NATURALISTIC APPROACHES TO CULTURE

Neurocognitive Development and Impairments

NATURALISTIC APPROACHES TO CULTURE

edited by
Csaba Pléh, Gergely Csibra and Peter Richerson

AKADÉMIAI KIADÓ, BUDAPEST

Printed in Hungary

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PREFACE:
BASIC ATTITUDES IN STUDYING THE NATURE/ CULTURE INTERFACE

Csaba Pléh, Matti Sintonen, Alain Peyraube and Eva Hoogland

On behalf of the European Science Foundation

During the last three decades, several attempts have been made to clarify the possibilities and limitations of naturalistic approaches to mind and culture. The most important new vistas arise from modern evolutionary theory but the issues also have, in the background, the traditional debates on reductionism and biological determinism.

Two broad kinds of approaches are discussed and compared in this volume:
1) During the past two decades, with the advent of evolutionary psychology and related developments, a new serious challenge has been made regarding *the biological routing of some of the most cherished cultural achievements and features of humans*. This challenge basically involves the idea that some of our cultural habits and propensities are the results of interactions between biological constraints and cultural shaping, rather than being constructed by culture alone.
2) Many scientists and scholars have argued, on the other hand, that there is a need to *reconceptualize nature and culture*. The notions of the *biological* and the *cultural* are based on dualistic thinking that is increasingly problematic, given the human refashioning of nature both through the "culturing" of natural environment and life itself and through human impacts on global climate and environment. Thus, many scholars have found it necessary to speak of "naturecultures" and "biosocialities."

There are, furthermore, technical issues involved here as well. One major obstacle to a better understanding and collaboration between naturalistic and cultural/humanities scholars is that of differences in methods and approach. This constitutes a barrier for communication within the subdisciplines in naturalistic domains and across the naturalistic and cultural fields.

The two broad paradigms mentioned above need to be thoroughly discussed, annotated by some of the technical barriers to understanding, e.g., by the barriers to understanding due to the technical and theoretical jargon in using neuroscience data and similar issues. Our book is a small step in promoting this discussion.

Some of the challenging issues involved in reconsidering biology and culture in their relations are the following:
– The "natural" origin and the "biology" of sociality.

– The naturalistic origins of human cognitive capacities, including cultural phenomena such as art, literature, music, etc.
– The usefulness of the concepts of "naturecultures" and "biosocialities."
– The interface between biological evolution and cultural evolution.
– Adaptation as exaptation in explaining culture.
– Biological (most importantly, neural and genetic) determinism and the prediction of human behavior.
– Universal and specific aspects of cultural systems such as languages.
– The neural circuitry of primary (language-like) and secondary (writing-like) cultural systems.

INTRODUCTION: SOME CRUCIAL ISSUES OF THE NATURE/CULTURE INTERFACE

Csaba Pléh, Peter Richerson and Gergely Csibra

The birth of the present volume

The Standing Committee on Humanities of the European Science Foundation supported a strategic workshop on the Naturalistic Approaches to Culture at Balatonvilágos, Hungary, between September 4 and 7, 2011. With the organizing efforts of the team of Csaba Pléh, Matti Sintonen, Alain Peyraube, and Eva Hoogland, a workshop consisting of keynote lectures and posters was held on the basis of a selection procedure led by the organizers.

The program of the workshop is shown below. Out of these presentations, the keynotes and a select number of poster presenters were invited to contribute to the volume. The present volume is an edited version of the original contributions of those presenters who finally agreed to contribute. We all hope that it will contribute to the ongoing discussions in the field.

5th September 2011
Natural pedagogy as an evolutionary adaptation Gergely Csibra, Cognitive Development Center, Central European University, Budapest, Hungary
Multilingualism and the theory of mind Ágnes Kovács, Cognitive Development Center, Central European University, Budapest, Hungary
Why imitation is selective and cost-sensitive, and what difference it makes Olivier Morin and Jean-Baptiste André Institut Jean Nicod, Paris and Central European University, Budapest, Hungary
Discussion *Developmental science and the nature–nurture issue* Teleconference with Judit Gervain, Laboratoire Psychologie de la Perception, CNRS, Paris Chair: Csaba Pléh
Discussion *How to explain cultural behavior on the basis of evolution and neuroscience?* Chair: Gergely Csibra
Poster session 1. *Language and culture* Orchestrated by Ágnes Kovács Poster presenters: Bambini, Valentina; Fusaroli, Riccardo; Halloy, Arnaud; Nánay, Bence; Lim, Ai Keow; Mascaro, Olivier; Hegnes, Atle Wehn; Iciar, Alvez Pérez; Sosišc, Rajna

6th September 2011
Biocultural approaches to mind and knowledge   Eugenia Ramirez-Goicoechea, Department of Social and Cultural Anthropology, UNED, Madrid, Spain
The evidence for culture-led gene–culture co-evolution   Peter Richerson, Department of Environmental Science and Policy, University of California, Davis, CA, USA
The item/system problem in cultural evolution   Nick J. Enfield, Max Planck Institute for Psycholinguistics and Radboud University, Nijmegen, The Netherlands
Discussion   *How culture shape the mind*   Chair: Matti Sintonen
Poster session II. *Culture in animals and children*   Orchestrated by Olivier Morin   Számadó, Szabolcs/Zachar, István; Claidière, Nicholas; Verpooten, Jan/Joye, Yannick; Schwab, Christine/ Bugnyar, Thomas; Kis, Anna /Wilkinson, Anna; Téglás, Ernő; Kampis, Dóra/Király, Ildikó/Krekó, Kata/Topál, József
7th September 2011
Discussion   *How to move ahead: Is there a naturalistic theory of all cultures, or are there grounds to expect that one will emerge?*   Chair: Peter Richerson

Some words about the contributions

The nature/culture issue certainly has a long tradition, as mentioned by *Frost and Richerson,* who point out the dangerous progressivist simplifications of evolutionary theory by many social scientists, and by *Enfield,* who reminds us of Darwin's parallels between the history of species and the history of languages.

The chapter by *Csaba Pléh* selects three crucial phases in this 150-year-long modern history. James Mark Baldwin is certainly a worthwhile precursor of recent efforts with his analysis of learning phenomena as instruments to speed up evolution by natural selection, without questioning it. This is accompanied in Baldwin by a central role of imitation in the transmission of cultural knowledge, and in the creation of the Self. Karl Bühler is less known as a founding figure of extended Darwinism. Pléh proposes that with the analysis of triple selection pools for instincts, learning, and thought, Karl Bühler in the Vienna of the 1930s was responsible for the idea of universal selection theory as a unifying theory of biology and culture. This idea was taken by Karl Popper and Donald Campbell, and it recently showed up in the Tower of Selection metaphor of Daniel Dennett. These historical lessons are important because they partly illustrate the way recent debates were fought earlier. In the combination of proximal and distal biological models and a clearer comparison of competitive and cooperative elements in human biology, these historical lessons also show the ways in which we are smarter today.

Karl Frost and Peter Richerson start with a critical stance, trying to show that the seeming discrepancies between biology and culture are often based on ignorance. They point out

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that cultural variation is possible because of a biological feature, the very efficient cultural learning system of humans. In their view, this is accompanied by a strong impact of culture on our genome, for example, by selecting a digestive system that goes along with changes in food production. Another crucial issue in their analysis is the recognition that biological systems and human society should not be treated with physical universalism in mind. Variation is essential to these systems, and therefore the outdated opposition between qualitative and quantitative should be replaced by better models that are able to handle variations due to cultural learning.

Eugenia Ramirez-Goicoechea in her chapter starts off from a detailed critique of the traditional nature/culture divide, practiced by both culture researchers and biologists. Concerning the recent naturalizing theories, she highlights that theorists have an uneasy time to reconcile determinism with the observed cultural diversity. A way out is the recognition of epigenesis even in the unfolding of the influence in the genome, which projects a more flexible image of determination. Her basic proposal is that the traditional divisions should be replaced by a more dynamic biosociocultural metatheory.

As indicated by the historical chapter of Pléh, in the recent development of naturalizing social models, the biological foundations of prosocial behaviors have become a central issue. *Olivier Morin* analyzes the issue of how models can be made which favor imitation and, at the same time, avoid adopting maladaptive behaviors. He shows that a more balanced, less automatized view of imitation and altruistic behavior is needed.

The empirically motivated papers deal with cross-species and cross-age comparisons, which are crucial to the understanding of the naturalistic attitude to culture.

Jan Verpooten and Yannick Joye start from niche construction as a crucial naturally founded cultural practice. They summarize evidence that nest building may have been more important in hominid evolution than mere tool use. They analyze the issue of the relations between architecture, nakedness, and clothing. Regarding monumental architecture (such as temples), they compare different theories that either postulate an advertising advantage of costly signaling or propose that monumental architecture has its own sensory advantage. In sum, Verpooten and Joye clearly show that the nature/culture interface is best studied in the search for the explanation of basic aspects of human cultures, such as buildings.

Bence Nánay takes a particular stance and claims that the biological analogies of culture should be analyzed in microbial evolution. This could accommodate both the speed of cultural change and the lateral transmission. At the same time, he argues that for culture the genetic analogy should be property replication, which is more like a phenotype transmission idea. It is important to see, however, that Nánay presents these ideas as an issue of analogies, rather than as a literal identity between microbial and cultural evolutions.

Ever since Darwin and Wolfgang Köhler, monkeys and apes have been considered as the most important animals in anchoring cultural issues into evolutionary biology. The paper by *Eduardo B. Ottoni and Tiago Falótico* follows the tradition of classical ethology. They survey a large number of studies on primates, discussing the possibility of culture-like transmission in tool use. On the basis of their own observations on tool use, they discuss the possible selective advantage of the development of a cultural mind in hominid evolution.

Dóra Kampis, Ildikó Király and József Topál review the literature on selective imitation in young children and present their own study on 2-year-old children, which shows how the

social and instrumental aspects of intelligence are combined. In particular, their claim that "cultural transmission is a mixture of propagating knowledge from the instrumental and social domains" means that children are flexible learners but if they are taught in a naïve pedagogical setting, they learn from adult models, and then stick to these models. They are cultural, but culturally conservative, learners.

The Theory of Mind, our ability to attribute thoughts and intentions, beliefs and desires to our peers, is treated as a crucial factor of human sociality by several new theories. *Ai Keow Lim* reviews the rich empirical literature, both observational and laboratory-based, and the different theories underlying them, and also presents a cross-cultural comparison of 2–4-year-old Singaporean and British children in the ToM development. She observed both universalities and differences. Pretend play and role playing seem to be central determinants of ToM development. Lim argues that the unfolding of ToM should be interpreted as a result of cultural learning, rather than as a simple age–maturation issue.

Language has always been a crucial issue of the nature/culture interface from the time of Steinthal and Darwin on. Out of the many papers dealing with language, 3 specifically deal with it in this volume. *Nick J. Enfield* takes the example of language change to argue that simple models of item change, such as transformations during borrowing, are able to explain changes in the system as well. The transmission chain he postulates follows Dan Sperber's model. There is a constant flux between mental and public events, and with each transmission a change appears in the existing system.

Judit Gervain, by reviewing her own studies and the literature of over half a century, shows how the initial *nature versus nurture* issue regarding language has become ramified. Today, we more and more clearly see the kind of biological preparations that children bring to the task of language acquisition. They seem to be prepared to represent a certain kind of acoustic stimulus (speech, which they do not like backwards), their brain is prepared to sequential acoustic processing at birth, and they are ready to finalize their sound system with high efficiency. This is natural preparedness for a certain kind of social learning with a peculiar kind of stimuli.

During the last five decades, the study of language, especially its ontogeny, has been one of the most important arenas for the *nature versus nurture* debate, i.e., the question of whether human knowledge comes from the species' genetic endowment (nature), or whether most of it is learned from the environment through experience (nurture). Nurture-type theoretical positions, such as Boas's view, dominated the first half of the 20th century, grounding natural languages in culture and its acquisition in stimulus–response cycles, learning, and imitation (Skinner and Mowrer). After the cognitive revolution in psychology in the 1950s and with the advent of developmental neuroscience, naturalistic approaches emerged and became dominant in the field (Chomsky and Pinker), although nurture-type accounts did not disappear (cf. Tomasello). The last 10–15 years have witnessed the appearance of a new synthesis, whereby innate mechanisms, learning and experience, perception, as well as social factors have all been acknowledged to play important roles in the development of language. In this new perspective, the question is shifted from a simple *nature versus nurture* dichotomy to exploring the mechanisms that are responsible for aspects of language acquisition and their interaction with one another.

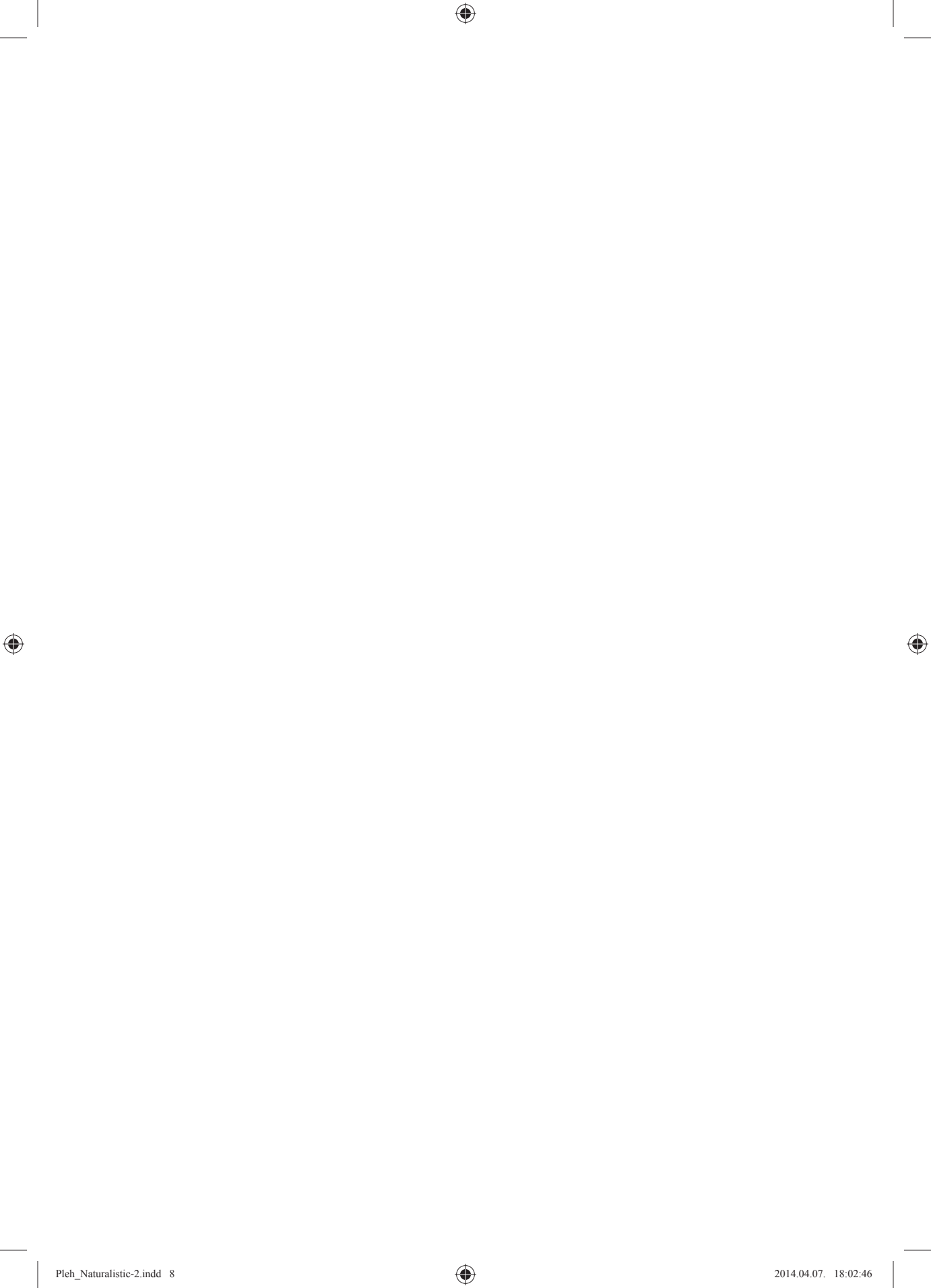*Arnaud Halloy and Olivier Wathelet* present case studies of certain widespread cultural practices such as cooking. Through these practices, they show that the attitudes of cultural

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anthropology and cultural ethnography are both necessary to understand how cultural systems are shaped and stabilized through cultural learning.
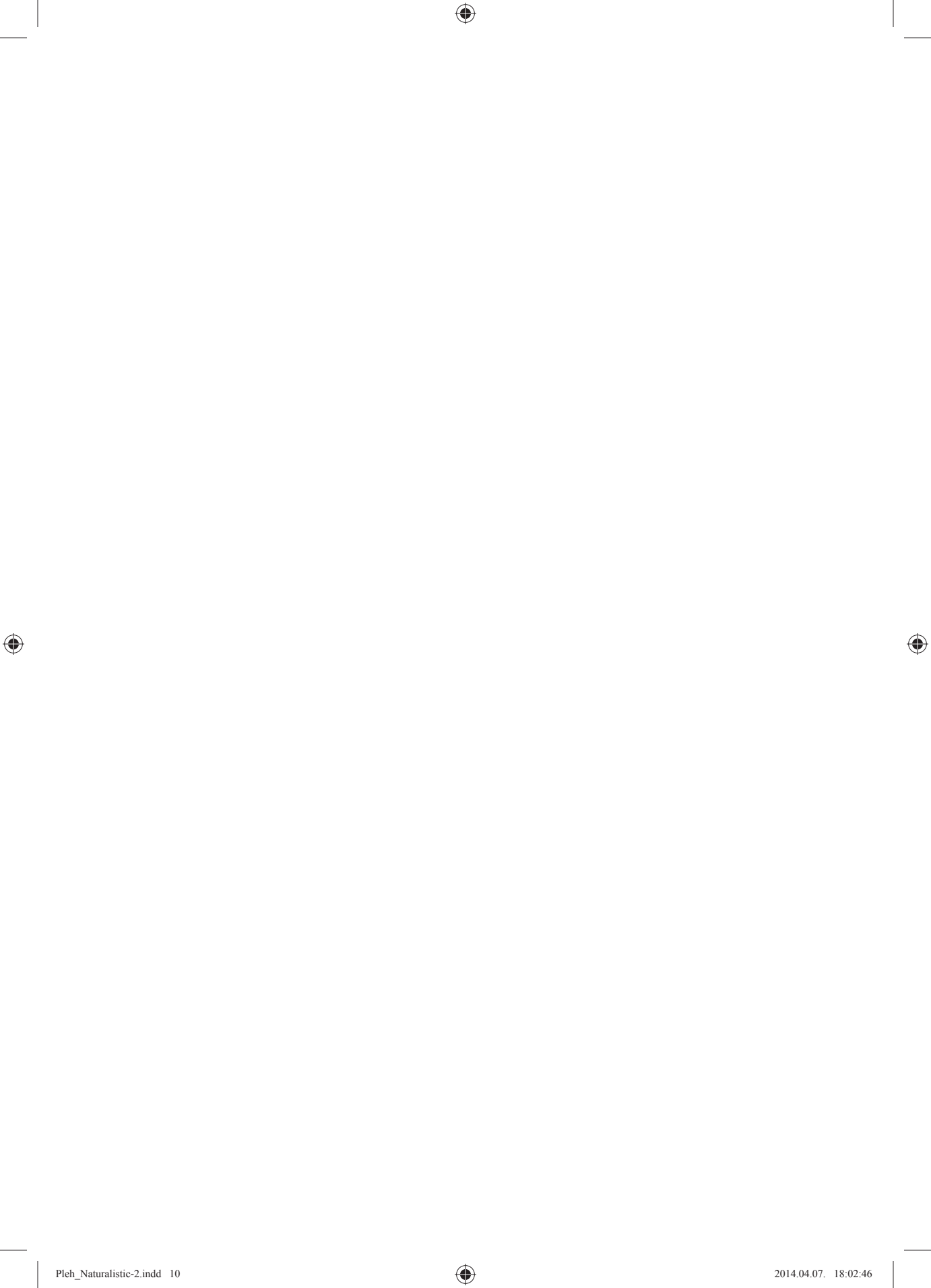
Acknowledgments

THEORETICAL APPROACHES TO THE NATURE/CULTURE INTERFACE

HISTORICAL ROOTS OF THE NATURALISTIC APPROACHES TO CULTURE: FROM BALDWIN THROUGH CAMPBELL TO DENNETT

Csaba Pléh

The advances of present-day naturalism

The naturalistic approach has a long tradition in psychology, even in its modern forms: it has been with us since the mid-19th century. Advances in our knowledge of the nervous system and in understanding "the transmutation of species" have been the eternal moving forces. During the last generation, many of the traditional vicissitudes and traps of these approaches have seemed to be resolved or at least softened. There are several basic reasons for this change, which all have to do with a more complex image replacing traditional dualities with at least triangles and models of multiple causation (Pléh 2008):

- Psychologists as well as naturalistically minded social scientists entertain a double faced biology in parallel, treating proximal and distal factors as proposed by Mayr (1982) together. They tend to forget the traditional division of labor, where either neuroscience or evolution is used as a frame of naturalistic reference for psychology.
- Genes and plasticity are treated together in evo–devo programs, not as exclusive factors, both in biology (Müller 2007) and in developmental studies in psychology (Lickliter 2008; Ellis and Bjorklund 2005).
- Elementary sociality is treated as a basic starting point rather than as a result of external constraints (Tomasello 1999, 2009; Gergely and Csibra 2005; Csibra and Gergely 2009). We do not have to believe in 'supraindividual minds' or the like to deal with the social aspects. Even the social aspects of the human mind should be found in the mind itself. This is of course a simplification. As Peter Richerson (2013) pointed out to me,[1] "in the case of cultural evolution, population level processes do real work. The mind is important but it is the population that is the reservoir of the cultural information that (human) minds acquire."
- Naïve hermeneutics is postulated with the idea that the social search for meaning is treated as part of our human nature (Dennett 1990).

This change of outlook has multiple consequences for the study of cultural phenomena as a crucial type of social phenomena. In the present paper, I shall try to show that during its 150 years, the Darwinian approach to psychology has attempted an evolutionary interpretation of cultural phenomena several times, and these traditions may give interesting inspirations for recent research.

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[1] Peter Richerson has helped me with careful reading and several useful comments that are occasionally included in the text itself.

A list of ancestors

It would be futile to overview the entire Darwinian enterprise in its impacts on psychology. I would rather concentrate on historical traditions that specifically relate to the issue of *naturalization of culture.* Still, in Table 1, some hints are given concerning what I consider to be substantial achievements of psychological evolutionism over its 150 years of history.

Table 1. Some substantial successes of evolutionary psychology over 150 years

Success	Name	Challenging aspect
Instrumental learning	Thorndike Skinner	Selection tower thinking?
Critical periods	Lorenz	Closing factors in humans?
Hierarchy of behavioral organization	Jackson–Freud	Alternative roots of development
Attachment and its styles	Hermann, Harlow, Bowlby	Lifelong effects?
Species specific behaviors	Lorenz	Are there human ones?
Social learning	Baldwin	Causes of culture?
Empathy and altruism	Baron-Cohen	How human specific?
Bell curve of abilities	Galton	Ethnic and gender factors
Personality types	Pavlov	How far inherited?
Extreme variations	Simonton	Talent and evolutionary pathology

There were three ways in which Darwinism and the evolutionary ideas of the late 19th century at large have played a crucial role in the formation of a (then) alternative, more dynamic and functional psychological thinking that can be contrasted to classical unanchored experimental psychology of the Wundtian kind. They currently contribute to the opposition to a disembodied representational cognitive psychology (Pléh and Gurova 2013). The notion of adaptation applied to the mind, the very idea of development, both of the 'race and the child,' as well as the emphasis on individual differences are the cornerstones of early psychological evolutionism that persists to this day. The combination of these inspirations is far from being trivial. Yet some recent applications of evolution in psychology openly deny, for example, the relevance of individual differences (Cosmides and Tooby 1992).

For much of the 20th-century social science, Darwinian proposals carried the unfortunate social overtone that there are primitive cultures and languages, contrasted with developed modern ones (Haeckel 1904). Many social scientists have critiqued this attitude. From Franz Boas on, the emphasis on the equality of cultures and languages has been overextended towards questioning any use of evolutionary theory applied to human society (see Lewis 2001). This has resulted in three features of standard social science summarized by Pinker (1997):
  – The human mind became interpreted as an unbound general purpose learning machine with no (biological) constraints. This is of course an oversimplification on the part of Pinker. As Peter Richerson (2013) reminded me, most of the time behaviorists supposed such constraints as presented by Baum (1994).
  – Cultures were supposed to differ radically from each other.

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- These cultural differences and varieties were assumed to shape the formation of individual mental architecture.

This traditional Standard Social Science Model (SSSM) view treats humans as entirely flexible beings, with a relativistic praise of the power of cultures. There were several slightly different approaches navigating between naturalism and SSSM emphasizing the role of interactions in implementing this cultural determination, or even, cultural unfolding, from James Mark Baldwin through Georg Herbert Mead, Henri Wallon, Lev Semjonovich Vygotsky up to Michael Tomasello and Richerson and Boyd, as of today. In this version, knowledge would be interpreted as inherently social, but it would become an integral part of the individual mind, not through some unidentified process of social instruction, but rather through interactions with others.

In what follows, I shall try to show that three major ideas of the Darwinian era still have relevance for our understanding of the natural foundations of culture:
- The issue of social learning in Baldwin's work.
- Pools of selection according to Karl Bühler.
- The vicarious selection cycles of Donald Campbell and Daniel Dennett.

Baldwin and his effect

James Mark Baldwin was one of the crucial American figures who applied evolutionary ideas to development (Baldwin 1894a), to society (Baldwin 1909, 1911), and who interpreted development as a non-trivial evolutionary tuned process of social learning (Baldwin 1894b, 1896). Baldwin was very productive (see Cairns 1992 about his life). Near the end of his life, he himself summarized in a statement what was important in his achievements (Baldwin 1930: 29):

> The things I value …: first, the genetic *Method* pursued and, secondly, the *Results* acquired in genetic and social Psychology and Philosophy. These results may be briefly summarized as follows:
> 1) *General and Experimental:* Child Study results; Imitation and Circular Reaction; Motor Interpretations generally.
> 2) *Evolution:* The theory of Organic Selection; the theory of Genetic Modes, serving as the basis of Genetic Science and of General Evolution.
> 3) *Social Psychology:* The social origin of the Self; the Correlation between personal and social growth through the processes of Imitative Assimilation and social "give-and-take."
> 4) *Genetic Logic:* ... 'Instrumentalism' of knowledge and thought; development of Affective Logic and the theory of Value…
> 5) *Aesthetic Psychology:* Nature of Art Appreciation; the place in philosophy of Aesthetic Intuition (Pancalism).

Baldwin was a very ambitious theoretician. He was not much worried about the detailed description of given phenomena, but concentrated on the big picture of both individual

minds and the evolving human mind as such. As his present-day interpreters summarize his message, "[i]n sum, Baldwin epitomized the modernist quest to understand the basic processes and the structure of those processes within a grand developmental theory. Against the spirit of today's piece-meal research, Baldwin strove for a philosophically coherent system that could account for mental development not only of the child, but of the species. Through such aims, Baldwin went on to sketch the course of development, outlining the relationship of ego, alter, and socius" (Ferrari, Runions and Fueser 2003: 7).

Baldwin (1894a, 1894b, 1897) as a psychologist dreamed of accounting for development and change by developmental social psychology rooted in evolutionary ideas. While his idiom was definitely progressivist when talking about society, he tried to avoid the organicist analogies of Spencer: "The progress of society in its method, direction, and demanding motives is similar rather to the development of consciousness than to that of biological organisms" (Baldwin 1897: 521).

Baldwin in his *Mental Development in the Child and the Race,* published in 1894, summarizes the importance of evolutionary ideas for the study of children, and also outlines a specific theory about the origin of mind. The essence of the methodological principle is that child development *provides explanatory principles* for "adult psychology." The analysis given by traditional laboratory psychology can only be proved through data on the formation of mental processes. Translated into modern terms, cognitive psychology has to have a developmental and an evolutionary embedding. Developmental psychology for Baldwin is a theoretical discipline: it helps to answer the problems of traditional psychology: "The genetic theory[2] reverses all of this (structural questions of adult consciousness). Instead of a fixed substance it assumes a developing, growing activity" (Baldwin 1894a: 14).

The theoretical developmental psychology elaborated by Baldwin has two key elements that are with us today as well. The first is his conception about *the genesis of self.* According to him, self and self-consciousness are developmental products. The separation into Ego and non-Ego comes around in the process of interaction with other peers, and being social has a constructive role in the genesis of the internal world that was taken to be self-sufficient and self-enclosed by classical psychology. In his book on ethical principles and social life, he outlines his ideas that imitation is crucial for social integration – an idea taken up from Tarde (1890). Imitation and circular reaction (i.e., the repetition of an action which tends to keep up its own stimulating process, like when mother and child smile at each other) are interpreted by Baldwin (1894a, 1894b) as internal processes as well, as a sort of internal boosting, that obtains meaning in a social setting (Baldwin 1897: 15):

> The 'ego' and 'alter' are thus born together. … And the two get purified and clarified together by this twofold reaction between project and subject, and between subject and eject. My sense of myself grows by imitations of you, and my sense of yourself grows in terms of my sense of myself. Both ego and alter are thus essentially social; each is a socius, and each is an imitative creation. … This give-and-take, essentially imitative, constitutes a 'dialectic of personal growth,' which is at the same time that of social or-

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[2] We have to remember that in Baldwin's usage *genetic* meant 'developmental' and did not have the meaning which we assume today.

ganization. Society, genetically[3] considered, is not a composition of separate individuals; on the contrary, the individuals are differentiations of a common social protoplasm.

The conclusion is that the individual is a "social outcome, not a social unit" (Baldwin 1897: 15). We are members of one another. The oppositions, conflicts, antinomies of personal and social life are late developments, which are sharpened by the rise of reflective and ethical thinking.

This social conception of the genesis of mind, ego, and consciousness was taken up by George Herbert Mead (1934), combining inspirations from Baldwin and William James. Baldwin has had a continuous and successful influence in American psychology, as well as in French psychology, and his ideas show up in the work of Piaget (1962) and especially Wallon (1941), as analyzed in detail by Vyt, Bloch and Bornstein (1994).

The Baldwin effect

Baldwin's work has recently become much quoted and analyzed due to the importance of the "new factor in evolution" which he introduced (Baldwin 1896), which was much later called the Baldwin effect (Simpson 1953).[4] The effect has become famous since it entails the idea that behavioral, ontogenetic adaptive changes may have a later influence on the organic development of the species, without being Lamarckian. It is very important to emphasize the anti-Lamarckian element here. Baldwin goes back 11 times(!) to strongly indicate that his approach provides an alternative to neo-Lamarckism. It is ironical that today, with the advent of clear models of epigenetic transgenerational inheritance, this issue is again seen in a new light (see Charney 2012).

We can summarize the "new factor" as a twofold claim:
– The abundance and selection process that characterizes Darwinian evolution is true for the individual life as well, that is, the extension of selection to individual development as proposed later by Karl Bühler, Karl Popper, Donald Campbell, and Daniel Dennett.
– These steps of individual selection may later have an influence on the life and therefore the habits of subsequent generations, creating a social inheritance effect, with the use of imitation.

In order to understand the intricacies of the proposal of Baldwin let us try to reconstruct the logic of his argument:
– Standard organic evolution is too slow as a process to account for the dynamic changes in behavior.
– The traditional view of inherited behavior is too passive.

In order the preserve the dynamism of the evolutionary approach to the mind, mechanisms are needed that *speed up behavioral change* and involve variation and activity on the part of the organism, without challenging the separation of the generation and the selection

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[3] I.e., developmentally. (Author's note.)

[4] For a good book about the recent rising interest, see Weber and Depew 2003.

steps in the cycle. Baldwin goes on to list several factors that, from a behavioral perspective, allow for changes over the individual lifetime. He starts off from a table characterizing the factors of ontogeny.

Table 2. The factors of ontogeny

Ontogenetic modifications	Ontogenic agencies
1. Physico-genetic	1. Mechanical
2. Neuro-genetic	2. Nervous
3. Psycho-genetic	3. Intelligent – Imitation – Pleasure and pain – Reasoning

Baldwin clarifies that the first issue is how these modifications can be adaptive, and the second is how they become stable psychological traits. Interestingly enough, for the psychologists, the first issue is very crucial since it entails Baldwin's theory of social learning. The second issue has become the core and crucial one for philosophers of biology and for theoreticians of evolution since it involves gene-environment interactions (Baldwin 1896: 441–442):

Now it is evident that there are two very distinct questions which come up as soon as we admit modifications of function and of structure in ontogenetic development: first, there is the question as to how these modifications can come to be adaptive in the life of the individual creature. … The organism manages somehow to accommodate itself to conditions which are favorable, to repeat movements which are adaptive, and so to grow by the principle of use. This involves some sort of selection, from the actual ontogenetic variations, of certain ones – certain functions, etc. We … apply the phrase *Organic Selection* to the organism's behavior in acquiring new modes or modifications of adaptive function with its influence of structure. The progress of the child in all the learning processes which lead him on to be a man, just illustrates this higher form of ontogenetic adaptation. We then reach another question, second; what place these adaptations have in the general theory of development.

1) *Organic Selection* is the basic principle of selection over the individual organism's lifetime (as contrasted to genetic selection) (Baldwin 1896: 552–553):

Organic Selection. The process of ontogenetic adaptation considered as keeping single organisms alive and so securing determinate lines of variation in subsequent generations. Organic Selection is, therefore, a general principle of development which is a direct substitute for the Lamarckian factor. … *Organic* in the phrase was suggested from the fact that the organism itself cooperates in the formation of the adaptations which are effected, and also from the fact that, in the results, the organism is itself selected; since those or-

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ganisms which do not secure the adaptations fall by the principle of natural selection. And the word *Selection* used in the phrase is appropriate for just the same two reasons.

As Jolivet (2007: 317) summarizes the biological view:
– Environmental changes make a phenotype P adaptive.
– Some organisms acquire P and flourish in the new environment.
– There is selection on genes to make P innate.

The Baldwin effect, while creating an evo–devo issue about the determinants of development, also raises interesting possibilities of diminishing selection pressures due to behavioral and niche changes through the Baldwin effect. If we use clothing, heating, and air conditioning, due to these cultural changes, there is less need for morphological adaptation to heat and cold. In this regard, the present-day biological interpretation of the Baldwin effect also relates to the issue of niche construction and its role in shaping evolution (Laland, Odling-Smee and Feldman 2000).

What is very crucial for psychologists is that Baldwin maintains that there is a continuity here with behavioral variation and change during the individual's lifetime. He characterizes this continuity between physical and mental change at the end of his life in the following way (Baldwin 1930: 1):

… since it is the one principle of Organic Selection working by the same functions to set the direction of both phylogenesis, the physical and the mental, the two developments are not two, but one. Evolution is, therefore, not more biological than psychological, … the individual organisms' accommodations … while not physically inherited, still act to supplement or screen the congenital endowment during its incomplete stages.

This is similar to what Richerson and Boyd (2005) and Boyd and Richerson (2009) call gene-culture coevolution today.

The use of tools that change the environment and in this way modify behavior is in a sense an important realization of the "new factor." Young (2012) gives a similar characterization of these functions and a clear historical reason why the new factor was so important for Baldwin's developmental, behavioral aspects. While Baldwin did not want to become a Lamarckian, he still was struggling against total preformism. He wanted to preserve the dynamicity of Darwin in his theory of individual development, to preserve plasticity in development.

2) *Learning based on reinforcement.* Baldwin, like Thorndike with his cats, also recognizes the importance of the child's ability to learn on the basis of the consequences of acts. The pleasure–pain principles and the so-called law of effect are as valid for habit formation as for genetically transmitted behaviors: "habit is the tendency of an organism to continue more and more readily processes which are vitally beneficial" (Baldwin 1894a: 476). The essential thing about habits is "the maintenance of advantageous stimulations by the organisms' own movements" (Baldwin 1894a: 477).

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3) *Imitation* is a strong and efficient human tool to shortcut the search for behavioral variations. While reinforcement based learning speeds up adaptation, imitation is a further process to shorten the routes.

4) *Social heritage.* In humans, these processes add up to learning from the social environment that constitutes the social heritage. Social learning is beneficiary for the species (Baldwin 1896: 553):

Social Heredity. The acquisition of functions from the social environment, also considered as a method of determining philogenetic variations. It is a form of Organic Selection but it deserves a special name because of its special way of operation. It is really heredity, since it influences the direction of philogenetic variation by keeping socially adaptive creatures alive while others which do not adapt themselves in this way are cut off. It is also heredity since it is a continuous influence from generation to generation. … [S]ocial adaptation sets the direction of physical phylogeny and physical heredity is determined in part by this factor.

Baldwin clearly sees this as a function of cultural inheritance (Baldwin 1896: 553):

It keeps alive a series of functions which either is not yet, or never do become congenital at all. It is a means of extra-organic transmission from generation to generation … it keeps alive variations, thus sets the direction of ontogenetic adaptation, thereby influences the direction of the available choices.

On a descriptive non-committal level, there are three ways in which Baldwin's "new factor" can be implemented:

1) Epigenetic modulatory effects. Since the genetic makeup presupposes environmental effects and organistic "trials," certain solutions here will have more survival value. In this regard, Baldwin deals with the hot issue in evolutionary theory about the precise role of epigenetics, as Waddington (1942, 1957) does, and as we have already seen it.
2) The habit system itself also shows a selection cycle. This is the reinforcement based learning.
3) Habits develop cranes. For Daniel Dennett (1996: 164), the Baldwin effect is basically learning under the impact of consequences:

the essence of the Baldwin effect is that creatures capable of reinforcement learning not only do better individually than creatures that are entirely hard-wired; their species will evolve faster because of its greater capacity to discover design improvements in the neighborhood. According to this point of view, natural selection operating on 'spontaneous variations' is sufficient alone to produce determinate evolution (without the inheritance of acquired adaptations or modifications), since – and this is the new point – in each generation variations in the direction of, or 'coincident' with, the function to be developed will favor the organisms possessing them, and their descendants will profit by the accumulation of such variations. … [T]he individual organism's accommodations,

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made through learning, effort, adaptation, etc., while not physically inherited, still act to supplement or screen the congenital endowment during its incomplete stages, and so give the species time to build up its variations in determinate lines.

The fate of selectionism within psychology: The role of Karl Bühler

In the 1920s and 1930s, before the extended Darwinian theory took shape, there was a non-trivial downfall of evolutionary thinking in biology and social sciences as well, related to the birth of SSSM, as well as to post-war pessimism (Harrington 1996). There was a group of psychologists, biologists, and philosophers in Vienna, however, who maintained some radical aspects of the Darwinian theory, extending it not only towards psychology, but towards epistemology as well. They entertained two crucial ideas, which were relevant for the possible naturalization of culture:
  – A multilevel theory of selection.
  – A continuity claim between elementary and symbolic, cultural forms of behavior.

Karl Bühler, the leader of the Vienna Institute of Psychology, and a central figure in this extension, postulated three 'concentric' levels of selection: "For me, in Darwinism the concept of play field seems to be productive. Darwin has basically known only one such play field, while I point to three of them [...] These three play fields are: instinct, habit and intellect" (Bühler 1922: VIII).

It is a basic idea in evolutionary biology, cognitive sciences, and even in contemporary cultural studies that mechanisms of change are characterized by a two-step Darwinian cycle. This extended cycle was first proposed by Bühler (1922, 1936). The three basic cycles of this model are distinguished as shown in Table 3.

Table 3. Bühler's reconstructed theory concerning the three cycles of selection (after Pléh 2008)

Features	Instinct	Habit	Intellect
Pool of selection	Individuals	Behaviors	Thoughts
Roads to selection	Darwinian selection	Reinforcement	Insight
Proofs	Species specific behavior	Associations New combinations	Detour
Originator	Volkelt, Driesch	Thorndike	Köhler
Organization	"Naturplan"	Associative net	Mental order

The essence of these models is the proposal for optimized mechanisms of change, where novelty generating and selectional phases are separated. The first phase is responsible for creating new reactions to environmental challenges, while the second phase is responsible for adequacy, for the accommodation to the environment.

1) *The Darwinian selection cycle.* Changes here are comparatively slow since the generators of change are random mutations, and changes involve high risks. As Richerson

(2013) reminded me, this was a classical vision. Recently, many comparisons show that genetic artificial selection can be very fast in some cases, and that the relative speed of cultural and evolutionary change depends on the life cycles as pointed out by Perreault (2012). In Darwinian selection, as Bühler first expressed it, our fate is at stake.

