relate to qualitative changes in the learner's cognitive development, including, for example, perception, memory, and speech (Chaiklin 2003).

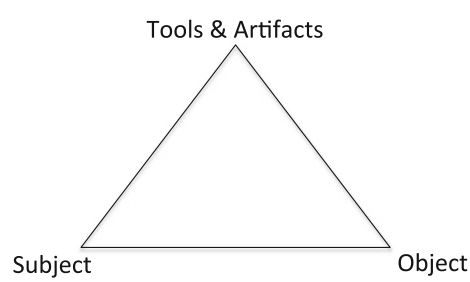

Fig. 1 Vygotsky's mediational triangle (adapted from Vygotsky 1978)

Since Vygotsky's conceptions, activity theory has developed to consider how goal-orientated human activity is affected by cultural-historical context. Daniels (2001) notes that activity theory concerns the "understanding of the ways in which human action shapes and is shaped by the contexts in which it takes place." To this end, Bernstein (1981, 2000) presents a framework highlighting a structural level, focusing on the social division of labor, and an interactional level, focusing for example on the pedagogic context between the teacher and the pupil. Daniels (2006, p. 46) argues that

> … the challenge is to theorise the Vygotskian concept of tool, or cultural artifact, as a social and historical construction and to describe it in terms that reveal that construction. Bernstein provides the structural level of analysis and Vygotsky furnishes the theoretical framework which can account for the position of the individual.

This feedback between activity and the production of cultural artifacts is something that, in a quantitative and testable formulation, can be addressed using cultural niche-construction theory. One possibility, considered below, is to make explicit consideration of within-individual learning dynamics in an evolutionary framework.

There are a number of quantitative models accounting for various forms of within-individual learning dynamics (e.g., Atkinson 1972; Rascorla and Wagner 1972). A set of models that explicitly accounts for Vygotskian-type scaffolding on learning dynamics has been developed by van Geert (1991, 1995; van Geert and Steenbeek 2005). Their approach is to use a logistic growth formulation to model the cognitive growth or learned competence of an individual for a particular skill (e.g., vocabulary, grammar, or mathematics) or cognitive attribute. These models recover the wide range of dynamics found under standard logistic mapping across growth rates and can be tested against empirical data using measures of the learned or developmental variables and the type of scaffolding over time.

Scaffolding by a teacher, parent, or some aspect of the learning environment can be implemented by altering the cognitive growth rate or by affecting the carrying capacity for the logistic cognitive growth. The model can also incorporate the sensitivity of the teacher's scaffolding behavior to the cognitive growth of the student. For instance, in parent–offspring settings, parental sensitivity to attachment behavior can mediate growth of a developmental variable (van Geert 1991). These processes can result in both smooth and stepwise shifts in cognitive growth. Negative scaffolding effects can also be incorporated, as might result from inappropriate teaching techniques or from the intentional suppression of particular behaviors. Similar dynamic-systems models have also been developed to address other social influences on development, such as the effects of sociometric status on involvement during dyadic play interactions between children (Steenbeek and van Geert 2007).

The evolutionary consequences of van Geert's (1991) scaffolding model can be examined by embedding the learning dynamics within a cultural niche construction model (e.g., Laland et al. 2001; Feldman 2008). For instance, consider a variant of Laland et al.'s model (2001), where socially learned scaffolding traditions (trait **E**) differentially generate a scaffolding resource R, which affects the cultural fitness of learned variants (trait **A**) by explicitly modifying logistic learning dynamics. This type of model can account for trans-generational persistence of material culture, R, on learning, and cases where a distinction is required between a scaffolding tradition (trait **E**; e.g., sensitive or insensitive) and the actual learner-state-specific scaffolding, R. Otherwise a class of two-cultural-trait model without R might be sufficient, where evolution of a cultural trait is affected by a *cultural background* (Feldman 2008). Furthermore, Cavalli-Sforza and Feldman's (1981) formulation of multivariate linear evolutionary models, distinguishing *target*, *concomitant* and *latent* variables, may also be useful to capture, in this case, the interdependence of the learned traits, environmental scaffolding for learning, and genotypic contribution to the trait, respectively.