2) *Learning mechanisms.* On the basis of environmental feedback, from the many solution attempts produced by the reaction repertory of the organism, the ones leading to success (obtaining food, obtaining the praise of the teacher) lead to the stabilization of adaptive, fitting habits, as the trial-and-error conceptions of Thorndike and Baldwin showed it. The goal is the survival of the individual. Since these processes are based on neural mechanisms rather than on changes in the genome, changes in this cycle are much faster. Whereas the Darwinian mechanism requires at least a few generations to see a large change in a behavioral trait, changes in learning may occur in the magnitudes of hours, or, in higher mammals, in the magnitude of a few minutes.

3) *Thinking.* Humans, and to a certain extent non-human primates as well, form particular representations of the world. Mental representations due to their structural features lead to newer and newer representations. Thoughts in a way tend to have their own life. (This was the vision of the time and of Bühler. Of course, all that we know of some bird cognition today was not available back then.)

Several non-solipsistic social systems provide for their relation to the world. Many of these are individual, such as insight, but some of them arise from a fourth cycle, from the world of culture. The idea-based selection system is able to move in the fastest way, even in a predictive manner. While learning requires hours or minutes, for insightful understanding – once we have the representation systems – sometimes seconds are sufficient. As Richerson (2013) mentioned, this is true "under ideal conditions perhaps. It turns out that people are rather limited in their ability to make predictable large scale innovations. The evolution of simple artifacts like dinner forks and paper clips took an appreciable time to evolve."

4) *Culture.* It might seem strange to interpret culture as a selection system. Still, several broad theories try and do this strange move. Culture might be taken as a system where different varieties are produced, and then, in the world of integrative mechanisms of culture, in the context of social communication, some of them are taken as valid, some as invalid. For example, a new procedure emerges somehow to cut sheets of paper. This procedure becomes accepted in cultural selection when others are able to imitate it with ease and in an unequivocal and reliable manner.

Culture, on the one hand, can be interpreted as a subsystem that combines blind habits based on cycle 2 with rational insight and representation based on insights of cycle 3. This combination is either based on imitation or on rational argument and on specific mechanisms like constrained imitation emphasized by Richerson and Boyd (2005) and Boyd and Richerson (2009).

The unity of biological and meaningful elements in human life is the second lasting impact, the continuation of Bühler's speculations on pools of selection. For Bühler, intention based, teleological and holistic organization is true of all behaviors, and it creates unity between the work of biology and that of the mind: "The distance between the integrated behavior of the amoeba and human scientific thought is certainly impossible to grasp. Still, on

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the basis of the most modern observations both can come under two common concepts: they are holistically organized and are characterized by meaningful events" (Bühler 1927: 127).

In his book on the crisis of psychology and then in his theory of language (Bühler 1934), this continuity between elementary and symbolic forms of behavior is presented as a detailed theory of three maps of human behavior as well as three functions of language. The internal, the behavioral, and the cultural–social have to be treated in a common model. On the one hand, Bühler was in the uneasy position of defending the reality of abstractions in directing human life, and, on the other hand, he was at the same time defending naturalism with a strong Darwinian flavor.

The continuation of selection theory into evolutionary epistemology

In the 1930s–1970s, the majority of psychologists with a remaining evolutionary interest, worked with children, animals, and individual differences, with transparent consequences of evolutionism, but with a much reduced theoretical interest compared to Baldwin's or Bühler's. The theoretical work was continued, however, in the frame of naturalized (and therefore psychologized) epistemology (Quine 1969) to use evolutionary theory to resolve issues of epistemology. Psychology in this way became an interpretation of Kantian epistemology as in the *épistémologie génétique* proposed by Piaget (1972), or of mental architecture as proposed by Popper (1972) and Campbell (1974) in their evolutionary epistemology of knowledge systems.

In two respects, Popper followed the path set for him by the *Denkpsychologie* tradition and Bühler. He rejected the traditional sensualist reductionism of psychology. This showed up as a triumphant overcoming of the problem of induction in his theory of knowledge (Popper 1976). Popper attempted to give a biological interpretation of the mental domain, and for this resolution of the puzzle of induction, he used a problem-solving model of change illustrated in Figure 1.
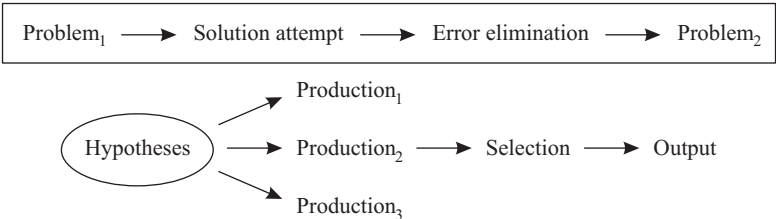
Figure 1. The solution–production–selection cycle according to Popper (1972)

The essential moment for Popper is the separation of production generation and selection, and the organizational similarity of all these cycles, from genes to social selection generation. Mid-20th-century evolutionary epistemologists, most notably Donald Campbell (1974), worked out these ideas in more detail into a general theory of trial-and-selection based systems. These principles can be seen as the most abstract generalizations of the Darwinian ideas, as summarized in Table 4.

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Table 4. The multiple systems of selections according to Campbell (1974)

Domain	Example
Science	Hypothesis–Solution–Choice
Cultural accumulation	Selection in technology
Language	Language variation
Observation and imitation	Social insects
Thought supported by memory	Imagery based solutions
Visually supported thought	Köhler: insights in apes
Habit	Rearranging control systems
Instinct	Organismic perceptual systems
Vicariating locomotion	Echolocation
Problem-solving not relying on memory	Tropisms
Genetic adaptation	Genetic variation and change

All the selections proposed by Campbell have an underlying general structure:

1) All inductive growth of knowledge involves *a blind variation–selective retention cycle.*
2) This entails *variations, consequential selections, and a retention and transmission of selected elements.*
3) Short-cutting mechanisms have *an element of trial and error in their functioning as well, replacing locomotion by mental search, for example, and risking your ideas rather than risking your life.*

Number (3) in this list implies that 'intelligent' and mindful solutions also come around as consequences of selections. Later models, such as Hull et al. (2001), identified universal Darwinism with universal selections showing selections in species in neural networks and in immunology. Dennett (1996) with his Selection Tower metaphor would include individual behavioral and mental thought selection in this system.

What happens with the advent of evolutionary psychology?

The main proponents of the challenging neo-Darwinian program of evolutionary psychology (Cosmides and Tooby 1992; Pinker 1997) try to reduce culture as well to basic adaptive mechanisms. Bolhuis et al. (2011) summarized their provocative ideas as follows:
– The human mind is adapted to an ancestral environment.
– Gradualism: our mind does not adapt fast enough to new environments. There is a Stone Age man living behind modern facades.
– Massive modularity.
– Universal human nature.

Bolhuis et al. (2011) pointed out that today one would need a more flexible vision. First, one should consider the unfolding of niches, and in this way gene-environment coevolution. One should also look for broader adaptation than merely single behavioral traits, and in this process the understanding of development and a consideration of proximal mechanisms, i.e., the underlying neural structures and functions, should be used. Thus, evolutionary psychology should not be dropped but should include a broader set of problems and methods.

The difference between the present situation and the situation many decades ago is not to be found in our questions (our curiosity about whether animals can think or whether society was a natural system have already existed in the past 150 years), but in the larger data sets and the more sophisticated methods available today. For a redefinition of psychological issues in an evolutionary framework, the research of experimental cognitive psychology leads to a better understanding of the inner world of the human mind. We know better today what it is exactly that we have to explain.

Another factor was the development of human ethology into an experimental science along with discussions concerning sociobiology. The differences and continuities between sociobiology and evolutionary psychology (EP) are not at all as trivial as one sometimes feels. EP is a new vision, compared to sociobiology, since it deals with the inner world (it treats the psychological side as belonging to the proximal stage of explanation in the sense of Mayr [1982]), and it takes into serious consideration the results and methods of experimental psychology. There is, of course, considerable variation here. Some EP advocates easily deduce proximal mechanisms just from the foundational commitments of evolutionary theory lines, while others, as also represented in the present volume, try to find out how mental machinery and mental development really work. This is a big change compared to the attitude of sociobiology, which sometimes tended to treat the mental realm as an epiphenomenon. The change does not only flatter the permissible vanity of psychologists but broadens the levels to be dealt with in interpreting behavior.

Within that trend, the new approaches that assign sociality to the individual mind try to elaborate a theory of primary sociality which, at the same time, would not be instructionist in the sense of Cziko (1995, 2000). These attempts usually rely on the analysis of cooperation and empathy, primary attachment processes, the formation of a Theory of Mind, and the unfolding of intentional attribution both in children and across species, as Baldwin wanted a century ago. This is in line with Humphrey's 1976 proposal that social pressures were the basic factors in developing the human mental architecture. They all entertain a set of commitments towards the following:

– Humans are necessarily social beings; society itself is merely a modulation or a derived feature of this primary sociality.
– The roots of this sociality have to be looked for in individuals.
– One can talk about emergent interactionism in this sense.

The idea that the study of culture might be combined with evolution in the sense of denying essences is taken in a more complicated manner than it was first thought of, not as a relationship between existing cultures of today. One could imagine culture building capacity as a central, innate biological feature of the human mind, as emphasized recently by Tomasello (1999), who postulates that cultural learning as an adaptation is the basis of culture, and not the other way round. This is again an oversimplification. Richerson (2013)

reminded me that there is an assumed interaction between social learning abilities and culture here: "The capacity to learn socially will increase, permitting the protoculture to get a little more sophisticated. Repeated rounds of gene–culture coevolution will eventually favor a quite sophisticated capacity for learning socially and an accompanying sophisticated culture to learn."

Similarly, the natural pedagogy approach of Csibra and Gergely (2009) and Gergely and Csibra (2005) presupposes that using the evolutionarily given constraints of mutuality and learning from adult cues, cultures are built up and maintained by an evolutionary learning process.

Interpreted in this way, the issue of culture is the issue of how to build these variant cultures and what advantages are brought about by the mere existence of culture and of representations that are liberated from the constraints of the here and now. This has always been a sensitive issue for biologists. Tivadar Huzella, a Hungarian biologist, characterized it in the following way: "Man stores the experience of his ancestors in costumes, writings, science, and art. This ability for 'external memory' is what actually differentiates man from the animals" (Huzella 1936: 197).

It is interesting to see what the fate of the selection models is in this rebirth of naturalized sociality. The analogical nature of the selection models proposed by Campbell (1974) in their most extensive form has often been criticized. Many authors have discussed the speed of cultural change as opposed to the conservativism of biological evolution and the Lamarckian nature of cultural change. These interpretations are summarized in Table 5. They are presented together with a strong criticism given by Hull (1982), who questioned the simplified contrasts. We can add to this that, from Baldwin's time on, while the unity of the mechanisms was emphasized, it was clear for the Baldwin–Bühler–Popper–Campbell line that with the more symbolic and more cultural selections speed increases and risks are reduced. Their "teleological argument" for higher cycles is exactly an account for the speed of change.

Table 5. The emphasis on differences between biological and cultural evolution and their critique by Hull (1982)

Opposition	Biological evolution	Cultural evolution	Hull's criticism
Category boundaries	Biological: Sharp	Fuzzy, mushier categories	Species is a dynamic concept as well
The course of change	Darwinian: Selectionist	Lamarckian: Intructionist	Instructions in culture are not omnipotent
Teleology	No goals	Goal driven processes	Culture has accidental features as well

Hull (1982), reacting to these controversies, pointed out that a naïve opposition that biology and culture are based on an oversimplified interpretation of biological processes. For example, it is not true that biological categories (species) are always sharply delineated. On the level of both biological and cultural concept formation, scientific categories, for instance, are dynamically changing 'historical' categories. Human communities are not fixed, and neither are biological species: isolated cultures may become separated, fairly well-

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bounded ethnic groups when communication between them is sufficiently rare, in the same way as species bifurcate due to isolation. Concerning intentionality and goal directedness, both Hull and Dennett (1987, 1996) claim that humans freely apply the intentional stance, but this should not create the illusion that teleology would be valid in the outside world as well. As Dennett (1990), in a paper with the provocative title "The interpretation of texts, people and other artifacts," pointed out, there is no principled difference in the human treatment of evolution, the interpretation of each other as intentional agents, and the interpretation of cultural objects like literary works and other human artifacts. With regarding to all of these, one can take the intentional stance, but we should not take this too substantially, we should use it merely as an interpretive strategy. Thus, in this regard, there is no difference between biology and culture. According to arguments like that of Baldwin's, learning agents can influence the evolution of the genes or their culture.

Barrett, Dunbar and Lycett (2002) show in their textbook that even the nearly exact (genes) versus the much less exact (culture) reproduction is rather questionable. They mockingly compare the "heritabilities" in biological and cultural traits. Interestingly enough, some of the cultural traits show as much correlation within human populations as biological traits do. The heritability of height is 0.86, and that of religion is 0.71. "Cultural transmission, it seems, is both reliable and surprisingly robust by comparison with genetically transmitted traits," as Barrett, Dunbar and Lycett (2002: 356) claim. The same is true for the comparison of the speed of cultural and evolutionary change (Perreault 2012).

One can take a reversed vision of the cycles as well. Starting from the cycle of culture, some subsystems, such as science, create socialization patterns which direct the learning systems of cycle 2 from the world of thinking that corresponds to cycle 3. We teach the new generation to read, write and count, in order to provide them with representational systems that allow for faster mental selection and more efficient planning.

Since the time of the synthesis of Mendelian genetics with Darwinism, the relationship between levels of selection rests on the assumption that biology has no inheritance of acquired characteristics, not even in the domain of behavior. Results obtained in selection cycle 2, through individual learning and knowledge accumulation, can in no way have an influence on cycle 1. At the same time, characteristic interactions do take place between cycles 2 and 3, as well as 3 and 4. Several proposals today, the most notable among them being that of Tomasello (1999) and Gergely and Csibra (2003), point out that a striking feature of humans, even in contrast with other primates, is the teaching attitude. We are a teaching and learning species, prepared to learn from our seniors and to teach the juniors, and from early on we apply a pedagogical stance, as Gergely and Csibra (2003) phrase it. This means that in the selection system of cycle 2, we have peculiar expectations for inputs coming from cycle 4, from culture. We have expectations that "others (or teachers)" shall direct our learning systems according to comprehensive systems of expectation and the world of thinking, and cycle 3 shall come through this teaching–culture interaction. Starting from the theory of culture one could also raise several arguments to the effect that one of the advantages of modernization would be the move of culture towards creating more and more subsystems that allow for a wider control over cycles 2 and 3, i.e., over learning and thinking. This directing influence, as Donald (1991, 2001) outlined it, means that the representational systems arising from cycle 3 have an influence on individual learning and information processing mechanisms. According to Donald's conceptualization, these subsystems create

cultures of different types, and this is the framework of having feedback from cycle 4 given to cycles 3 and 2.

There is one more interesting difference brought about by our modern age that still has to be elaborated. The original nature–society–culture continuity aims mostly fit into a selectionist metatheory. The recent interest in the social mind, on the other hand, combines the Machiavellian and the pro-social elements of human social relations. There are many details already in place, but it is still an interesting future task for the theoretical interpretation of the heritage of the naturalization of culture to clearly see the relationships between these two modes of sociality.

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IS SCIENCE POSTMODERN?
CULTURAL EVOLUTION AS AN EXAMPLE

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Introduction

We argue that many of the alleged differences between humanities and science based approaches to studying human behavior are largely mythical. We will illustrate using evolutionary approaches to human behavior as our exemplar. On the one hand, few humanist scholars understand the complexity of contemporary evolutionary theory and many humanities scholars' perceptions of evolutionary theory are based on simplistic non-Darwinian ideas of 'progressive' evolution harkening back to the (distinctly non-Darwinian) Social Darwinism. On the other hand, many scientists using evolutionary theory to understand humans themselves fail to understand the complexities introduced by culture in the human evolutionary process and thus replicate past mistakes in the application of the theory of evolution to human behavior that excite the suspicions of humanists.

This debate is sometimes framed as two positions: postmodernists, on the one hand, who believe that human culture is too complex and historically contingent to be studied effectively through context-independent, deterministic models of linear, progressive development, and evolutionists, on the other hand, who believe that human behavior is definitively constrained by genetic fitness criteria and that the development of social forms follows directly from considerations of genetic fitness. We argue that there is at least a third position which does not fall on a spectrum from one of these positions to the other: cultural evolution and gene-culture coevolution. This position takes culture seriously as a collection of processes that are fundamental to understanding human behavior. Culture has powerful and pervasive effects including having important effects on genetic evolution in our species. We hope that our effort to clarify the issues at stake in understanding human evolution will lead to a more productive discussion than the "science wars" of the past generation.

The theory of gene-culture coevolution exemplifies how a proper science of culture in fact echoes several of the themes that humanists take especially seriously, like the importance og agency. Human agency plays a large role in how culture evolves, a fact well described by Darwin (1874) in *The Descent of Man*. Cultures in turn create environments in which genes evolve. Because cultural evolution is rapid compared to genetic evolution, cultural evolution can play a leading role in the evolution of human genes. We know a few clear cases of agency infusedcultural evolution leading to genetic change (many more are likely to be discovered) in which the agency of humans played a creative, even reflexive, role. The "evolution development" and "niche construction" research programs illustrate this kind of reflexivity in human history and individual development.

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While there is not one single position that one could call "the postmodern" perspective, there are a number of recurring critiques of empirical social science generally, and evolutionary social science specifically, emerging from the humanities and more humanistic strains in the social sciences. We do not attempt to address every extant critique in this article or say that cultural evolution theorists are in agreement categorically with all of them. Instead, we suggest that the position of cultural evolutionists often parallels those of postmodern theorists around many issues centered on the interconnectedness and complexity of culture, the historical contingency of social development, the importance of human agency, and the utility of qualitative versus quantitative methods. Moreover, while these critiques do have legitimate targets within the self-identified community of scientists, this community, as that of the humanities, is represented by a wide variety of perspectives. The "science wars" have traded on stereotypes that are not conducive to useful discussions.

Cultural evolution

For our purposes, it is useful to think of culture as the body of knowledge, opinions, skills, norms, and so forth that humans learn from other humans by imitation and teaching (Richerson and Boyd 2005). Other social organisms have simple forms of social learning, but human psychology and human development are highly specialized to support the relatively accurate and faithful acquisition of large amounts of quite complex information by imitation and teaching. This is not necessarily the only useful definition of culture – we only claim it is one useful definition, useful because it highlights the limitations of theories based on simple genetic evolution models criticized by both humanist scholars and cultural evolution theorists.

Culture obviously changes over time. At least in most contemporary societies, change is rapid enough to be observed by everyone. We variously celebrate and deplore such changes, but no one denies them. Perhaps in the past societies changed so slowly that the people involved did not notice, but historians, archaeologists, and paleoanthropologists have certainly documented that they did change.

To 'naturalize' cultural evolution, we advocate a strategy pioneered by the psychologist Donald Campbell (1965) and first put in mathematical form by Luigi Cavalli-Sforza and Marcus Feldman (1973). The work starts with the idea that culture is a system of inheritance. This idea follows directly from the definition above. We acquire culture from other individuals by teaching and imitation as much as we get our genes from our parents. The existence of a fancy capacity for high-fidelity imitation is one of the most important derived characters distinguishing us from our primate relatives, who only have relatively rudimentary abilities to imitate and teach. We are also an unusually docile animal with an innate norm-psychology. We are unusually sensitive to expressions of approval and disapproval by parents and others, and have an innately primed attempt to imitate others, to teach, to establish group norms, and to enforce those norms (Tomasello et al. 2005; Csibra and Gergely 2011). Thus, parents, teachers, and peers can shape our behavior rapidly and easily compared to training other animals using more expensive material rewards and punishments. Finally, once children acquire a language, parents and others can communicate new ideas quite economically to those who do not know them. This economy is only relative: although

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we get our genes all at once at the moment of conception, acquiring an adult cultural repertoire takes some two decades. Humans ultimately acquire a repertoire of culture that rivals the genome in size and complexity. We have used the faculty for culture to create a stunning diversity of subsistence technologies, social institutions, arts, crafts, languages, and belief systems. Biologists have known since Darwin's (1874) discussion "On the Races of Man" in the *Descent* that all humans are a single biological species with rather trivial organic differences between them (Darwin 1874: 237):

> The American aborigines, Negroes, and Europeans are as different from each other in mind as any three races that can be named; yet I was constantly struck, while living with the Fuegans on board the "Beagle," with the many little traits of character showing how similar their minds were to ours; and so it was with a full-blooded Negro with whom I happened once to be intimate.

Yet, in a cultural sense, we are something like a vast adaptive radiation (the evolutionists' term for a swarm of species with a recent common ancestor but having evolved adaptations to diverse habitats). Our cultures do differ from a biologist's 'good' species in that ideas can spread fairly readily from one culture to another, much as genes can in bacteria. Darwin contrasted the organic similarity of humans of different races with differences arising from different customs (Darwin 1874: 239).

Using modern data and statistical methods, it seems that humans are at least ten times more variable culturally than genetically (Bell, Richerson and McElreath 2009).

The existence of cultural transmission means that culture has what evolutionary biologists call "population level properties." Individuals' behavior depends on the behaviors common in the population from whom they acquire beliefs, just as individuals' anatomy is dependent on the genes common in the population from whom they acquired their genes. Teaching and imitation mean that any individual's ideas are potentially immortal and might influence every future human. Cultures are webbed together by teaching and imitation in something like the same way species are webbed together by the transmission and recombination of genes in sexual reproduction.

The cross-cultural diversity of human behavior is staggering, but for the most part we are limited to learning those extant in our culture in our time. In the long run, the commonness or rarity of genes or culture in the population is a product of what happens to the individuals who teach others or not, and are imitated or not. The analogy is more than a curiosity because population biologists have developed a formidable kit of empirical and theoretical tools to analyze this intricate interplay between the individual and population levels. In the terms sociologists often use, population biologists have the means to make the sociologists' macro–micro problem tractable. By now a considerable number of empirical and theoretical scholars pursue cultural evolutionary research strategies (Mesoudi 2011).

In this exercise, we think it best to wear the analogy between genes and 'memes' most lightly. For example, we have resisted using the term *meme* to describe the 'unit' of cultural transmission because the basic structure of culture need not be unit-like or otherwise more than very loosely analogous to genes. Culture is most un-gene-like in many respects. Culture has the principle of inheritance of acquired variation (what one person invents another can imitate). We are not necessarily blind victims of chance imitation, but can pick

and choose among any cultural variants that come to our attention and creatively put our own twist on them. We do not have to imitate our parents or any other specific individuals but can always be open to a better idea from any member of our social network or from media like books and television. The innovative part of the Darwinian analysis of cultural evolution has been to explore the impact of such differences on the cultural evolutionary process, letting model results and the existing empirical facts, not analogies, guide the research. Substantively, cultural evolution turns out to have its own unique adaptive properties and its own unique suite of characteristic maladaptations, some examples of which we discuss here.

Maladaptations are epistemologically more interesting than adaptations. The trouble with adaptations is that the competing theories – creationism, genetic fitness optimizing, cultural evolution, macrofunctionalism, rational choice theory – all predict that adaptive behavior will be common. Each theory's predicted maladaptations are much more distinctive. For example, W.D. Hamilton (1964) deduced from the principles of natural selection acting on genes that organisms should engage in altruistic acts only when the benefit to the recipient exceeds the costs by a factor greater than the reciprocal of the relatedness by descent between them, his famous $b/c > 1/r$ rule, where b measures benefits of an act ego performs for a recipient individual, c measures the cost of this act to the ego, and r measures the proportion of genes shared by the ego and the recipient. In most cases, the maximum r can be is ½ (parents and offspring, full siblings) and drops off rapidly for more distant relatives. Since in most animal species, individuals have only few relatives with appreciable r, Hamilton's theory predicts that altruism will be massively undersupplied compared to a mutually most beneficial case where help to others is supplied whenever $b/c > 1$. Every individual would be better off if every other followed the $b/c > 1$ rule instead of the $b/c > 1/r$, but natural selection on genes cannot favor such acts. With the exception of humans and a few other special cases, Hamilton's rule predicts the maladaptively low amount of animal cooperation quite well. Human societies are a theoretical puzzle because they typically include much cooperation between distantly related and unrelated people. We have adaptively evaded a rule that otherwise seems to have nearly the law-like force of a physical principle, given genetic inheritance. Cultural evolutionists argue that cultural inheritance and evolution preserve more variation between groups of unrelated and distantly related people than can genes, leading to selection for tribal and larger scale cooperation in our species (Richerson and Henrich 2012). Moreover, the processes of cultural group selection are diverse, including selective survival, selective borrowing, and selective migration. Imperial systems like China and Rome spread in part by military conquests of smaller or weaker societies followed by assimilation to the culture of the victors. But people also learn from the successes of their neighbors, and they voluntarily migrate and assimilate, often importing ideas that the host culture finds useful. And sometimes the victors learn from the people they invaded.

The unique features of the cultural system of inheritance are predictable from the elementary consideration that selection on genes to increase our capacity to learn from each other would surely not have favored this rather costly system if it did only what genes could do for themselves. One important advantage of the cultural system is the linkage of individual and collective decision-making processes with transmission to create a system for the inheritance of acquired variation. Given that decision rules partly derive from the

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action of selection on genes and hence are adaptive, on average at least, a system that responds both directly to natural selection and to adaptive decision-making forces will be able to adapt to varying environments more quickly than can organisms that adapt by genes and non-transmitted learning. Strategically plagiarizing the learning of others, while also being willing to learn yourself when the opportunity arises, creates a system that can adapt swiftly to new conditions without a crippling expenditure of effort on individual learning. Individual learning is heavy lifting, and culture allows us to share this load among many individuals. This system has roots in the common capacity to transmit simple behavioral variants by social learning, as has been well studied in our closest relative, the chimpanzee (Whiten et al. 1999). But the chimpanzee's (and all other social learning species so far studied) social learning skills are rudimentary compared to humans (Tennie et al. 2009; Dean et al. 2012).

Secondly, accurate and rapid social learning allows humans, but seemingly not other species, to accumulate innovations so as to build up, historically over many generations, more sophisticated cultural adaptations than individual people could possibly have invented for themselves. The Arctic adaptations of the Inuit and their relatives and the ocean voyaging adaptations of the Austronesians (Polynesians and related peoples) are examples. Human cultural adaptations are not only dramatically different from place to place and time to time but are also as complex as organic adaptations that would take much longer to evolve. The Inuit adaptation to the Arctic and the San adaptation to the Kalahari are impressively complex and impressively different on a scale that would result in different species if accomplished by organic evolution. In support of these theory-derived conjectures, we note that humans evolved during the Pleistocene, a period of high frequency climatic variation (Richerson and Boyd 2005), and we became an unusually widespread animal by middle Pleistocene times. The ability to adapt quickly to a temporarily variable environment is easily put to use adapting to spatial variation as well, adapting a tropical ape to live in temperate and eventually periglacial climates. We eventually became completely cosmopolitan using subsistence strategies tailored to practically every terrestrial and amphibious habitat on the planet. We believe that ability of the cultural system to rapidly create sophisticated adaptations to niches that persisted for a relatively few generations was the main advantage that paid the overhead of our large brain and long learning curve.

The hominid lineage probably had rudimentary forms of culture stretching back to our last common ancestor with the other apes. Oldowan stone knapping goes back to 2.6 million years, and quite sophisticated stone tool-making goes back at least 100,000 years; discoveries in Africa keep pushing back earliest dates for various techniques. Over this long span of time, genetic and cultural evolution most likely became entangled. Genes most certainly must have adapted our brains and behavior to acquire and manage culture. Much cultural variation is obviously adapted to promote human survival and reproduction, as Julian Steward (1955) and his followers demonstrated long ago. Charles Lumsden and Edward Wilson (1981) argued that gene-culture coevolution would lead to powerful selection on genes to keep culture on a leash so that cultural evolution would be tightly constrained to be adaptive.

Probably, no one really doubts that the mechanisms considered by Lumsden and Wilson (1981) are important. Humans have used cultural adaptations to become a strikingly successful species; our genes have benefitted from our having culture. But that is only part of the story. Because cultural evolution is so fast in comparison to genes, culture in

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many ways has become unleashed. If a novel cultural variant arose not restrained by an existing genetic 'leash,' genetic evolution of such a leash would be limited by the random arising of a genetic variant that would act as such a stronger leash. If such a genetic leash were to arise, culture would have already moved well beyond the original variant, making the new genetic variant potentially irrelevant. While a simple genetic reduction in social learning ability could potentially eliminate this behavioral genetic problem, it would also throw out the rest of the benefits of culture and so would likely not be successful in the immediate future. Human culture, on this argument, was and is a successful adaptation for human genes precisely because the genetic leash is very long, allowing cultural processes to let human cultures range widely in a search for successful adaptations to diverse environments. Thus, cultural evolutionists have come to roughly the same conclusions about the relative roles of genes and culture in human development and in human history as have many humanists.

The theory of cultural evolution is curiously parallel to the concept of 'social construction.' The role of genetic universals in the cultural evolution picture are important but the most important universal of all is the capacity for imitation and teaching that allows a lightly guided process of cultural evolution to explore a huge design space, for example with regard to diet. Human cuisines obviously have to satisfy basic requirements for protein, energy, and essential micronutrients, and genetic leashes certainly help select cuisines to satisfy these requirements. No humanist would deny that genes have such a role to play. They and cultural evolutionists merely point out another obvious fact. These basic requirements have been satisfied in a host of different ways as cultures exploit a diversity of wild and domestic resources using cooking and a large variety of other processing techniques to make otherwise inedible things edible. We can still eat many of the same lightly processed or unprocessed foods like ripe fruit that our ape ancestors and relatives depend upon, but these make up a modest fraction of most cuisines. Rather, we have used culturally acquired skills like cooking to exploid food resources that are impossible for other apes to use, and do this over and over again in almost every terrestrial and amphibious environment on the planet.

Wide-ranging culture in turn seems to have played a large role in shaping human genes. Culture creates novel environments to which genes have to adapt. Because cultural evolution is faster than genetic evolution, culture-led gene-culture coevolution is potentially as important as, or more important than, genetic leashing mechanisms. Selection for physiological adaptations to plant rich diets and various adaptations to the epidemic diseases of denser populations in the wake of the evolution of agriculture are well documented (Laland, Odling-Smee and Myles 2010; Richerson and Boyd 2010). So far, the evidence is less striking for evolutionary events deeper in the past. But a reasonably good case can be made that the innate aspects of our social psychology were shaped by tribal scale selection for culturally transmitted cooperative social institutions. If we want to look at it this way, cultural evolution has played an active leading role in shaping human genes. In some non-trivial sense, we can say that human nature is socially constructed and we arrive at this conclusion via wholly naturalistic assumptions.

It must be said that the picture we have just painted of the creative role that we argue cultural evolution has played in human evolution is fiercely contested by some other evolutionists. Edward Wilson (1998) remains a 'tight leash' genetic reductionist, and certain

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evolutionary psychologists doubt that what we call culture plays anything but a strictly sub-ordinate role in human adaptation (Tooby and Cosmides 1992; Pinker 2010).

We now turn to the way cultural evolution and gene-culture coevolution relate to important issues raised by postmodernist humanists and humanistic social scientists.

Historical contingency

Some humanists and scientists hold history and science to be antithetical human endeavors. In this view, history seeks to explain the development of human behavior through sequences of idiosyncratic events, and science seeks to define physics-like absolute laws of human behavior that are context independent. This is a false dichotomy (Boyd and Richerson 1992). It is easy to show that natural selection generates historically contingent patterns of change. True, the simplest models of selection acting in the simplest environments act like classic exceptionless scientific 'laws.' However, real environments and more realistic models generate much more complex and fundamentally unpredictable trajectories of change. Empirically, we see the impact of historical contingency in evolutionary biology when we look closely at the suites of organisms that live in similar environments in different biogeographic regions. While we observe many convergent similarities in, say, wet tropical forests around the world, there are many conspicuous failures of convergence as well. For example, in the tropical and subtropical Americas, the hovering hummingbirds are a diverse group of nectar-feeding and pollinating birds. In Africa, the perching sunbirds are the principal specialized nectar feeders and pollinators. The forms of flowers in the two regions have coevolved with the hovering versus perching habits of the principle pollinators. In this sense, Darwinian evolution actually predicts that trajectories of change will be historically contingent, being based fundamentally on the arising of essentially blind, random variation. Once one moves beyond the (much too commonly used) oversimplifications of evolutionary equilibrium, historical contingency becomes even more important with such problems as frequency dependence of fitness, interactions between different variants, and developmental and niche construction feedbacks on evolutionary trajectories. Not only does Darwinian evolution predict path dependency of change, but it also predicts that fitness generally will only maximize fitness locally. Globally fitter species may exist but evolution may not have selected for them. Empirically, the frequent success of species introduced from other biogeographic realms suggests that not every species that could have evolved in a particular realm actually did so.

The historcal contingency vs. universal laws argument has a long history. One of the best known early proponents for the 'physics-like' notion of social development was Spencer, who in the late 1800s advocated a non-Darwinian, progressive model of evolution. From Spencer, we inherit the common misunderstanding that evolution predicts clear trajectories of social change, from the primitive to the modern. The highly deterministic physics of the day was taken as the basic model of scientific knowledge. Boas (1887) contrasted these early notions of cultural evolution with the notion that cultural development would be locally idiosyncratic, based on local innovation and diffusion of cultural variation, which are foundations of modern cultural evolution theory. Boas's fieldwork program was devoted to the documentation of cultural variation and the quest for regularities. His conclusion was

that context independent regularities in human development were much rarer than popularly thought and that where they existed they were often riddled with exceptions. He arrived at this conclusion not by argument against empiricism as methodology, however, but through empirical observation using both quantitative and qualitative methods (Lewis 2001).

It is not a question of whether to use empirically framed models or not, but of model choice. Cultural evolution models based on social learning actually predict historical contingency, and long-standing empirical observation supports this view, a position actually shared by postmodernists and scientists. It is not a question of science vs. humanities.

Agency

In the debate about the relevance of social structure vs. agency in the ongoing construction of, and possible changes to, social relations, agency is conceived as the freedom of motion of individual agents delineated by the social structure, and social structure is conceived of in terms of these limitations (Giddens 1976). Empirical approaches to social science are often criticized for simplifying away important variation in individual perception and agency. Noting the structural importance of individual decision making, many, including Weber (1922) and Watkins (1957), have argued that in order to understand a system, we must understand it in terms of the perspective of the individual, thus advocating methodological individualism. Sidestepping the philosophical question of the nature of free will, we look at agency as the capacity for choice amongst a range of behavior and the question of relevancy of agency as a question of the reflexivity between agency and structure. We find a strong agreement between Giddens's (1976) theories of structuration and cultural evolution models, which, taking the strategy of methodological individualism, model social systems as assemblages of individuals (agents) who behave in ways strongly affected by society via processes of social learning (imitation, conformity, teaching, indoctrination, etc.). In these models, agents are not treated in a physics-like, deterministic fashion, but probabilistically, reflecting the range of behavior possible within the structure of society and indicative of our lack of ability to predict precisely what the individual will do within that range. The random element in the models reflects culture's ability to explore 'design spaces' in a historically contingent creative way. Theoretical social forces like conformism and group norms are modeled in cultural evolution models as individual tendencies to conform to observed dominant behaviors in a social group.

Structure in cultural evolutionary models arises out of individual psychology, albeit integrated over many individuals and over time, all in a particular historical and ecological frame. In this way, cultural evolution models are just mathematically formalized versions of specific models of structuration. Moreover, the specific choices made by individuals may or may not be important for the cultural evolution of the population, depending on the specifics of the model. In some instances, a choice may be overwhelmed by other factors. In others, a single innovative choice could change the trajectory of the whole system in vital ways. Of course, most individual innovations wink out without significant effect, but at the root of most significant effects will lie innovations made by individuals. Taking the approach of methodological individualism as a starting point, cultural evolution models predict the possibility of stable structuration through a feedback between individual choice making and

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structure manifest through observed choices of others. This echoes Bourdieu's idea of the habitus and field (Bourdieu 1977). Cultural evolution goes beyond these static models, however, demonstrating other contexts in which the agent/structure or habitus/field relationship will be destabilized by cultural innovation, the product of human agency.

In the models we make of cultural evolution, we speak of 'decision-making forces.' Some of the most important forces acting on culture are the choices individuals and groups make in deciding what ideas, skills, attitudes, opinions, and so forth to adopt. Darwin, in the *Descent of Man,* spoke of such forces as the example of the best people, customs, and public opinion being the more important causes of moral progress than natural selection in "civilized times" (1874: 192) Leaving open the empirical question of decision-making biases driving moral progress as envisioned by Darwin, it is clear that Darwin envisioned important roles for this kind of individual decision making in the evolution of culture, in potential opposition to simple natural selection. Models of cultural evolution not only utilize these kinds of decision-making possibilities, but actually predict that they will arise via processes like cultural group selection (Richerson et al. n.d.). The vast diversity of human subsistence systems, social institutions, languages, artistic creations, religions, and philosophies testifies amply to our individual and collective creativity. Harnessing creativity more efficiently than genes can do is the most significant feature of culture.

Complexity: diversity vs. linearity, and truth vs. prediction

A number of critiques of scientific methods revolve around the complexity of human society. While all but the most extreme versions of critique of science accept the utility of the (relatively) simple deterministic laws of physics in predicting the phenomena they claim to model, postmodernists posit that the extreme complexity and interconnectivity of human society makes for a system that will not be explainable through simplified mathematical models. Starting from Heidegger and continuing with Weber and others, the critique is that a scientific project of attempting to discover universal laws and deterministic linear processes of social development from primitive to more advanced are doomed to failure. Lyotard (1979) famously characterized postmodernism as a healthy skepticism for metanarratives. Lyotard (1979) claimed that while objective reality may exist, it is impossible to discover a true model of underlying phenomena through which other models can be explained.

While this critique does have legitimate targets within science, many natural and social scientists agree that such universal, physics-like laws are not likely to be found in human behavior and many other complex phenomena affected by historical contingency. These conclusions come out of a mathematical analysis of complexity. Darwinian cultural evolution specifically does not posit a linear progression of social organization, except in very specific constrained circumstances, where both the environmental circumstances *and* the range of cultural variations repeat. For example, Esther Boserup (1965) showed that, contrary to a Spencerian model of cultural development that would posit that agriculture advances linearly from hunter gatherer through horticulture to modern agriculture, this change is driven specifically by population size, not "advancing culture." Robert Netting (1993) showed that this was in fact reversible with reversing population densities. Cultural evolution argues that this pattern repeats due to strong selection pressures combined with a

reliably stable toolkit of agricultural techniques available in the cultural repertoire (which includes memory and learning across social groups). Where cultural selection pressures are not so clear and strong and where there is not this reliable, stable toolkit of cultural variants to be selected on, cultural evolution predicts a proliferation of cultural variants and has further reasons to predict widespread diversity and non-linearity of social development.

Biologists realize that the phenomena they study are exceedingly complex. As ecological statisticians Burnham and Anderson (2002: 20) put it, "we believe that 'truth' (full reality) in the biological sciences has essentially infinite dimension, and hence full reality cannot be revealed with only finite samples of data and a 'model' of those data." This view is echoed by Mayr (1982). Boas (1887) viewed culture similarly. The number of relevant variables is too large to ever be able to generate in the real world a data set large enough to test hypotheses of interest, and the best we can hope for are context specific rules or tendencies that will tend to break down out of their (usually unknown) contextual boundaries. Many biologists and social scientists are thus postpositivist. Human cultures exhibit the same complexity and diversity as other biological phenomena. Very many questions can be asked about human phenomena; there are no authoritative final answers to any of them. At best, we may be fairly certain that some answers to a given question may be contextually and conditionally better than others. We agree with Lyotard in this sense, that if there is an objective truth or metanarrative, it will be beyond our humanly limited ability to model, and so we are limited to a plurality of narratives (models) which are contextually applicable.

If the complexity and diversity of evolving genetic and cultural systems cannot be understood in terms of general laws, can we do science at all? The approach that has evolved in evolutionary biology and ecology supposes that we have some hope of understanding complex and diverse phenomena, but only locally (Richerson and Boyd 1987; Burnham and Anderson 2002). A particular instance of evolution has likely been influenced by many different factors, some strong, some weak. With limited data – and data is always limited – we can hope to explain only the strong factors. But the strong factors in one case will not be the strong factors in other cases. Therefore, we try to have as large a toolkit of candidate explanations as we can in the hope that one or a small set of models can capture the strong effects in as many cases as possible. With a large box of sound tools we will be better equipped to account satisfactorily for a wider range of phenomena we encounter and to create useful predictions in a wider array of circumstances, always with the proviso – expectation even – that in the future better tools and more data might make current best explanations seem quite naïve.

Thus, it appears vain to hope for a 'totalizing' metanarrative, or Truth, that society is the sum of individual actions. As Burnham and Anderson (2002: 58) point out, in deriving an information theoretic goodness of fit measure to compare how well alternative models fit the data, an assumed "full truth" term in the derivation becomes an irrelevant constant. In the end, we can estimate from our data which of our models is closer to "full truth" but only relative to the other models. We do not have any idea how far our best model is from "full truth"! The information theoretic approach also penalizes models in a principled way for their complexity. This is because too complex models will fit the noise in our data as well as whatever slivers of truth we can extract from it, distorting our picture of the slivers themselves. Thus, we are generally forced by the limitations of our data to work with quite simple models compared to what we know is an ever so much more complex "full truth."

The question for the Bayesian scientist then becomes one of whether a model's predictions are useful or not, not whether the model is "true". Bayesian and information theoretic model comparison methods (like AIC and BIC) formally account for a priori assumptions of model probability and for amount of data in comparing the relative utility of the different models to prediction. In this way, the relative usefulness of the models depends on the individual perspective in terms of assumptions (priors), experience (data), and values (question asked), as well as on the models (theories) to which they are being compared. In this way, many scientists today agree with the analysis of Max Horkheimer in his critique of positivism and the claim that scientists will always be limited by their own available perspectives (Horkheimer 1972). From this position, we understand the necessity for a debate of values and the appropriate questions to ask, wich may change our model formation, and we always maintain an openness to incorporate new data and new models.

Thinking about such study systems as biology and human behavior and the purpose of model construction not as objective "Truth" finding, but as developing relevant predictive tools, we can then discuss when such tools are expected to work well in terms of helping us make functional decisions and when they work miserably. Our *understanding* of a system boils down to having a good hunch of what models will work best in what situations. Trader-statistician Nasim Taleb (2008) provides a very timely example of this issue of contextual relevance of models in writing on the reckless financial decision making of government and Wall Street economists in the run-up to the 2007–2008 financial crisis (see also Whitehead and Richerson 2009). Economists deploy enormous amounts of resources to create vast data sets on which to make predictive models in which there are vast sums of money to be gained or lost. As such, one can expect that within certain contexts, specifically, near the data set, predictions should at least be better than chance, which they do tend to be. These models will often be a best fit model given the data used to generate the fits. Taleb, however, divides the world of decision making into four quadrants based on two variables: (a) complexity of the relationship between the variable analyzed and the policy decision, and (b) the containment of the variation in the variable. Where variations in events of interest are in fat-tailed distributions (variation is not well contained) and where the impacts of these events are highly sensitive to this variation, we can expect that our models will be worse than useless. Variation in economic data, such as returns from the stock market, set a trap for the unwary modeler. Short runs of data are adequately fit by simple risk models based on the normal distribution of variation. Typical economic datasets are not long enough to adequately fit more complex models. But we do know qualitatively that behavior of the stock market is dominated by big, rare events like the Great Depression and the late 20th-century stock market boom, of which a dataset may have only one or two exemplars, too few to guide model fits. As Taleb (2008: 10) writes, "no model should be better than just any model" in this situation. This is specifically the context that economists were claiming that their models fit: prediction far outside of the range of their data and applied to variables whose policy implications were highly complex. To paraphrase Taleb, a blind guess would have been better, for then it would have at least been transparently random in its relationship to reality. Economists were steering the global economy using models they knew or should have known to be wildly inappropriate. Their skinny-tailed models fit their data well, but a qualitative understanding of economic time series, and the fat tailed real world more generally, should have been enough to inicate that the models were dangerously unrealistic.

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Interestingly, statisticians working on highly applied problems, such as Burnham and Anderson and Taleb cited above, have given us some of our deepest insights into the limitations of scientific methods. Both of us have been applied scientists at points in our careers. Applied science highlights risks of being wrong. Basic scientists who get the wrong answer damage their reputation. Applied scientists who are wrong damage their reputations *and* the people and other organisms harmed by their mistake. Applied science is also usually political. Applied scientists are exposed to variations in world views and ethical principles that basic scientists have the luxury of ignoring. They see exercises of political power on a scale larger that the infighting over awarding grants and publishing. In the world of applied science, we often cannot afford the ramifications of mistakes arising from blind faith in theory.

To restate, postpositivist science is not centrally concerned with absolute Truth, but in understanding and prediction on a much more local scale. Evolutionists and ecologists have become rather humble about what they hope to know and apply in the face of problems of 'essentially infinite dimension.' (Perhaps economists have now learned this lesson too.) For example, in the late 20th century, applied ecologists developed the strategy of "adaptive management" (Walters and Holling 1990). The concept takes it for granted that we understand only a fraction of what is going on in any ecosystem. Management activities will inevitably be based on incomplete information and inadequate models. Such activities are comparable to experiments. We can anticipate that they will often have unforeseen consequences, but by studying them as experiments we can hope to acquire more and better data, improve our models and do better next time. We can also anticipate that external shocks or our own activities can trigger important variation on dimensions which in the past did not vary enough to be important. There is a sort of 'law of conservation of ignorance' at work. We cannot know the Truth about any complex, historical system, and even if we could, it would not remain the Truth for long!

We could not agree more with postmodernists in this case about the dangers of claims to a metanarrative, a context-independent universal model. Issues of such inappropriate claims of knowledge will continue to have vitally important global economic and political ramifications.

Qualitative vs. quantitative methods

In his call to interpretive methods and hermeneutics, Heidegger points out the limitations of quantitative analysis, the necessary simplification in order to translate a rich and complex situation into numerical language. Some humanists from this point of departure make rather bold claims about the unsuitability of numbers for understanding human behavior. Similarly, there are scientists who turn their nose up at qualitative research, suggesting that truth only comes with quantification. This is another false dichotomy. Many, if not most, practicing social scientists understand the mutual support and contextual utility of quantitative and qualitative methods. Most evolutionists, ecologists, and geologists are proud of their natural historical abilities. Ethnographers, historians and others interested in humans use the same techniques. Acute observations and ordinary reasoning are the quickest and cheapest way to get a general feeling for a phenomenon of interest (Henrich and Henrich 2007: 3–4). Many quantitative research questions emerge out of the hard ground work of exploratory qualitative

research, and arguably the big picture of any complex system cannot be understood without the kind of thick description advocated by Geertz (1973). Donald T. Campbell is quoted as saying, "All research ultimately has a qualitative grounding" (Miles and Huberman 1994, see also Leijonhufvud 1997).

At the same time, our natural reasoning skills are not terribly well suited to rigorous logic, and our raw observational skills deal with quantities quite poorly. Verbal reasoning can be handicapped by the imprecision of word meanings and by polysemy. Mathematical models and quantitative observation are merely prostheses or instruments to aid the mind, rather like spectacles, telescopes, and microscopes aid the eyes. In the contemporary approach to hermeneutics, called objective hermeneutics, this is referred to as the efficiency of quantitative methods (Oevermann et al. 1987). Translation into mathematics simply makes our descriptions more precise, which does not make them truer but facilitates the assessment of their accuracy relative to other descriptions of the system. Mathematics makes for a narrow, precise picture of a detail or a dimension of a system, whereas qualitative methods give a broad and rich but soft focus narrative about a system. The question becomes one of when the sacrifice in terms of richness of description is justified by the precision of analysis, a question which rests on the qualitative hermeneutic research, which sets the parameters of debate, the values which guide research.

The Bayesian theory of empirical inference formalizes a relationship between quantitative and qualitative methods. First, we distill all our basic understanding of the problem at hand to construct our priors. Much of this exercise is typically qualitative. For example, we may have good qualitative grounds for suspecting that our problem's variance is dominated by big rare events. Then, we consider that quantitative data and update our priors. If our time series inadequately resolves big rare events, we will hardly adjust our priors at all after considering the data. The problem is dominated by big rare events, uncertainty is high, and the quantitative data we have do little to reduce the uncertainty. Better to understand this than take action on a bogus quantitative model that generates a precise but useless prediction.

Far from ignoring qualitative research, empirical social scientists essentially rest upon it. Qualitative and quantitative research support each other. Quantitative research, being simply a formal translation of simplified verbal models into the language of mathematics is no more than a specific breed of qualitative description that is amenable to more efficient methods of analysis and more precise and accurate application of logic. The question of utility of these qualitative descriptions vs. quantitative models is essentially then one of model comparison, and the answer of relative utility is dependent on available data and the question being asked. What becomes interesting is when methods are combined in a single analysis. When qualitative and quantitative studies agree, we feel more confident in an assertion. When they disagree, we become doubtful of our ability to predict the situation and new research questions are opened up. Neither method is a priori closer to the truth.

Conclusion

The thesis of this chapter is that there is less disagreement than is often presupposed between what are considered postmodern critiques of science and the views of many scientists themselves. The communities of researchers engaged in interpretive versus empirical approaches

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to the study of human behavior both have wide ranges of opinions. Not only does the range of opinions within the two communities have significant overlap, but so do the communities themselves, as individual research groups use both qualitative and quantitative approaches to given questions to avail themselves of the strengths of both methods. We do not attempt in this chapter to engage with all extant critiques of quantitative social science. For example, it is beyond the immediate scope of this article to address the issues of power and privilege in science or the distorting power of money on science, and we confine ourselves to just noting that we basically agree that all rhetorical forms have their own scopes of power, and that evolutionary biologists in the thick of biodiversity conservation fights or environmental scientists and policy scientists dealing with the highly politicized fight over global warming are fully aware of this from their own personal experience. This chapter instead has the more humble goal of showing how many contemporary qualitative social scientists and cultural evolutionists particularly are in agreement with some of the claims frequently described as critical postmodern perspectives. The stereotyped view of a two-position debate between postmodernism and empirical social science fails to capture this agreement around the historical contingency of culture, the importance of human agency in the trajectories of culture, and the inaccessibility of Truth due to the complexity of cultural systems. Moreover, these social scientists, particularly ones using the theories of cultural evolution, do not just take these positions as a priori assumptions, but actually arrive at these findings from empirical study and the logical implications of their models. recognized by empirical social scientists for their individual contextual utility and their mutual support. Finally, as social scientists, we join in the chorus of criticism of those who attempt to use grand theories of human behavior to direct government policy without a sense of the strict contextual limitations of all theories of human behavior.

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BIOCULTURAL APPROACHES TO HUMAN MATERIAL–SYMBOLIC PRACTICES AND KNOWLEDGE

Eugenia Ramirez-Goicoechea

To Tim Ingold,
unintented master and teacher

In this chapter, I argue for a biosocial/biocultural shift in how we think of human lives, affairs, and actions, including the mind and knowledge.[1] I am convinced of the necessity of a more comprehensive and holistic approach to humans as persons and collectivities, as special organisms entangled in dynamic complex environments. One of the main obstacles for this orientation is in our deeply entrenched *nature/culture* divide, which is the trademark of our dualistic tradition of thought, both in folk systems of knowledge/practice as well as in science production. The first part of my work concerns a) a brief account of how this dualism is practiced in neo-Darwinian thinking, as a hegemonic practice and theory in the so-called life sciences, as well as in the social sciences, especially in social and cultural anthropology. Then I move on to propose b) an epistemology shift based on theories of dynamic, self-organized, complex non-linear developmental systems, which, I credit, will help in a non-dualistic encompassing view of what and how it means to be(come) a human being. This reflection leads the rest of my contribution. Working upon this epistemic reflection, I try to c)deconstruct essentialized notions of *nature,* both as environment and as underlying architectures of organisms. The adaptationist program, universals and particulars, and the post-genomic turn in systems biology will be discussed. Next comes d) a renovated concept of *culture,* not in opposition with biology, with the neo-Darwinizing of *culture* as a biased way to 'naturalize' it, but considering the anthropogenic origins of our eco-social environments for living and development, and the constitutive role of our material–symbolic practices and imageries in this niche-building, in which biological and socio-cultural aspects are not ontologically separated. A non-reductionist, non-dualistic, non-overlapping *biosociocultural* approach, in which psychology, history and political economy are also

integrated, provides for a wider, comprehensive, and fruitful theoretical frame when dealing with the complexity of human lives and their doings in a relational world. Last but not least, and in connection with the rest of the paper, I suggest e) a non-reductionist interpretation of knowledge, but as embodied, situated knowledge experienced and co-produced through flexible distributed participation in epistemic communities. A shift to neurocultures and neurosocial aspects of knowledge is also considered. Finally, f) I review some epistemological and political conditions for true interdisciplinarity and advance in the study of humans and their ways of be(com)ing. The coalescence of human material–symbolic practices and individual and collective constructions of local/population biologies is analyzed as a particular case in which the heuristic advantages of such a biosociocultural orientation is to be seen. To conclude, g) I finish with some considerations for a biosociocultural theory of mind and knowledge.

Dualistic thinking and the nature/culture divide

Introduction

Epistemologies consist of how we think and address ontological*(ized)* beings, objects, relationships, qualities, types of causality, agency, etc. They conform to general frames of how we understand the world and our mutual assemblies with it.

Although not exclusive to us,[2] binary thinking is prevalent in Western intellectual/practical traditions, both in *common sense* intuitive psychologies and folk taxonomies, as in science production.

Epistemologies embrace specific paradigms as broad conceptual–practical categories that are at the core of theories, which in turn inspire specific methodologies and guide data production, analysis, and interpretation.

Many of our commonly taken-for-granted antinomies and oppositions acquire this dual format as well: (a) *nature/culture,* nature/nurture, biology/culture, biology/society, genetics/development, evolution/development; (b) animal/human; organic/inorganic, genotype/phenotype, phylogeny/ontogeny; (c) mind/matter, mind/body; (d) real/symbolic, material/symbolic, organic/symbolic; (e) cognition/emotion, reason/senses, innate/learned-acquired; (f) subject/object, individual/society; (g) action-practices/norms, intention/action, representation/discourse, mind-categories/action, thinking/doing, cause/effect; etc.

This paragraph is especially concerned with the *nature/culture* dualism from wich.

The division between life sciences and humanistic and sociocultural sciences is very much one of the outcomes of this kind of epistemology.

Nature has been the traditional object of study for the broad scientific domain called *natural/life sciences. Humans, societies* and *cultures* were placed 'outside' *nature,* their study being relegated to the humanities, social sciences and certain psychologies. However, and despite a diversity of interests, theories, methodologies, and data production, Euro-American social sciences and humanities were historically constituted against the so-called *natural* and *life sciences.*[3]

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[2] See Astuti 1995.

[3] With some exceptions. See Boas 1982.

In my opinion, this divide is untenable anymore. First of all, because our unconnected and arelational partitioning and practicing of a world split into these "two houses" (cf. Latour 2004)[4] is ethnocentric – it is a historical, sociocultural, and political invention. It is but a very specific one among other possibilities. There is diversity in how humans may construct and relate to a world, whatever way this is defined and lived.[5] Ours is quite far from other holistic epistemologies and ontologies that show interconnectedness and environmental *communalism* (Pálsson 1996).[6] Our *nature/culture* division is but a reductionist simplification: it leaves out more than it takes in because it does not allow for a comprehensive theoretical account of the dynamicity and complexity of humans-in-the(ir)-world, constitutively built by their eco-historical relations with themselves and non-human entities. Secondly, this view jeopardizes alternative knowledge production based on discipline hybridization and true interdisciplinarity. Thirdly, it prevents ethical and political global and local practices for world sustainability and future.

In my view, a *nature/culture* deconstruction is necessary if we want to provide a much more integrative view of human affairs in a relational world, that is, a biosocial and biocultural approach to human material–symbolic practices and knowledge production. Making visible some "roads not taken" by hegemonic trends in science production (Stotz and Griffiths 2008: 38), and uncovering the metaphors and broader systems of reference onto which they are anchored will help us develop further enriching and challenging explorations and research.

The nature/culture divide in neo-Darwinian thinking

When Hugo de Vries (1848–1935) rediscovered G. Mendel's experiments on reproduction, Darwinian evolutionary theory conflated with genetics in what J.S. Huxley named as the *new synthesis* and Romanones as *neo-Darwinism.* In this turn, population genetics (Fisher 1930; Maynard Smith 1958; Cavalli-Sforza and Feldman 1981) and neo-Darwinian accounts of evolution[7] reduced biology to genetics and life evaporated from biology.

Neo-Darwinian thinking, be it in evolutionary theory, population genetics, sociobiology, behavioral ecology, gene-culture co-evolution theory, evolutionary psychology, *memetics,* etc., relies heavily on the *nature/culture* division.

Nature is understood in a twofold fashion. First, as *nature-out-there:* the autonomous extracorporeal environment that we name 'reality,' which imposes itself onto us and other forms of life to be either controlled, or transformed, or adapted to. Second, as *nature-in-here:* our genetic endowment.

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[4] Thanks again to C. Pléh for recommending to me Latour's ideas on the topic.

[5] See Descola and Pálsson 1996; Ellen 1996; Ingold 2009, 2011, Viveiros de Castro 1998, 2003; Ventura i Oller 2012.

[6] Wholeness, connectedness, and restitution of equilibrium are issues in many Amerindian cosmological, religious, and ecological beliefs and practices, as well as in some African and Australian native groups, and also in Buddhism and Taoism, in spite of the dualistic thinking in other domains (i.e., *yin/yang,* etc.)

[7] Behavioral ecology, evolutionary psychology, modularity, and domain specificity theories of mind and cognition, sociobiology, memetics, gene-culture co-evolution theories, etc.

It is argued that the organism is a container/carrier/replicator/of genes.[8] The gene is the unit of inheritance, selection, and evolution. It pre-exists all other life constituents and processes as an ontological essence, a discrete replicating unit, bounded and self-contained (Ingold 1990). Genes are segments of a macromolecule called DNA that reside in the nucleus and the mitochondria of the eukaryotic cell. They contain the digitally ordered code of instructions (information) for protein production that will specify phenotypic traits. What is *transmitted* through the generations, therefore *inherited,* is a bunch of genes with instructions for species genotypic continuity. Phenotype is the linear forward outcome of the genome but the environment (the well known *G+E* formula). There are no possible reversal effects from the phenotype to the genotype (Weismann 1893). Therefore, neo-Darwinian thinking is *gene-centered* and, ultimately, *deterministic.*

Carriers of genes, either as individuals and/or populations, adapt, in the long run, to an external changing and challenging *nature* that pre-exists and is independent of the organisms that inhabit it.

Behavior is conceived as measurable action observed, which is modeled without any consideration to subjective involvement or constitutive interconnectedness of actors. It is equated to *culture,* and it is renamed as *extended phenotype,* which, in the end, depends on *genotype.* Genetic determinism is the ultimate explanatory for behavior: both evolve following similar rules (see more later).

These neo-Darwinian approaches exhibit a fundamental methodological individualism, which means that all collective phenomena are to be explained from the individual. Society is understood as a *population,* the aggregation of monadic individuals where the whole is the sum of its parts[9] rationalistic instrumentality of choice, action and decision is the underlying motivation of behavior.

Nature and culture in social and cultural anthropology

Social scientists have also been captured by the *nature/culture* divide spell, taking this dichotomy for granted.

Human *nature* was traditionally considered a biological given (cf. works of Durkheim, Malinowsky, Radcliffe-Brown, Lévi-Strauss, cultural materialism, symbolic anthropology), not concerning social and cultural interests. Sociocultural anthropology assumed man to be the finished product of organic evolution, onto which *culture* would shape its real form (see Geertz 1973b). Humans as material bodies were already there for *culture* to work upon – a theoretical approach that we can still see in *postmodern* anthropology (see next section).

Social sciences and humanities share with the life sciences a paleomorphic hierarchical ontology of world phenomena,[10] with its implicit down–up causal hierarchy: first comes the world of physics, chemistry, geology, etc.; then life in the way of genetics, biology, evolution; after, the individual, studied by psychology and its different branches; the social,

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[8] In *population genetics,* the unit would be the *population* itself, i.e., a group of organisms that shows specific allele frequencies.

[9] Entomology became the model for human social relations (Ingold 1989).

[10] Cf. Sinha 1996; Shore 1996.

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societies, groups, come next, studied by sociology, political science, economics, law, etc. On the top, and at the end, like a last epiphenomenal decorative element, comes the *cultural, culture,* the object of ethnography, ethnology, social and cultural anthropology, either as the qualification of human groups or as endless forms of traditions, technologies and/or symbolic ways.

For social anthropology, *culture* has traditionally been conceived to be the many different ways in which people organized and gave meaning to their social lives. A multiplex world of *cultures* and *societies* (as if these were contiguous terms!) appeared, contributing to a mosaic of endless variation and particularism; relativism was its theoretical and methodological counterpart.[11] *Nature* has never been considered in its organic and biological sense, but only as a culturally and historical constructed ontology that makes true the sociocultural centrism of the discipline. Still scorned by the excesses of 19th-century ethnocentric evolutionism, evolution was excluded from the discipline; so was the organic. Biological anthropology took over this issue, deepening the divorce between different branches of anthropology, at least in Europe. Questioned in respect to their capacity to produce general laws and prediction as a criteria of their *scientific* legitimacy, the social sciences in general and social anthropology in particular were relegated as ideographic disciplines, incapable of predictive knowledge and accounts of universals, only good for ethnographic description.

The *postmodern* turn provided us with a critical deconstruction of a Euro-American *modernity* reassessment of human superiority over the world and all its creatures. Questioning the philosophical, political, and ideological frames that underlie modern unlimited faith in (European) human rationality, postmodern critique also problematized the *nature/culture* binarism in technology, politics, and science (Haraway 1989, 1991). Postmodernity did indeed 'culturalize' the concepts of *nature* and *human nature,* taking sociocultural, historical, and political determinism to its limit.

Epistemological shifts: Dynamic systems theories, self-organization, complex non-linear systems, and development

It is clear that putting humans *back into nature* in the way of subsuming the former into the latter does not take us beyond the *nature/culture* divide. Neither does so the other way round: ignoring evolution and the organic, and only deconstructing discourse and practices.

In order to be able to deconstruct parts of these theories, I have dedicated some time and energy to dynamic systems theories General (dynamic) Systems Theories (Bertalanffy 1976). Self-organization and autopoiesis provided me with clues for understanding systems and their environments. Complexity theory and non-linear dynamics seemed well suited for reassessing the social beyond any reductionism. Developmental systems theories (DST) helped me to rethink ongoing processes and change (see Oyama, Griffiths and Grey

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[11] The anthropologists' reception of Saussure's arbitrariness and unmotivation of the linguistic sign and the metaphor of culture as a *text* reinforced this particularistic and relativistic view of the cultural realm.

2001a).[12] It is not that I have tested these theories against sociocultural phenomena – the intention was to be inspired by the articulation of a more holistic narrative of what and how it is to be(come) humans.

In their origin, dynamic systems theories are mathematical theories for the description of complex systems' behaviors in time. In the broader sense, they bring together a complex set of theories from a broad range of disciplines that emphasize the self-organization and non-linearity (non-additive, non-homogeneous, non-simple cause–effect relationality) that produce, through development, both stabilization and change through novelty and emergent process.

Here I cannot but briefly sketch some of the basic tenets of these theories that I have found really stimulating for leaving behind the *nature/culture* antinomy, moving towards a more comprehensive and fruitful approach in the study of humans and humanity.

Autopoiesis and self-organization

Autopoiesis means self-creativity. Autopoiesis is a property of some systems which, because of this feature, we may call *autopoietic systems.* Autopoietic systems[13] are relatively self-organized and autonomous in the sense that they allow for micro-events and micro-relations, while maintaining possibilities for broad communication and interrelationship throughout the system and with the environment. Autopoietic systems develop on their own once they reached a non-turning point without outside synchronization, primal cause, or external intentional agency. S. Kauffman (1993) mentions this as "order for free." Once in motion, systems develop on their own.

Thanks to an *operational closure,* a loop, these systems actively *select* an *outer* domain of specification (Varela et al. 1991), an *environment* through which they build their own inner space as a *constituted order,* reducing and simplifying external complexity. Closure is never totally accomplished nor fulfilled. Boundaries are continuously arranged and rearranged.[14] Order and disorder, noise, perturbations are part and parcel of the system environment with mutual and continual readjustments by means of the recursive effects of loops and feedbacks.

Thanks to their constitutive interactions with their environment, relations become regular patterns of continuous prospective action for the present and future viability of the system (i.e., the organism). Autopoietic systems are always contingent, with no ontological essence to them; they are constituted by their history of development and connectedness.

All living creatures – including humans – organize their lives and environments in co-ontogeny and co-evolution with other life beings, with which they may be *structurally coupled* (Maturana and Varela 1992).

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[12] For a full review and the challenging insights they may provide for a biosociocultural approach, see Ramirez-Goicoechea 2013a: Chapter 3.

[13] For all that follows, see Maturana and Varela 1980; Maturana 1981; Maturana and Varela 1992; Varela et al. 1991; Morin 1977, 1991; Jantsch 1980; Zeleny 1980; Kauffman 1993; Thelen 1985; Thelen et al. 1987; Luhmann 1995; Rose 1997; Lorite Mena 1982; Gomila 2011; Perez-Taylor 2002.

[14] The cell membrane is the first organic closure that we know of. It establishes an internal space – less complex than its diverse variable environments. Membranes are osmotic, maintaining continuous openness for biochemical interchange. For some, they are the cell's *brain.* See Lipton 2005.

Autopoietic systems show recursiveness, the property of monitoring and acting upon themselves (Luhmann 1995: 179), in a kind of reworking, redescription (Karmiloff-Smith 1992) and homeodynamic self-regulation (Rose 1997), which may also incorporate novelty and change. Autopoietic systems can be found everywhere: in cells, organs, organisms, persons, groups, societies, etc.

Complexity

Complexity is an attribute of many dynamic systems. It is a property of systems by which their elements are interconnected to many other parts and elements, with which they continuously exchange and process information (Cramer 1993; Bak 1996; Lewin 1992; Reyna 2002) at different hierarchical degrees (Wimsatt 1994).

Micro-dynamics among elements depends on their neighboring parts, as in neuronal cyto-architecture (Edelman 1988), and the weight of each interconnection. The organization of the system results from the global effect of its responsiveness to all these possibilities of interaction.

Complex dynamic systems oscillate between order and disorder. While limiting disorder, they also maintain flexibility for possible change (Nicolis and Prigogine 1989). Noise and perturbations may be co-opted for further reorganization and creativity (novelty), opening new possibilities as well as new constraints. Change can spread to multiple levels or be kept at bay temporarily at a local scale.

A complex dynamic system may evolve into a critical state, in which interconnectivity increases to the limit (Cramer 1993; Lewin 1992). This state is called *self-organized criticality* (Bak 1996). The outcome of this situation is a partial or total reorganization of the system, an emergency, a *bifurcation* (Thom 1972), a *schismogenesis* (Bateson 1958), a *singularity* because of the unexpected new phenomena it may produce.

Reorganization can give birth to an *emergency,* a non-linear phenomenon produced at different micro–macro levels, either by the global dynamics of the system (Gellman 1995) or locally by its many micro-systems. Complex dynamic systems may become organized around attractors (Prigogine 1980; Madore and Freedman 1987), understood as gravitational forces/points/states/cycles around/towards which parts of the system or its globality[15] may evolve.

Non-linear causality cannot be predicted by a simple function of changed conditions; cause–effect links cannot be traced in full (Thelen 1989) because of the dynamicity of the system and the multiple trajectories of its parts between different attractors.[16] Change is neither deterministic nor random – it is stochastic: probable but never certain; there is selectivity within limits.

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[15] Not necessarily its totality.

[16] Some complex systems are also called *chaotic systems* because they are very sensitive to initial conditions and any local perturbation, although minimal as these may be, producing an amplified chain of effects, unpredictable in its evolution (e.g., *the butterfly effect,* cf. Lorenz 1965, the *domino effect*). That is the case with the weather, traffic, the behavior of masses in a panic situation, etc.

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Developmental systems theories (DST)

Developmental systems theories can be considered a special orientation within the big label of dynamic systems theories. These theories – which in truth can be considered as epistemologies – have established a milestone in rethinking life processes in their full dynamicity (Oyama 1985, 1992; Oyama, Griffiths and Gray 2001a). The organisms' properties, capacities and activity are the outcome of the emergent properties of developmental systems when engaging with the environment and themselves in ongoing processes.

Developmental processes are generative and relational fields for interactions and forms to emerge (Lewontin 1983; Ingold 1991). DSTs emphasize interactional causality and sensitivity to past and present conditions. Development is understood as a constructive structuring process and an endless source of stochastic change (see sections on *Human material–symbolic practices as culture* and on *Brain, mind and knowledge: Rethinking cognition*). DST is in radical opposition to neo-Darwinian paradigms, which have never considered development or ontology.[17]

Systems biology and *postgenomics,* non-adaptationist evolutionary thinking (Müller and Newman 2005: 487), evolutionary developmental biology (evo-devo; Gilbert 2001; Carroll 2005), evolutionary epistemology (EE; Wuketits 1984; Callebaut and Stotz 1998; Gonthier 2006); *developmental sciences* (Magnusson and Cairns 1996) all focus on an epistemology that insists on change, ontogeny, and development. With these inspiring epistemologies, we will be better equipped for a proper critique of the *nature/culture* split. That is what I will try to do next.

De constructing *Nature*

Nature as underlying essence and universals

Rooted in specific historical and philosophical conceptions, the *life sciences* have stressed the universality of *nature's* laws.

All living organisms on earth develop under physical, chemical and biological principles but there are *many ways* to do so for different organisms and their constitutive eco-relations.[18] It is one thing to understand *universal* as common, probable patterns, and it is another to assume it to be the underlying essence of things.

Besides, what is particular, singular, unique depends on the system's actual processes of eco-organization, hierarchical complexity (scale), and perspective.[19] Diversity and generality can be found at any empirical level, depending on view, scale, and phenomenic

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[17] Social and cultural anthropology have not considered development either. For some exceptions, see Mead 1977; Whiting and Child 1953; Toren 1993; cross-cultural psychology.

[18] As the 19th-century German mathematician Georg Cantor would have said, the infinite comes in different sizes and sets, although not everything is possible.

[19] So does *context,* which is sometimes referred to as sociocultural and historical frames, or the ecosystem, which is sometimes referred to as environment. Context may be defined at multiple scales, depending on phenomenological complexity and perspective.

complexity. Nothing is more idiosyncratic and particular than biological processes such as neural epigenesis, brain connectivity, or gut flora. Nothing is more *universal* than human co-ontogenetic biology, psychology, and socioculturality in the way of kinship, reproduction, and sexuality regulation, the organizing of production, consumption, and distribution, the constitution of a moral order, the producing and organization of individual/collective knowledge and meaning, the ordering of affects and emotions, the socialization, education, and bringing up of children, etc. As Jean Piaget (1971) used to say "what is inevitable should not necessarily be innate."[20]

As general repetitive shared patterns, *universals* can only come to be in their local and historical incarnations (Ramirez-Goicoechea 2009: 116). They are not ontological givens. They are always specified in particular evolving/developing systems and their eco-relations. All extant humans belong to the same species, *sapiens sapiens,* also called *modern human* (Cann, Stoneking and Wilson 1987; Ingman 2000). But there is no such thing as a pre-existing *human nature,* previous to its contingent developmental constitution. In this respect, *humans* do not have *nature* (so-conceived) "but history" (Ingold 2013), that of their evolved/developed organic, psychic, sociocultural, and political individual/collective life courses.

Taking universals as constraints is another reductionism that cannot stand up for inspection anymore. It is widely accepted that *nature* – identified as *genetics, biology, evolution* – determines the scope of human diversity and behavior. On the contrary, infinite particularity and possibility are attributed to *culture–society.* However, there is no empirical evidence for this belief: constrains and possibilities have nothing to do with such dichotomies. The structuring/structuredness of human conventions through personal/collective embodiment (i.e., in *habitus,* cf. Bourdieu 1980), objectivization (Ramirez-Goicoechea 2008), and *entification,* in the way of publicly constituted practices, discourses, imageries, institutions, norms and rules, procedures, beliefs, values, ethics, ecological practices, political action, regimes of truth etc., can become strong constraints for the evolution and development of human biologies, activities, and experiences, even for human sustainability on earth.

Rethinking adaptation

The idea of *adaptation* was strongly criticized by Richard Lewontin (1978) because it presupposes the capacity of an organism to solve a problem imposed by an external and independent environment.[21] *Adaptationism* is, in the end, functionalist: as a trait exist, it must have been selected; if it was selected, then it is so because it is useful (Sahlins 1976). The argumentation is *post-facto* and tautological: if something satisfies some necessary condi-

[20] "It is an inconvenient truth that the onset of behavior is before birth" (Alberts 2008b: 270). Traits, behaviors, and capacities, which were earlier thought to be innate, genetically driven, are now being understood as the result of prenatal developing systems of experience (Gottlieb 1997) in which "[e]ach sensory system begins to function while still undergoing maturation, so each system could contribute to its own normal prenatal (as well as postnatal) development" (Gottlieb 2001: 44–45). Only through function does structure realize in development as a unified transactional event throughout time (Gottlieb 2001). Innate behavior is mistakenly thought as *genetic* (Griffiths and Machery 2008), but it should be understood better as the "extended inheritance of epigenetic factors which are reliably reproduced with the help of ontogenetic niche construction" (Stotz 2008: 360–361)*.*

[21] Charles Darwin was not sure himself whether "natural selection" could explain the evolution of complex organs such as the eye (Darwin 1859/1975).

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tions, it does not follow that it was meant to exist for that, that it is the primal cause, or that no other ways could produce the same results (Shweder 1991). Biological systems are not tautological in the sense that they always follow an axiological truth. Although possibilities are not unlimited, different non-linear outcomes may be produced by different means. There are no rules or algorithms that specify all possible becomings.

Some time ago, Richard Lewontin (1978) proposed the word *adaptability* as a better concept for the organism's possibilities to develop sustainable interactions with its environments in situations *de facto* (Rose et al. 1976). *Adaptability* and *evolvability* depend on the history of the organism's structural coupling with other living and non-living entities with which it co-develops and co-evolves (Lythgoe 1979). Hence, "natural selection" is viewed as a process of co-determination between the organism and its environment (Lewontin 1983), through which there is an integration of variables with *adaptational* effects (Gould and Vrba 1982: 14). This perspective allows us to think of the products of evolution not as optimal but as satisfactory outcomes for the organized self-reproduction of the organism (Varela et al. 1991: 195–197).

From a non-deterministic evolutionary perspective, evolution is the result of the interplay of a variety of opportunities, which are locally defined (Jacob 1977) and set in motion in a specific time and place. There is no progress or purpose: things could always have been otherwise (Monod 1970). Evolution is, in the end, undetermined (Gould 1983, Lewontin 1983).

From genes to development and epigenesis: Systems biology and postgenomics

As mentioned before, in the modern evolutionary synthesis or neo-Darwinism, genes became the structural units of inheritance, selection, and evolution – they became the micro-constituents of what *nature* as life is. The standard view of genetics and genomics placed the emphasis in the DNA molecule. As bounded discrete segments of a macromolecule called DNA that reside in the nucleus of the eukaryotic cell, genes were assumed to be digital chemically written codes of instructions (information) that produced proteins for specific phenotypic traits. Knowing their grammar, the code of life could be deciphered.[22]

Fortunately, this conception is now under strong scrutiny. Without sound empirical evidences, we cannot tell beforehand where a gene starts or ends because DNA segments swap and shift places and recombine continuously (Charney 2011). Generally, splicing, shuffling, and reshuffling DNA segments are the first conditions for protein production (Pearson 2006).[23] DNA segments interact continuously with other genomic products in different hierarchical and complex relations: in the cell and its organizing cyto-architectonic environments, and with respect to other histological, hormonal, and physiological network systems. Regulatory integrated mechanisms of proper environmental signals and their combination with specific activational factors determine which DNA sequence will be recruited for transcription, when and where, including its starting and ending, what coding and non-coding parts will be spliced, how the remaining parts will be reassembled and, if so, translated, what

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[22] See Searle 1990, for the absurdity of this approach in cognitivist modular thinking theories.

[23] RNA may also produce proteins during development thanks to modified small mRNA transcripts.

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nucleotides will be inserted, substituted, or deleted, and what novel nucleotide information will be produced in the sequence of genomic products (Stotz 2006).

Genomic regulation is a part of cell physiology (Shapiro 1999; Stotz 2008). Genes, on their own, have little predictive capacity – apparently they are not predictive even of disease predisposition (Lock and Nguyen 2010: 339–347).

In genetics, linear causality does not apply. No single gene has been empirically proved to be responsible for the variation of a complex phenotype (Plomin and Ho 1991).[24] Biological complexity cannot be predetermined genetically (Rose et al. 1976). There is no straight path "from DNA to RNA to protein to phenotype" (Lock and Nguyen 2010: 334), through which we could establish a specific gene one-to-one for any trait (Moss 2001: 87), only many-to-many relations between genomic materials and phenotypic outcomes are possible by way of stohastic developmental processes. The effect of genes is indirect and manifold; genotype–phenotype linear directionality is but an "illusion," whose study is "fraught with ambiguity and uncertainty" (Rindos 1985). DNA can only be read in the growth process of the organism; void of context, the genome is an abstraction, a product of modern scientific invention (Ingold 2004: 214, 215).

In the *post-genomic* era of systems biology, which came to life during the 1980s, a crucial shift took place. The question was readdressed to the type of biological process DNA sequences intervene in, and when and how they do it (Gerstein et al. 2007: 678). This entailed epistemological, theoretical, and methodological changes towards systems dynamics, complexity, non-linear causality, and development. Instead of independent self-sufficient bounded genes, the idea is having a *reactive genome,* activated, stimulated, and partly regulated by the dynamics of cell activity and its environmental signals (Shapiro 2005). Cells regulate the genetic engineering of the genome system architecture specifying and demarcating its products. As the immunological system shows, the cell's natural genetic engineering contributes to enhancing the efficiency of the search for those genome configurations that encode functional complex systems, favoring the hierarchy of system architectures, even taking control of DNA restructuration (Shapiro 2005: 96–97).

Genomic materials and products are to be considered within dynamic hierarchically organized network subsystems that interact with each other at specific times and places within the cell, working as *developmental resources* (Moss 2001; El-Hani 2007). This new orientation understands biological processes as self-organized/mutually constituted relations between parts and whole in the tempo-spatial dynamics of the cell's activity, where the interconnection and intercommunication of signals and networks are produced in the intertwining of contingency and determinacy (Keller 2005).

The stress on developmental biology points towards the decisive importance of *genomics plasticity* (Speybroeck 2002) in ontogeny. Genetic activity is neither independent of, nor outside the organism's developmental system (Gottlieb 2001: 47, 48) – rather it is a part of it. Regular interactions may turn into reliable expected statistical patterns that sculpt the organism's life and, in doing so, open up further paths of stability/change (Lehrman 1953: 345). Biological patterning, structuring, and material realization are the complex result of developmental cycles of contingencies (Oyama et al. 2001b). Considering the organism's

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[24] Gene-association studies have looked for the specific genes that would explain concrete traits and behavior.

properties as the result of developmental processes is becoming unavoidable, both in post-genomics and in evolutionary thinking (Müller and Newman 2005: 487).

Developmental continuities and changes interfere with genomic dynamics in different ways and at specific moments. This is what *epigenesis* is about. *Epigenesis* is the directional molecular process of genetic activation, expression, revelation, suppression, and regulation (Monod 1970; Ho and Saunders 1979). It is the developmental process of *what, how, where,* and *when* genomic materials are silenced[25] or expressed – and how much – through guidance and regulation of other genomic products, including what are called regulatory genes (i.e., the *Hox* genes group, the *tool kit* for vertebrates' bilateral symmetry). Phenotypic differences (local biologies) are mainly due to the functional absence of a present resource at a specific time and place in an interactive network of biochemical interactions as the result of heterochronic complex assemblies of interdependent development systems (Rose 1997).

Epigenesis is environmentally sensitive. As a biochemical process, it is triggered as the stochastic responsiveness of the organism to subtle environmental changes at particular developmental moments and places (Goldschmidt 1940; Bastow et al. 2004). It is not a random process as natural selection is assumed to be, but a probable, albeit not certain, not determined process, framed in its possibilities. Epigenetic changes may produce important phenotypic differences at the *population* level across generations, with important evolutionary consequences[26] (see below). We are well equipped now for another 'turn of the screw' in the questioning of the *nature/ culture* divide

Human material – symbolic practices as Culture

Neo-Darwinizing culture as a way of 'naturalization'

Two different lines of thought coexisted in Euro-American modernity: that of human singularity and superiority thanks to humans' abilities for rationality, and that of placing humans

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[25] Most biomedical research concentrates on those genes that *have not been expressed* (in due time and place), and not on those that have been and may cause a disorder. More than 90% of breast cancers "are not associated with any germline mutation" (Moss 2001: 89); most cancers of any type are related to the aberrant methylation of gene promoter regions (Esteller et al. 2001; Lin and Maher 2010), that is, to epigenetic changes. Epigenetic marks are also related to metabolic and cardiovascular problems, inflammatory bowel, auto-immune diseases, schizophrenia, and autism spectrum disorders (ASD).