Practice Theory

Although Vygotsky's early 20th-century Russian academic environment was different from that of practice theorists, both interests are linked by the question of how the notion of collective consciousness (see Durkheim 1938) could be incorporated into individual consciousness (Edwards 2005). Practice theory was born out of an historical debate among sociocultural anthropologists over the persistence and stability of structure in a social system. In brief, structural functionalists and cognitive structuralists such as Durkheim (1938) and Lévi-Strauss (1962) favored a top-down perspective, where social structure retains its form through the imposition of sanctions upon individuals and can be analyzed horizontally as a function of structural relations. This provoked antithetical bottom-up arguments, consistent with an historical (vertical) analysis of a social system, such as Tarde's (1903) preference that agency and variation in individual psychology affected the spread of novel ideas, and Barth's (1969) strong view that a social system was simply a by-product of individual self-interest.

Historians such as Carr (1961) pointed out that both horizontal and vertical approaches were required to explain a social system. Among European sociocultural

anthropologists, this consilience was found in practice theory, with the recognition that "agents' strategies constitute local society and culture" (Layton 2000, p. 112), where individual (or agent) behavior is not only affected by resource- and rule-based structures in the social system but can also shape these structures. Giddens (1984, p. 25) described this as a "duality of structure" in his concept of *structuration*. Rather than considering agents and structures, in the form of rules and resources, to be independent sets of phenomena, the structural properties of social systems "are both medium and outcome of the practices they recursively organize" (p. 25). In other words, rules and resources influence social behavior, and vice versa. The structural properties are the "medium … of the practices," as they include learned rules and physical resources that affect social behavior. They are also the "outcome of the practices," as the characteristics of the rules and resources are modified as a consequence of the social behavior.

From a niche-construction perspective, rules and resources affect the social structure of a society. This social structure constitutes a constructed environment that can affect cultural selection on learned characteristics of the rules and associated affordance of resources. Note that Brown and Feldman (2009) make a subtle distinction between *social selection* and *cultural selection* when pertaining to learned roles or public expectations, rather than "belief" in a concept, respectively. Also, this form of niche construction is often called social niche construction rather than cultural niche construction, as the constructed environment is the social structure in a social system (Brown and Feldman 2009; Boehm and Flack 2011). However, a researcher focusing on the effect of this constructed environment on the process of learning may prefer the term *developmental niche construction*.

In his development of NCT, Odling-Smee (2007) distinguishes between informatic and physical forms of resources in the environment, where the former can be manifest in, for example, behavior that affects what is learned (e.g., public information) (see also Odling Smee and Laland 2012, this issue). Giddens uses similar components within his *structure*. The equivalent to informatic resource is Giddens' conception of *rules* consisting of *codes of signification*, as characterized by symbolic order or particular modes of discourse, and *normative elements,* including regulations, which can result in the mobilization of sanctions in conjunction with asymmetry of domination or power in the social system. Rules are not conceptualized without *resources*, which are seen as "the modes whereby transformative relations are actually incorporated into the production and reproduction of social practices" (Giddens 1984, p. 18). Two principal forms of resources are taken to be *authoritative* and *allocative*, where the former refers to the (transformative capacity for) control over persons or actors and the latter to the (transformative capacity for) control of material products. These types of resources, including heritable wealth and property, have already been addressed within a niche-construction framework as forms of ecological inheritance (Lipatov et al. 2008; Rowley-Conwy and Layton 2011; Shennan 2011).

For a niche-construction interpretation of practice theory, it is helpful to distinguish between the mental entities of ideas, values, or expectations that may be subject to cultural selection, and behavior, which can constitute part of the selective environment (Brown and Feldman 2009; Lipatov et al. 2011). Bloch (2008) made a similar distinction when referring to the *transcendental social* and the *transactional social,* related to Firth's (1954) distinction between social structure and social organization, respectively. The transcendental social consists of imagined notions of public roles or grouping that exists separately from the individuals who hold them or by whom they are constituted. By way of distinction, the transactional social corresponds to the everyday interactions between people that may hold these roles. Bloch argues that humans are unique in their capacity to construct the transcendental social and for it to affect the transactional social. For instance, the leader of a war-mongering clan can remain leader even after his or her physical prowess has diminished. The notion of the public role and accompanying norms of transaction and resources associated with the holder of this role can affect the nature of the social environment manifest in everyday interactions.