[26] The evolutionary consequences of this flexibility should not be underestimated, and they can be put forward in the critique of reductionist rigid adaptationist program. When environmental conditions change, cell physiology may change very quickly as well, with or without *adaptive* consequences (Bossdorf et al. 2008). When changes are long-term, adaptability concerns the DNA. But when changes are produced in an intermediate evolutionary chronology, the space between two and one hundred generations, cell memory, and epigenetic inheritance contribute to a good enough interrelation with the environment promoting the persistence of a population without the long time and investment involved in the search of equilibrium (Jablonka and Lamb 2005). Through *novelty, innovation,* and *origination* (Müller and Newman 2005: 490 & ff) phenotypic plasticity due to epigenetic changes may be selected in a population (West-Eberhard 2003). There is evidence of the evolutionary role of DNA methylation (especially cytosine methylation, cf. Jones and Takai 2001; Zhang et al. 2007) in animal genomes, so that 25% of mutations that separate chimps from humans occur at CpG sites (Elango and Yi 2008).

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back into nature. Charles Darwin himself lived under this paradox.[27] What it is that can be thought of as *human nature* is quite a politically contested issue (Marks 2010: 513).

This *naturalization* of human *behavior,* human relations (society, sociality), human 'ways' *(culture),* and the human mind pretended to include the study of humans under the scope of the *life sciences.* A big part of them had been colonized by neo-Darwinian thinking, and its epistemological and theoretical tenets. Under these conditions, naturalising culture and affairs human were equated to *neo-Darwinizing* them. This move consisted of recapturing humanity and culture under the shade of genetic determinism and evolutionary fitness.[28] In my opinion, and in that of others, a very reductionist approach arises from this intent be it as Socio-biology, Evolutionary Psychology, Behavioral Ecology and the like.

Notwithstanding, *culture,* understood as socially transmitted *information,* is said to have influence on genetic evolution. A gene-culture co-evolution theory was developed from this assumption (Durham 1991; Richerson and Boyd 2004; Frost and Richerson, this volume).[29] *Dual-inheritance theory* (DIT) argued for a dual evolution: there was *genetic* evolution and there was *cultural* evolution, both following the same Darwinian evolutionary forces (Boyd and Richerson 1985; cf. 3). The problem is that a very particular conception of biological evolution laws (cf. supralaws) is imposed on *culture* and behavior: they are explained following the same Darwinian principles of *variation, selection,* and *inheritance.* Nonetheless, each claim can be refuted.[30]

In respect of inheritance, *culture* "does not evolve," at least "not as you think" (Ingold 2012). *Culture* is not *inherited* as your "grandma's portrait" but lived and embodied throughout our developing life course of becoming human, thanks to a socialized and enculturalized ontogeny (Ramirez-Goicoechea 2011).

As for *selection, cultural* human products are selected but in a very different manner: through externalization, objectivization, and *entification,* taken into the collective as well as (inter)subjectively incorporated[31] in meaningful interactional and relational contexts. *Historically and socioculturally made relations and artifacts* are transformed into non-contingent *social facts* (Durkheim 1982), parts of our structuring/structured environment that we take for granted, as *naturalized* evidences and ontologies devoid of their human social history of constitution. These make up the environmental landscapes we live by, where new generations will grow and transform as part of their own life lines, with more or less autonomy and dependency. Selection comes from the stochastic effects of intentional and non-intentional actors – including non-foreseen effects of action – in continuous relationality at different scales of complexity. Selection is conjointly orientated by a political economy of

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[27] For a detailed account of this process of *naturalizing,* see Pléh (this volume).

[28] In its more reductionist version, *culture* 'helps' *genes* adapt to *nature*.

[29] *Cultural-led* co-evolution of gene-culture is taken to be a progressive and relatively recent episode in human evolution, and human practices are starting to be incorporated in the picture (Richerson and Boyd 2004), which is a very welcomed advance from my point of view.

[30] It is not true that social anthropologists have not dealt with these issues, but they have departed from a less linear and deterministic epistemology and theory, very much ignored by non-literate academics in the field. Aspects of social reproduction and continuity in diversity, between stabilization, control, order, and conformity, dissent and change, have always been relevant issues in social and anthropological theory and research.

[31] By means of practices of repetition, rutinization, typification, schematization, procedural knowledge, ritualizing, institutionalizing, discourse, and representation, etc.

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the social (political, economical, ideological) distribution of means, resources, and tools that empower some individual/collective agencies, at the cost of disempowering and disfranchising others, in a current of imposed reifications according to specific regimes/attractors of truth, legitimacy, norms and values.

As for *Variation* difference, change, and similarity have always been part of the anthropological agenda.[32] As Rindos (1985: 72) puts it, "the variation necessary for selection exists because axes made by different individuals differ and those made by individuals of different traditions also differ in response to differing 'systems of representation,'" always allowing for the generation of "new variants that are subject to selection." We can think of sociocultural systems at global and local levels, in terms of their generative property for variation and change (Burns and Dietz 1992), improvisation and innovation. Diversity is an intrinsic quality inherent to the world we construct and encounter in the criss-crossing with other life trajectories and *wayfarings* (Ingold 2011: 156–164).

What the sociocultural is about

One of DITs' developments has been *memetics,* invented by the renown biologist and anti-creationist Richard Dawkins (Dawkins 1976, 1982). He conceived of *culture* (*extended* phenotype) as a collection of *memes,* units of replicated behavior by imitation[33] that evolve the same way as genes do.[34] Within a cybernetic paradigm of communication as a linear process of transmission/diffusion/reception, perturbations, dissonance, and variation are taken as deviations, errors, *biases* of what should be expected for such an organism, or as a shift (due to learning equated to *culture*) in what should be expected from a genetically determined behavior. Therefore, change, which is inherent and intrinsic to any phenomenological process, is difficult to explain. But from a dynamic non-linear approach, "it is the copying that originates" (Geertz 1986: 380). Cultural evolution is not about information replication. Reproduction inevitably entails improvisation (Ingold and Hallam 2007), innovation, and recreation (Willis 1993–1981) within certain flexibility and stability of forms. Small variations can be systemically co-opted and interconnected bringing forth novel events and possibilities. Recreation, redescription, reinterpretation, and multiple ways of embodiment in multilocal contexts and times are at the core of what *culture* is about.

In spite of its possible reifications, *culture* is not a *thing* with an ontological status previous to how humans make a life of their own in a multiplex diachronic fabric of interrelationality and intersubjectivity. Neither are there many *cultures* around a variegated world,

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[32] Reassembling and commonality, shareability, heterogeneous uniformity and conformity should also be accounted for. Human objectivized and institutionalized products may become attractors embodied in discourses, actions, representations, relations, norms, rules that mediate and structure conjoint intersubjective experiences in similar ways, by which people identify themselves and others as part of a more or less shared environment.

[33] Not that imitation is to be misjudged. It is a leading force in socialization, empathy, and enculturation, that goes well beyond copying not as copying (Ramirez-Goicoechea 2013a: IX).

[34] Dan Sperber added to this the epidemiological paradigm of virus spreading so that *culture* would be distributed in a population as *contagious ideas* (Sperber 1985, 1994). Both *memetics* and the *epidemiology* of representations have been at odds with any kind of psychology (except *evolutionary* psychology) ineffectually trying to explain why replication is never completely reliable.

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as the idiosyncratic character of identity/difference of particular bounded groups on a one-to-one basis, i.e., one group/one culture (Díaz de Rada 2010). Times have long passed when ethnographers used to think of human *cultures* as units to which *sociodemographic groups* would belong (and vice versa).[35]

For humans, there is no single *cultural* system or version that people *belong to,* but there is a *rhizomathic* multicentered space that conforms to a relational place for action and discourse. In this non-essentialist, non-reifying view of *culture,* what is important is the dynamics, the relational aspect. That is why some of us talk about the *sociocultural* as a qualifying constitutive feature of our evolved/developed/practiced humanity: there is no way for humans to be social without being cultural.

Culture is the social practice of how we build our material–symbolic conditions of existence. And this is a complex, non-linear stochastic process of construction and continuous reorganization, description, and redescription in a relational human space/time with ourselves and other living and non-living beings of our material–symbolic conditions of existence. This is an individual (biographical) and collective endeavor in a variety of chrono-topical settings that allows for possibilities under constraints, one of which is the social distribution of autonomy and the power to do so.

Anthropogenic environments: Worlds of our (or others') material–symbolic practices

Gene-centered biology, standard evolutionary theories and cognitivism consider the organism as a passive agent determined by its genes, natural selection, and innate cognitive devices (see more later). However, an open concept of *niche construction* can illuminate this issue.[36]

Organisms, as ecosystem engineers via *niche construction,* are agents of their own sustainability and change for themselves and for others. This is possible thanks to an ongoing process of *enactment* (Maturana and Varela 1992; Varela and Dupuy 1992), where, the organism's acting is *perceptually guided* by its own specific evolved/developed abilities for knowledge, including its *affordances* (Gibson 1979, from von Uexküll 1926) from von Uexküll (1926), phenotypic plasticity (Kampis and Gulyás 2008, West Eber-Eberhard 2003), developed skills, and dexterities (Ingold 2000).

Organisms are particular places for growing and developing in the specific *ways* of a relational world in which they unfold by means of their own life activities, and they are unfolded in their own specific morphology, moving capacity, responsiveness, and epistemic awareness (Ingold 2004: 216).

Humans are special niche-building individual/collective actors, from both a phylogenetic and an ontogenetic perspective. They do not exist detached from their own practices by

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[35] *Cultural membership* is not an intrinsic quality of group individuals, but a continuous practice of belonging and recognition. So called *cultural boundaries* are dynamic constructions, not impenetrable walls but more or less osmotic membranes, which allow for more or less permanence, and not positioning and identification. Limits are always a matter of definition and practice, scale, and perspective.

[36] Cf. Lewontin 1982, 1983; Odling-Smee et al. 2003; Gottlieb 1992; Day et al. 2003; Bateson 1988.

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which they get to appropriate and transform their means and conditions of existence. Human practices encompass material and symbolic aspects. Transformation of materiality, ideas, classifications, representations, beliefs, and values are embedded in our actions, by which they themselves come into existence.[37] For humans, all ecological relations should include the perceptions, ideas, and values through which they try to make sense of their own actions (Descola and Pálsson 1996; Ellen 1996; Horigan 1988). It is more a matter of connecting action with meaning and personal/collective subjectivity than that of linking behavior with its determinants (Geertz 1983: 34).

The anthropogeny of our sociosymbolic–material conditions of existence was already mentioned by Karl Marx in *The Eighteenth Brumaire of Louis Bonaparte* (1852/1963) and the *Contribution to a Critique of Political Economy* (1859/1978). Activities produce social relations, institutions, and technologies with specific consequences for our (and others, conspecifics or not) evolving/developing lives.

Through continuous determinate/contingent processes of action-in-relationality/relation-in-activity, objectivization and institutionalization, historically and culturally situated humans build material–symbolic structures that can be stabilized as scaffolding foundations for future processes and structurations to emerge. Therefore, we can speak of an *ecological niche* that is the possibility for our own human(ized) existence where we recognize ourselves as heirs of our predecessors' previous practices, representations, and experiences, a world that we will inevitably change/re-produce, as our children and grandchildren will do alike when living their own existences.

Thanks to our evolved/developed skills for cooperative practical knowledge and knowledge in communities of practice in specific social and politico-economic evolutionary contexts, we have been able to produce/transform our material–symbolic conditions of existence and the type of articulations between living and non-living actants. This has promoted the opening up of our cognitive, practical, and relational world to new amplifications/bifurcations that, in turn, have triggered/scaffolded new capacities and assemblages for further creative environmental appropriations and transformations, with important evolutionary consequences (Fuentes 2009; Richerson and Boyd 2004). Biosociocultural affordances and the scaffolding properties of our somatic and extrasomatic material-symbolic works (Shore 1996) all articulated dynamically and locally with specific selected properties of our surroundings, have made up our actual and possible worlds.

In these, we also have to include political and economical worlds, in which autonomy, knowledge, and decision are socially distributed. Human practices and ideologies with respect to social organization and power, social distribution of economic deprivation, inequality, discrimination, exploitation, food scarcity, risk exposure, etc. are imposed and embodied by people during their life course.[38]

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[37] See Marx 1859. Cf. Ingold 1986; Pálsson 2009; Bourdieu 1972.

[38] In practices and ideologies of nutrition, diet, psychobiological rhythms, drug consumption, exposure to pollution and toxics, stress, emotional insult, work conditions, leisure and restorative activities, exercise, sociality, medical and health experiences, life-styles may have enduring consequences on health and biological responsiveness.

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Developmental niches

Anthropogenic environments also form an integral part of what Karola Stotz (2008) calls *developmental niche construction,* a set of stable environmental non-linear interrelated resources that are provided by the organism's species antecessors, its "parents" and its own experience throughout life (West and King 2008: 384).

This concept of ontogenetic niche refers to how species-typical behaviors develop through active, context-dependent processes. This developmental environmental niche is constituted by a complex system of agents and agencies, blurring the artificiality of the *nature* and *nurture* dichotomy. It includes molecular, cellular, ecological and social (and *political*) experience and memory, plus all other pre-,[39] peri-, and postnatal developmental resources for the organism.

These environmental influences have complex ways of affecting the epigenetics of human biology throughout the life course, especially during critical developmental stages as well as through the generations.[40]

The quality of home environments (Maccoby 2000), and their combined possible emergent consequences with other variables such as poverty (Bradley and Corwyn 2002; Propper and Rigg 2007; Kim-Cohen et al. 2004), trauma, and catastrophes affect people's early and later developmental niches. Vulnerability, violence, and abuse, including stress and psycho-emotional suffering, have effects on cell metabolism, oxidation, and aging (Cherkas et al. 2006).[41]

Social interaction and relations with parents, siblings, and others that provide nurturing and caring, stimulation, and affordances for development (Alberts 2008a), interaction, and learning are all part of the developmental niche. Parenting styles are directive social, cognitive, and emotional factors for children's development. Parental practices facilitate progeny incoming into a semi-structured world of embodied experiences, attention guidance, opportunities for learning, action, observation, participation, communication, and monitoring of appropriate engaged/engaging interactivity.

Brain, mind and knowledge: Rethinking cognition

Cognitivism: Bio-logos of the brain, mechano-logos of the mind

Cognitivism is a very specific orientation of the broad interdisciplinary research program of the cognitive sciences, which has reached a hegemonic status in academia, research, financial support, education, and the media, spreading in popular thinking and public opinion.

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[39] There is a whole bioculture of parenting, ecological, economical, political, and kinship ideo-practices that precede conception, having important stochastic effects in progeny during embryogenesis, foetus development, peri- and post-natal experiences, and life course (Ramirez-Goicoechea 2012).

[40] See Bygren et al. 2001; Kaati et al. 2002; Pembrey et al. 2006, Roseboom et al. 2001; Lumey 1993b.

[41] For an in-depth account of the *biopsychologicalness* and *biosocioculturality* of epigenetics processes see Ramirez-Goicoechea 2013b.

Cognitivism represented a shift to the behaviorist tradition concerning our inner mechanisms of behavior: not only could they be empirically studied but they also explained animal and human conduct. Behavior is what happens in the mind.

Mind and human *behavior* have been 'brained,' thus, as any other organ, it could be placed within the empirical and methodological framework of the life sciences. Traditionally belonging to the humanistic fields, mind and behavior were *naturalized,* therefore emptied of any sociocultural, historical, or biographical content.

This bio-*logos* of the mind appeared in neo-Darwinian theories linked to its most important tenets: the dualistic epistemology of genetic determinism, environmental essentialism and reification, the universal architecture of the brain, and linear evolutionary thinking (see above).

As *brain–mind* centered, cognitivism focused primarily on *cognition* over any other mental phenomena. Reasoning, propositional thinking, classifications, problem-solving, planning are what human mental processes are about. In that, it is quite aligned with Euro-American modern *rationalism.* Uprooted from all the rest of God's creations, and empowered to subordinate them to their needs and goals,[42] Descartes came to found our superiority on our ontological and moral difference that placed us in a unique genre for a unique and only species, *homo* (Linneo 1758).

The focus is on the thinking individual devoid of any subjective involvement with its (his/her) environment. Cognitivism assumes the epistemic agent as a disembodied, acontextual, asocial, ahistorical, thinking organism emptied of any constitutive life history and experience of interconnectedness and relationality. Accordingly, with a rationalistic primacy, there is a strong computational digital approach. Cognition is equated to information, either receiving it as *input* or producing it as *output.*

Capacities are inherited and depend mainly on genotype; they are hard-wired in the individual's brain as an instance of the species. A *real-out-there* environment places cognitive challenges on the epistemic agent to be solved, thanks to its evolved genetic capacities; a set of algorithmic rules help decodifing *the real* in the form of representations. If we know these algorithms, then we know how the mind works and how cognition is produced. Cognitivist practitioners dismiss cross-cultural comparative research because they assume that the brain works the same way everywhere, irrespectively of time, place, personal and collective experiences, and environments (Dominguez 1997).[43]

Another theoretical development of the cognitive science research program, sometimes linked with the former, has been that of *domain specificity* and mind *modularity.* Stemming from Fodor's modularity theory of peripheral perceptual devices (Fodor 1983), humans are thought to have hard-wired, genetically incorporated cognitive devices that are supposed to encapsulate a particular domain of the world, in the way of Kantian synthetic a priori, giving structure to the information that comes from different sensory devices.[44] Universal

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[42] "And God blessed them: and God said unto them, Be fruitful, and multiply, and replenish the earth, and subdue it; and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth" (Genesis 1:28).

[43] The study of *neurocultures* can refute this assumption.

[44] The *natural* domain (Atran 1990; Carey and Spelke 1994), the physical domain (Gellman 1995), the social domain (Trevarthen 1980; Hirschfeld 1988; Gómez and Núñez 1998; Whiten 1991; Byrne 1995; Baron-Cohen

modular capacities would explain, it is argued, why children learn some things, i.e., language, more easily than others, at similar ages, and in all cultures (Chomsky 1957; but see Ramirez-Goicoechea 2006).

An epistemological and paradigmatic principle of theories of *modularity* is that all humans share a common cognitive architecture in the form of mental universals. This would explain what are envisaged as universal continuities in world ontologies and *natural kinds,* psychological plausibility, and *common sense.* Evolutionary psychology, as a neo-Darwinian account, posits this universality in the evolution of the *sapiens* mind to Pleistocene conditions, insisting on a universal genetically endowed *intuitive psychology,* that would be *evoked* for particular cognitive tasks (Boyer 1994).

Some kind of an evolved brain in our species is an evolutionary fact, although what a module may be is still under discussion.[45] The same can be said about specificity at particular degrees of complexity and mental tasks.[46] Paradoxically, these theories ignore neuroscientific research and comparative animal cognition, among other neglects (see Panskepp and Panskepp 2000). Another flaw is the ignorance of sociocultural and historical mental diversity, especially when it comes to defining constitutive boundaries, semantics, practices, and values (Descola 1996; Hviding 1996; Akimichi 1996) through which practical knowledge and knowledgeable practice are construed (i.e., folk taxonomies, classificatory systems, and *natural kinds*). Instead of innate *givens,* mental specializations could be better understood as the stochastic outcomes of dynamic systems of evolved/developing abilities[47] interacting within specific socioecological environments.

Modularity and domain specificity theories of mind deny any kind of general intelligence as in Piaget's psychology. But not all mental processes are modular (i.e., attention). Furthermore, general capacities do not need to be less functional than specific ones (Karmiloff-Smith 1992). Conceptual blending, amodality, and cross-modality are possible candidates for holistic mental capacities at some degrees of hierarchical complexity. Cross-modality has to do with knowledge that is applied from one module to another because some link has been established between domains, as in metaphor – a mental ability – and conceptual blending. Vico already mentioned that our capacity for specialization is limited (Fernandez 1991) but we have enormous possibilities for combining old things into new ones in new

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1991), the mental and psychological domain (Cosmides et al. 1992), the moral (Wright 1995) and religious domain (Boyer 1994), communication and language (Chomsky 1957, 1980; Pinker and Bloom 1994; Fernald 1992), the symbolic (Sperber 1985; Leslie 1987), sex and mating (Ridley 2003; Buss 1994), the technological domain (Mithen 1996), and so forth – it is supposed that we have a specific evolved innate cognitive module.

[45] Paul Griffiths (2004) distinguishes between different kinds of modules: developmental, functional, and virtual. All of them mean different things for evolutionary psychologists and neuropsychologists. Mental modules do not have to necessarily correspond to neurofunctional modules. What may appear as a specific module may only be an aspect of the performance of a functional neural system. Besides, it is possible that different parts of the brain may belong to the same functional module that, notwithstanding, is the outcome of different developmental modules. Modules can be semi-decomposed as subsystems within a hierarchical system with which they relate as they do with other subsystems since their inner dynamics is the principal motor of development.

[46] *Referential open* words (names, verbs, and adjectives) are processed by different neural systems than *closed* ones (connectives, pronouns, determinants, and adverbs; cf. Neville 1991).

[47] Induced by *cognitive windows* (Gottlieb 1971) activated chrono-topically during ontogeny for selected learning and experiencing.

contexts. In fact, cross-modality is one of the main sources for creativity, *in-re*-novation and diffusion lying at the core of *sapiens* mental evolution.[48] Cultural models that privilege some sensory–perceptual mental experiences over others (Feld 1984) and strongly institutionalized meanings and inferences (Bruner 1996; Quinn and Strauss 1993) are constraints/possibilities for both specificity and cross-modality.[49]

Modular theories also rely on a certain *mecano/lego* paradigm, typical of Western *mechanicism* (Shore 1996). The mind would be an articulated structure with no centrality or neighboring interdependence of elements, in which the whole is the sum of its parts. A functional *geography* of mental processes derives from this theoretical position. Clinical studies of brain damage and psychological impairment have given some experimental foundation to this assertion. Brain activity and its localization can be measured by blood flow to specific areas at specific moments, thanks to the latest *fMRI* (functional Magnetic Resonance Imaging) technology.

Brain laterality for language is one of the examples more frequently put forward in this kind of argument. The cognition/emotion dualism is also based on this brain cartography: left brain hemisphere for cognition and language, right brain side for emotion (Cacioppo and Petty 1981; Tucker 1981).

Some kind of brain *localizations* may be accepted for some processes and degrees of mental complexity. But neurologic dynamics and mental elaboration are complex enough to be restricted exclusively to some distinctive regions. Most abilities are complex enough to be distributed in several areas. Sight alone implies the intervention of more than 30 different brain areas (Kellman and Arterberry 1998). Brain areas may also be co-opted and shared at some point for different mental activities (Calvin 1997). Some cortex areas may be polymodal, elaborating information from various sensory–perceptual devices. In evolution, as in development, and in brain reorganization after neurological damage, some parts increase their connectivity for multiple tasks. Severe neurological impairments point to the enormous flexibility of the brain (Battro 2000).[50]

Both hemispheres are connected through the corpus callosum and are embedded in multiple mental processes (Ross and Mesulam 1979). There is evidence of the left hemisphere modulating neurological right side activity as well as organizing some social manifestations of the emotional sphere. Reafferent neurological connections of perceptual areas in the cortex are connected both to the pre-frontal evaluative cortex and to the limbic system (LeDoux 1998; Panksepp 2001), which is an evolved trait of modern humans (Reyna 2002). The relevance of the amygdala in social judgments has been proved (Adolphs et al. 1994). Many

[48] Evolutionary stages may be seen as different moments of the functional specialization of some neural structures together with the openness that increased neural connectivity brings about.

[49] Indo-European languages show a canonical structure of thematic roles (agent, object, and recipient; cf. Aitchison 1996) that enhances some thinking–linguistic structures at the cost of others.

[50] The superior colliculus and parietal cortex show poly-modality. In congenitally deaf children, parietal and temporal areas normally engaged in speech elaboration and comprehension are invaded during development by visual nerves responsive to peripheral vision (Neville 1991). Blind people, dolphins, and bats process sound and eco-location in the same brain area where seeing people elaborate spatial information, with depths, distances, and shapes, almost like in 3D. Kinesic and haptic experience in blind people – as in Braille reading – are also mainly processed in the visual cortex area (Maturana and Varela 1992). Taxi drivers are well known to have expanded their neural connectivity for spatial functions.

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mental structures in the cortex are triggered by the limbic system, which, in turn, is funda-mental for memory and mental processing (Laird et al. 1982), decision making (Damasio 1994), and planning.

The ontogeny of these specializations and their possible brain localizations should not be ignored (Gibson and Petersen 1991; Gibson 1996). At birth, brain hemispheres have redundant capacities that ontogeny will reduce: left hemispheric specialization for language starts around the first year (Scheibel 1991), so does emotional cortex structuring in the right hemisphere (Davidson 1984). For something to be general or to show ethological and/or ethnographic coincidence, it does not need to be *genetic*. Prenatal development – embryonic and foetal – and the generative entrenchment of epigenetic processes can become important constraints/possibilities for the brain and its activity, thus becoming distinctive paths for mental directiveness and specificity.

All in all, it seems better to speak of diffused modularity and soft brain geography.

A neurosocial evolved/developed mind

To a higher degree when compared to other primates (Holloway 1996), hominids and espe-cially *homo sapiens* are born before their brain is fully grown, as it will continue to grow out of the uterus environment.

Our evolved brain finishes growing in size and connectivity thanks to experience in specific environments during ontogeny, the generative field of biological–organic, psycho-logical, sociocultural, and historical–political relationships of the individual in his/her life course.

At birth, our brain weighs a quarter of what it will weigh in adults. In the first year, the human head grows to more than 60% of its size at birth (Passingham 1982). This growth slows little by little, but connectivity and structuring of the cortex do not, they continue until adolescence, when the myelinization of all nerve fibers is completed (Fuster 1989; Gibson 1991). Between 2 and 6 months of age, synapto-genesis multiplies by ten thanks to the profusion of dendrites. At this time, the number of synapses is double than that of an adult. Around 12 months of age, most of inactive synapses and neurons, because of lack of stimu-lation and reinforcement, die (Hebb 1949; Kellman and Arterberry 1998: 27; Huttenlocher 1994; Wiesel and Hubel 1963).

Animals with high encephalization, such as primates, also have a long childhood and youth, in which synapsis structures take shape through the social interaction provided by parenting, play, and further experience. Compared to our close non-human primate rela-tives, infancy, childhood, and youth are even longer in the anatomically modern humans.

Long ontogenies entail big parental and family investments in terms of nurture, care, and socialization. A big part of brain growth and synaptic structuring takes place in the social environment of caregivers and siblings, as the perinatal and postnatal periods are special pe-riod is a special moment for stimulation in all mammals with important cognitive effects in the newborn. Infants' experience will be a key factor for neural connectivity, which will pro-gressively be shaped by way of a particular/common sociocultural setting and its socializing manners. The main structural network building in the brain – connectivity and structuring of cortex – finishes in adolescence, a specific stage in the *homo sapiens* life course (Bogin

1988), in which nerve fibers myelinization is completed, coinciding with sexual maturity and other important biosociomental developments (Gibson 1991; Locke and Bogin 2006).[51] Although neural structures vary in flexibility for reorganization, constraints are not rules, and cortical neural reorganization continues to different degrees during lifetime (Edelman 1992; Dreyfus 1979; Kostovic 1990).

The difficulty when studying the brain is precisely that its essence relies on its dynamics more than its structure. Behavior cannot be deduced from the map (Stewart and Cohen 1997) because brain connectivity structures and reorganizes itself while neuronal synaptic activity happens. Our brain, and especially our neo-cortex, is a complex self-organized autopoietic system (Changeux 1986; Erdi 1988; Laughlin, McManus and d'Aquili 1990), where structuration takes place *in-the-making*.

In conclusion, thanks to the sensory and mental openness of the baby's growing brain-in-the-body-out-of-the-uterus, we can speak of an ecological brain (Bateson 1972) that is socially elicited, scaffolded, and upgraded during his/her co-ontogeny with his/her caregivers that provide nurture and care under specific historic, ethnographic, and social conditions for the child's further biosociomental development. That is why we can also speak of a sculpted (Bates 1979) *encultured brain* (Downey and Lende 2009).

Epistemic communities and situated knowledge. Cognition in practice

The social ecology of knowing is normally neglected in most cognitivist accounts. But *the social* and *the knowing* are part and parcel of our ecologically evolved/developed humanity.

Knowledge is produced in social interactive, intersubjective, and engagional settings, in which early socialization works as a generative entrenched embodied mental frame. Caregivers bring forth and structure these abilities in pre-verbal children thanks to sensory-motor stimulation and the psychobiological organization of the baby's rhythms, body language, and emotional and indirect communication (Schieffelin 1990; Hendry and Watson 2001), guided and educated attention (Butterworth and Jarrett 1991; Pálsson 1996), infant (in)direct speech (baby talk, motherese, see Fernald 1984), anticipatory cognitive and emotional stimulation (zone of proximal development, see Vygotsky 1978), and alternate participation as in turn-taking (Hobson 2002). Socialization, as a dialogical ethnographic and historical situated teaching–learning experience, is a scaffolding process (Bruner 1983), with children providing developmental clues for the adult's structuration of a suitable frame from which the child will progressively build a shared world of his/her own (in connection with that of others). Features are saliently focused demanding the selective attention of the child, reinforcing with value and emotion what has been selected (Fernald and Mazzie 1991), varying within specific linguistic and cultural contexts.[52] The education of attention founds shared rules (Mercer 2000) about ways, contexts, and relevance, of what goes on without saying, of what others make us trust of what our (their) world is

[51] Many of Piaget's developmental stages have correspondence with neural myelinisation and the neurological changes it indicates (Gibson 1996).

[52] See Ochs and Schieffelin 1984; Harkness and Super 1983; Grossmann et al. 1985; Sagi et al. 1985; Pye 1986.

about – which we will incorporate as intuitive, self-evident, and unquestioned knowledge. What the child learns through joint attention and guided discovery (D'Andrade 1981) in an intersubjective observational and/or participatory context is to adopt a specific directive perspective, where and how to look, listen, what and when to pay attention to, how to build up new knowledge from old one, how to creatively rework previous mental elaborations, and how to learn to learn (Bateson 1972).

For humans, the context for knowledge is an *upgraded* one (Bruner 1983) – that of the knowings and doings of many generations, inscribed and externalized in the diversity of a materialized world of objects, artifacts, and tools for memory (Donald 1999), where the history of the group's material–symbolic practices are objectivized and represented for (re-)incorporation. Ingold (2000: 5) defines *skills* as "the capabilities of action and perception of the whole organic being situated in a richly structured environment" that is not *inherited* from one generation to another but incorporated "into the *modus operandi* of the developing human organism through training and experience in the performance of particular tasks."

This structuring does not only derive from a cultural history of objects. It has very much to do with institutionalized relations and relatedness, ways of learning (Rogoff and Morelli 1989), procedures (Gentner and Stevens 1983), and practical knowledge as embodied *know-hows* (i.e., *habitus),* collective canonical use as normative, evaluative, aesthetic, and moral orders (Sinha 1996), as well as systems of validation, truth, and legitimacy (Foucault 1999) that also depend on a social, economical, and political unequal distribution in the access and disposition of means and for knowledge. It is the *constitutive order* of a social structure encompassing situated in *cognition-in-practice* (Lave 1988).[53]

Knowing is a personal project as much as it is a social one (Marchand 2010). From an evolutionary, ethological, psychological, and ontogenetic point of view, the *tank-thinker* is a collectivity – to which individuals recognize and feel themselves as co-participants/members, to different degrees of participation (Lave and Wenger 1991), identification, and commitment.

In this respect, we all belong to *epistemic communities.* These are not *populations,* aggregates of individuals that share information or memes, which are thought to be contagious like viruses. Instead, they are collective producers of particular knowledge depending on their active positioning in a network of other epistemic communities. Epistemic communities are normally framed by institutional settings and resources, within a social and political distribution of knowledge. They are defined by a practice of *interthinking* (Mercer 2000). As in expert systems, cooperative thinking is an evolutionary and developmental human practice, which has been demonstrated as being very successful when solving problems or unusual tasks. Mental challenges, resources, and tools are defined and evaluated locally depending on many interrelated proximal and distal factors (Alvard 2003), constantly defined and redefined along activity/interactivity, contributing to the ongoing redescription of relevant contexts and situations for intellectual/collective epistemic agency. In this practice, people exchange and produce knowledge by means of their dialogical intersubjectivity, discussion, and negotiation, depending on status, position, power, seniority, and leadership

[53] Interactive contexts, the definition of the situation, actors expectancies, and taskonomy (Dougherty and Keller 1982) are also ingredients of this situatedness (cf. Ramirez-Goicoechea 1991).

dexterities (Götsch 2013), and *peripheral* participation (Lave and Wenger 1991). Epistemic outcomes are usually externalized and inscribed by means of a diversity of technological devices, and they are more or less publicly accounted for, if not kept for secretive purposes in exclusive bounded groups.[54]

Mind, body, and experience: Cognition in practice

The mind/body dualism is another historical and sociocultural intellectual and practical process in our thinking tradition, taking out of cognition whatever relates to the senses and emotions.

In the mind/body dualistic approach to cognition, the epistemic individual is taken as being totally disembodied, ignoring any biographical and experiential conditions of the knower. The brain is the headquarters of our clean-of-flesh thoughts. But the mind has to be understood as the emergent outcome of systems of neuronal connections in our brain-in-the-body with the-rest-of-the-body. An absent body perspective is oblivious of any kind of subjectivity: emotions, desires, motivation, and intention, all of them being corporal–mental workings that imply different kinds of subjective involvement. Only through our body can we really produce knowledge, as the interweaving of cognition, memory, practice, and emotion in an eco-social environment.

During the late 1990s, the concept of *embodiment* has become a key concept in interdisciplinary approaches to knowledge. Embodiment theories (Johnson 1987; Lakoff 1987; Johnson and Lakoff 1999; Putnam 1999) speak of cognitive structures that emerge from recurrent sensory-motor patterns that allow for action to be *perceptually guided* (cf. infra). Cognition depends on the kind of experiences that we have thanks to a body embedded in an encompassing biological, psychological, and cultural context (Varela et al. 1991): it is *embodied knowledge.*

Let us take the case for movement. In experiential sensory-perception, conceptualization and some kind of motricity are blended, producing what has been named as *embodied knowledge.* Tests implying mental rotation activate brain areas involved in the physical rotation of objects when trying to turn them around for better viewing (Windischberger et al. 2003). Similarly, when thinking of a verb, the hemodynamic activation of pre-motor dorsal and posterior parietal areas involved is to be found, which does not happen with names, showing that there is a close link between verbal representation and visuo-spatial action-orientated knowledge (Berlingeri et al. 2008).

Sensory-motor connections can be established as well for mirror neurons in imitation (Rizzolatti et al. 1996; Iacoboni et al. 1999), empathic identification (Ramachandran 2000), and vicarious experiencing, and suffering. Body movement is important for the development of mathematical conceptual thinking, as has been shown in different cultural settings[55]

Ultimately, this conception of knowledge is not phenomenological. Experiential cognition does not preclude inference, abstract or formal thinking. *Not everything* needs to be

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[54] I.e., sects, government committees, intelligence networks, terrorist cells, etc.

[55] It does not entail that children devoid of motricity may not achieve this kind of meta-thinking by other means, thanks to brain plasticity and other redescribed experience.

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previously experienced as such. Disembodied knowledge is possible thanks to the recursiveness of knowledge production in which body awareness is not present in our working memory[56], neither may be context nor historical/biographical conditions of knowledge production. Abstract concepts and propositional thinking can be thought of as the stochastic results of dynamic self-organized processes of description, redescription, and re-redescription (Karmiloff-Smith 1992) of recursive patterns made possible thanks to special types and grades of evolved and developed neuronal connectivity, in which the successive cycles of emergent knowledge are progressively disembodied and dehistoricized, becoming autonomous and *dependently* independent.[57] Once in motion, they may work as new frames for further knowledge production, even possibly becoming attractors for further stochastic epistemic outcomes. That is how further degrees of abstraction are produced, communicated, and materialized.

Cognition and emotion are mental activities that have also been split in Western accounts of what the mind is.[58] The role of the limbic system, the amygdala, and emotions in cognition have been pointed out by many authors (Damasio 1994, 1999; Mora Teruel 1995). Emotions are involved in decision making because they point towards saliency, relevance, value, purposes, communication (Schieffelin 1983), and directionality for action (D'Andrade 1995; Williams 2001). Emotions and feelings tell us about how things go in the world for us and for others. Emotions are like an "information holding system," reverberating loops that keep information active for further mental purposes (D'Andrade 1981). They allow us to concentrate attention and energy on certain aspects of the situation, to organize and reorganize them hierarchically (Vandamme 1988). Emotional deprivation and depression, diminishing exploratory activity, social intelligence, and mental tasks that require holistic perspective have been reported for other primates as well. They are fundamental in the construction of social knowledge (Hoffman 1981) and anticipation, and in their role for intelligible interaction and relationality.

Knowledge and meaning

The cybernetic view of cognition is linear: we perceive through our senses, decode information, and then process it, turning raw information into cognition. But this is not so: we put much more of ourselves into what is simply called perception (Searle 1990). The concept of *perceptual guided action* from Held and Hein (1958) helps us understand what we are referring to here: how perception, action and knowing are all linked (Maturana and Varela 1992;

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[56] This phenomena may have induced Descartes to speak of pure rational thinking independent of the senses and the body (cf. Leder 1990).

[57] That is how the apparent paradox between experience and inference in the cognitive discussion can be looked at from a different angle. The empiricist and rationalist debate could be seen in a new light if relations between experience and cognition are contemplated as autopoietic, where there is self-organization and relative autonomy.

[58] For alternative accounts of cognition and emotion, see Clark 1997; Harre and Parrot 1996; Turner 1996; Williams 2001; Lupton 1998; Ramirez-Goicoechea 2001.

Thelen 1985; Bates 1979). There is no ontological split between action[59]/practice/experience and knowledge. In the very notion of *praxis,* what is enacted, thought, and lived are joined together (Grawitz 1979). Through action, perceptual–cognitive systems select a meaning-ful environment from which experience is generated for further actions/relations (Gibson 1979). Peirce (1983) already insisted that thinking was acting in a chain of thoughts and actions (see also Wertsch 1998; Garfinkel 1967). Thinking, classifying, decision making, planning, and remembering are already actions/experiences, even if only because something happens in our brain-in-the-body, as *inward-directed action,* in contrast to, but linked with, *doing* as an *outward-directed action* (Ingold 1994). Perception is independent of neither our conceptual schemes (Lakoff 1987; Johnson and Earle 1987) nor our previous experiences (Freeman 1991).

An o*bjectivist realism* of a world *out there,*[60] to be recaptured in the brain by way of rep-resentations, is reconfigured into an *experiential realism* (Putnam 1999; Johnson and Lakoff 1999) that is built through practice and engagement. Things are not more *real* because they fit our *mental representations* more or less but because they are lived through experience and because we attribute meaning to them. Our qualitative (D'Andrade 1981; Chalmers 1997) and *decorated* version of the world is somehow *virtual, figments of reality* (Stewart and Cohen 1997). Our world is perceived to be enacted and lived from different experiences of subjective engagement, sensory-mental bodily states, reflexivity, working memory, and awareness (Halton 1995; Tambiah 1990; Ramirez-Goicoechea 2005).

Information is not what social epistemic agents deal with. The order (disorder) of the sociocultural world is the order (disorder) of meaning (Geertz 1973a, 1973b). Epistemic practices produce meaning because there is a community of practitioners that share an im-plicit socially distributed knowledge and memory (Connerton 1989), a series of intersub-jective presuppositions about the intelligibility of actions and actors (Weber 1922), his/her *logics* (Carrithers 1992; Sainsaulieu 1985), the anticipation of the evolution of action (Goody 1995), as well as its expected outcomes and results (Ginsburgh and Harrington 1996). Something is relevant to us not because it broadens up our *information* about the world (Sperber and Wilson 1986) but because it appeals and affects us due to our engagional intersubjective relationality (Toren 1983).

As a result of all this, the epistemic agent can be understood as an enacting agent that in-corporates a perspective, priorities, beliefs, values, previous experiences, and expectations, with he/she may not be aware of.

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[59] Action, practice, and experience are not reduced to actual participatory agency. For instance, depending on different sociocultural and historical contexts, children are differently immersed in the pragmatic world of their caregivers, in a stage/landscape where things happen (and do not happen) *to them:* child-rearing practices, participant/non-participant observation in interactive (non-)communicative settings (as in imitation, empathy, and self-identification, etc.).

[60] As a socio-political construction that places the uncontested, the unquestioned, and the indisputable in *nature* (Latour 2004).