The knowledge acquired through Lave and Wenger's situated learning appears consistent, at least superficially, with what Giddens (1984, p. 170) referred to as *practical consciousness*, i.e., "the rules and tactics whereby daily life is constituted and reconstituted across time and space." Similarly, another practice theorist, Bourdieu (1990), used the term *habitus* (similar to Aristotle's *hexis* and Mauss's 1934 *body techniques*) to describe an "individual's reconstruction of the rules and tactics deduced from others' actions" (Layton 2000, pp. 12–13).

Giddens (1984, p. 26) was particularly interested in the differentiation of public roles and their interaction within a society and took individuals to be rather strategic, or at least well informed, "expert 'sociologists.'" In contrast, Bourdieu's *habitus*, as inferred by the term, typically relates to an individual's non-reflexive or non-strategic understanding that is proposed to result in the reconstitution of the social system over time (Layton 2000). Thus, Lave and Wenger's (1991) recognition of competition between the roles of *old-timers* and *newcomers* during situated learning would appear to be consistent, at least conceptually, with a process that can result in the type of public role differentiation presented in Giddens' structuration framework.

Under Giddens' scheme, rule- and resource-based structures may affect the learner's behavior, which can then affect these structures (e.g., either reinforced or altered) with intended or unintended consequences. The Tunisian "burning man" catalyzing the recent Arab Spring might be an extreme example of such unexpected consequences. From a niche-construction perspective, the revolutionary activity provides a selective environment that can have a substantial effect on cultural selection of rules and the concomitant utility of resources.

Distributed Cognition

The ecological inheritance of semantic, or algorithmic, information is an important component of NCT (Odling-Smee 2007; Odling-Smee and Laland 2012) and is central to a number of hypotheses relating closely to *distributed cognition*. These ideas focus heavily on the symbolic representation, or meanings and values, attributed to components in the environment and their relevance to cognition.

Donald's (2000) *hybrid mind hypothesis* suggests that semantic memory systems can be augmented by "extended" storage. Donald (2000, p. 20) notes that

> culture is the store-house of crucial replicative information for certain aspects of our collective cognitive matrix, without which we cannot reproduce the cognitive systems by which we now function as a species. The memory repositories of culture allow our species to transmit across generations the codes, habits, institutional structures, and symbolic memory systems that are needed to operate a significant portion of the processes of modern cognition in human culture.

A number of niche-construction proponents have also considered the human capacity for modification of the epistemic environment (Wheeler and Clark 2008). For instance, Sterelny (2003) notes the importance of *cumulative downstream epistemic engineering* through the construction of cognitive niches, affecting the opportunities for learning across generations. He argues that the buildup of ecologically inherited semantic information most likely provoked the gene–culture coevolution of ecologically inherited information with the predisposition of parents to scaffold the development of interpretive capacities (cognitive development) in offspring.

A similar position is taken by Cole (1995, p. 190), who notes that "the species-specific characteristic of human beings is their need and ability to inhabit an environment transformed by the activity of prior members of their species. Such transformations and the mechanism of the transfer of these transformations from one generation to the next are the result of the ability/proclivity of human beings to create and use artifacts–aspects of the material world that are taken up into human action as modes of coordinating with the physical and social environment." Similarly, Wheeler and Clark (2008, p. 3566) consider aspects of structured learning environments as *extended cognitive systems*: "Non-organic props and aids, many of which are either culturally inherited tools or structures manipulated by culturally transmitted practices, might themselves count as proper parts of extended cognitive processes."

It has been argued that the ecological inheritance of extended cognitive systems can play important roles in cumulative cultural evolution by affecting developmental learning environments (Hutchins and Hazelhurst 1991; Sterelny 2003; Herrmann et al. 2007; Whiten and van Schaik 2007; Boyd et al. 2011). A likely key factor for these environments is proposed in Moll and Tomasello's (2007, p. 1) *Vygotskian intelligence hypothesis*, "that the unique aspects of human cognition—cognitive skills needed to create complex technologies, cultural institutions and systems of symbols, for example—were driven by, or even constituted by, social cooperation" (see also Dean et al. 2012). The resultant processes of epistemic engineering may have contributed to the so-called *sapient paradox* (Renfrew 2008), whereby behavioral modernity, found in material culture from an explosion of innovative technology and symbolic systems, evolved in modern humans 100–150k years after the evolution of anatomically modern humans (Donald 2000; Wheeler and Clark 2008; Sterelny 2011).