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Epilogue: Interdisciplinarity and the biosociocultural path

Beyond nature/culture: Biossocioculturality

In the previous sections, I have tried to propose a way out of the *nature/culture* binarism with the help of several epistemologies and theories that speak of dynamics, self-organization, complexity, non-linearity, and development. Such an attempt has not only pretended to question the essentializing standard ideas, determinism, and reductionism of any kind, but also to offer new insights for further non-dualistic interdisciplinary explorations. It is legitimate and necessary to expose and deconstruct underlying paradigms of science discourse and practice (i.e., history, sociology, and anthropology of science, life sciences, technology, and society [STS] program, etc.). But as part of this epistemic community, I also feel the commitment to offer something more than a critical account: tools for a more enriching holistic account of what it is to be(come) human(s). In doing so, I have tried to think of ensembles of biology, development, evolution, human eco-environments, sociality, *culture,* and knowledge.

To name such an integrative perspective and its conceptualization, and in the absence of a better terminology, I have put forward the word *biosocioculturality,* in which I also include constructivist psychology, history and political economy. Far from another reification, it should be understood as a qualifying property of the specific organisms as we come into being. This view goes which goes well beyond the study of *cultural effects* on *life.* Neither do we speak of a kaleidoscopic array of multifactorial overlapping phenomena. *Culture* is not another factor of biology, evolution, cognition, behavior and the like: it is part and parcel of the complex ensembles that constitute our recognizable humanness, in all its variety of ways. *Nature* and *culture* are not universal ontological domains but ethno-local historical ways of classification and partitionings of environments.

Certainly, and fortunately, I am not the first to vindicate such a shift in the human sciences. Moreover, this is not a corporative shift of social anthropologist.[61]

Any discipline that is interested in human lives and their doings should be sensitive to this claim, be it biology, philosophy, developmental sciences, ecology, medicine, bioethics, human ethology, cognitive sciences, psychology, political, economical and social sciences. Social and cultural anthropology could also benefit from such an integrated and holistic approach if more research is done within this frame. Disciplinary hybridization and conflation will come both as a precondition and a result of this endeavor.

Interdisciplinarity and hybridization through epistemological inclusiveness

It is clear to me that the problem with interdisciplinarity is not in the differing methodological and research practices, or in the lack of a common lexicon, or the absence of communication among different practitioners. Nor has it to do with any kind of *interface.* It de-

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[61] Cf. Ingold 1986, 1990, 2004; Goodman 1998; Goodman et al. 2003; Goodman et al. 2005; Lende et al. 2005; Stotz and Griffiths 2008; Pálsson 2009; Morin 1973; Maturana and Varela 1992; Bohm 1980.

pends on something much more entrenched and enduring: the difficulties in co-producing knowledge.

Epistemological divergence is one of the major obstacles between the life sciences and the humanities/social sciences. Our different paradigms jeopardize any kind of agreement on the core concepts and big labels we talk about: human, humanity, life, environment, *nature,* evolution, cognition, *culture,* society, action, practice, learning, etc. *Conceptual integration* is not *vertical integration* (as in Cosmides et al. 1992) but operational conflation of knowledge; it is not produced top-down nor down-up, but horizontally and obliquely.

Only those disciplines that reflexively question their own reductionist frames of mind and open up to other epistemologies may be ready for building common grounds onto which we can build up a more in-depth and comprehensive understanding of humans' similar and differing ways among themselves and with respect to other life beings. This requires a big dose of scientific boundary transgressing *promiscuity,* taking seriously the work of other scientists, becoming as much as possible literate in other fields of knowledge.

The goal should be coming together in negotiated understandings where specialists are respected, taken seriously into account, and heard, in a dialogical conversation between different areas of research and theory. What is at stake is the possibility of engaging in a dialogic conversation that may lead to a more inclusive understanding and knew knowledge production.

Respect and appreciation of all contributing disciplines, equal possibilities for expression, participation, communication, and public and politic support, recognition of legitimate knowledge production in their own fields and experience, and inclusion in forums and meetings in what they may be specialists of (i.e., anthropologists on *culture* and *society*) are also basic and unavoidable requirements for true and fair interdisciplinarity. The constitution of mixed communities for discussion and research would be the next step.

In my view, claiming the right to monopolize *culture* by *neo-Darwinizing* it, as if this would guarantee its scientific status, is not a good starting point as it ignores and despises a whole tradition of knowledge production that has so far (with its flaws and ups and downs, like in any other discipline) provided accurate accounts of what *the social* and *the cultural* mean through history and diversity. A narrow and reductionist view of what knowledge may be, however *expert* this may be, cannot disregard the sociopolitical, historical, and ideological conditions of its production. I am not saying that what researchers, labs, academia, and other institutions produce is not relevant and *legitimate* (under specific parameters), only that it should be recognized that all our human productions are situated, and that what is understood as *science* is also contingent to its genealogies, contexts, and explicit or not instrumental orientation.

Thus, I postulate that social and cultural anthropology is a scientific practice that has its protocols, procedures, rules, and norms that produce legitimate knowledge within a community of practitioners.[62] Social anthropology in the 20th and 21st centuries covers a wide range of topics and issues far beyond its traditional fields and the Bronislaw Malinowski (1884–1942) era: from globalization to biomedicine and biotechnology, neuroanthropology, nutrition and diet, informational technologies and cyber cultures, performance, visual repre-

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[62] *Experimentation* should not be a condition for scientificity; in fact, neither astrophysics, nor theoretical physics, nor mathematics, nor most of geology, etc. are experimentally validated in all cases.

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sentations, the media, sound cultures, political economy, world crisis and catastrophes, organization cultures, art dealers, and the institutionalization of value, to name only but a few.

For those inspired by neo-Darwinian determinism, be it in genetics, evolutionary studies, and/or cognitive sciences, we suggest a more accurate non-linear understanding of cultural embeddedness in human lives, which entails paying more attention to holistic theory and research. One example. *Population thinking* should include emergent properties and stochastic causality of non-linear emergencies of social relations, social practices, and meanings. Human societies and eco-biosocialities are to be considered as the global outcome of individual and collective actors constituted in and by their interconnectivity and intersubjectivity, besides all non-pretended effects in the realm of public historical and situated objectivization and *entification*. This is not to deny that the concept of *population* may be useful at specific scales of phenomenic complexity/simplicity, which has produced relevant knowledge in particular fields of research (i.e., Cavalli-Sforza 1991; Cavalli-Sforza, Menozzi and Piazza 1993).

On the other hand, it is already time for social and cultural anthropology to include *life* in its concerns (Ingold 2009). We cannot be out of the scientific convergence which our society of knowledge demands today. Although necessary and always valuable, we cannot be satisfied only by an anthropology of science that deconstructs the *ins-and-outs* of expert knowledge production in research institutions, prestigious journals, *tank-thinkers,* and cyber-*gurus* in the web.

We have studied reproduction, ecological relations, classificatory systems, bodily inscriptions, learning, emotions and feelings, sociality, sex, gender, power, art, symbolism, language and communication, childhood, adolescence, rites de passage, health issues, aging, and many other aspects. But with very few exceptions, the lack of any reference to biology is outstanding, be it genomics, epigenomics, development, evolution, hormones, neurobiology, sensory perception, motricity, etc. We should also be more literate in biological anthropology, and the procedures and execution of lab work and experimentation, which are interdisciplinarily founded.

Our socioculturality is not independent of our biologies but intertwined with the organic, the evolutionary, the psychological, and so forth. Our biosocial body is not the blank slate onto which anything may be inscribed, but the complex dynamic outcome of an evolutionary and developmental process in which genomic and epigenomic processes are interwoven with our sociocultural, historical, and biographical practices of being alive.

Our embodied experience and psychological plausibility (although in part socially built) is not infinitely diverse. We cannot disregard the paramount relevance of biological, neuroscientific, psychological, evolutionary, and archaeological studies any more, not only as background contexts, but as part of the explanatory model of the evolved/developed biosociocultural organisms that we are.

It is well known that symbolic, cognitive, linguistic anthropologies have traditionally had problems with the mind and the mental.[63] This also has to come to an end. We have

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[63] The role of psychological anthropology and cross-cultural psychology (see the works of, R. D'Andrade, R. Shweder, R. LeVine, R. Levy, G. Jahoda, I.M. Lewis and many others) has to be strongly recognized and appreciated. The need for a comprehensive theory of knowledge and mind has fortunately been put forward by a few social and cultural anthropologists as well, i.e., by B. Shore, C. Toren, R. D'Andrade, C. Strauss, N. Quinn, etc.

to come to terms with mental phenomena as part of our bodies and their performances, as constitutive of our social relations. To use the expression *material–symbolic practices* means to stress the coalescence of the material in the symbolic, and the embeddedness of the symbolic and ideographic in our eco-appropriations/transformations of our environments.

Social and cultural anthropologists have to become full participants in the research program of the cognitive sciences, to be included as qualified and legitimate scholars in the matter, working together with other anthropologists who are now taken as the only legitimized representatives of the discipline because they align with neo-Darwinian accounts of mind, *culture,* and behavior.

When studying *rites de passage* and the social inclusion of children, the young, and adolescents as fully recognized members of society – because of what can be expected of them in terms of agency, social responsibility, and moral observation – we must take into account the bodily neurology of myelinization in development; the neurobiological changes triggered by our rituals, and our sensory-motor social activities, as well as the relevance of neurotransmitters, hormones (oxytocin, vasopressin), and the limbic system in sociality, bonding, relating, affections, identifications, belongings, memories, and the neurological aspects of social cognition in respect of our classificatory systems and categories.

Neuroscientific research now has a strong impact in the *human nature* discussion, as well as concerning ethical, philosophical, education, economical, political, and legal aspects (Frazzetto 2011). In the neurosocial and neurocultural turn, the culture/cognition debate has found a promising path in reconfiguring the brain and mental relations with the sociocultural, in which *culture* is recognized as inherent to all kinds of neural activity (Domínguez Duque et al. 2010) – but only if humans are not reduced to "cerebral subjects" (Ortega and Vidal 2007).[64] A further disruption to the *nature/culture* division is to be obtained from this transdisciplinarity.

In respect to evolution and evolutionary thinking it is not that social anthropologists do not accept Darwin's theories, or that they are incapable of understanding evolution modeling. What we cannot is to accept are some of its underlying paradigms. *Darwinism* can be of interest for the social sciences as long as it recognizes ethnographic diversity and it is culturally sensible in a non-essentialized, non-deterministic fashion, including constitutive relations of humanness and the relevance of semantics. It is possible to be Darwinians without being determinists (Marks 2003).[65] In any case, social and cultural anthropologists should pay attention to evolutionary processes as necessary, although not sufficient, conditions for becoming persons under proper developmental constitutive environments.

Primatology should also be of interest in the social and cultural anthropological agenda (King 2004). So should ethology, but only if it is interdisciplinary (Cranach et al. 1979), eth-

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[64] See *blogs.plos.org/neuroanthropology.*

[65] Sociologists T.R. Burns and Thomas Dietz (1992; Dietz et al. 1990, 1992) integrate evolutionary thinking in the understanding of complex sociocultural systems, but not from the view of sociobiology. They distinguish between two concepts. On the one hand, *evolutionist* is a progressive orientated linear trajectory towards a foreseen end, in which macroscopic factors are perceived as the main forces of movement so that little attention is paid to agency. On the other hand, *evolutionary* refers to the genesis of variety and communications as the result of microdynamics and selective agents in which outcomes cannot be anticipated but are stochastic, probable – because they are within limits – but still uncertain.

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nographically sensitive (Eibl-Eibesfeldt 1993), and non-behavioristic (Griffin 1992; Ristau 1990).

In the end, what is at stake is the coming together of human studies freed from the *nature/culture* cage and disciplinary autocracy. A lot is still to be done, but an enticing journey opens up in the human sciences landscape for all who are willing to participate.

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WHY CULTURAL TRANSMISSION IS SELECTIVE AND COST-SENSITIVE, AND WHAT DIFFERENCE IT MAKES

Olivier Morin[1]

The influence of culture on maladaptive behavior is one of the most vexed issues for a naturalistic approach of culture to tackle. The long shadow of the sociobiology debate extends over the problem. As is well-known, the Darwinian approaches inspired by the work of Hamilton, Trivers or Williams caused an uproar among social scientists. Opponents made much of the fact that the anthropological record is rife with instances of biologically maladaptive behavior, from adoption of non-kin to heroic sacrifice (Sahlins 1977). When this argumentative strategy met with cultural determinism, the view arose that culture causes an unusually high amount of maladaptive behavior in the human species, starting with altruistic conducts.

Hamilton's (1964) rule holds that natural selection, insofar as it can act in our species, will favor cooperative behaviors only if they benefit those who cooperate, or their kin, directly or indirectly. As a result, under the action of natural selection, altruistic behaviors (defined as behaviors that result in a neat fitness loss for the agent) should either be directed towards kin, or selected against. This view comes with two important caveats. First, natural selection is not all-powerful. It may be blurred by drift; it may get stuck in local optima. Moreover, the minds that it builds are not omniscient robots but imperfect wetware. Even the simplest strategies of cooperation occasionally get bogged – caring for one's offspring, for instance. As a result, many animals maladaptively adopt a young cub from another species (Hrdy 2009: Chapter 7). Second, Hamilton's rule does not rule out cooperation between non-kin. Anyone can cooperate with anyone, as long as they or their kin benefit from it. Sharing in a common good produced by a cooperating team is a benefit. So is avoiding punishment. Cooperation, according to Hamilton's rule, is not restricted to small family units waging a perpetual war with other family units. It is merely limited by a rule of mutual benefit (and that limit is only as strong as the importance of natural selection).

Does culture make any difference to Hamilton's rule? Karl Frost and Peter Richerson (this volume) answer yes: human cultures have 'escaped' Hamilton's rule, the backbone of the received view of cooperation in biology. They are not alone. Gintis et al. (2003: 153), who define strong reciprocity as a "predisposition to cooperate with others and to punish those who violate the norms of cooperation, at personal cost, even when it is implausible to

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expect that these costs will be repaid," claim that "strong reciprocity is adaptive in the sense of emerging from a gene-culture coevolutionary process." In other words, thanks to culture, adaptation by natural selection favors a form of maladaptive altruism.

Is this plausible? The answer, I will argue, depends on how clever we take cultural transmission to be. Two divergent views seem to coexist in the literature on gene-culture coevolution, often in the same authors. The first view holds that agents acquire culture blindly, in bulk, having no notion of the costs and benefits of imitating one thing or another. As a result, transmission acts against our interests, and culture readily yields biological altruism. The second view sees cultural acquisition as selective and cost-sensitive. Therefore, cultural transmission yields only small amounts of maladaptive altruism, no more than what we would expect from any other imperfect decision-making mechanism. The ambiguity deepens when arguments backing the second view are offered in support of the first. This paper argues for the second option, and in favor of a clear dissociation between the two.

Why cultural altruism as usually conceived is based on dumb imitation

Consider two models often cited to argue that biologically altruistic punishment evolves by cultural transmission: Guzmán et al. (2007) and Henrich and Boyd (2001) both model a population where norms of cooperation and norms of punishment are applied by some agents, whom others can copy. The norm of cooperation is a norm of mutual help: the agents endorsing its benefit in the long run. The norm of punishment, in those two models, is genuinely altruistic: agents punish other agents at a cost to themselves, without getting anything in return. Some agents are predisposed to copy others; some agents are not. Those who copy reproduce the norm of mutual help. As a result, they fare better than non-copiers because mutualistic cooperation is beneficial. However, there is a catch: the agents who copy the (beneficial) norm of mutualistic cooperation *must* also copy the (detrimental) norm of punishment. Selectivity is not an option. Agents who copy still fare better than non-copiers because the costs of punishment are assumed to be smaller than the benefits of cooperation, thus making the overall package beneficial (for a more complete analysis, see André and Morin 2011).

With such models, Henrich and Boyd (2001) show that natural selection favors genes predisposing individuals to imitate more faithfully the behavior of others, altruism included, while Guzmán et al. show that natural selection favors genes coding for conformist imitation. In both cases, cultural transmission, backed by natural selection, promotes the diffusion of a genuinely altruistic behavior. These results are surprising because altruistic punishment entails a net fitness loss for the punisher, a loss uncompensated by reciprocity, gains in reputation, or avoidance of retaliation.

There seems to be, however, a simple way for agents to avoid this loss: obey the norm of mutually beneficial cooperation, but not the norm of altruistic punishment. Maladaptive altruism would immediately collapse if genetic evolution simply endowed individuals with the ability to distinguish helping (benefitting the individual) from punishment (detrimental to individuals), and imitate one but not the other. Choosy agents would enjoy a fitness

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boost, as they would be able to reap the benefits of others' compliance with altruistic norms, without paying the cost. If selective and cost-sensitive imitators were introduced, cultural transmission would, arguably, be unable to cause genuine altruism to evolve.

Thus, these models' spectacular result rests on the implicit assumption that, when they imitate others, agents are not selective. They pay no attention to the cost of what they copy. In the words of Richerson and Boyd, "individuals must adopt what they observe with only marginal modifications. As a result, we may often adopt maladaptive behaviors" (Richerson and Boyd 2005: 161).

According to Richerson and Boyd's widely shared opinion, two simple imitation heuristics play a major role in cultural transmission: prestige-biased (copy the prestigious) and conformity-biased (copy the many) imitation. As Boyd and Richerson (1985) have shown, such heuristics have many benefits when compared to random imitation, or when measured against no culture at all. This, however, sets the bar quite low: prestige and conformity can be rather dumb. They can lead us to imitate behaviors whose costs should be obvious, like kamikaze suicide (to cite one of Richerson and Boyd's favorite examples). If such blind imitation heuristics have maladaptive consequences, how could they evolve?

A typical answer to this question starts by highlighting the shortcomings of individual cognition. We are, the argument goes, often unable to evaluate the fitness costs and benefits of a set of possible behaviors. We have to make do with imperfect and indirect cues. Conformist and prestige-biased imitation are based on such cues: the prestige and number of adopters for a given practice give a rough and indirect estimate of its usefulness. Maladaptive 'mistakes' inevitably result – this is true of individual learning as it is true of social learning: there are no perfect Darwinian robots.

Yet, in certain situations at least, the cues exploited by conformist and prestige-biased imitators are much less inaccurate than other cues. As a result, individuals who attend to these cues (and nothing else) may, in certain conditions, outsmart and eventually outbreed those who rely on individual learning. This supposes social learning based on conformity and prestige alone is, on balance, more adaptive than most alternatives. This is not incompatible with social learning causing, in absolute terms, higher amounts of maladaptive altruism (as compared to individual learning). Social learning may have enormous benefits that offset its cost; alternatively, its maladaptive effects may be restricted to the domain of cooperation. In both cases, the individual harm of cultural altruism is more than compensated. This is the basic mechanism of Herbert Simon's docility hypothesis (Simon 1990, 1993): human cultures exact an "altruism tax" from those they help.

In the rest of this chapter, I will sketch three arguments against this view:

– Most models of the evolution of cultural altruism rest on the implicit assumption that public and private sources of information cannot be combined, or selectively used. We must either learn as blind imitators or forego cultural learning. This assumption is improbable.
– Prestige- and conformity-biased imitations do not qualify as "simple heuristics that make us smart." They are simplistic heuristics that make us dumb.
– The empirical case for blind and costly imitation in humans is not as strong as it appears. Both blind imitation and costly imitation are frequent, but the conjunction of the two is, I will argue, harder to come by.

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The case for drawing on a diverse array of sources of information

The information we may use to guide our decisions stems from many kinds of sources, public or private. On the side of public information, we find arguments, testimonies, etc., carrying our culture's accumulated knowledge. The number and prestige of models is only one piece of public information among many. Private information includes everything we learn from individual experience (combined with some innate intuitions).

 Models of the evolution of cultural altruisms (such as Guzmán et al.'s [2007] or Henrich and Boyd's [2001]) tend to treat social learning as an alternative to individual learning. Individuals are either entirely incapable of learning from others, or blindly dependent on the cultural package they are given. Going cultural means forsaking cognitive resources that could help us notice certain costs and benefits (like the dangers of being a kamikaze).

This view is, I think, misleading. Just because culture is a useful *complement* to individual learning, does not make it a good *substitute*. In some domains, private information cannot be replaced. As Friedrich Hayek (1945) argued, private knowledge is not a smaller, inferior version of the general stock of public information. It possesses at least two uniquely valuable properties.

First, you have privileged access to your own private information: the knowledge of what you did in the last five minutes, the knowledge of where you were living a few years ago, etc. is much cheaper for you to retrieve than it would be for anyone else. It is also much more reliable: the occasional self-deception notwithstanding, you are not as interested in misleading yourself as you would be in misleading others. Second, there are things about which you can only be privately informed. Nothing can inform you about your preferences, for instance, like private knowledge can. Insofar as your preferences differ from those of others, their choices tell you nothing about what you would gain from copying them. Any suitably prudent decision heuristic should tell us: pay attention to the things that only you know about.

Blindly following the many and the prestigious is neither simple nor smart

To this, proponents of dual inheritance theory usually reply that consulting many sources of information entails some computational cost. Focusing on one type of cue is cheaper. Thus, crude imitation heuristics are preferable to more sophisticated strategies, in spite of the mistakes they cause. Richerson and Boyd (2005: 120) refer to Gigerenzer's "fast and frugal rules of thumbs" (Gigerenzer and Goldstein 1996). According to Gigerenzer and colleagues, those "simple heuristics that make us smart" have two precious qualities. First, they use a small number of cues, thus sparing us a costly search for information. Second, because they discard confounding information, they are more accurate than more exhaustive decision-making mechanisms.

Yet, blind imitation of the many or of the prestigious has none of these properties. The cues it uses are quite hard to retrieve, and the useful information it discards makes it less accurate than selective, cost-sensitive imitation.

The number and prestige of models is not an easy cue to fetch from the environment. Consider prestige. Vague cues like general reputation track the possession of useful knowl-

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edge in a mediocre way. For instance, among the Tsimane, a reputation for wisdom is only weakly correlated with one's knowledge of medicinal plants (Reyes-Garcia et al. 2008). This problem can be solved by using more specific reputational cues, such as people's abilities as hunters, their success in politics, etc. But these cues are hard to build, hard to track, hard to evaluate. Anthropologists Hill and Kintigh (2009), working among the Ache of Paraguay (who hunt for their food on a daily basis) have tried to observe the relative success of hunters while controlling for obvious confounding factors. Gathering the data, they report, took 14 000 observations over 27 years (not to mention the difficulty of computing the results). To avoid this, one might trust the testimony of others on such matters – but then, one would have to keep in mind the reputation of informers, which brings us back to where we started. Compared to private information (easily accessed by definition), prestige and reputation cues lack the frugality that is supposed to make them appealing.

Gigerenzer and colleagues have always been clear on one point: in their view, rules of thumb are adaptive because they are *more* accurate. They *make us smart* by discarding confounding information. In their reference paper on simple heuristics, Gigerenzer and Goldstein (1996) thus conclude "[m]odels of inference do not have to forsake accuracy for simplicity. The mind can have it both ways." Crude imitation rules do not have it both ways. They discard a lot of useful information, to concentrate on indirect and uncertain proxies. Indeed, they yield unusually high amounts of altruism precisely for that reason.

The evidence for blind imitation in humans has been overstated

A nice example of this is provided by the many replications of Asch's famous conformity experiment. It is well-known that a substantial minority of people will systematically endorse the false opinion of a majority (Asch 1951). But one should note that, in most versions of the experiment, imitating the majority entails no cost at all. What happens when penalties and rewards are introduced? In a modified version of Asch's paradigm, Baron et al. (1996) asked subjects to recognize, in a lineup, an individual they had previously seen on a picture. They varied both the amount of information available to the subjects (by changing the time of exposure to pictures), and the importance of the task (by introducing monetary incentives). Subjects blindly imitated a misleading confederate when the stakes were not high, or when their own personal information was unreliable (when the task was difficult). They trusted their own judgments otherwise, that is to say in the condition where the stakes were high and the task was easy. In other words, they imitated in a sensible and cost-sensitive way.

It is true, however, that a number of empirical findings challenge this view of imitation.

Overimitation

The study of so-called *overimitation effects* provides many reports of children copying pointless gestures in addition to the ones they are supposed to imitate. Overimitation is found also in adults (McGuigan et al. 2011). In at least one experiment, children overimitate in spite of the fact that it diminishes the reward they would get if they completed the task faster (Lyons et al. 2011).

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The causes of overimitation may be multiple and are not yet well understood. One leading author on the topic, Derek Lyons, sees overimitation as reflecting a misunderstanding of the causal power of the overimitated gesture. If true, this would imply that children over-imitate because it seems to them beneficial. This interpretation is supported by the fact that overimitation decreases when the lack of causal connection between the irrelevant gesture and the desired effect is made obvious (Lyons et al. 2007). Another interpretation might be that overimitation is, quite simply, *fun*: it adds some challenge to otherwise somewhat boring activities (all the more so when the subjects are told they are not supposed to copy the useless gesture, or that it will make it more difficult to win a reward). Even in the rare experiments where overimitation carries a small cost, it is unclear whether the fun (or the apparent benefits) of overimitation offset this cost.

Other cases of blind imitation in children

Children are more likely to act generously or violently when they have witnessed a model behaving generously or violently (Bandura 1963; Bryan 1971). In the "jar studies" in particular, children are made to win a small reward in chips (which may be exchanged for toys), and then told they may give a part of it away to a child in need. Children are quite likely to show some generosity, with or without imitation. However, when the experimenter sets the example by giving away her own chips, children are more generous. Yet the effect is weak, and it does not fit easily with current theories of imitative altruism. Instead, the authors of these studies suggest that imitation enhances giving merely because "the witnessing of a novel behavior without reprimand would subsequently increase the likelihood of such behavior."

The contagion of deleterious behaviors

Many authors have argued that behaviors as costly as suicide, homicide, tobacco use, or obesity could readily spread by imitation (Christakis and Fowler 2009; Phillips 1974). These researchers argue that deleterious behaviors tend to cluster in time, in space or in social networks, in a way which is consistent with a contagion model. That much is true, but recent papers remind us that the clustering of suicides, tobacco use, or obesity need not reflect imitation (Lyons 2010). They are entirely consistent with at least two alternative explanations. First, the clustering of costly actions may be produced by some overlooked confounding factor. Individuals may be influenced by a common cause rather than imitating one another. Second, people with a propensity to smoke, commit suicide, or become obese might not be randomly dispatched in space, in time, or in social networks. They might be attracted to certain points by the presence of similar individuals, a phenomenon called *homophily* (Steglich et al. 2009). Aral et al. (2009) estimate that properly taking these biases into account would reduce the estimated influence of contagion by a factor of 3 to 6.

What about celebrity suicides? The effect of celebrity suicide on suicide rates is, depending on the studies, small (Yip et al. 2006), neutral, or even negative (Baron and Reiss 1985). But most importantly, it has never been compared with the effect of simple celebrity deaths.

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People committed suicide after Lady Diana's involuntary death (Hawton et al. 2000). Non-imitative suicide caused by grief appears at least as strong as allegedly imitative suicide.

This rather cursory review admittedly fails to cover all the possible cases of costly and blind imitation. Its goal was, more modestly, to sketch the many alternative mechanisms that could, in my view, explain away most alleged cases of blind and costly imitation.

What it would entail to abandon blind and costly imitation

Doing without the docility hypothesis does not force us to jettison the view that cultural institutions make an immense difference to the pattern of cooperation in our species, especially between non-kin. It just means adopting a model of cooperation that does not take uncompensated sacrifices as its cornerstone.

In their most recent writings, Boyd and Richerson (2009) seem to be going in this direction. In their model of altruistic punishment, only the cheapest kind of biological altruism is required. People primarily cooperate because they fear punishment; those helping actions are not altruistic: they benefit helpers, who enjoy reciprocity and avoid punishment. The norms of punishment are themselves grounded in the fact that people are ready to punish even at a personal cost. Those second-order retributive actions are genuinely altruistic, but they are cheap. At equilibrium, most individuals cooperate and are never punished: one might not have to punish at all. The threat of it suffices. Thus, the costs of altruistic punishment are so small that even a reasonably cost-sensitive imitation heuristic might occasionally fail to detect it (Henrich and Boyd 2001).

I will leave aside the question of why we would *more* readily imitate altruistic punishment, merely *because* we hardly ever see it happen. Instead, I will point a possible point of agreement between this model and my argument: if mistaken imitation is rare, biological altruism should be just as rare, and human cooperation should be backed instead by sanctions, rewards, reputation-monitoring, etc. Human cooperation would not be, for the most part, biologically altruistic. (Or, if it were altruistic, it would not be because of culture.) This position, however, is quite at odds with the cultural group selection and strong reciprocity hypotheses, or at least with one of their major selling points.

Their proponents see human cooperation as "fundamentally incompatible with the biologists' model of the self-regarding reciprocal altruist" (Gintis et al. 2003: 154). In this, it is "a huge anomaly" (Fehr and Fischbacher 2003) in the biological world. Because of culture, says the theory, humans generally and systematically differ from non-humans in their readiness to help and punish at a net inclusive fitness cost to themselves. This argument is what allows cultural group selection theorists to account for cooperation in anonymous contexts when it cannot benefit the givers (Fehr and Fischbacher 2003). If, however, altruism is a product of maladaptive imitation, and imitation is mostly flexible and cost-sensitive, cultural altruism cannot be an important feature of human cooperation. This, of course, does not mean human generosity is to be negated or simply explained away; but it is not likely to be explained by a mixture of cultural transmission and natural selection.

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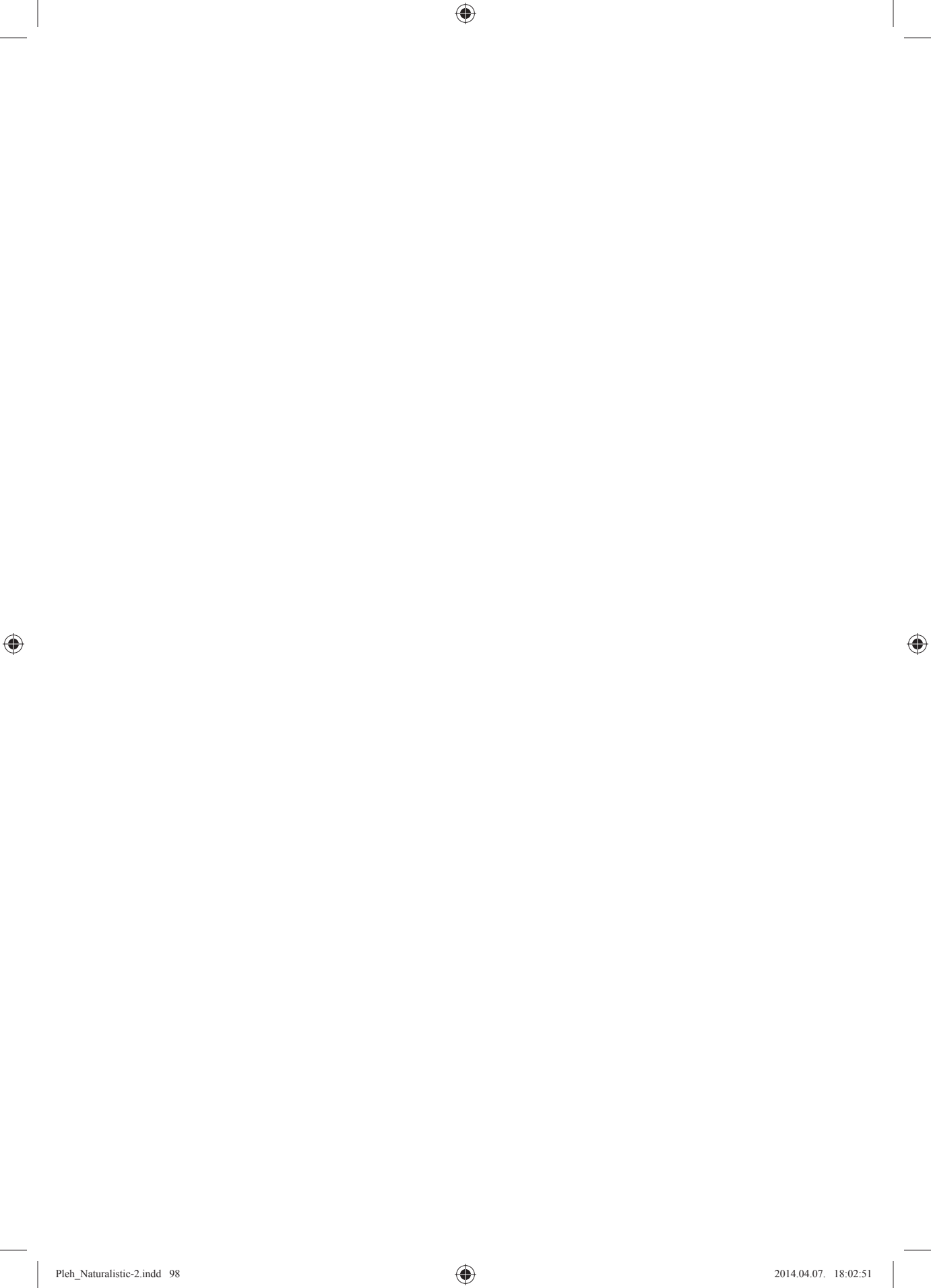
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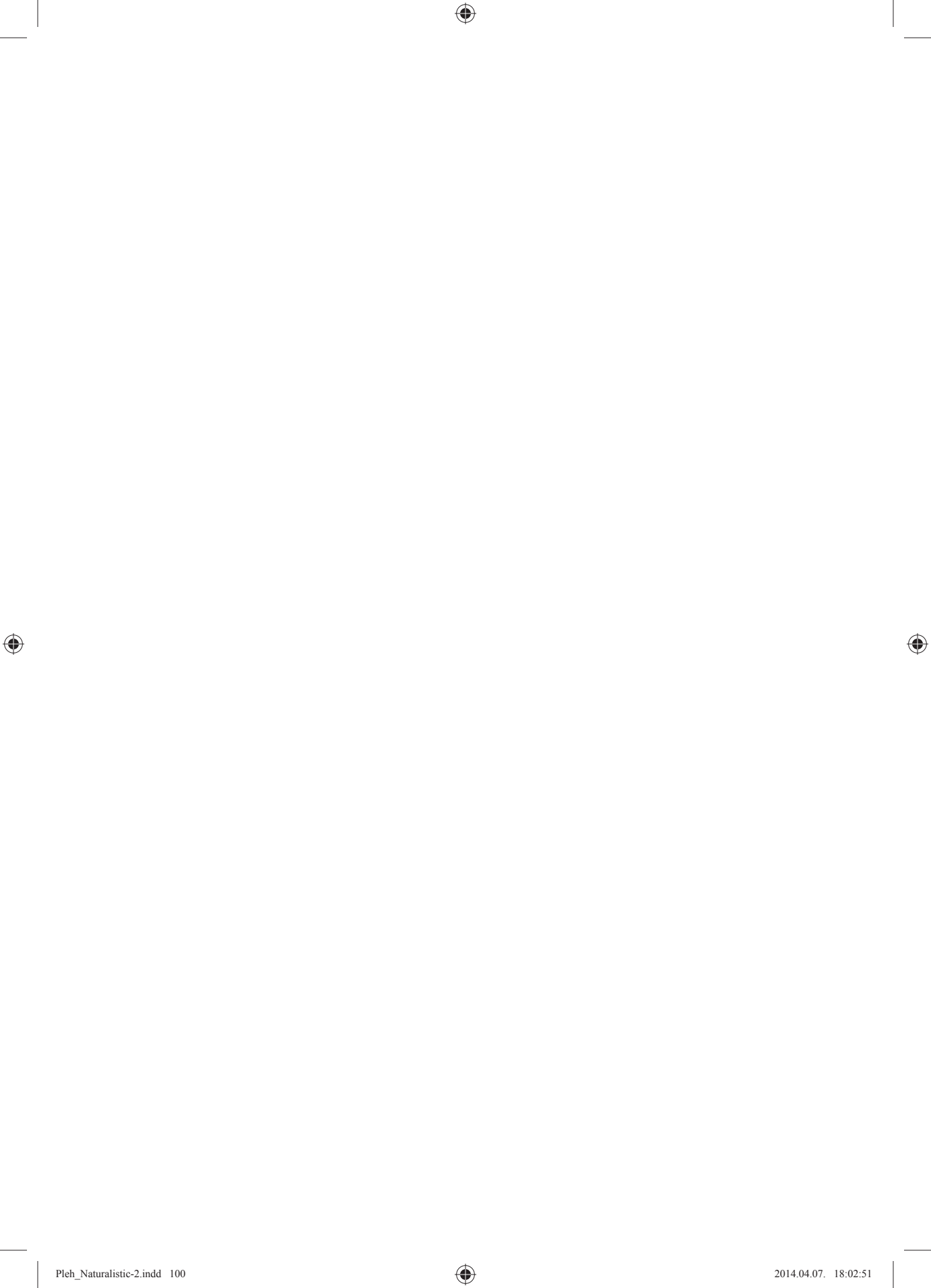
EVOLUTIONARY INTERACTIONS BETWEEN HUMAN BIOLOGY AND ARCHITECTURE: INSIGHTS FROM SIGNALING THEORY AND A CROSS-SPECIES COMPARATIVE APPROACH

Jan Verpooten and Yannick Joye

Introduction

Rather than being a recently invented practice, building homes and other architectural constructions, such as temples and monuments, are a perennial part of the human behavioral repertoire, which may have had an important impact on human cultural, genetic, and ecological evolution. Studying architecture from a biological and evolutionary perspective may thus be relevant to the understanding of human evolution; and vice versa, a biological and evolutionary perspective may enhance our understanding of architecture as a crucial part of human life. Yet, human architecture has hardly been investigated from a biological and evolutionary perspective.

In this chapter, we aim to contribute to this much-needed approach to architecture. First, we investigate the evolution of human building aptitudes from a phylogenetic perspective. Then, we address the evolution of aesthetic aspects of architecture and its eventual signaling purposes from a comparative perspective relying on models from signaling theory.

Definitions

Animal building behavior

Building behavior is a kind of construction behavior, like tool making. Whereas it is difficult to non-arbitrarily distinguish tool making from building, construction behavior can be unambiguously defined as follows: "something must be constructed and it must necessitate behavior" (Hansell and Ruxton 2008). For example, coral polyps just secrete coral skeleton, gradually building up reefs, whereas the caterpillar building its pupal defenses employs behavior (Hansell 2007). The basic premise for treating building biology as a single field, a biologically coherent subject, is the biological argument of convergent evolution. In this case, it is that the rules of physics apply universally to all builders and they also share many of the biological hazards in common. Couple this with the fact that there are a limited number of good solutions to any problem and you have a conceptually useful field of study (Hansell, pers. comm.). Since there is no reason to assume that any species would escape the rules of physics, hazards, and logic, this building biology framework should also work for the human species.[1]

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[1] In case we would have to conclude that the building biology framework does not apply to humans, it tells us something interesting as well. It would mean that humans are unique in a way that affects human buildings. In such a case, the cross-species perspective on building would help to spell out in what sense humans are unique.

Architecture

The *New Oxford American Dictionary* distinguishes between two meanings of the term *architecture.* The first interpretation of architecture is "the art or practice of designing and constructing buildings," whereas the second one equates architecture with "the style in which a building is designed or constructed, especially with regard to a specific period, place, or culture, e.g., Victorian architecture." In this chapter, we will address both these aspects of architecture (i.e., 'architecture as building' and 'architecture as the aesthetics of buildings') from an evolutionary and cross-species perspective.

Roles of architecture

Most buildings created by humans are homes. The primary function of homes is to protect humans and their offspring against biotic and abiotic hostile forces, such as (among others) adverse meteorological conditions, predators, or enemy outgroups. Beyond this mere utilitarian function, many buildings are constructed in a specific style: architecture often also has an – intended – aesthetic function, in the sense that many buildings are designed to be perceived. Interestingly, these are also the two main functions of non-human animal constructions. Most of them serve either intraspecific communication, (i.e., displays such as the decorated bowers of bowerbirds), or protection (i.e., nests, trapping function notwithstanding) (Hansell 2005). The argument that will be put forward in this chapter will be built around these two main purposes of human and non-human architecture. In the first section of this chapter, we focus on the protective purposes of buildings, and the evolution of the human building aptitude mainly from a phylogenetic perspective. In the second section, we devote attention to the aesthetic component of architecture, which we will consider from the perspective of signal evolution. In both these sections, we will investigate the potential interactions between the evolution of building aptitudes, and the signaling functions and the protective functions of architecture throughout evolutionary time.

Building

The origins of human building aptitudes

Did human building aptitudes evolve for the signaling and/or protective purposes which architecture perennially seems to exhibit? Or did they merely emerge from co-option of another aptitude such as tool behavior? To address these questions, it is necessary to take a look at our extant and extinct closest relatives and at the prehistory of *Homo sapiens.*

Tool behavior is relatively rare in the animal kingdom. The commonly held view is that this is due to the fact that tool behavior is cognitively constrained, i.e., only 'smart' animals are capable of evolving it. However, recently, Hansell and Ruxton (2008) put forward an intriguing alternative explanation for the rarity of tool use. They claim that tools are rare because they are often not useful. In support of their hypothesis, they note that, first, tools are generally not a substantial part of the ecology of species identified as tool users; and,

second, tool use has had little evolutionary impact as a driver of speciation, especially in comparison with species that show construction behavior more generally. For example, although crows and finches provide the most numerous examples of tool use in birds, the parrots, noted for their general intelligence, provide few examples of tool use in the wild (Lefebvre et al. 2002). Hansell and Ruxton (2008) suggest as a possible explanation for this that parrots, with their ability to grasp objects in their feet as well as to manipulate them with their beaks, find few circumstances in which a tool would offer an added advantage. In contrast to tools, nests are quite widely distributed in the animal kingdom (Hansell 2005). However, there is no reason to suppose that this is the case because nest building is generally less cognitively constrained than tool behavior. Both can be complex and flexible in some species and stereotyped in other. Rather, nests, in contrast to tools, are very often useful, as they serve the crucial function of protecting builders and their kin against biotic and abiotic hostile forces.

This pattern holds in extant hominids. All great apes routinely build nests, while their tool use is only facultative. Orangutans, for example, do not use tools in the wild (some notable exceptions notwithstanding, see van Schaik 2006). In chimpanzees, tool use seems important as a foraging method only to some chimpanzees at some times of the year (Hansell and Ruxton 2008). However, both species of great apes daily build night nests, and they may even make day nests as well. Chimpanzees are born, spend the majority of their lives, and often die in their nests. One functional aspect of nest building in chimpanzees is that of comfort for sleep, but the functions of chimpanzee nest building are probably multiple (Stewart et al. 2007). Chimpanzee nests are neat, compact, and sturdy structures. Hansell and Ruxton (2008) doubt that the making of a stick tool is cognitively more complex than the making of such a nest.

Sabater Pi et al. (1997) infer from the prevalence of nest building in great apes and from indirect archeological evidence that extinct hominins (e.g., different species of Australopithecus and *Homo habilis*) may have been nest builders as well. A speculative proposal is that *Homo sapiens* inherited this aptitude for building (culturally, genetically, and/or ecologically) from its hominin forebears. Post-moulds, and oval, or circular stone rings may be direct evidence of shelters constructed by Homo species. At any rate, as suggested by Hansell and Ruxton (2008), these findings indicate that nest building may have been a more important factor in the evolution of human construction aptitudes than tool behavior. But what about signaling, the other main function of building in humans and in the animal kingdom? May signaling functions of constructions have played a role in the evolution of human building aptitudes?

With the exception of humans, building for signaling purposes seems virtually absent in the primate lineage. This is surprising since it is safe to assume that, for example, great apes, who construct nests and tools, are cognitively and anatomically perfectly capable of constructing artificial signals. Is it because signaling constructions are for some reason not very useful to non-human primates? The absence of signaling structures in primates stands in stark contrast with the fact that in many bird and fish species artificial signaling is an essential part of their natural behavioral repertoire. Many of these signaling systems are intersexual, but not all (e.g., Sergio et al. 2011). It is an intriguing biological conundrum why humans stand, in this respect, closer to birds and fishes than to their closest non-human relatives.

Considering the widespread human inclination to create signaling structures, humans are the exception to the rule within the primate lineage. As far as is known from the archeological record, the first signaling constructions in the human lineage are artifacts and include adorned tools and complex art such as figurines and rock art. These consistently began to appear from about 35 thousand years ago onwards (Powell et al. 2009).

This brief discussion suggests that the primary evolutionary force in the evolution of human building aptitudes was nest building, while signaling and tool construction co-opted these aptitudes and may have become subsequently secondary forces driving the further elaboration of building in humans.

The biological consequences of building

Material culture is often regarded as a crucial factor in the evolution of intelligence and human ecological dominance. However, as Hansell and Ruxton (2008: 74) point out, "evidence from construction behavior other than that of tool behavior (such as nest building) has tended to be excluded from the debate on the evolution of human intelligence and ecological dominance." Yet, the foregoing discussion suggests that nest building has been more common, useful, and potentially as cognitively demanding as tool behavior during human evolution. Therefore, we may expect that, if material culture has impacted the evolution of intelligence and human ecological dominance, it may have been nest building that played a crucial role – and, perhaps to a lesser extent, tool behavior.

The evolution of intelligence

Van Schaik (2006) and others suggest that material culture bootstraps intelligence. If artifacts are useful and if more intelligent individuals can produce more useful artifacts through imitation and invention, a positive evolutionary feedback loop arises between intelligence and material culture. Van Schaik (2006) refers to tools, but following the above reasoning (cf. the section on the *Origins of human building aptitudes*), nest building may have been at least just as important in this process. And there is an additional reason why it may have been above all nest building rather than tool behavior that has promoted intelligence. Early hominid nesting sites may have created a social environment ideal for exchange of information further bootstrapping intelligence (Fruth and Hohmann 1994). Moreover, one may speculate that in as far as the elaboration of nests or shelters provided ever more protection against hostile forces, the role of active (wakeful) vigilance might have lost some of its importance during sleeping. This further bolstered the evolution of deep sleep, which is known to be a prerequisite for highly complex cognition functioning (Coolidge and Wynn 2006).

Ecological dominance

Since building should assist control over the environment, an association between architectural innovation and extension of habitat range may occur (Hansell 2005). For example,

Hölldobler and Wilson (1990) contend that nest building in some species of weaver ants has significantly contributed to their ecological dominance. Could this be the case for humans as well?

From fur to roof

Human nakedness may have evolved as an adaptation to keep the body cool, which enabled ancestral humans to cover increasingly large foraging distances in the ancestral African savanna. (Wheeler 1984, 1996; Chaplin et al. 1994; Jablonski and Chaplin 2000; Jablonski 2010). Glands that produce watery sweat rather than (ancestral mammalian) oily sweat may have evolved in concert with human nakedness for extra cooling efficiency. If nakedness is an adaptation to keeping cool while running under a burning hot sun, being furless may in turn be unfavorable when the body is inactive, for example during resting. Since all mammals inhabiting the savanna today have fur, except for the exceptionally large ones such as rhino's and elephants, it seems reasonable to suppose that the thermoregulatory function of fur is important – even in a tropical climate. Fur protects against wind and precipitation and helps the organism to keep warm. We speculate that the evolution of nakedness was facilitated by the elaboration of nests replacing the function of fur when being inactive. Great ape nests are relatively simple open constructions. Perhaps, the invention and cultural transmission of a roof construction, which changed the basic great ape nest into a hut-like configuration, was necessary for the functional shift towards nakedness. Based on fossil evidence (i.e., essentially modern body proportions, which would have permitted prolonged walking and running), Jablonski (2010) estimates that the hominin transition to furlessness may have been well under way by 1.6 million years ago. If our proposal is correct, an elaboration of nest building should have occurred more or less synchronously. However, as discussed above it is very hard at this stage to find any direct evidence of the timing of this shift because shelters and nests would have been mostly made of organic, and hence perishable, materials.

Out of Africa

Once roofed nest building was in place, it may have contributed significantly to the rapid colonization of other continents. The fact that humans did not grow back fur during or after colonizing habitats with much colder climates is indicative of this. By comparison, mammoths, which are even bigger than extant elephants, had fur to protect themselves against the cold. Similarly, vultures, whose heads and necks are more or less featherless, have a feathery coat on these body parts in colder climates. It is therefore quite unusual that humans in colder climates did not grow back fur. We suggest that renewed genetic selection for fur may have been dampened by the protection that built structures (i.e., roofed nests or huts) offered. A genetic response to environmental change is usually slower than a cultural one (Boyd and Richerson 1985). In this case, learning and socially transmitting the art of using local materials to build huts dampened the need to grow fur again, which is consistent with (cultural) niche construction theory (Laland and Brown 2006).

Clothes and caves

There are two problems with the from-fur-to-roof proposal: namely, the use of clothes and caves in humans. Regarding caves, one may argue that these are naturally occurring shelters, which may have provided all the necessary protection from biotic and abiotic hostile forces. The availability of caves might thus have made the practice of building huts largely unnecessary. However, while it is indeed the case that caves and other naturally occurring shelters were available to our forebears, there is reason to believe that they were used far more sporadically than commonly assumed. Our ancestors could not only rely on caves for their protection. Since we now know that their lifestyle closely resembles that of contemporary hunter-gatherers, the typical group of ancestral humans probably had to cover large annual foraging distances. They may have had one or more base camps or other sites to which they returned annually, but most of the time they travelled long distances. Culturally maintained knowledge on how to use local materials to build temporary, but high-quality shelters with little effort seems to have been crucial for maintaining that nomadic lifestyle. Moreover, caves which are both accessible and suitable for resting are not that widely distributed in landscapes, nor is their location/entrance very easily detected and remembered. Our ancestors were not the 'cavemen' as the old high school textbooks portrayed them – which is further evidenced by extensive studies of cave sites where remnants of human presence have been found. These studies indicate that these caves were only sporadically used. This is even the case for caves where cave art has been found, leading archeological researchers to postulate that caves were mainly used for ritual purposes, rather than as homes.

Another issue with our from-fur-to-roof proposal relates to the use of clothing. Obviously, clothing can offer important protection against hostile abiotic forces, such as wind, precipitation, and cold. Although clothing may have been a factor in the relaxation of renewed genetic selection for human fur in colder climates, we do not think it made shelters redundant for these protective functions. Yanomami Indians, living in the tropical Amazonas area, for example, do not wear clothes but they use shelters and windscreens (Eibl-Eibesfeldt 2008). Shelters may alternatively be explained as a protective structure against predators, but this does not explain the Yanomamis' use of windscreens. In cold environments, the protection potential of clothing against wind and rain is limited. Especially during sleep, shelters, like huts, may have provided the necessary protection against windy and rainy weather conditions and maintained a relatively stable environmental temperature.

Signaling

Signals are designed to be perceived. Since the aesthetic aspects of architecture, just as the aesthetic aspects of any human artifact, are designed to be perceived as well, it is useful to consider them from a signaling perspective. By contrast, awe-evoking sunsets or grand mountain views obviously also appeal to our sense of beauty, but they are not designed for that purpose. Especially, the overall morphology of religious edifices (e.g., the cross-shaped plan of cathedral), which nearly always includes decorations and ornaments, has a clear signaling or communicative purpose rather than only a utilitarian one. In biology, communication and signaling between individuals have been extensively studied, from a theoretical as

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well as an empirical perspective. Here, we will attempt to demonstrate how these empirical and theoretical findings may shed light on the evolution of aesthetic/signaling aspects of human architecture.

As we have argued in the previous section, signaling was probably relatively unimportant for the initial evolution of human building aptitudes and for the culturally, genetically, and ecologically inherited building practices. However, once the practice of building became established it could have easily been exapted to signaling purposes as well, leading to the emergence of built constructions that served both signaling and directly utilitarian roles (in addition to the existing merely utilitarian constructions), and even constructions that exclusively served signaling purposes, such as monuments. Before addressing the question which particular signaling purposes architecture may serve and why, we give a short review of the main models of signaling theory. After this, we aim to prove these models' relevance for explaining key features and characteristics about human architecture. Three models of signaling theory will be discussed: (a) arbitrary coevolution, (b) sensory exploitation, and (c) costly signaling. These models are mostly applied to explain the evolution of mating traits and mating preferences, and they can be formulated either as complementary (explaining different aspects of signals and their evolution in a given signaling system) or as mutually exclusive mechanisms. There is ongoing discussion about which of these models is the predominant mechanism in intersexual selection. Since they apply, in principle, to any sender–receiver system, including human (cultural) communication systems (Boyd and Richerson 1985), such as architecture, a similar comparative evaluation of these models is relevant in this context.

Arbitrary coevolution

Prum (2010) recently argued that the Lande–Kirkpatrick mechanism – better known as Fisher's runaway process[2] – is the appropriate null model of signal evolution against which alternative models can be comparatively evaluated. In this model, no additional evolutionary forces on either senders or receivers are assumed (i.e., arbitrary coevolution between signalers and receivers). Although developed in the context of intersexual selection, the model applies to aesthetic evolution in general and predicts that arbitrary coevolution occurs between aesthetic signals/traits and aesthetic preferences (Prum, pers. comm.). The model thus implies that the aesthetic characteristics of architecture and human preferences for these characteristics are entirely determined by intrinsic factors of the system, i.e., they are evolutionarily neutral.

A number of case studies on human artifacts demonstrate that arbitrary aesthetic evolution can indeed occur. For example, Rogers and Ehrlich's (2008) study suggests that symbolic adornments for Polynesian canoes have no differential effect on survival from group to group. Similarly, Bentley et al. (2007) show that the steady turnover in "pop charts" – including the most popular music, first names, and dog breeds in the 20th-century United States – fits a random copying model. These compelling findings demonstrate that in some cases aesthetic tastes and styles are evolutionarily neutral. Yet, the research question here

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[2] The Lande–Kirkpatrick version includes both stable and unstable equilibrium conditions.

is whether this arbitrary coevolutionary process applies to aesthetic evolution in general, including architectural styles, or whether it only applies to these local and specific communication systems. Also, one should bear in mind that the aforementioned studies only demonstrate that style or taste *differences* are arbitrary. This, of course, says nothing about whether the aesthetic signaling system as a whole is evolutionarily neutral or not. Again, consider religious architecture as an example. Stylistic differences between Gothic and Roman architecture may be evolutionarily neutral, while other, shared aesthetic aspects of these styles may not be, for example, their monumentality (see sections on *Monumental architecture and costly signaling* and *Monumental architecture and SE*).

Costly signaling

The mechanism

In contrast to the null model, costly signaling (CS) does assume an additional selective pressure external to the context of the signaling system. CS implies direct selection on the senders and, consequently, indirect selection on receivers' responses to the signal. This additional selection on senders is a consequence of a realized cost of the signal. By displaying to being able to bear this handicapping cost, the sender reliably signals its quality. Receivers, on their part, benefit from adjusting their response according to sender quality.

Mostly, a number of criteria are discussed for signals to be counted as handicaps or costly signals. Based on the main handicap results in Grafen's seminal paper (1990), signals can be considered as handicaps if they are (a) honest, (b) costly, (c) and costlier for worse signalers. For example, a recent study showed that a raptor species nest decorations act as reliable signals of viability, territory quality, and conflict dominance of a signaling pair to floating conspecifics (Sergio et al. 2011). By experimentally enhancing nest decorations, researchers showed that in this communication system honesty was maintained by social punishment, which seems to conform to the CS hypothesis (but see Szamado 2011).

Monumental architecture and costly signaling

The mechanism of CS seems particularly relevant to explain religious architectural constructions (e.g., temples, cathedrals). On the one hand, the monumental aspect of such religious buildings appears to serve a signaling rather than a utilitarian function. The domes, towers, or the extraordinarily high ceilings of religious buildings, are of little to no direct practical use. On the other hand, costliness speaks of the fact that a lot of additional effort, resources, and energy go into building monumentally. Given that monumentality is a signal, we would not expect that differences in monumentality are arbitrary to receivers. These observations have led archeological researchers to suggest that religious monuments trans-temporally and cross-culturally evolved because leaders/elites used them to signal their status to commoners and competitors. Specifically, such monumental edifices have been interpreted as 'devices' for vertical stratification, serving to introduce social ranking within communities.

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What is the precise mechanism according to which monumental architecture is thought to have fulfilled this socializing role? According to Trigger (1990), such edifices are a clear example of conspicuous consumption (Veblen 1899) because they are largely non-utilitarian and because their construction required massive amounts of energy. By their ability to control that flow of energy and to recruit the labor that was necessary to harness that flow, the (elite) builders – or the ones commanding to construct these buildings – unambiguously demonstrated towards other members of the society that they were the ones that were actually holding power. Non-elites' low social ranking became further underlined by the fact that the elite had the ability to recruit them for participating in building the monumental structure. Or as Trigger (1990: 125) puts it,

> [m]onumental architecture and personal luxury goods become symbols of power because they are seen as embodiments of large amounts of human energy and hence symbolize the ability of those for whom they were made to control such energy to an unusual degree. Furthermore, by participating in erecting monuments that glorify the power of the upper class, peasant laborers are made to acknowledge their subordinate status and their sense of their own inferiority is reinforced.

One of the issues with Trigger's account is that it begs the question as to how building non-utilitarian structures could have conveyed an adaptive benefit to the elite builders. Borrowing from the work of Zahavi (1975), Neiman (1998) argues that monumental architecture should be understood as illustrating the handicap principle, i.e., CS. By being able to 'waste' their energy to such buildings, the elite builders reliably signaled to others that they had an excess of power/energy, deterring rival elites to enter into a competition with them. To followers such grand edifices reliably illustrated the elites' qualities as potential leaders. According to Neiman (1998) monumental architecture can thus be viewed as "a form of 'smart advertising,' wherein the signaler accrues the benefits of increased access to labor and resources as a result of paying the cost of construction, and nonsignalers can benefit from associating with more capable elites" (Aranyosi 1999: 357). In the long run, monumental architecture, as an instance of 'wasteful advertising,' gave the elites privileged access over resources and mates, which enhanced their reproductive success. Note that a CS perspective need not necessarily be limited to architectural monumentality per se. Architectural decorations, such as ornamentation, might as well be considered as costly signals. This might be analogous to animal kingdom. For example, red, orange, and yellow carotenoid-dependent ornaments are hypothesized to be a general form of an immunocompetence handicap (Folstad and Karter 1992). The idea is that carotenoids have dual but mutually incompatible roles in immune function and signaling (Lozano 1994). Animals with carotenoid-depended sexual signals are actually demonstrating their ability to 'waste' carotenoids on sexual signals at the expense of their immune system.

Regardless of whether the hypothesis that monumental architecture resulted from CS would prove theoretically and empirically valid or not, it offers an interesting perspective on architecture from a Darwinian and signaling perspective. This is reinforced by the fact that much of what is nowadays known as 'architecture' often has monumental aspects. So, any model trying to attempt to elucidate the evolution and function(s) of monumental architecture from a Darwinian viewpoint goes a long way in explaining some of the function(s)

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of architecture. It should be noted, however, that there seems to be a near consensus among evolutionary archeologists that a CS explanation suffices to explain monumental architecture. Apart from Joye and Verpooten (2012), no attempts have been made to link other signaling models to this building strand. Yet, to avoid the pitfalls of a confirmationist research attitude, CS should be comparatively evaluated against other signaling models. Moreover, regardless of its plausible prevalence in humans, the current methodology may not be suitable to demonstrate the strategic cost or the wastefulness of the signal, which is a necessary condition for CS (Szamado 2011).

Sensory exploitation

In this section, we explore the sensory exploitation (SE) model (a) as a complementary explanation to CS, and (b) as a true alternative (i.e., mutually exclusive) mechanism for the evolution of monumental architecture. We first introduce the specifics of the SE mechanism. After this, we investigate SE's explanatory potential for monumentality in architecture, as well for other aesthetic properties such as decorative and compositional elements in architecture.

The mechanism

Sensory exploitation is a model that is increasingly receiving attention (e.g., Ryan 1998; Arnqvist 2006). Central to SE is that senders evolve display traits to exploit pre-existing biases of receivers,[3] or biases that are under strong selective pressure in another context than the SE system such as perceptual biases adapted for finding food or avoiding becoming food. These male traits may often be costly, but that does not necessarily mean that they reliably correlate with quality, which is a requirement to regard the trait as a costly signal. In recent years, theoretical evidence (see Fuller, Houle and Travis 2005) as well as empirical evidence (see Rodriguez and Snedden 2004) for the role of SE in sexual selection has been steadily accumulating, establishing it as a valuable alternative to CS.

Take, for the sake of comparison with CS, again the example of colorful signals that are carotenoid-dependent. SE suggests an alternative explanation for the female preference for red, orange, and yellow carotenoid-dependent ornaments. Rather than being an indicator of male quality, they may be mimicking signals to which females are biased. In support of SE, Rodd et al. (2002) indeed found evidence that female guppies' *(Poecilia reticulata)* preference for males with larger, more chromatic orange spots results from a sensory bias for the color orange, which might have arisen in the context of food detection. With respect to animal built constructions, relevant in this context, similar findings have been made. Madden

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[3] Usually the term *sensory exploitation* is interpreted quite broadly, referring not only to the exploitation of sensory biases, but also to the exploitation of receivers' emotional and cognitive biases. Moreover, biases do not need to be innate but can be learned as well, given that they are maintained by strong functionality outside the signaling context. Therefore, sometimes the more inclusive term *receiver psychology* is used.

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and Tanner (2003) found that some species of bowerbirds prefer to eat fruit of a similar color to the decorations found on their bowers.

Some studies offer clear evidence of SE as a true alternative to costly signaling (CE). For example, in a well-documented case, male water mites mimic prey in order to attract the attention of females (Proctor 1991, 1992). This case illustrates the strong version of SE because it precludes CS to operate. CS requires signal receivers to choose on the basis of perceived quality, whereas here females are clearly tricked and are thus unable to exert any choice. Notice, however, that SE and CS are not necessarily mutually exclusive, although theoretically they can be formulated as such (Fuller et al. 2005). There also exist weaker versions of SE theory that may complement models like CS. They commonly explain specific aspects of costly signal evolution, for example, why a costly signal takes on a specific wasteful form rather than another one. This weaker version of SE is commonly called *sensory drive,* and it focuses on aspects such as signal efficiency (Endler 1992). Often, however, a clear distinction between sensory drive and SE is unwarranted, and usually these theoretical variants are lumped together. The strong version of SE differs from the null model in the same way it differs from CS in that it precludes coevolution between senders and receivers. Applied to architecture, this means that if it were shown that human responses to architecture are largely determined by preferences that are/were selected in another context, rather than by coevolution with architectural styles (which, whether CS or not, i.e., arbitrary coevolution, refer to a quality of the sender), this would qualify as evidence that SE is the main mechanism underlying the evolution of architectural aesthetics.

Exploitation of human biases in architecture

Many studies suggest that humans experience an adaptive lag, that is, a mismatch between current selection pressures and behavior (Laland and Brown 2006). For example, humans have a biologically prepared fear for archaic dangers, such as snakes or spiders, but they do not have such prepared fears for modern threats like cars (Marks and Nesse 1994). Evolutionary psychologists, such as Cosmides and Tooby (1987: 280–281) give the following description of this mismatch:

> [t]he recognition that adaptive specializations have been shaped by the statistical features of ancestral environments is especially important in the study of human behavior. … Human psychological mechanisms should be adapted to those environments, not necessarily to the 20th-century industrialized world.

Laland and Brown (2006) contend that, while it is a truism that any animal, including humans, experiences some adaptive lag, the mismatch between an animal and its environment is generally compensated by niche-constructing activity. We assume that SE is one of the mechanisms through which niche construction is obtained and selection against archaic biases dampened. We propose that architectural environments, which are part of the constructed human niche, are shaped by the exploitation of these archaic adaptive human biases. This exploitation process may – in principle – be neutral, beneficial, or maladaptive to human receivers. To stick with the example of the maladaptive lack of fear of cars, it might

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be no coincidence that BMW's have "angry" face-like fronts (Windhager et al. 2011). This can signal that these cars are in fact relatively more dangerous to vulnerable road users than average cars. Similarly, we expect that utilitarian buildings may acquire signaling features as a result of SE. In the following sections, we speculate about the kinds of pre-existing human perceptual, cognitive, and/or emotional biases that may become exploited in architecture, and about the functions – if any – they serve.

Architectural compositions and decorations

There have been a few attempts to approach architectural aesthetics from an evolutionary perspective. One such perspective takes habitat theory as its starting point,[4] which was originally proposed by Orians and Heerwagen (1992). This perspective can be accommodated to the SE framework, which in turn allows comparative evaluation with other models. Central to habitat theory is the assumption that the human species has 'inborn' (aesthetic) preferential biases for particular landscape features and/or organizations, and elements that were invariably present in ancestral environments (e.g., animal life, water features). Preferential biases for these features/organizations and elements are claimed to be evolved adaptations. They increased genetic fitness by enhancing the probability that ancestral humans would explore environments which offered them sufficient opportunities for protection (e.g., against predators, weather), and which guaranteed the availability of resources. These preferential biases are claimed to be present in architecture.

Within this context, it has been proposed that humans have a preferential bias for park-like or savanna-type environments (Orians and Heerwagen 1992). These environments are sometimes believed to be the environments in which humans evolved. Among other characteristics, savanna-type environments are relatively open, have a fairly even ground surface, are only moderately complex, and contain relatively high levels of biomass (Orians and Heerwagen 1992; Ulrich 1983). An evolved (aesthetic) preferential bias for environmental features or configurations typical to this biome made that early humans were drawn to environments where potential dangers (e.g., predators) could be seen from quite a distance, where locomotion was relatively easy and unimpeded, and which offered opportunities to "see without being seen" (cf. Appleton 1975).

In recent years some scholars have used the previous research findings to explain particular aspects about the aesthetics of architecture and the built environment (Joye 2007; Hildebrand 1999; Kellert 2005). The argument is that when humans are freely left to organize their living environments in a way which feels comfortable to them, they are inclined to integrate these preferential biases into architectural design because these features reflect a "good habitat." Constructing built environments/habitats that appeal to our senses should thus reflect these evolved preferential biases. For example, the fact that people like dwellings offering a broad and unimpeded view on the surrounding environment or prefer intermediately complex environments has been interpreted as a reflection of these biases, and specifically of the savanna bias (Appleton 1975).

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[4] Note that there are other uses of the term *habitat theory*.

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The fact that cities and buildings do not directly resemble savannas (except for their parks, perhaps) may be seen as a problem for the hypothesis that they mimic a savanna environment. However, this hypothesis only states that the bias for such an environment would be (architecturally) expressed if humans were freely left to choose. Therefore, a plausible reason for the lack of savanna-like features in human-built surroundings may be that we are just not often in a position to choose. To put it in more mechanistic terms, this kind of SE is probably often overridden by stronger selective pressures, such as the need for protection from current biotic and abiotic hostile forces.

Perhaps a more serious challenge for this 'savanna hypothesis' is the human behavioral ecology view that humans evolved as opportunistic ecological generalists in variable environments (Smith and Wishnie 2000). As a result, humans are behaviorally flexible and can accommodate themselves to a wide range of circumstances and habitats (Smith, Borgerhoff Mulder and Hill 2001), It seems, however, that a significant part of this accommodation is achieved through niche construction (instead of behavioral flexibility), which in turn negates modifying selection on pre-existing biases (Odling-Smee et al. 2003). In turn, this would then favor the savanna hypothesis. Yet, the claim for a human-evolved preference for savanna-like environments remains relatively speculative claim given that our human ancestors also lived in other types of biomes, both before and after dwelling the African savanna.

A more convincing case of SE in architecture can perhaps be made if we consider the elements that have been invariably present across the range of possible habitats human ancestors have inhabited and that were especially relevant to their survival. It seems that above all the category of 'living things' seems to qualify, specifically animals (including conspecifics) and vegetative life. It is a truism that during human evolution negotiating successfully with animals – either predator or prey – as well as the ability to locate and gather foods of vegetal origin (e.g., roots, flowers, berries, and herbs) were of crucial importance to human survival. Given these selective pressures, it has been claimed that humans evolved a number of (affectively guided) detection, recognition and memory mechanisms (Barrett 2005). Consistent with this, experimental research supports the claim for the existence of domain-specific cognitive (i.e., attentional, memory) and emotional mechanisms to deal with the category of living things. For example, children already at a very young age are able to make a differentiation between (crucial features differentiating) animate and non-animate categories (Gelman and Opfer 2002). Neuropsychological research into so-called "category specific deficits" points to the existence of domain-specific neural areas that are specialized in storing knowledge about living/animate entities (e.g., animals, vegetative life; cf. Caramazza and Shelton 1998).

Regarding the category 'plant life,' females seem to have a number of cognitive advantages over males, possibly reflecting an evolved/ancient division of labor (i.e., females as gatherers, males as hunters). For example, Neave and colleagues (2005) found that females are quicker than males in recognizing plant targets and in remembering the location of those targets (for similar results, see Schussler and Olzak 2008). Research also indicates a female, as opposed to a male, advantage for location memory for fruits (New et al. 2007; Krasnow et al. 2011). Data from semantic knowledge studies point out that females have an advantage to males for knowledge about plant categories (Laiacona et al. 2006).

With regard to animal life it has been shown that neurons in the right amygdala respond preferentially to pictures of animals, which might reflect the evolutionary significance of

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this category of animates (Mormann et al. 2011). Pratt and colleagues (2010) found that animate motion captures visual attention more readily than inanimate motion. New, Cosmides and Tooby (2007) report that respondents are faster and more accurate in detecting changes to scenes containing animals than to scenes with inanimate objects such as vehicles. Eye movement studies show that respondents are more likely to attend to animals than to objects, and animals are also attended longer in time than objects (Yang et al. 2012). Of further importance is that lesion studies show that males are more likely to become impaired for knowledge about plant life than about animals. Scotti et al. (2010) argue that factors other than familiarity need to be taken into account to explain this animal advantage. Specifically, they speculate that this pattern reflects males' role as hunters in ancestral times.

Our SE perspective on aesthetics predicts that these pre-existing and strong adaptive biases for living things can become exploited in architectural constructions. The fact that across all human cultures there is a perennial tendency to adorn architecture with ornamental elements that refer to the animal kingdom and/or that bear close resemblance with botanical elements (e.g., flowers, fruit) seems to support this prediction. And indeed, studies such as Windhager et al.'s (2011), in which it was found that in a real-life setting (window displays in a mall) the presence of animal life is found to lead to increased attention and exploration, suggest that these universally human adornments of architecture effectively evolved by exploiting human biases for living things.

We have discussed the attention-grabbing potential of architecture in which life-like elements are integrated. Living things, however, may grab attention for two quite distinct reasons: finding food, and avoiding becoming food. As a consequence, this process is mediated by either positive or negative emotional responses, respectively. This is somewhat neglected by evolutionary psychologists, who tend to focus on preferences in the context of art. For example, Pinker (1997) argues that art evolved by pushing human "pleasure-buttons." We believe, however, that both negative and positive emotions have played a role in the evolution and propagation of art. Pleasure may be an important proximate mechanism mediating the SE process, leading to "aesthetically pleasing" architectural features. However, we do not think it is the only proximate mechanism mediating the evolution of art. Aversive emotions, such as fear and disgust, are much stronger than positive emotions, such as joy, which makes sense given their adaptive significance in life-threatening situations. Stronger biases are easier triggered, and therefore we can assume that – all else being equal – they have a higher chance of being exploited by artificial elicitors. This may lead to a lasting incorporation of these artificial elicitors in the culturally and ecologically maintained environment of which architecture is part. Consider some fear-evoking features of buildings, such as pointy spires, which may mimic teeth, or monumental heights, inducing anxiety or submissiveness in observers, etc. These features may be experienced as aesthetically grasping because they attract otherwise adaptive attention, and they may lead to an intense emotional experience because the body is preparing itself for 'fight or flight.' In the past, institutions have indeed employed frightening features/elements for signaling dominance and for inducing obedience and/or compliance in community members (e.g., in Gothic cathedrals).

In the following sections, we discuss a potential ultimate function of SE by through monumental architecture. Specifically, we claim that by exploiting awe – which is an intriguing mixture of positive and negative emotions, and a common response to monumentality – monumental architecture ultimately served social organization within and across communi-

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ties. However, it may also be that frightening architectural features get propagated for no purpose at all. They may persist and get culturally copied just because they grasp attention. For example, highly disgusting stories are found to more readily spread in a population of social learners than less disgusting stories (Heath, Bell and Sternberg 2001). Through a similar process of negative emotional selection, architectural features may get propagated across time and space. While architecture can thus exhibit aesthetic features through 'purposeless' SE, this begs the question as to why not all human-built constructions exhibit aesthetic features exploiting such biases. In modern societies, buildings are often merely utilitarian and are entirely devoid of all possible aesthetic features (consider the large suburban apartment blocks built for the ever-growing population of urban dwellers). Probably, this is due to the fact that SE can be overridden by the function of providing protection against biotic and abiotic hostile forces.

Monumental architecture and SE

As complementary to CS

Neiman's (1998) CS perspective says that particular aesthetic attributes about architecture fulfill(ed) an adaptive function for their elite builders and the commoners that perceived them. However, as pointed out elsewhere (Joye and Verpooten 2012), if it is assumed that CS indeed plays a role, it can only partially explain the (evolved) function of monumental architecture. Specifically, it remains silent about the question why the waste of (building) energy has systematically become concentrated into a particular monumental building form. It seems that many monumental structures derive their monumentality in large part from the fact that they are very high, and/or contain visual cues which further accentuate that height (e.g., vertical features). But if wasting energy is the primary thing that matters, why did the elites invest their available energy in building one high building form rather than in – say – a range of smaller buildings? This question is far from trivial, and it points out that the formal appearance of monumental architecture also contributes to its proposed social function.

In both human and non-human animals, the perception or presence of cues indicative of large size – such as height or verticality – is associated with power/dominance. This so-called *bias for bigness* speaks from different behaviors. For example, during dominance displays in non-human primates, the dominant animal (or the one trying to dominate) creates impressions of dominance through grandstanding or other bodily changes (e.g., pilo-erection) (De Waal 1982). In humans, making oneself taller, adopting wide and "open" body positions (Huang et al. 2011), or standing on an elevation (Schwartz et al. 1982) increase perceptions of dominance and power and even cause submissive behavior in observers (Tiedens and Fragale 2003). Important to our account is that similar effects are obtained with simple verticality or size cues. Judgments about power/dominance are often framed as differences in vertical space, where a high ('up') versus low ('down') vertical position are associated with the powerful versus powerless, respectively (see e.g., Schubert 2005; Giessner and Schubert 2007; Moeller et al. 2008).

We contend that monumental architecture exploits the bias to associate height, size and verticality cues with power/dominance, and, in so doing, contributes to vertical social strati-

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fication. Analogous to a (human or non-human) individual performing a dominance display, monumental architecture forces the observer into submission, or at least attempts to instill feelings of inferior social ranking. According to this view, the actual appearance/gestalt of the edifice, and not solely the recognition of the energy invested in the building process, furthered monumental architecture's social role. Note furthermore that inasmuch as monumental architecture is a signal of prestige, such edifices might have also motivated people to attach to the dominant group/authority that is embodied in these buildings (Henrich and Gil-White 2001).

Because of their massive scale, instances of monumental architecture probably very intensely stimulate the proposed bias for bigness. When this happens, the emotion of awe might become triggered because awe is a common emotional response to stimuli that are characterized by overwhelming vastness (Keltner and Haidt 2003). Paralleling the effects of perceiving the bias for bigness, experiencing awe makes individuals more prone to feel submissive toward the individual/institution causing this emotion, and it can spark sentiments of smallness/nothingness. Note, however, that if monumental architecture indeed causes awe, then this might reveal an additional social function of such architecture (apart from vertical stratification). Empirical research shows that awe leads to feelings of oneness with others (Van Cappellen and Saroglou 2012), makes people identify with a larger group (Shiota et al. 2007), and makes them feel more connected and committed to others (Saroglou et al. 2008). One of the possible mechanisms is that through its grandeur, monumental architecture shakes individuals' mental structures and causes feelings of (cognitive) insignificance in them, with the result that people are inclined to 'flock together' as a way to compensate for those feelings. An SE perspective on monumental architecture can thus reveal additional social functions of this building strand.

An alternative to CS

The CS account of monumental architecture is not without problems. On the ground of empirical data and theoretical considerations, it may be useful to consider alternative explanations, based on SE, for example, as well.

As discussed at length in the section on CS (see the section on costly signaling), CS can only operate if a number of conditions are fulfilled. One condition is that the wastefulness of the signal needs to be a reliable indicator of a hidden quality of the sender. In the case of monumental architecture, this means that there must be a correlation between the leader's quality and the monumentality of the construction. A problem to the CS account of monumental architecture is that this correlation emerges from receivers comparatively evaluating signalers before making a choice. That is, commoners must be able to compare monuments of different potential leaders before choosing whom to follow – much like female bowerbirds visit and inspect several bowers of males before deciding with which one to mate (Madden 2003). This is the only possible way for the evolutionary establishment of the link between the signal and the hidden quality. Of course, this does not seem to be a very plausible scenario for commoners. Once born in a society, a commoner would most likely have stayed in that society, without ever being exposed to the monuments of the leaders of other communities.

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If this argument is correct, CS is precluded as the mechanism underlying the function of monumental architecture because it requires from commoners a free comparative evaluation of the leaders' monumental accomplishments. While it seems plausible that style differences in monumental architecture have no differential effect on survival from group to group (cf. Rogers and Ehrlich 2008; cf. the arbitrary coevolution model outlined in the section on arbitrary coevolution), it is unlikely that the monumentality of the religious buildings itself stems from an arbitrary coevolutionary process. Instead, there must have been a selection pressure that stably pushed religious architecture in this direction across different cultures and epochs.

If it is not CS and arbitrary coevolution that drives monumentality, does it make sense to turn to SE as the only viable explanation? At the very least, we may speculate that SE does more than merely complement CS with respect to religious monumental architecture, and that it may even be possible to formulate it as a true alternative explanation to CS. As we have seen in the section elucidating the mechanism of SE, the prerequisite for SE to occur is that the receivers' choice is precluded because they are tricked. Might monumental architecture as well function as a perceptual trap that tricks human receivers? At least two possibilities are conceivable.

First, we could stick to Trigger's (1990) and Neiman's (1998) view that leaders indeed use their power over commoners and resources to construct monumental buildings. But instead of reliably signaling their hidden – in Neiman's (1998) account, genetic – quality by a costly signal, they trick commoners by overpowering them with the awe-invoking appearance of their monuments.

A second alternative hypothesis that might be worth exploring is the idea that monumental architecture evolved as a consequence of some form of self-exploitation. Self-exploitation is a specific case of SE in which senders are – by accident – receivers as well (Verpooten and Nelissen 2010). For example, male fiddler crabs are attracted to their own courtship constructions (Ribeiro et al. 2006). Similarly, it may be that commoners act both as senders and receivers of the signaling system; they may have been actively participating in building public monuments merely as a result of the awe-experience such monuments induced. Under this scenario, the monuments get propagated by a form of emotional selection (cf. Heath et al. 2001). We have only briefly hinted at two possible alternative hypotheses for monuments based on the mechanism of SE. However, we think that given the explanatory power of SE in signaling evolution, it deserves further exploration with respect to this specific communication system as well.

Conclusions

In this chapter, we have deployed a biological and evolutionary perspective to human architectural accomplishments. We have distinguished and investigated two main purposes of architecture: a protective function and a signaling function. Based on a phylogenetic approach, we have speculated that the protective function of architecture has been the main selection pressure on the evolution of human building aptitudes, which in turn may have promoted the evolution of human intelligence and ecological dominance. Contrary to other primate genera, these building aptitudes were, at a later stage in the evolution of Homo

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co-opted for artificial signaling, which can also be found in other species, especially in fish and birds. We have comparatively evaluated three models of signal evolution with respect to architectural aesthetics employing a special focus on monumental architecture. Although at this stage our approach may not allow drawing any definitive conclusions, we hope that the pluralistic biological and evolutionary perspective we explored will prove fruitful for further investigations of the biological and evolutionary relevance of human architecture.

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CULTURAL REPLICATION AND MICROBIAL EVOLUTION[1]

Bence Nánay

Introduction

We have a very elegant and efficient theory for explaining certain biological changes from population to population: the theory of natural selection. The theory of natural selection has a remarkable explanatory power: it can explain something very complex, such as the structure of the human eye or the fit between the organism and the environment in terms of something very simple, the dumb causal processes of births and deaths. A tempting idea is that the same explanatory scheme could be used to explain some complex non-biological, more precisely, cultural phenomena (Richerson and Boyd 2005; Sterelny 2006a; Lumsden and Wilson 1981; Hull 1988, 2001; Fracchia and Lewontin 1999; Dawkins 1976, 1982a, 1983; Cavalli-Sforza and Feldman 1981; Aunger 2000; Dennett 1995; Campbell 1956, 1960, 1974; Toulmin 1967, 1970, 1972; Kantorovich 1989; Bradie 1986; Popper 1963, 1972, 1974, 1978; Nanay 2011b – the list is obviously far from being complete). This is exactly what theories of cultural evolution attempt to do.

There are numerous important differences between biological and cultural evolution. The question is whether the explanatory scheme of the theory of natural selection could be applied in the cultural domain *in spite of* these dissimilarities.

In this paper, I want to focus on three salient differences between biological and cultural evolution:

1) Cultural evolution is very fast, much faster than biological evolution.
2) In the case of biological evolution, information transmission is vertical: we inherit our genes from two individuals only (our parents). This is not true for cultural evolution, where information is also transmitted laterally, from peers to peers.
3) The fidelity of information transmission in the case of biological evolution is much higher than in the cultural case.

There are many more widely discussed differences: it has been claimed that cultural evolution is Lamarckian, whereas biological evolution is Weismannian, etc. (Hull 1980, 1981). But I will focus on (1), (2), and (3) here.