The social sciences bring into focus a large range of cultural phenomena that may be subject to cumulative cultural evolution and effects of developmental niche construction, but for which there has been negligible enquiry from within the field of cultural evolution. A common definition of cumulative culture, referring to cultural traits that could not be invented by a single individual, lends itself to the analysis of technology. However, epistemic engineering can potentially also affect contexts such as symbolic representation in rhetoric, narrative, metaphor, the epistemological social, belief systems, and cognitive attributes investigated by cultural psychology and cultural neuroscience (Cole 1995; Squire 2000). To quote Stotz (2010, p. 496), "It is not just that epistemic engineering supports apprentice learning in a structured learning environment, in addition cultural and symbolic representations on top of a narrative tradition facilitate concept formation, the acquisition of cultural knowledge, and perceptual adaptations which scaffold the extraction of data from a sea of experiences."

Unlike standard cognitive-science approaches, the field of distributed cognition considers cognition in terms of the change in relational structures, including components that are internal and external to the mind. Hence, the focus is on

the interaction of people and artifacts rather than just assessing individual cognition "within the head" (Nardi 1996, p. 39). Hutchins (1995) criticizes the cognitive sciences for not incorporating the cultural process, which generates artifacts, in their understanding of the individual. He asserts that this can lead to the over-attribution of intelligence (or aspects of cognitive facility) to the mind in order to explain observed behaviors, which instead should be considered properties of sociocultural systems that include both biotic and abiotic phenomena. For instance, Hutchins argues that computation resulting from a mathematician manipulating symbols on a chalkboard is not occurring inside the head of the mathematician but rather is a consequence of interaction with the external symbols (also see the *Hypothesis of Extended Cognition* and *Extended Mind Hypothesis*; Clark and Chalmers 1998; Clark 2011). Computational tools that automate these sequences of symbolic manipulation are models of a sociocultural system rather than cognition internal to the mathematician. On this basis, Hutchins criticizes cognitive scientists and artificial intelligence research that have attempted to use the computer as a model for the human mind. NCT can be used to examine the developmental and evolutionary feedback between internal mental facility and external resources that make up the sociocultural system. Fragaszy (2012, this issue) makes a similar point with respect to the study of animal traditions.

The notion of a sociocultural system, consisting of human agents and nonhuman artifacts, has also been called a *socio-technology of assembly* by some sociologists (also see *actor network theory*). For instance, a public hearing might require distinctive combinations of social networks between socially constructed agents, protocols prescribing who can speak when, and technologies including microphone and stopwatch (Girard and Stark 2007). This assembly holds some equivalence to a developmental-system unit in developmental systems theory. Principally used in regard to biological evolution, developmental systems theory advocates a *parity thesis* that "the roles played by the many causal factors that affect development do not fall neatly into two kinds, one exclusively played by DNA elements the other exclusively played by non-DNA elements.… Instead, there are numerous important distinctions to be drawn amongst the causal roles played by developmental factors" (Griffiths and Gray 2005, p. 420). While this thesis is open to criticism (see Gilbert 2003), a similar argument can be considered with respect to the cultural evolution of sociocultural systems of distributed cognition, where the development of cognition is affected by learned rules or axioms in conjunction with artifactual symbolic representation in material culture (a closely related term is Clark's (2011) *Parity Principle*; Clark and Chalmers 1998).

Conclusion: The Cognitive Developmental Niche

A common theme of situated learning, activity theory, practice theory, and distributed cognition is the emphasis that learning is a process of construction of knowledge and beliefs that is structured by the cultural environment. However, there appears to have been little attempt in the literature to relate all four theories in the context of both a developmental and an evolutionary framework. Depending on the research emphasis, the theories can be situated within various grand schemes, and from a cognitive developmental perspective, components of the theories can be drawn together under Gauvain's *cognitive developmental niche* (1998; developed from Super and Harkness 1986), which delineates three hierarchically organized subsystems relating cognitive development to culture.