The aim of this paper is to argue that when it comes to (1), (2), and (3), cultural evolution is much more similar to microbial than to macrobial biological evolution. As a result, we are

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better off using microbial evolution as the model of cultural evolution. And this shift from macrobial to microbial entails adjusting the theoretical models we can use for describing cultural evolution.

Macrobial versus microbial evolution as a model for cultural evolution

Here is an odd fact about the literature on cultural evolution. It invariably takes macrobial evolution to be the model of cultural evolution. When it compares the biological and the cultural domain, it really compares the domain of macrobial biology and culture.

But macrobes are not the only biological entities – in fact, they are not even the most widespread ones. Evolutionary biologists and philosophers of biology have been actively ignoring microbes, and this, arguably, has been a mistake. We may be able to understand important facts about biological evolution if we understand the microbial world (see, for example, O'Malley and Dupré's 2007 manifesto). And my proposal in this paper is that we may be able to understand something important about cultural evolution if we take microbial evolution, and not macrobial evolution, as its model.

Microbial evolution is in many respects very different from macrobial evolution. Here are three important (and conspicuously numbered) differences:

1) Microbial evolution is very fast, much faster than macrobial evolution (see e.g., Lawrence 2002).
2) In the case of macrobial evolution, information transmission is vertical: we inherit our genes from one or two individuals (the parent[s]). This is not true for microbial evolution, where information is also transmitted laterally – this is called *lateral gene transfer,* where the transfer of genetic material from one organism to another happens by conjugation, transduction, or transformation (Bushman 2002; Thomas and Nielsen 2005; see O'Malley and Dupré 2007: 167–168 especially for a philosophical analysis of this phenomenon).
3) The fidelity of information transmission in the case of macrobial evolution is much higher than in the microbial case (see e.g., Lawrence 2002; O'Malley and Dupré 2007).

In other words, the three differences I considered in the last section between biological and cultural evolution were in fact differences between macrobial and cultural evolution. And we find exactly the same differences between macrobial and microbial evolution. The conclusion is that we would be much better off using microbial evolution for modeling cultural evolution.

The aim of this paper is to cash out what this shift of emphasis from macrobial to microbial evolution in the analysis of cultural evolution would entail in terms of the theoretical framework we can use to model cultural evolution.

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Two ways of thinking about natural selection

There are two distinct ways of conceiving of selection processes. According to one, selection is the heritable variation of fitness. According to the other, it consists of repeated cycles of replication and interaction. These two models of selection[2] give us very different ways of formulating evolutionary explanations, and they even yield different kinds of evolutionary explanations.

According to the first model (Lewontin 1970; Maynard Smith 1987), selection should be described as the heritable variation of fitness. A typical formulation is the following (see also Lewontin 1970: 1; Endler 1986: 4; Ridley 1996: 71–72; Godfrey-Smith 2007: 515).

„A sufficient mechanism for evolution by natural selection is contained in three propositions:

1) There is variation in morphological, physiological, or behavioral traits among members of a species (the principle of variation).
2) The variation is in part heritable, so individuals resemble their relations more than they resemble unrelated individuals, and, in particular, offspring resemble their parents (the principle of heredity).
3) Different variants leave different numbers of offspring either in immediate or remote generations (the principle of differential fitness)." (Lewontin 1980: 76).[3]

According to the alternative concept, selection consists in repeated cycles of two separate processes. As Ernst Mayr says, "natural selection is actually a two-step process, the first one consisting of the production of genetically different individuals (variation), while the survival and reproductive success of these individuals is determined in the second step, the actual selection process" (Mayr 1991: 68; see also Mayr 1982: 519–520; 2001: 117; 1978). David Hull calls these two steps replication and interaction (Hull 1981; 1988; Hull et al. 2001). Hull defines selection as "[t]he repeated cycles of replication and environmental interaction so structured that environmental interaction causes replication to be differential" (Hull et al. 2001: 53).

In turn, Hull (1988: 408) defines the unit of replication, the *replicator,* as "an entity that passes on its structure largely intact in successive replications" (see Hull 1980: 318 for a slightly different definition). The unit of interaction, the *interactor,* on the other hand, is defined as the "entity that interacts as a cohesive whole with its environment in such a way that this interaction causes replication to be differential" (Hull 1988: 408; see Hull 1980: 318).

This replication–interaction model of selection was introduced as an improvement on the heritable variation of fitness model, and it is supposed to clarify a number of details left implicit therein. More precisely, the replication–interaction model has been thought to help us to understand what is at stake in the units of selection debate: if selection is replication plus

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[2] I will refer to these two ways of conceiving of selection as two *models* of selection, acknowledging that my use of the concept of models is different from the way this term is used in biology.

[3] According to Lewontin (1980: 76), each of these three propositions is necessary for evolution by natural selection (besides being jointly sufficient).

interaction, then we should not talk about the units of selection, but rather about the units of replication and the units of interaction, which may not be (and in fact most often are not) the same. The thought is that the replication–interaction distinction in itself will not solve this problem, but it is supposed to help us to formulate it in such a way that would make it possible to tackle it (see e.g., Lewontin 1970: 7; Brandon 1982, 1988, 2006; and especially Lloyd 2001).

In the last decade or so, more and more evolutionary biologists and philosophers of biology have been arguing against the replication–interaction model. Their main claim is that replication is not necessary for evolution by natural selection, or, as I will put briefly, for selection.[4] As a result, the *heritable variation of fitness* model has become more and more widely used.

In the cultural evolution literature, both of these models are present. The most famous, but not the only, example of the replication–interaction model in the domain of cultural evolution is meme theory. These two models are also often applied to the cultural domain without a clear attempt to distinguish the two – as in Richerson and Boyd (2005: Chapter 3), where the first half of the chapter uses the heritable variation of fitness model, whereas the second half uses a version of the replication–interaction model, without any explicit acknowledgement of the difference between the two.

My aim is to point out that regardless of whether the heritable variation of fitness model or the replication–interaction model is better suited for describing macrobial evolution, the heritable variation of fitness model faces serious problems when applied to microbial evolution. And it faces the same problems when applied to cultural evolution. In other words, we are better off using the replication–interaction model for describing microbial and cultural evolution.

The heritable variation of fitness and microbial evolution
The heritable variation of fitness model may look straightforward, but in fact it is not. What this account of selection entails very much depends on the way in which we interpret the concept of fitness. And there is no agreement on a number of important features of this concept.

Is fitness a causal or a statistical concept (Matthen and Ariew 2002)? Is it a population-level or an individual-level concept (Millstein 2006)? What entity do we attribute fitness to, individuals or to trait types (Sober 1981; see also Nanay 2010b, 2011c)? If the former, is an individual's fitness the same throughout its life (Ramsey 2006)? If the latter, how should we individuate these trait types (Nanay 2010a)?

The two most influential questions about fitness and about selection are whether they should be taken to be population-level or individual-level phenomena, and whether they are

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[4] There is an important terminological difference in the way the concept of selection is being used in the literature. Some ask whether replication is necessary for *evolution by natural selection* (Okasha 2007; Godfrey-Smith 2007), others ask whether replication is necessary for *selection* itself (Hull 1988; Neander 1995; Hull 2001; Nanay 2005). I assume that these are two different ways of asking the same question (the question of whether replication is necessary for *evolution by natural selection*) and I will use the latter formulation because it is simpler. If the reader prefers the former one, he/she should read 'evolution by natural selection' instead of ' natural selection' in what follows.

causal or statistical concepts (Matthen and Ariew 2002; Walsh et al. 2002; Millstein 2006; Brandon 2006; Bouchard and Rosenberg 2004; Rosenberg and Bouchard 2005; Stephens 2004). It has been pointed out that the concept of fitness is used in two different ways: as an "ecological descriptor" and as a "mathematical predictor" (Sober 2001: 319; this distinction may be traced back to Kitcher 1984: 50). Building on Sober's distinction, Mohan Matthen and André Ariew (2002) made a distinction between "vernacular" and "predictive" fitness.[5]

Vernacular fitness is a measure of the "overall competitive advantage traceable to heritable traits" (Matthen and Ariew 2002: 56). Predictive fitness, in contrast, is the "expected rate of increase (normalized relative to others) of a gene, a trait, or an organism's representation in future generations" (Matthen and Ariew 2002: 56). Vernacular fitness plays a role in the informal presentations of natural selection, whereas predictive fitness is used in mathematical formulations of population genetics. Vernacular fitness is a comparative measure, whereas predictive fitness is a quantitative one. Vernacular fitness is usually taken to be a cause of selection, whereas predictive fitness is taken to be a measure of selection, not its cause.

Matthen and Ariew (2002) argue that we should only use the concept of predictive fitness. Others defend the concept of vernacular fitness and insist that it is an individual-level concept (Bouchard and Rosenberg 2004; Rosenberg and Bouchard 2005). Yet another group of philosophers concede that it is a population-level concept, but maintain that it is a causal one (Stephens 2004; Millstein 2006). There are some further questions about fitness. Is it fixed throughout the organism's lifetime (Ramsey 2006)? In what way does it depend on the environment and how can we characterize the environment it depends on (Abrams 2007)?

Before we get entangled in the Byzantine debates surrounding the concept of fitness, we should take a step back and ask: why should we conceive of selection as the heritable variation of fitness at all? There are important cases of natural selection where it is not clear how the heritable variation of fitness account could even be formulated.[6]

An important aspect of the heritable variation of fitness account is that it talks about parents and offspring. Both what Lewontin calls "the principle of variation" and what he calls "the principle of differential fitness" (Lewontin 1980: 76) are principles about the parent–offspring relation. But there are cases of natural selection where it is unclear what should be considered as the parent and what should be considered as the offspring. Here are two such cases: selection among clonal organisms and in the microbial world. For the purposes of this paper, I will focus on microbial evolution (but see Nanay 2011a on clonal selection). It is important to note that these are not marginal cases of natural selection (on how widespread and important clonal reproduction is, see Godfrey-Smith 2009: 71–72; Bouchard 2008; on the importance and relevance of the microbial world, see O'Malley and Dupré's 2007 manifesto).

As we have seen, a striking feature of most microbial population is lateral gene transfer, the transfer of genetic material from one organism to another by conjugation, transduction,

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[5] Ariew and Lewontin (2004) refer to these two concepts of fitness as "Darwinian" and "reproductive" fitness.

[6] I leave aside some further potential problems with the heritable variation of the fitness account, for example, that it presupposes that the parent and offspring generations do not overlap (see Ariew and Lewontin 2004). I assume that the heritable variation of the fitness account could be modified in such a way that it could deal with this potential problem.

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or transformation (Bushman 2002; Thomas and Nielsen 2005; see O'Malley and Dupré 2007: 167–168, especially for a philosophical analysis of this phenomenon). Lateral gene transfer makes natural selection (and evolutionary change in general) in the microbial world more rapid and more frequent than it is among macrobes (see e.g., Lawrence 2002).

But how can we talk about the heritable variation of fitness in the case of lateral gene transfer? Lateral gene transfer is not from parent to offspring. It is from offspring to offspring. This, again, makes it difficult to even formulate the principle of variation and the principle of differential fitness of the heritable variation of fitness account (see O'Malley and Dupré 2007 for a summary of how lateral gene transfer in the microbial world challenges our existing evolutionary accounts).

Could we not defend the heritable variation of fitness account by arguing that lateral gene transfer should be considered a simple mutation from the point of view of the organism that is on the receiving end of the transfer? This move is indeed open to the proponents of the heritable variation of fitness account, but it is difficult to see how it will help. Lateral gene transfer can have varying degrees of fidelity. Thus, it can, in principle, give rise to *bona fide* evolution by natural selection that may even lead to adaptation. But lateral gene transfer is (by definition) not an intergenerational change. And this makes it impossible to talk about the change of fitness values, as fitness is defined with reference to (some features of) the parent generation and (some features of) the offspring generation. When lateral gene transfer gives rise to evolution by natural selection, this cannot be described with the help of the heritable variation of fitness account.

It seems then that, while the heritable variation of fitness account may or may not be the right model for macrobial evolution, it is unlikely to be the right way to describe microbial evolution. But, because of the structural similarities between microbial and cultural evolution, it is also unlikely to be the right way to describe cultural evolution. The argument I gave in the last couple of paragraphs can be easily rephrased with regards to horizontal information transfer in the case of the cultural domain. If we want to understand cultural evolution (and microbial evolution), we are well advised not to use the heritable variation of fitness account. We should turn to the replication–interaction model.

The replication–interaction model and microbial evolution

The replication–interaction account of selection is a genuine alternative to the heritable variation of fitness account, but it has different versions and the most widespread of these is widely assumed to be highly problematic. We can distinguish two versions of this account, the *replicator–interactor account* and the *property-replication account.* The former has been repeatedly criticized. I argue that we should use the latter when modeling microbial and cultural evolution.

The replicator–interactor account

According to the first version of the replication–interaction account, replication is the copying of an entity, the *replicator.* Hull defines the replicator as "an entity that passes on

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its structure largely intact in successive replications" (Hull 1988: 408; see also Godfrey-Smith 2000; Brandon 1990; see Nanay 2002 on the concept of replicator). The unit of interaction, the *interactor,* on the other hand, is defined as the "entity that interacts as a cohesive whole with its environment in such a way that this interaction causes replication to be differential" (Hull 1988: 408). I will call this version of the replication/intersaction account the *replicator–interactor account* as it identifies replication with the copying of an entity, the replicator.

In the last decade or so, many philosophers and biologists have argued against this replicator–interactor account of selection (Okasha 2007: 15–16; Godfrey-Smith 2007: 515; 2009; Avital and Jablonka 2000: 359; Jablonka and Lamb 1995; Richerson and Boyd 2005: Chapter 3; Griesemer 2000: 74–76; 2002: 105). Their main claim is that the copying of replicators is not necessary for selection; hence, selection cannot consist of repeated cycles of replication (conceived of as the copying of replicators) and interaction.

There are ways of transmitting information (for example, extragenetic inheritance) that do not count as replication but that are (given other conditions) sufficient for selection (Okasha 2007: 15; Avital and Jablonka 2000: 359; Jablonka and Lamb 1995: 3). Samir Okasha summarizes this line of objection: "evolutionary changes mediated by cultural and behavioural inheritance cannot be described as the differential transmission of replicators" (Okasha 2007: 15). To put this objection in more general terms, selection can happen if there is sufficient phenotypic parent–offspring resemblance. Replication is not needed (Okasha 2007: 15). One example is maternal effects, i.e., cases in which large mothers have large offspring as a result of laying eggs with larger food reserves (Uller 2008).

The property-replication account

It is important that these problems are problems for the replicator–interactor account and not for the replication–interaction account in general. Remember that the original alternative to the heritable variation of fitness account was the view that selection consists of repeated cycles of replication and interaction. It is an additional requirement that replication should be thought of as the copying of an entity, namely, the replicator.

We may be able to salvage the general gist of the replication–interaction account if we deny that replication is the copying of an entity. We could conceive of replication as the copying of property-instances (Nanay 2011a; see also Nanay 2002: 113). The hope is that this version is not vulnerable to the objections raised against the replicator–interactor account. I will use the term *property-replication account* for this version of the original replication–interaction account to contrast it with the replicator–interactor account.

It is important to clarify the difference between these two versions, i.e., what is meant by entities and properties here. The cup in front of me is an entity. It has lots of properties, some interesting, some others less so. Its color is one property, its shape is another one, etc. Thus, the copying of an entity and the copying of one of the properties of this entity are very different processes. Properties are always properties of entities, of course. But it is possible to copy a property of an entity without thereby copying the entity itself. The claim is that replication is the copying of properties: we can have a replication process without there being

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a replicator that is being copied.[7] The definition of replication would then be the following (Nanay 2011a: Section 4): property P of object (a) is a replica of property Q of object (b) if and only if: (1) P is similar to Q and (2) Q is causally involved in the production of P in a way responsible for the similarity of P to Q.

An important feature of this definition is that (a) and (b) are not necessarily objects of the same kind. Object (b) may be an apple, and object (a) a color photograph of this apple. The color of the photograph can be a replica of the color of the apple under my definition, but this does not mean that the objects themselves are replicas or copies or replicators in the old sense of the word.

This notion of replication is very weak: many non-biological copying processes, like photocopying, will also qualify as replication. Is this a problem? No. The same is true of the traditional concept of replication as the copying of replicators (Godfrey-Smith 2000; Nanay 2002). Importantly, any account that conceives of selection as the repeated cycles of replication and interaction needs to acknowledge that not every replication process will be particularly interesting from an evolutionary point of view. But this is what we should expect: the notion of replication is only the starting point for an account of selection. Further additional criteria need to be met in order for replication to lead to selection: replication needs to give rise to an interaction process that makes the next round of replication differential.

How can this property-replication account handle the objections to the replicator–interactor account? First, according to the property-replication account, both extragenetic inheritance and cultural transmission can count as replication. Nothing in the definition of replication suggests that the replicated property needs to be a property of the DNA. Thus, extragenetic properties can replicate as much as the properties of the DNA can. If property P of the offspring is similar to property Q of the parent, and the latter is causally responsible for this similarity, then we do have replication, regardless of whether these properties can be called genotypic or not.

Crucially, the transfer of cultural information also counts as replication if we understand replication in the way that property-replication suggests: cultural properties are being replicated. Remember that the definition of replication was the following: property P of object (a) is a replica of property Q of object (b) if and only if: (1) P is similar to Q and (2) Q is causally involved in the production of P in a way responsible for the similarity of P to Q. As P and Q can be any property in this definition, cultural information transfer would qualify as replication, as long as both (1) and (2) are satisfied.

More generally, if we accept the property-replication account, then phenotypic traits can replicate. Take the maternal effects example I mentioned in the last subsection. According to the property-replication account, there is a property that replicates in this case: the property of being large. The offspring's instantiation of this property is similar to her mother's (in as much as the degree of similarity between the size of the two individuals is higher than it

[7] Biologists call the properties of organisms 'traits.' If someone prefers this concept to the concept of properties, he/she can rephrase my definition of replication as 'the copying of traits.' But as the replicated properties are not necessarily properties of an organism, I will talk about properties, rather than traits, in what follows in order to preserve generality.

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is between the size of two randomly chosen individuals in the population), and her size is causally responsible for this similarity. Thus, we do have selection in this population, but we also have replication. We do not have replicators though.

Property-replication and lateral gene transfer

So far, everything looks promising: the property-replication account is not susceptible to the objections that were raised against the replicator–interactor account. But the real question is whether the property-replication account is a genuine alternative to the heritable variation of fitness account. More precisely, can it handle the cases of selection in the microbial world that were problematic for the heritable variation of fitness account?

If we accept the property-replication account, then microbial evolution will pose no problem as lateral gene transfer will count as a replication process. Lateral gene transfer is the copying of an entity (and its many property-instances) from one organism to the other. And this counts as replication under any account of replication: both the replication–interaction conception and the property-replication conception. Some replication processes will happen from parent to offspring, some others from offspring to offspring.

If either kind of replication processes gives rise to environmental interaction that makes the next round of replication (again, either parent to offspring, or offspring to offspring replication) differential, we have a selection process, conceived as the repeated cycles of replication and interaction. We can talk about selection in microbial populations without running into the problems that the concept of fitness poses in this context.

And the same goes for horizontal information transfer in the case of cultural evolution: it counts as replication in the sense that the property-replication view uses the term. Some replication processes will happen from parent to offspring, some others from offspring to offspring. If either kind of replication processes gives rise to environmental interaction that makes the next round of replication (again, either parent to offspring, or offspring to offspring replication) differential, we have a selection process, conceived as the repeated cycles of replication and interaction.

We then get the following picture: there are three ways of modeling natural selection, the heritable variation of fitness account, and two versions of the replication–interaction account, the replicator–interactor account and the property-replication account. We have seen that the heritable variation of fitness account is unlikely to be able to be the right way to think about cultural and microbial evolution because it cannot handle lateral gene transfer and horizontal information transfer. The replicator–interactor account has been facing various objections. The best bet for those who want to understand cultural and microbial evolution is then the property-replication account.

Property-replication and cultural evolution: Cultural replication without memes

As the most famous account of applying the replication–interaction model to cultural evolution is meme theory, one may worry that the shift from the heritable variation of fitness

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model to the replication–interaction model I am encouraging in the context of cultural evolution would amount to a return to meme theory.

Much of the recent discussion of cultural evolution has been revolving around the concept of meme. The distinction between replicator and interactor was originally famously introduced "as a generalization of the traditional genotype–phenotype distinction" (Brandon 1990: 125). This means that there can be, and supposedly there are, entities other than the gene that would count as replicators. The main candidates for such replicators have been memes.

Memes are defined as the "units of the cultural transmission" (Dawkins 1976/1989: 192; see also Dawkins 1982a, 1982b). According to meme theory, cultural phenomena can be explained, at least partially, with the help of the following evolutionary model: memes are pieces of information, and they compete for survival in a way quite similar to genes; the difference is that they compete for the capacity of our minds. A meme can be a tune, the idea of liberalism, or the habit of brushing one's teeth. Those tunes will survive that can get into and stay in many minds. The ones that fail to do so will die out. Meme theory is clearly a way of applying the replicator–interactor model to the cultural domain.

Meme theory is still extremely popular (see Blackmore 1999; Dennett 2003, 2006; Aunger 2002; Distin 2005), but it has been severely criticized for various reasons, partly for worries about the ontological status of memes (Sperber 1996; Wimsatt 1999; Fracchia and Lewontin 1999; Richerson and Boyd 2005; Sterelny 2006a, 2006b). What are these cultural replicators supposed to be?

There have been various attempts to answer this question (Dennett 2006: 80–81, 349–350; 2003; Aunger 2002: 311–322; Distin 2005). An influential strategy is to say that both genes and memes are really just pieces of information, and there is nothing ontologically worrying about the concept of information (this is Dennett's and Distin's response; but see Aunger's more restrictive version). Note that this view violates the concept of replicator the original replication/interaction model was presupposing.[8]

It is important to note that meme theory applies the replicator–interactor model to cultural evolution. My proposal, in contrast, has been that we should apply the property-replication model instead. If we do so, we can bypass the ontological worries meme theory faces. This move would replace the notion of cultural replicators, that is, memes, with replicated cultural properties.

It has been argued that whether or not we buy into meme theory, there are processes in the cultural domain that can be described as replication (Richerson and Boyd 2005; Sterelny 2006a, 2006b).[9] If we accept my definition of replication, then we can explain these processes without postulating ontologically suspicious entities, like memes.[10]

[8] They are not reproducers either: a meme and its copy do not have any material overlap.

[9] Of course, there are ways of giving an evolutionary account of cultural change without talking about cultural replication (see Cavalli-Sforza and Feldman 1981; Lumsden and Wilson 1981). My point is that if we want to talk about *cultural replication,* we can do so without positing memes.

[10] Note that this application of the account I proposed here would have interesting consequences with regard to an important debate about cultural evolution that has emerged within the context of meme theory. A crucial question about cultural replication is whether it needs to be specific to one kind of physical substrate. In the context of meme theory, this question is about whether meme replication needs to be specific to one kind of physical substrate. Robert Aunger (2002: 154 and 157) argues that it is. Kate Distin (2005: Chapter 11; see also Dennett

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It is important to note that if we acknowledge that there are processes that could count as cultural replication, we do not need to be thereby committed to allow for cultural selection (as replication is not sufficient for selection), let alone cumulative cultural selection that could explain why certain cultural features are the way they are. If we accept my definition of replication, this will not salvage meme theory, or even the very idea of memes. But it would make it possible to talk about cultural replication, without specifying what the replicated entities would be, or without positing the existence of memes.

Conclusion

The aim of this paper has been to argue that we should use microbial, rather than macrobial evolution as the model for understanding cultural evolution. And the emphasis on the similarities between microbial and cultural evolution as well as on the differences between microbial and cultural evolution should persuade us to abandon both the heritable variation of fitness model and the replicator–interactor model when it comes to understanding cultural evolution, and use the property-replication view instead.

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2003, 2006), in contrast, argues that memes can replicate in different substrates. If we accept my definition of replication, then replication does not have to be specific to one kind of physical substrate: it is properties that get copied, regardless of the substrate. And the same is true of cultural replication. Hence, my account is siding with Distin and Dennett (and not with Aunger) in this question. It is also important to note that the question of substrate-specificity is an important one as long as we allow for cultural replication, regardless of whether we talk about memes.

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SOCIAL LEARNING, BEHAVIORAL TRADITIONS, AND THE EVOLUTION OF SOCIALITY IN NON-HUMAN ANIMALS: THE CASE OF TUFTED CAPUCHIN MONKEYS

Eduardo B. Ottoni and Tiago Falótico

Social learning, behavioral traditions, and cultural processes in non-human animals

The recognition of social learning as an important adaptation even among non-human animals was already explicit in the works of Darwin and Wallace (and, of course, Romanes), and became hard empirical science more than half a century ago, with the research on birdsong learning (Marler 1970). The notion of 'animal cultures,' although floating in our 'meme pool' since then, and being the focus of a growing number of conferences and reviews, remains, to say the least, a contentious question, plagued by definition issues.[1]

In one extreme view, many cultural anthropologists adhere to variants of Tylor's definition of culture (1871, apud Hutchins 1995) as "that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society." In this sense, *culture* and *civilization* were synonyms – and being something acquired *by man* was part of the definition.

At the other end of the spectrum, many biologists would equate *culture* to social learning or social information transfer in general.

But even anthropologists studying behavioral traditions in non-human primates under a clearly evolutionary framework may disagree on this 'broader' use of the term *culture.* Susan Perry (2011) documented a complex repertoire of conventional, group-specific social rituals of white-faced capuchin monkeys *(Cebus capucinus),* apparently designed to test the strength of social bonds, but she refrains from labeling them "cultural," considering that "culture" involves more than geographically variable traits, or even social learning – including things like "group identity," symbolically linked to socially learned traits, and "social norms" (though she does not dismiss the possibility of finding evidence of such features in non-human societies; cf. Perry 2009).

The term *traditions,* preferred by Perry and others, besides avoiding the more 'loaded' meanings associated with *culture,* allows for a more 'operational' definition that can be of practical use by animal behavior researchers.[2] As defined by Fragaszy and Perry (2003), "a tradition is a behavioral practice that is relatively enduring… that is shared among two or more members of a group, and that depends in part on socially aided learning for its generation in new practitioners."

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[1] A full discussion of these issues would be beyond the scope of this chapter. For a recent overview on 'culture wars,' see Laland and Galef 2009a, 2009b.

[2] But, as McGrew (2003) notes, "tradition" suggests vertical transmission (as well as "relative endurance"), and cultural transmission includes short-lasting, horizontally transmitted "fads."

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We can also think about *culture* as the overall extra-genetic channel of social information transfer (in a counterpoint to *genetics,* as in the *gene-culture coevolution* or *dual inheritance* approaches; cf. Cavalli-Sforza and Feldman 1981; Boyd and Richerson 1985), and *traditions* as particular behaviors acquired through socially biased learning.

One common understanding is that culture depends on language. Apes in captivity apparently mastered symbolic languages to a certain extent (Gardner et al. 1989; Savage-Rumbaugh et al. 1989), as did African grey parrots (Pepperberg 1994), and functional referentiality was experimentally demonstrated in the alarm calls of wild vervet monkeys *(Chlorocebus pygerythrus;* Cheney and Seyfarth 1990). Hauser et al. (2002), reviewing Chomsky's claims on the unique nature of human language under the light of recent evidence on animal communication, concluded that it is only our capacity for *recursion* (which allows for complex syntax and second- or n-order intentional statements) that sets human language apart from communication in non-humans. We do not know enough, yet, about how complex the communication in other species can be, but, anyway, "communicative language may be a sufficient condition for culture, but not a necessary one" (McGrew 2003) – at least if we are willing to drop the 'symbolic' part of the definition.

Michael Tomasello (1999), a psychologist who studies both children and chimps, believes that social learning in non-humans is a product of simpler cognitive processes, such as stimulus enhancement (i.e., socially biased learning about environmental features), while imitation in humans makes copy fidelity, and, as a consequence, the emergence of cumulative culture, possible.[3] Underlying human complex imitation, for him, is the capacity for "joint attention" – which requires the possession of a Theory of Mind (ToM; cf. Premack 1988).

In this view, culture is usually associated with *teaching.* Many animals alter their behavior to facilitate learning by immatures (Terkel 1996), which is usually called *scaffolding,* and, in some cases, they seem sensitive to feedback – as the adult meerkats who apparently adjust their behavior to the changes in the proficiency of pups, while handling scorpions as prey (Thornton and McAuliffe 2006; in this report, the term *functional teaching* was employed; *teaching* in its stricter sense, though, implies a ToM, to allow for the understanding of other individual's ignorance). Moreover, human teaching may constitute a unique adaptation enabling social learning by communication (especially useful for things like conventions, arbitrary referential symbols, or cognitively opaque skills), a "natural pedagogy" (Csibra and Gergely 2011).

Behavioral traditions and cultural processes in non-human primates

The provisioning of free-ranging Japanese monkeys *(Macaca fuscata)* near beaches triggered a series of unexpected behavioral "innovations:" the most notorious, introduced by a juvenile female, consisted in washing potatoes in a stream to remove the sand (Kawai 1965). This new food washing technique was followed by two other: the washing of provisioned wheat (which floats, while the sand sinks), and the washing of potatoes in salty seawater, "seasoning" them. The enhanced activity by the beach set the conditions for another innovative behavior, the consumption of the smaller fish left over by fishermen. All these

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[3] Although Tomasello et al. (1993) recognize imitative capacities in chimpanzees.

innovations spread in the monkey groups following patterns predictable from their network of social relationships and became established in these populations, apparently, through socially aided learning (Huffman 1996).

Though Japanese primatologists had long before proposed the existence of cultural processes in non-human primates (Imanishi 1952, apud Huffman 1996; Nishida 1987), it took some decades more until the dichotomous Western view on the relationship between Nature and Culture made room for an evolutionary approach to social information transfer in non-human animals.[4]

But even Imanishi did not use the Japanese word for *culture*, instead he used a neologism based on the English word, and those early studies on Japanese monkeys' socially learned behaviors (Kawamura 1959; Kawai 1965) employed the term *sub-culture*, to avoid equating monkeys' social learning with *human culture*. Afterwards, most researchers studying behaviors that seemed to be perpetuated in an animal population by some form of social transmission referred to them as "sub-," "pre-" or "proto-cultural."

A change in this attitude started, fundamentally, as a consequence of the outcome of long-term field studies such as Goodall's (van Lawick-Goodall 1970), which showed us an unexpected level of complexity in the social life (and social cognition) of great apes in general, and chimpanzees *(Pan troglodytes)* in particular (Wrangham et al. 1994). Besides the social "manipulations" in their "political" life (also described in captivity by de Waal 1982, 1989), we are now well-familiarized with a wide range of objects modified and used as tools by wild chimpanzees. And as happens with some other behavioral patterns (see ahead), many of the variations among populations in their tool use repertoires cannot apparently be explained by ecological or genetic differences alone.

In 1978, McGrew and Tutin reported their first observations about the "grooming handclasp," a communicative gesture present in one chimpanzee population but absent in another (variations were later found in other groups), an apparently arbitrary behavior that seemed to satisfy most operational definitions of culture. McGrew (1992) subsequently showed that many behaviors in the wild chimpanzees' repertoire satisfied the "criteria for recognizing cultural acts" proposed by Kroeber (1928, apud McGrew 1992), and initiated a trend of dropping qualifiers such as "sub-" or "proto-," especially when talking about chimpanzees (Laland and Galef 2009b).

The potential role of social information transfer in the diffusion of some complex foraging techniques by wild chimps was brought into evidence by McGrew's "Chimpanzee Material Culture" (1992), where a comparative overview of data from many field studies showed a degree of sophistication and of interpopulation variation so far unexpected in non-humans,

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[4] This "evolutionary view," it must be noted, can assume very distinct forms: if under an extreme sociobiological version (Dawkins 1976) a clear dichotomy between "replicators" (genes or "memes") and their "vehicles" is preserved, in models conceiving the relations between genetic inheritance and behaviorally transmitted information as a "dual inheritance" (or "gene-culture coevolution;" cf. Boyd and Richerson 1985) system or through "niche construction" processes (Odling-Smee 1996; Laland et al. 2000), the distinctions between evolution and ontogeny become much fuzzier, since behavioral traditions, even though being products of a species' evolutionary history, can only be established and transmitted if actively built during individual and group histories (Avital and Jablonka 2000).

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suggesting, beyond ecological determinants or "innate," "species-typical" behavioral patterns, a critical role of socially biased learning in individual ontogenetic development.

These hypotheses gained strength from laboratory evidence showing that the observational learning capabilities of chimps go beyond "stimulus enhancement," to include, for instance, the ability to reproduce different sequential steps in the opening of a problem box, as demonstrated by different models, conspecifics or not (Whiten et al. 1996), the so-called "program-level imitation" (Byrne and Russon 1998), which amounts to learning about the behavior of another individual (and not only about its final product). More recently, experiments with captive chimpanzee groups (Whiten et al. 2007) on the diffusion of alternative techniques for extracting food from problem boxes demonstrated the effects of social biases (observed techniques exhibited by the models) on the individual learning of the task.

The existence of behavioral traditions has, since then, been proposed in many taxa, from apes, cetaceans, and elephants, to birds and fish, and in distinct domains, such as social structure and dynamics (de Waal and Johanowicz 1993; Sapolsky and Share 2004), social knowledge (McComb et al. 2001; Bradshaw et al. 2005), communicative behavior (Whiten et al. 1999; Rendell and Whitehead 2001; van Schaik et al. 2003; Perry et al. 2003), foraging techniques (with and without tool use), dietary preferences (McGrew 1992; van Schaik et al. 1996; Whiten et al. 1999; Panger et al. 2002), and migration routes and schooling sites (Helfman and Schultz 1984). And in most of these studies, the use of the label *culture* became increasingly more commonplace.

Interestingly (and counterintuitively), the current evidence for culture is stronger for "humans plus a handful of species of birds, one or two whales, and two species of fish" (Laland and Hoppitt 2003) than for apes (in part because the critical experimental tests would be more problematic with primates than with fish, for both practical and ethical reasons).

Genetic, ecological, and social determinants of behavioral variability in non-human animals

The permanence of a given behavioral pattern in the repertoire of an animal social group is always the outcome of the interaction of genetic and environmental (social and asocial) factors; it can remain constant for generations as a consequence of (1) predominantly endogenous characters (genetically transmitted), (2) similar histories of interaction with the environment, or (3) by the transmission of these patterns through interactions between individuals. Galef (1976) operationally defined *social transmission* as involving only cases where social interaction is *sufficient* for the acquisition of the behavior (but not *necessary,* as in certain interactions that are fundamental for the normal ontogenetic development of the species), constituting an alternative to the direct interaction between the individual and the environment, and promoting a greater behavioral homogeneity that lasts longer than the receptor–transmitter interaction.

The synthesis of comparative studies on behavioral variability among chimpanzee populations came in Whiten et al.'s (1999) overview on "cultures in chimpanzees," which mapped the occurrence of 65 behavioral patterns throughout the natural distribution range of *Pan troglodytes.* It was not just about 'material culture' anymore since the list of behaviors was not restricted to the use of objects, and was directly inspired by Galef's model: to uphold expla-

nations centered on the role of social information transfer in order to account for intergroup differences and intragroup similarities, this comparative study tried to sort out differences explainable by genetic differences (when observed in transition areas between subspecies, suggesting possible 'innate' differences between them), or by particular environmental pressures or affordances (related, for instance, to availability, or to the absence of the *necessary* environmental elements), which could constitute potentially *sufficient* explanations.

Whiten et al.'s (1999) study allowed us to see behavioral variability among wild chimps' populations under a new light: behavioral patterns not easily explained away by genetic or ecological determinants were found not only in tool use and other food acquisition and processing techniques, but also in dietary preferences, communicative and affiliative gestures, body care, and, possibly, in the use of medicinal plants.

The notion of cultural traditions among hominoids gained strength after the discovery of the use of tools by a few populations of orangutans *(Pongo pygmaeus;* van Schaik et al. 1996): even though this species is very dexterous in captivity settings, tool use by wild groups was observed only under very particular conditions of gregariousness and social tolerance.

It was pointed out, though (Fragaszy and Perry 2003), that this "comparative" (sometimes called "ethnographic") approach cannot prove nor falsify claims that any given behavior constitutes a *tradition,* not only because of being prone to "false negatives" or "false positives" (see, for instance, Humle and Matsuzawa 2002), but, first of all, because it does not take into account what should be the critical evidence to label any given behavior as *traditional:* an effective role of social influences in its acquisition by individuals. The "process model" proposed by Fragaszy and Perry (2003) aims to locate traditions in a tridimensional space whose axes correspond to its duration in time, the proportion of the population exhibiting it, and the contribution of social influences in the generation of new practitioners.

These social influences, though, are generally hard to measure in naturalistic research – and here lies the importance of the controlled conditions provided by the laboratory, or the more favorable conditions offered by the observation of semi-free populations.

The general spatial and temporal patterns revealed by comparative studies, the above-mentioned caveat notwithstanding, can be useful in many ways (van Schaik 2003). Firstly, they tell us which behaviors are species-typical, and which are rare or only observed in particular populations: this information can guide our investigation strategies. Secondly, these patterns can help us to identify correlations between behavioral characters and prominent genetic or ecological factors. Sometimes, they can also help in the detection of telltale clues of socially influenced behaviors, such as behavioral discontinuities associated to geographical barriers preventing intergroup diffusion (Whiten et al. 1999; van Schaik et al. 2003). Studies like Biro et al. (2003) highlight the usefulness of combining approaches (comparative, ontogenetic, and experimental) when dealing with cultural innovation and transmission processes by non-human primates in the wild.

Tool use and social traditions in non-human animals

On the one hand, communicative behaviors such as chimps' "handclasp grooming" or white-faced capuchins' "social rituals" (Perry 2011) have the useful quality of being apparently

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free from ecological constraints. On the other hand, behavioral patterns involving the use of objects as tools, though evidently more prone to biases related to environmental constraints and affordances, usually have the nice qualities of being quantifiable in their costs and benefits, and of leaving physical remains which are measurable and comparable and which tend to last longer than the behavior itself (with relevant consequences for both potential conspecific apprentices and human researchers).[5] Being so, it is not surprising that, as happened in the study of the behavior of extinct hominins and early humans, tool use has played a prominent role in the study of animal traditions.

Tool use was once strictly associated with (human) culture and seen as a defining feature of our species ("Man, the toolmaker;" Oakley 1949). Nevertheless, depending on the breadth of the assumed definition, the scenery on animal tool use changes. Considering spider webs as tools could seem appropriate (even though webs are not 'detached objects'), while including, say, feces thrown by arboreal animals on potential predators (Chevalier-Skonikoff 1990) might be stretching the concept too much. In our research, we adopted Beck's classical definition of tool use as "the external employment of an unattached object to alter more efficiently the form, position, or condition of another object, another organism, or the user itself, when the user holds and directly manipulates the tool during or prior to use and is responsible for the proper and effective orientation of the tool."[6] For a recent discussion and a proposed definition that includes the mediation of the information flow between organism and environment (and not only changes in physical properties of objects), see St. Amant and Horton (2008).

Tool use does not necessarily require complex cognition or social learning – it can result from quite stereotyped and generalized, species-specific (or "context-specific;" cf. Parker and Gibson 1977) behaviors, such as the quartz-pebble-enhanced traps of *Ariadna* spiders (Henschel 1995) –, which is quite distinct from the creative tool-aided problem-solving strategies exhibited by captive apes (Köhler 1925).

Reports of simple forms of plastic tool use in the literature include, among other species, bottlenose dolphins (Krützen et al. 2005), Asian elephants (Hart et al. 2001), otters (Hall and Schaller 1964), beavers (Thomsen et al. 2007), Egyptian vultures (van Lawick-Goodall and van Lawick 1966), woodpecker finches (Eibl-Eibesfeldt 1961), and even octopuses (Finn et al. 2009) – leaving aside the reports about captives in many taxa. In recent years, the literature highlighted the complex cognitive capacities of corvids, including the use of tools by New Caledonian crows *(Corvus moneduloides)* that produce "hooks" and other kinds of modified objects to probe into tree branches' holes for larvae (Hunt 1996; Hunt and Gray 2004).[7]

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[5] Including the prospect of a new field of *primate archaeology,* proposed by Haslam et al. 2009.

[6] Beck (1980, apud its updated and revised edition: Shumaker, Walkrup and Beck 2011) provides an extensive review on tool use by animals. Alcock's (1972) similar definition, based on Goodall's (1970), refers to the "manipulation of an inanimate object, *not internally manufactured,* with the effect of improving the animal's efficiency in altering the position or form of some separate object," which thus excludes things like spider webs. And all these definitions exclude the quasi-metaphorical sense in which Kummer (1967) and others refer to the use of conspecifics as "social tools."