The first subsystem, "activity goals and values of the culture" (Gauvain 1998, p. 84), is strongly aligned with *activity theory* and highlights the influence of cultural niche construction on the development of goal-orientated activity. For instance, Liberian Kpelle tribal adults have been shown to perform poorly in some western mathematical and classification tasks compared to a sample of American adults, yet exhibit superior computation estimating rice volumes, which is a relevant and familiar context for Kpelle rice sellers (Cole 1996). Other variation in cultural values may also influence goal-directed cooperation or punishment (Henrich et al. 2005). Whereas the effect of the cultural learning environment on cognition is well recognized, its effects on neural structure are relatively unexplored. However, the new field of cultural neuroscience is starting to provide evidence for this (Chiao 2010). A famous case is the apparent enlarged posterior hippocampal volume found in London taxi drivers, who have to memorize *the knowledge* of the London streets (Maguire et al. 2000).

The second subsystem, the "material and symbolic tools for satisfying cultural goals and values" (Gauvain 1998, p. 84), concerns the cultural niche construction and ecological inheritance of informatic resources found in *distributed cognition*. Here, mathematical history provides particularly obvious examples, where invention of new notation systems, for instance Hindu–Arabic in place of Roman numerals or Feynman diagrams in quantum mechanics, dramatically alters the evolvability of a field. From a different field, resources used in symbolic ritual are thought to affect the development of religious knowledge and belief. For example, Whitehouse (2004) distinguishes between imagistic and doctrinal modes of religiosity, arguing that the former, characterized by low-frequency and highly emotive ritual, commonly results in "elaborate bodies of personal, exegetical knowledge, based on deep and enduring conscious reflection." In contrast, the latter,

characterized by intensive, repetitive ritual, allows particularly "cognitively challenging ideas to be learned" and for low variation of ideas within a population (Whitehouse 2008, p. 26).

Gauvain's (1998, p. 84) third, most broad subsystem includes "higher level structures that instantiate cultural goals and values in everyday practice." This subsystem includes the effect of social structures on *situated learning* through legitimate peripheral participation in a community of practice (Lave and Wenger 1991), including the development of emotions and identity, which can be reflected and retained in linguistic cognates (Malik 2000). *Practice theory* is also pertinent, highlighting the reciprocal relationship between structures in a society and the development and evolution of behavior (Giddens 1984). The broader effect of structures and cultural practices on cognitive development can also pertain to belief systems held by members of a community that can provide a cultural background, for example, shaping perceptions of causality and risk. Evans-Pritchard's (1937) classic ethnography *Witchcraft, Oracles and Magic Among the Azande* is a description of culturally dependent and internally consistent attribution of causality, where proximal causality of misfortune may be attributed to natural physical mechanisms, while simultaneously, ultimate causation is attributed to the supernatural.

To analyze aspects of Gauvain's *developmental cognitive niche,* it may be useful to develop cultural niche-construction models that explicitly incorporate the effect of the constructed learning environment on developmental learning dynamics, embedded within the evolutionary model. This is equivalent to integrating ecological dynamics, measuring individual cognitive growth or development, within evolutionary dynamics, measured at population level. Embedding ecological within evolutionary dynamics has already proved useful to address other complex nested systems. For instance, Alizon and van Baalen (2005, 2008) integrated within- and between-host dynamics to lend support for a convex tradeoff between pathogen transmission and the evolution of virulence, showing how optimal levels of virulence can be highly sensitive to parameters that might vary across individual hosts.

To conclude, Laidlaw (2007, p. 223) voices his concern that two distinct traditions (e.g., Jainism and Theravada Buddhism) cannot "be accounted for in terms of there being simply consistent and continuous transmission of shared beliefs, but rather by what Carrithers (1990, p. 141) calls a "patterned flow of contingencies and aspirations, routines and imaginative responses." As important to the transmission and content of the traditions as beliefs, are institutions, roles and relationships, practices … narratives and material culture." Theoretical frameworks such as cultural NCT can go some way to meeting this challenge by incorporating the effects of cultural-historical contingency affecting the development and evolution of cognition, beliefs and behavior.

Whereas explanations for the types of behaviors discussed above have focused on effects of the cultural-historical environment, this does not preclude accounting for demic selection and gene-culture co-evolution where appropriate. The field of cultural evolution is growing fast but is still sufficiently young that there are many issues from sociocultural and cultural psychology studies for which cultural NCT could provide traction, addressing sociocultural and historical contingency within a developmental and evolutionary framework.

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