[7] Though there are some suggestions of social influences on learning in the wild, laboratory studies (Weir et al. 2002) have shown a strong "innate" disposition in this species for the use of tools (as we found in our study on

Tool use by non-human primates

In 1995, i.e., by the time we 'discovered' the spontaneous use of tools by a semi-captive group of capuchin monkeys, though, widespread and diversified tool use in the wild by non-humans seemed restricted to chimpanzees.

The case of orangutans *(Pongo pygmaeus)* was particularly interesting, considering their performance in lab experiments (Byrne 1995), just like the dexterity of ex-captives in rehab facilities imitating tool use by human caretakers (Russon and Galdikas 1993). In the following year, the first reports on the use of tools by wild populations were published (van Schaik et al. 1996; see above).

Though captive gorillas *(Gorilla gorilla)* are also capable of using objects to solve tasks, the reports about tool use in the wild are extremely rare (Breuer et al. 2005; Wittiger and Sunderland-Groves 2007). Byrne and Russon (1998) observed, notwithstanding, structurally complex behavioral sequences in their manipulation of defended food items.

Intriguingly, the use of tools was never observed in wild bonobos *(Pan paniscus),* which is unexpected, considering their manipulative performance in the lab – including the preparation and use of lithic blades (Toth et al. 1993; Kathy et al. 1999).

Among Old World monkeys, apart from a few anecdotal reports, the only species where spontaneous and customary use of tools in the wild has been observed are long-tailed macaques *(Macaca fascicularis),* who use stones and shells to detach or break oysters, gastropods, crabs, and fruit (Malaivijitnond et al. 2007; Gumert et al. 2009).

Spontaneous and customary use of tools by capuchin monkeys

If the findings about the spontaneous use of tools by wild chimpanzees led us to rethink traditional views on the 'unique and exclusive' character of human technological abilities, the discovery of similar behaviors in a few 'atypical' monkey species – one Old World monkey species, one genus of New World monkeys – leads us to broader questions, focusing our attention not on phylogenetic proximity, but, rather, on the cognitive, ecological, and social conditions and mechanisms fostering the emergence of tool use and behavioral traditions.

Tufted capuchin monkeys have a broad distribution *(Sapajus spp,* formerly, *Cebus spp),*[8] from the north of South America to Southern Brazil, Paraguay and the north of Argentina, living in multi-male, multi-female groups ranging from 3 to more than 50 individuals. They have longer and socially more active infancies than similar-sized New World monkeys (Fra-

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tool use by hyacinth macaws; cf. Borsari and Ottoni 2005). But see Madden (2008) for evidences on "cultural" features on bower design and decoration by bowerbirds.

[8] Tufted (or "robust") capuchin monkeys used to be all included in the *Cebus apella* species, whose subspecies were then raised to species' level (*Cebus apella* [former *C. a. apella*], *C. libidinosus, C. nigritus, C. xanthosternos,* and *C. flavius* being the main species; see Chapter 1 in Fragaszy et al. 2004b for a review). Recently, molecular data (Lynch Alfaro et al. 2012) ratified the proposal of separating "robust" and "gracile" species into two genera, *Sapajus* and *Cebus.* So, under this revised taxonomy – while, for instance, Central American white-faced capuchins remain in the *Cebus* genus *(C. capucinus)* – our study species will all be referred to here as *Sapajus* spp – though in older texts, *S. libidinosus,* for instance, may be named *Cebus libidinosus,* or *C. apella libidinosus*).

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gaszy et al. 1991), and they exhibit a relative brain size closer to that of great apes (Rilling and Insel 1999). They are generalist and opportunist foragers, with a much-diversified diet, varying from fruit and other plant parts to animal prey like arthropods, eggs, and small vertebrates such as lizards, snakes, and birds. Many of these food items require complex search and processing techniques, whose acquisition is frequently suggestive of socially aided learning.

The dexterity of capuchin monkeys was already well known in the times of Charles Darwin's grandfather Erasmus, who described the stone-aided nut cracking by an old captive (1794, apud Visalberghi 1990). Anecdotes about captives in zoos abound, but systematic experimental studies started in the 1980s with Westergaard, Fragaszy and Visalberghi (see Fragaszy et al. 2004b for a review).

Behavioral convergences between tufted capuchins and chimpanzees (Visalberghi and McGrew 1997) are not limited to complex object manipulation, but are also reflected in other areas of their social lives (e.g., food sharing and tolerance towards the young), which makes capuchin monkeys a strategically important target in the comparative study of the evolution of primate cognition and sociality.

First studies with a semi-free group

The first reports of direct observation of spontaneous tool use by tufted capuchin monkeys came from semi-free groups in urban parks in Southern Brazil (Mannu and Ottoni 1996; Rocha et al. 1998; Ottoni and Mannu 2001). In our case, while replicating lab experiments on tool-aided problem-solving by Westergaard and Fragaszy (1987) in a semi-captive population on an island in the Tietê Ecological Park (PET) near São Paulo, Brazil, a student (Perondi, pers. comm.) heard percussive sounds coming from the woods in the so-called 'Preservation Area' of the park. When she inquired, a park keeper explained her, quite nonchalantly, that "those where the monkeys cracking nuts with stones…"

Our preliminary investigations showed that, in fact, capuchins from a group formed by animals (poached and retrieved by the authorities) that had escaped from the park islands (where the park management meant them to stay) were doing something very 'chimp-like:' using stones as 'hammers' to crack small *Syagrus* palm nuts to eat their endosperm and the eventual beetle larvae 'bonus.' Since there was no information available on their previous life histories, we could not rule out the possibility that this behavior was an artifact of their interaction with humans, either in the park or before their park-life, but there was already some indirect or anecdotal evidence available from the wild (Langguth and Alonso 1977; Fernandes 1991) suggesting otherwise.

The ontogeny of tool use in tufted capuchins

Our initial, "descriptive" phase in the research with the semi-free PET group was followed by a study on the ontogenetic development of tool use (Resende et al. 2008) – which made clear the importance of both infant curiosity and exploration, on the one hand, and of older individuals' (especially males) tolerance to their proximity and scrounging, on the other.

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Most mature individuals in the group crack nuts, although with variable frequency and efficiency,[9] but it takes about 3 years for a young monkey to start becoming proficient in nut cracking. Young infants frequently manipulate objects, including stones, by beating them against a substrate. 1-year-olds often attempt to crack nuts. However, the proper coordination of movements and positioning of nuts, 'hammer' stones, and 'anvils' (any hard and level substrate) is not usually reached until the 3rd year of their lives.

From an early age on, though, capuchins are keenly interested in nut cracking by other individuals. Conspecific observers are typically younger and less proficient than the observed nutcrackers. Here, the role of mothers as models is much less marked than in chimpanzees since males tend to be more active nutcrackers, but capuchin infants and juveniles can watch older juveniles or adult males, and some scrounging is also allowed. The food-related activities of dominant males tend to be quite attractive.

We propose that scrounging, as a proximate motivation, optimizes the conditions for the social learning of nut cracking techniques.[10] This implies that even simple cognitive processes, such as operant conditioning, can optimize the conditions for socially biased learning that can give rise to traditions.

Some of our findings point to an active, non-random choice of observational targets. In groups where stone-aided nut cracking is already well established (in the so-called "tradition phase;" cf. Huffman and Hirata 2003), young observers can follow a simple rule of thumb, and their curiosity is usually focused in the food-related activity of dominant males. But when there was a range of potential "observational targets" available, differing more in tool use proficiency than in rank, the observers seemed to be able to select the most "profitable" targets, preferentially watching the more skilled nut crackers (Ottoni et al. 2005), probably because such selective attention was likely to enhance scrounging payoffs (which, in turn, enhance social learning opportunities).

Mapping the occurrence of tool use by wild capuchin monkeys

There are virtually no reports of tool use by the Central American white-faced capuchin monkeys *(Cebus capucinus),* among which behavioral traditions on food preferences (Panger et al. 2002) and social conventions (Perry et al. 2003) have been described. And there are no reports at all from free-ranging populations of the South American non-tufted ('gracile') capuchin species (*Cebus* spp).

Among the tufted capuchins (*Sapajus* spp), most long-term studies in the wild were done, until recently, with forest-dwelling populations of *S. apella* or *S. nigritus,* and these provided us with apparently robust *negative* evidence of the customary use of tools (whilst there are a few reports of complex food processing), even though these species can show high dexterity in tool-aided problem-solving in the lab (Westergaard and Fragaszy 1987; Visalberghi 1990).

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[9] Especially in the early years of the research, when, we believe, tool use was still an innovation being disseminated in this group (Ottoni et al. 2009).

[10] See Caldwell and Whiten (2002) for a study on the scrounging facilitation of social learning in marmosets.

The first direct observations of tool use by wild groups came from two populations of *S. libidinosus* in the state of Piauí, in Northeastern Brazil – in Fazenda Boa Vista (FBV; cf. Fragaszy et al. 2004a), and in the Serra da Capivara National Park (PNSC; cf. Moura and Lee 2004; Mannu and Ottoni 2009). Since then, our surveys of other areas in Central-Western Brazil have shown that, for savannah-dwelling populations, the use of tools to crack open encapsulated food (Figure 1) is the rule rather than the exception (see Ottoni and Izar 2008 for a review). A comparative exam of the ecology and use of space by tufted capuchins along the genus distribution range led us to consider the degree of terrestriality – rather than food scarcity – as a stronger predictor of the use of tools to crack encapsulated food in present populations (Visalberghi et al. 2005).

Figure 1. Nut cracking and scrounging, FBV

The population in the PNSC, though, exhibits a broader tool kit: stones are used not only as 'hammers' and 'anvils' to crack hard fruit or seeds, but also as digging tools (to loosen and/or pull the soil; cf. Figure 2a) to access roots, tubers, or invertebrate ground nests, and wooden sticks are used to probe for water, insects, or to dislodge small vertebrate prey in tree trunk holes or rock cracks (Figure 2b). In a similar way to what has been observed among chimpanzees, the use of probes by tufted capuchins usually involves some degree of preparation or modification: the sticks are not only detached from trees and cut to a proper length, but, when necessary, leaves or side branches are trimmed, and the tips are thinned (Mannu and Ottoni 2009; Falótico and Ottoni submitted).

This "enhanced" tool kit favors the emergence of more complex behavioral patterns such as the use of "secondary tools" (i.e., tools used to produce other tools; Sugiyama 1997), as in the case of freeing a quartz pebble (to be used as a hammer) embedded in sandstone with the aid of a smaller stone, or the combined (sequential) use of stone hammers and stick probes to access insect nests in rotten tree trunks or prey in rock cracks. Also, the intensive and diversified use of stones as tools has probably propitiated, in one of our study groups in the PNSC (the Pedra Furada group), the appearance of a peculiar new kind of sexual display

by some females – the throwing of small pebbles at the dominant male they were following as target (Falótico and Ottoni 2013).[11]

Figure 2. Stone-aided digging and stick probe use, PNSC

Explaining the variation in tool kits among populations

If the degree of terrestriality can explain the differences in the use of percussive tools between tufted capuchins in savannah and forest environments, it does not seem to be a sufficient explanation for the rarity of the use of probe tools. On the other hand, probe tool use does not leave such conspicuous traces as stone-aided digging or nut cracking, and it is most certainly underreported (as so far it has only been observed in one wild group outside the PNSC).[12] It has never, though, been observed in FBV groups, which is the only other wild *S. libidinosus* savannah population with enough direct observation time to make us reasonably sure of its absence.

There is so far no clear explanation for the more diversified tool kits of PNSC groups. The abundance of quartz pebbles (as compared to their low availability in FBV) can be a relevant factor. More importantly, perhaps, their atypically large group sizes (some of them around 50 individuals, about twice the size of FBV groups, or three times that of average forest groups) could enhance the opportunities for both innovation and the diffusion of tool-aided foraging techniques and other behavioral traditions.

[11] Male nut cracking can perhaps also play a role as a sexual display (Boinski 2004; Moura and Lee 2010).

[12] The use of sticks to probe termite nests was recently reported in a group of the "rediscovered" *S. flavius* (Souto et al. 2011).

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Social structure and dynamics, and socially biased learning

Van Schaik et al. (1999) hypothesized that, for species with some degree of motor and cognitive dexterity and relying on extractive foraging, the cultural dissemination of complex food-processing techniques – tool use in particular – would depend on the degree of tolerance among individuals in the group, which determines the extent to which potential "apprentices" have access to the activity of the more experienced "manipulators." In the same vein, Coussi-Corbel and Fragaszy (1995) proposed that the typical inter-individual distances tolerated in a given species (which vary as functions of age, kin, and rank relationships) determine the level of behavioral detail that can be socially transmitted.

Our studies confirmed van Schaik et al.'s (1999) prediction that, given the above-mentioned genetic, ecological, and social preconditions, the emergence of tool use traditions could be possible even in a New World primate species. Nonetheless, Kummer and Goodall (1985) emphasized the greater opportunity for less socially constrained individuals (such as the ones who forage alone or in smaller groups) to exhibit *innovative* behaviors. Since this is the case of sub-adult or young adult capuchin males, being less tolerated, their society can represent a favorable 'equilibrium' between these factors, facilitating both innovation and social transmission.

The evolution of tool use in tufted capuchins

Spagnoletti et al. (2012) analyzed the seasonal variations in food availability and nut cracking activity by FBV capuchins to pit the "necessity hypothesis" (i.e., tool use necessary to access fallback food items during resource scarcity) against the "opportunity hypothesis" (i.e., tool use maintained by repeated exposures to appropriate ecological conditions, such as preferred food resources necessitating the use of tools). The results clearly favored the latter hypothesis: nut cracking was not affected by provisioning, nor correlated with the availability of fruit and invertebrates. Monkeys crack nuts when these are available.

If necessity does not apparently hold as an explanation for the use of tools to access encapsulated food in present savannah populations (or at least in that particular population), it is still a likely candidate as an ultimate explanation for the evolutionary origins of tool use by tufted capuchin monkeys.

The Cenozoic was an era of severe climate fluctuations, with warmer periods alternating with glacial cycles associated with drier weather, which was reflected in cycles of expansion and retraction of the Amazon forest and the wetter types of savannah. These climate changes are thought to have prompted drastic changes in South American fauna: speciation processes affecting populations isolated by forest fragmentation constitute one major theoretical model to explain Amazon biodiversity (i.e., the refuge theory; cf. Simpson and Haffer 1978; Ab'Saber 2000). This may also explain the sudden diversification of New World primate species (Zachos et al. 2001, apud Schrago 2007).

The fossil evidence on the evolution of Platyrrhines is scarce – and virtually lacking for capuchin monkeys *(Cebus/Sapajus),* with no candidate fossils older than 4000 years –, and there are discrepancies among molecular methods. Based on the most recent analyses of genetic data, Lynch Alfaro et al. (2012) concluded that, isolated from their Amazon ancestors,

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tufted capuchins originated either in the Atlantic Forest of further inland, in savannah areas (which are now the *cerrado* and the *caatinga*), and in the last 750,000 years expanded out across the cerrado and back into the Amazon Forest.

The occupation of drier savannah environments may, at times, have exposed tufted capuchins to more extreme conditions than those currently observed in FBV and other savannah areas,[13] under which the consumption of encapsulated food can have started – as we hypothesize – out of necessity rather than out of opportunity alone.[14]

But even if adults (especially adult males, in the case of harder nuts) have the necessary cognitive and motor skills to use stone tools to crack open palm nuts, that, in itself, is only part of the solution. There is a 'life history' catch: since it takes some years until young monkeys acquire the skill and strength necessary to consume these items by themselves, when no other resources of easier consumption are available, youngsters must still be fed. So, tolerated scrounging by infants and younger juveniles would be a key component in this 'technological' solution to food scarcity. Incidentally, it also optimizes opportunities for the socially biased learning of tool-aided food processing.

Other potential traditions in tufted capuchins

Other potential behavioral traditions besides tool use, such as anting (as a chemical defense against ticks; cf. Verderane et al. 2007), or some forms of social play, deserve further inspection. The interaction with other species is a promising context for socially aided learning, especially when the costs of solitary, trial-and-error learning are high; snakes, for instance, can be either predators or prey, and the monkeys in PNSC react adequately, harassing from a safe distance or poking with sticks the dangerous ones, such as boas and rattlesnakes, and predating on the harmless *Colubridae* (Falótico and Ottoni submitted). Though the ontogeny of snake-related behaviors has not been examined so far, such encounters (especially threat events, which last longer and are more conspicuous) attract a lot of interest by nearby individuals, suggesting the potential effects of social traditions in snake discrimination learning by capuchin monkeys.

Future field studies with key wild populations will help us to examine the many questions raised by our current knowledge on tufted capuchin monkeys' tool use, such as the apparent 'uniqueness' of the Serra da Capivara population tool kit, the role of social learning on the ontogeny of the different kinds of tool use, and the interactions between group size, social dynamics, foraging strategies, and the emergence of behavioral traditions.

[13] Wright et al. (2008) suggest that the use of tools to crack palm nuts was the selective agent responsible for "robust" capuchins' relatively short hind limbs and massive forelimbs – with niche broadening anatomical specializations permitting the exploitation of a range of habitats and food resources.

[14] The use of digging sticks by chimpanzees (to access plants' underground storage organs [USOs]) was only observed in savannah populations (Lanjouw 2002; Hernandez-Aguilar et al. 2007). Access to USOs has been hypothesized to have played a key role in the initial hominin occupation of savannah environments (Laden and Wrangham 2005).

Cultural processes as selective pressures on the evolution of cognition and sociality

Hypotheses pointing to complex social dynamics as the main selective pressures driving the evolution of primates' big brains and complex cognition have been around for a long time (Chance and Mead 1953; Jolly 1966; Kummer 1967; Humphrey 1976).[15] These were collected under the label of the *Machiavellian intelligence hypothesis* (Byrne and Whiten 1998; Whiten and Byrne 1997), given the authors' emphasis on social manipulation under unequal and competitive conditions, where "tactical deception" is important to avoid unnecessary conflict over resources.

Van Schaik and collaborators, however, focused on the "brighter side" of the "social niche:" as socially aided learning of complex (or risky) behaviors became more and more important for survival, social motivations and cognitive capacities that enhanced the conditions for social information transfer have plausibly become the target of intensive selection pressures. The so-called *cultural intelligence hypothesis* (van Schaik and Pradhan 2003; van Schaik and Burkart 2011; see also Whiten and van Schaik 2007) extends to non-human animals the notion of a coevolutionary process (Cavalli-Sforza and Feldman 1981; Boyd and Richerson 1985) between culture and genetically-based cognitive capacities.

This evolutionary trend can explain sophisticated cognitive features, such as a theory of mind – but socially biased learning and the emergence of social traditions do not necessarily rely on complex individual cognition: they can be established upon 'humbler' cognitive and social features, such as the high motivation of youngsters to observe the behavior of older individuals (that can be driven by simple food reinforcement), and the high tolerance of adults to close proximity and scrounging by youngsters. This parsimonious model places complexity not necessarily into individual brains as such, but into the interaction between individual cognition and social dynamics – evoking concepts like "situated action" and "socially distributed cognition" (Strum et al. 1997; Hutchins 1991).

Bearing in mind than human culture can be a very particular sort of social learning, based on unique cognitive capacities such as a theory of mind, can be a wise approach. It seems equally important, though, to pay attention both to each species' specificities and to more universal aspects of social information transfer in animal societies. Figuring out which underlying features (in individual cognition or social dynamics) are exclusively human may help to understand what has made cultural complexity the defining feature of our species. Gaining a better understanding of similar processes in animals is essential to build a broader picture of an evolutionary science of social learning and culture.

As McGrew (2003) points out, "culture has escaped from anthropology" to other disciplines: anthropology studies culture as phenomenology; psychology asks questions about cognitive and social mechanisms; zoology and evolutionary biology study culture as an adaptation, under a neo-Darwinian paradigm – and cultural primatology can use the insights from all of these approaches.

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[15] All reprinted in Byrne and Whiten 1988.

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FIDELITY TO CULTURAL KNOWLEDGE AND THE FLEXIBILITY OF MEMORY IN EARLY CHILDHOOD[1]

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The role of imitation is of prevailing significance as a tool for knowledge transmission in relation to both the individual development of an infant when becoming a competent, knowledgeable individual, and the establishment of a cumulative culture spanning over generations (Csibra and Gergely 2009; Tomasello 1999; Boyd et al. 2011). While imitation enables individual learning based on environmental cues (and so the formation of new and inventive ideas), it also lets us pass knowledge from generation to generation and thus accumulate improvements and establish culture (Boyd et al. 2011).

Exhaustive research on children's imitation highlighted that young children show flexibility in their choice of social learning strategies, thus, blind imitation is not the only form they can use (for a comprehensive review, see Want and Harris 2002). It is well documented that children in various situations re-enact selectively (some examples are the following: on copying intentional actions but not mistakes or failed attempts, see Meltzoff 1995 and Carpenter et al. 1998; on imitating only those actions that are considered relevant in the situation, see Gergely, Bekkering and Király 2002; on copying only those intentional actions that seem causally related to the goal of the actions, see Brugger et al. 2007 and Király 2009). In other situations, however, children are ready to copy surprisingly faithfully (Whiten et al. 2009). Recently, it has been proposed that there is a dominant form of imitation, namely *overimitation*, a tendency to reproduce even the causally irrelevant actions of a modeled behavior (Lyons et al. 2007; Nielsen and Tomaselli 2010).

The main challenge for a developmental perspective is to explain the underlying mechanisms responsible for the choice between the above-mentioned, seemingly contradictory tendencies of selectivity and fidelity in imitation. Such an explanation could help us to understand why imitation is the most successful means for the propagation of cultural knowledge (Richerson and Boyd 2005). Moreover, it could highlight the possibilities of the integration of individual learning and social learning strategies.

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Explanations of flexibility in imitative performance

Interestingly, the phenomenon of selective imitation has been explained consensually in terms of children's understanding of others' goals and intentional actions, suggesting that the major function of selective imitation is learning (e.g., Bekkering et al. 2000; Gergely et al. 2002; Tomasello et al. 1993; Over and Carpenter 2012). At the same time, the most influential explanations of overimitation assume that the phenomenon is a sign for the need to learn about causally opaque but culturally significant artifacts as well (Gergely and Csibra 2006; Lyons et al. 2007; Whiten et al. 2009; Flynn and Whiten 2010).

Regarding the availability and relation of selectivity and fidelity in imitation, the various explanatory theories are different in their view despite the fact that they share the assumption that imitation is a learning strategy. On the one hand, a theory of Flynn and her colleagues (Flynn 2008) proposes that children initially imitate faithfully because they accept the information as culturally relevant and contributing to the maintenance of traditions. However, during their own practice, children reconsider the role of each action element with respect to the success of goal attainment: in their performance, irrational, inefficient elements tend to fade away. In that sense, Flynn and her colleagues (Flynn 2008) allow sensitivity to off-line factors, such as time and practice, thus, their model assumes a flexible learning process.

On the other hand, Lyons et al. (2011) in their account imply that information is automatically encoded in a causal manner. Children attribute causal importance to each and every action-element presented by a model – overwriting even their experience-based expectations if necessary. The automatic causal encoding unavoidably leads to high-fidelity imitation, as a result of an inflexible process.

There is a recent approach with the objective of providing an explanatory model for the dominance of overimitation and the existence of selective imitation in a single frame. According to Over and Carpenter (2012), the complexity of children's imitative performance can only be fully understood if the social context of behavior and the potentially emerging social motives are considered too. In their social psychological model, they claim that the goal of learning in itself, which is usually claimed to be the main function of imitation (see above), is only one factor that influences imitative behavior. There are other critical factors in determining what is copied that can be called social goals or social motives, namely, children's identification with the model and with the social group in general, and the social pressures which children experience within the imitative situation. In their view, selective imitation (emulation) and overimitation (high-fidelity imitation) are not independent processes but can be intertwined, and they might even interact with each other. They distinguish three cases of social learning situations, where the type of re-enactment depends on the particular constellation of the above-introduced specific learning or social goals on behalf of the child.

In cases when learning goals predominate, the goal of the copying is to acquire a new skill and reach the goal (hence, goal emulation). Therefore, in these cases children concentrate on the necessary steps to reach the action goal (that is, on the steps that are in causal relation with it). In this case, children pay attention more to the nature and details of the task – to the function and efficiency of the objects and the steps –, and less to their relationship with the model and their interaction.

Over and Carpenter (2012) show that even when the learning goal is important, overimitation might occur. Williamson and colleagues' (Williamson et al. 2008) results show that

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if children's previous experience suggests that they cannot solve the task alone, then they are more likely to faithfully copy the action of the model than in the condition when they had the experience that the task is easy to solve (this being the opposite case to when they selectively imitate because they 'know a better way' to reach the goal). In this way, however, we should say that faithful imitation emerges from an understanding of the situation, and it is not completely blind.

Another type of case is when learning goals and social goals cannot be separated from each other: they are either present in parallel, or they are strongly intertwined: such as when children learn cultural norms. The mixture of social goals and learning goals represents a special function: learning about the normative aspects of culture, about social rules that cannot just be learnt via individual learning. We will later return to the discussion of these types of situations.

The third type of copying situation is when social goals dominate. In these cases, identification with the model is of top priority for children, without necessarily aiming to learn a new skill at all. Rather, children wish to convey the message: "I am like you." The content of the social goals can vary with age. A related finding is that being imitated makes us like the imitator better because we like more those who are similar to us. In Meltzoff's (1990) study, he tested 14-month-old infants' reaction to a social partner. Results showed that infants preferred partners who imitated them to another partner who was reacting equally contingently but did not imitate them.

The advantage of the approach of Over and Carpenter (2012) is that, with the help of taking into account social motives and different social factors of the situation, it shows how different functions (both epistemic functions and social functions) of a copying process can be bridged and used in a dynamic way. They argue for flexibility on a level of a hierarchy that exceeds the epistemic function of cultural transmission. They describe the combination of the social and learning functions of imitation as a deeply social phenomenon, though without explaining the proposed dynamic relation of the two types of goals. An implicit assumption of this model is that there is an initial choice of the overall (learning vs. social) goal by infants triggered by situational factors. The problem arises, though, how to define what kind of factors result in the dominance of learning goals, or in the dominance of social goals, or in their combination.

An interesting subfield of imitation research can help us to specify the question more precisely. There are findings where children seem to either emulate or imitate based on the model's features, the social partner's characteristics. Difference in physical features (like gender or age), or behavioral cues (like success or competence) that imply reliability can influence the extent of learning new information (Henrich and Gil-White 2001). Indeed, unconfidence by itself is a factor that entails selectivity: if 2–3-year-old children have the opportunity to choose which model to learn from, they prefer the confident one (Birch, Akmal and Frampton 2010). A recent study by Elekes and Király (2012) revealed that infants react sensitively to the features of the model and the situation: they integrate both sources to learn the most information possible. Faithful imitation was only evoked when the model seemed to be knowledgeable and the situation was pedagogical. Whenever one of these conditions was not met, infants turned to emulative strategies.

These results highlight an interesting problem: the question of how the 'decision' is made about the goal the child has in a situation. The above findings lead us to the issue that in

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certain cases (as in the above-mentioned examples) it is even problematic to decide whether the goal was of a learning or of a social nature (or maybe both). Children's relation to the model (their understanding of the model's characteristics) causes the goal of learning to be more important, or rather, the fact that they know "a better way" to reach the goal makes them revise their relationship with the model. Hence, they do not feel a motive to identify with her because the model's knowledgeability turns out to be questionable. The social psychological framework of copying, therefore, offers flexibility in deciding the function of imitation in different situations. By this assumption, the model solves the apparent confusion of children's choice between selectivity and fidelity in their imitative performance with respect to their learning goals. However, this still cannot identify the causal factors that are responsible for guiding the 'decision' process.

Alternatively, if we step back to the theoretical perspective that (1) imitation is a successful means for cultural transmission, and thus (2) the main function of imitation is learning, then it can be proposed that even the deeply social aspects of culture need to be learnt first. Selective imitation is often regarded as a heartless, cool-headed act, serving individual learning, whereas high-fidelity imitation (overimitation) is often seen as a warm, social action, serving cultural knowledge transmission.

A theoretical angle that poses an overall learning function on imitation that facilitates both the acquisition of instrumental, functional information and the acquisition of social rules and socially constituted knowledge would suggest that fidelity and selectivity are guided by the content and type of knowledge in propagation. Indeed, in many ways selective imitation might subserve culture better since if we would simply copy each other, new knowledge would never arise. On the other hand, it would be really inefficient if we had to invent everything over and over again. A good selective imitator can produce an optimal combination of innovation and knowledge transmission (Király, Szalai and Gergely 2003; Richerson and Boyd 2005).

Natural pedagogy theory (Csibra and Gergely 2009) represents this perspective and argues that the guiding function of imitation is learning – not only about instrumental knowledge, but also about the socially constituted knowledge of culture as well. More specifically, the authors claim that imitation itself is only one form of how knowledge acquisition takes place. However, this model does not deny the role of social motives in triggering imitation in several cases, though it highlights that a pedagogical setting is in itself sufficient to activate a stance in children that the situation is for knowledge transmission. Hence, this model defines the factors that help children to choose whether the situation invites their learning goals or, rather, their social motives.

Indeed, this model expects high-fidelity imitation, but only in pedagogical situations. This model claims that ostensive communication triggers in infants a stance to accept the demonstrated behavior as a relevant and generalizable piece of cultural information, even when the action is cognitively opaque (i.e., it is seemingly not the most efficient way to achieve the goal state; they are unable to comprehend it by their instrumental, functional knowledge). This approach emphasizes that imitative behavior is guided by cognitive and informational adaptivity, and since high-fidelity imitation is triggered only in ostensive communicative situations (see Király, Csibra and Gergely 2013), this model presumes an on-line selection of what is to be learnt, guided by pedagogical cues. When the model produces her actions deliberately while engaging in ostensive communication with the infant, despite the fact that

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her action is cognitively opaque, her intentional choice guides infants to encode the socially relevant objective of the situation (i.e., learning about social rules).

Thus, pedagogy theory predicts that ostensive demonstration highlights aspects of situations that are worth learning, so the demonstration itself guides the process of selection: elements that are manifested as relevant and new pieces of cultural information are learnt, and thus they appear in re-enactment since they are encoded as generic information in the social domain. This means at the same time that the fidelity predicted by this theory in the case of social rules and knowledge presented in pedagogical setting does not appear as a result of choosing 'imitation' as a dominant form of social learning for this type of knowledge, it rather reflects that in the case of social rules the information content cannot be filtered by instrumental, functional reasoning, and by the means of pedagogical demonstration all of the elements are labeled as relevant.

In other words, children do not tend to choose between imitation and emulation depending on the situational requirements of the setting, but they always try to find the essentially irrelevant features of the situation that could be filtered out. On the one hand, when there are obvious physical, causal affordances that help their reasoning process, the result of this filtering reflects emulation as a form of re-enactment. On the other hand, when pedagogical settings induce relevance for an otherwise opaque behavior, the selection process results in richer content and appears in the form of re-enactment, which is similar to high-fidelity imitation. In essence, it is still the emulation of the subgoals of the situation that are labeled as relevant by the pedagogical demonstration. From this perspective, re-enactment by itself is the retrieval of the information that was encoded as relevant content in the modeling situation. Seemingly high fidelity imitation emerges as a result of an acquisition process that is evolved to encode the social rules and the socially constituted knowledge that cannot be interpreted by other interpretive schemas, like instrumental, functional, or efficiency rules.

Learning and memory processes in imitation

Overall, if we accept that imitation has dominantly epistemic functions, we need to take into consideration the competencies and processes constraining learning and memory on the individual level. As Richerson and Boyd (2005) emphasize, the nature of the behavior that is available to imitate is itself strongly affected by the psychology that shapes the way we learn from others. The way learning and memory factors influence and contribute to the form of copying was studied by Simpson and Riggs (2011). They tested whether 3- and 4-year-olds' imitative behavior depends on whether they are forming short-term or long-term memories of events. They predicted that when tested immediately after demonstration, children would find it easier to remember all the steps (including the irrelevant ones), whereas after a delay the memory of the irrelevant action would fade and result in selective imitation. Indeed, results showed that during immediate re-enactment, with fresh memory traces, children copied the demonstrated action faithfully, but after about a week's delay the semantically processed long-term memories were activated, and this led children to emulate the action sequence. This suggests that they rather use their semantic knowledge for problem-solving, and they do not recall the details of original actions.

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In an earlier study, Williamson et al. (2008) showed that 3-year-old children varied their copying strategies according to their experience with the task: they did not follow the new, alternative strategy if they experienced the task to be easy to solve, but if the situation changed and the task turned out to be harder than expected, children recalled the strategy of the model to solve the task.

Together, these results suggest that prior knowledge and children's memories related to the demonstrated event influence their copying strategies. Furthermore, the experience and the inferences drawn from the demonstrated behavior that is reflected in the social learning strategy depends on when the re-enactment takes place, and on the type of memory (i.e., short- vs. long-term) children have to rely on. Thus, it seems that in the case of long-term recollection children show a strong tendency to recall the 'essence', the more semantic elements of memories. Finally, it seems that children are able to flexibly reach back to those elements of the observed action that were previously labeled irrelevant and selected out, in cases when the relevance of these steps changes and the new context reveals the efficiency or necessity of these particular elements.

The above examples of flexible selective imitations seem to suggest that the behavior of children at retrieval can also be influenced by an adaptive, efficient strategy (e.g., in the Williamson et al. 2008 study). Furthermore, it seems that the selecting mechanisms in memory processes can influence behavior: in the case of Simpson and Riggs (2011), while online, right after encoding all of the observed elements were re-enacted, after a delay the memory's pressure led to selection. This suggests a picture of imitation where different strategies can be used flexibly, and which is sensitive to social factors, as well as to efficiency analyses of situations, and which can flexibly generalize and activate memory traces.

Nevertheless, the above results are not clearly conclusive on the question during *which* memory process information selection takes place or plays a significant role. In a broader framework of cultural learning, however, the prediction in this case is biased – since cultural information in essence does not need to be transparent for the individual learning system, selection processes should be guided online, during the phase of acquisition with the help of the expert teacher. As natural pedagogy theory proposes, the culturally expert teacher manifests the relevance of the demonstrated event steps and the explicit manifestation lets the novice learner filter out the culturally shared and relevant content of the demonstration. From the above focal question, it would mean that selection mostly occurs during the encoding phase.

If selection takes place during encoding, then it has to be decided immediately (1) which steps and elements are necessary (relevant), and which ones are unnecessary (irrelevant), and (2) what should be done with the irrelevant steps. The second point is especially important, since if the irrelevant steps are kept at encoding, then they have to be left out during retrieval. This leads us to the question of how the irrelevant elements are stored: is the whole action sequence stored in one memory, and the irrelevant parts are left out at retrieval? Or are they stored separately, and reached back to in case they are needed?

In a preliminary study, we investigated whether the memories and memory processes of children, which influence encoding as well as storing and retrieving processes, are flexible enough to adapt to a situation with changed contextual parameters. That is, what is the nature of selection observed in imitative behavior? Does it happen on-line, during the encoding phase (as predicted by a cultural learning perspective), or is it a flexible process and selection occurs in retrieval?

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In our experiment, we demonstrated 2-year-old children events with changing contexts, where the different contexts either verified or disproved the use of a novel tool as opposed to a familiar action to reach a certain goal. We tested that regarding the tool use with semi-opaque relevance, (1) what is the typical copying mechanism during immediate re-enactment? Do children selectively imitate the tool use in the condition where the context requires it, and leave it out when it does not? (Not only does tool use in the 'relevant' condition make reaching the goal easier, but it is also a necessary step without which it is not possible to reach the goal. In the 'irrelevant' condition, it is not necessary at all, and it is rather inconvenient and requires plus effort which is not justified by the context). And (2) whether in deferred imitation, if the context changes (i.e., from being irrelevant it becomes relevant, therefore, its function has to be recalled and the step inserted into the causal chain of action steps; or the other way around, from relevant it becomes irrelevant and, therefore, has to be eliminated from the action steps), children flexibly adapt their retrieval processes. More specifically, whether they leave out the step after the delay if it becomes unnecessary and integrate it into their actions when it becomes necessary.

We used two boxes to create the two separate contexts. The two boxes were almost identical; they differed in only one key aspect that determined the relevance of the tool use. The tool was a small finger glove with a Velcro-like ending that stuck to the little plush toys that were inside the box and whose retrieval was the goal of the action. One of the boxes had a small hole; therefore, the finger gloves were necessary to retrieve the toys (the fingers did not fit into the hole well enough to grab the toys). The other box had a large hole, therefore the gloves were unnecessary for the retrieval of the toys.

We also checked whether a step that is always irrelevant (rolling the finger with the glove on the top of the box) and never necessary to achieve the goal because it is not in the causal chain of events remains in the action sequence of the children on the first and second testing occasion. We call this step the opaque irrelevant step since it is unnecessary in both contexts but its function is opaque to the children.

Demonstration always included both steps in question: the step with the changing relevance and the always-irrelevant step. Half of the children saw the demonstration and performed the immediate re-enactment with the box with the big hole. A week later (without demonstration), they received the box with the small hole. The other half of the children received the two boxes the other way around. To see whether it is necessary to highlight the function of the tool, in order for children to selectively use it when necessary, we also varied whether we highlighted the situational constraint at the beginning of the demonstration (showing whether her hand fits into the hole), or not.

On one hand, the contexts on the two occasions were very similar since we had almost the same object and same situation (occurring at the same place, with the same experimenter). Nonetheless, they differed in one key element which might challenge children's memory processes. This is similar to the Williamson et al. (2008) study in the sense that the situation provides children with experience about the efficiency of the prepotent response, but, compared to the original situation, in deferred imitation we changed the contextual frames in both cases. One of the situations, therefore, is very similar to Williamson et al.'s (2008) study since the situational information changes in a way that a strategy, a means of action that was efficient before becomes inefficient; therefore, children have to implement another, previously observed but not yet used means of action as a strategy. Here, the decision of

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using one of the available (not demonstrated) means of actions is online, and later the retrieval of the other (demonstrated) one is made based on the efficiency criteria of action. In contrast, the other condition aims to test whether, if something has been learnt to be relevant and hence to be followed, children can update this social knowledge in accordance with the changing situational constraint with regard to efficiency indicators. In this case, if we assume that a means of action is manifested as a culturally or socially accepted way of attaining a specific goal, it is encoded as a subgoal of the situation. Hence, the choice criteria are more social than instrumental, the efficiency criteria do not apply, therefore, they cannot guide the retrieval later. This would test whether we unconditionally accept something that we regard as relevant during encoding. Still, it is worth seeing whether, despite of this, we can flexibly update the information formerly labeled as social affordance, and whether its (irrelevant) meaning becomes transparent. Hence, this makes it necessary to use immediate and deferred re-enactment (as opposed to Simpson and Riggs 2011), to see whether retrieval strategies change and adapt in a flexible way.

Results so far suggest that at immediate re-enactment children imitate the use of the tool selectively if the model previously directed their attention to the situational constraints determining the relevance of tool use. Far more children used the glove when it was necessary to achieve the goal, and almost none of them used it when it was not. Interestingly, at the second time (when they received the other box) they did not change their strategy: whatever they did the first time, they repeated the second time. With regard to the always-irrelevant step the picture looks slightly different: roughly one third of the children imitated this step the first time, equally in the two conditions. However, the second time, children who experienced the demonstration and the immediate re-enactment in the context where the tool use was irrelevant kept this step even in the second testing, but those for whom the tool use was relevant the first time, left out this step at the second timing.

It seems that children do not change their strategies even though their own action is proven to be unsuccessful the second time (in the condition where the tool use becomes relevant and, therefore, there is pressure towards it), or it is clearly unnecessary (where the gloves become unnecessary to use because their hands fit perfectly into the whole). This might suggest that selection happens during encoding, and this guides the appearance of the matching social learning mechanism. Furthermore, it implies that their memory processes indeed seem to be inflexible: it is not just that they 'forget' the element in question and, therefore, they cannot use it in the changed situation (in the condition where the successful goal attainment requires the recall of that specific element) since in the other condition (where the step in question becomes irrelevant) all they would have to do is to leave out that step.

This is in accordance with the model of natural pedagogy (note that the demonstration included ostensive communicative cues): the information that receives the label of generic social knowledge is kept stable and is considered relatively trustworthy. Knowledge transmission happens in a cultural situation, and even though at the first time there is immediate selection, later on that information is kept. In other words, information selection occurs during encoding as a result of cues that highlight the relevance of event elements for the infants. The selection process, in this sense, could be conceived as a result of social guidance in the demonstration situation, and not as filtering by the individual learning system. The significant role of the social partner in this process thus endorses the stability of information that was transmitted – a crucial aspect of cultural contents.

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This supports the notion that the process of imitation and emulation are not two separate entities since we propose that learning processes reflect the level of the goal hierarchy where emulation takes place. This stance can provide the basis for the seemingly faithful imitation of knowledge labeled as social information that produces less variability and result in more stable cultural knowledge transmissions. This can be more fruitful than parallel emulation or imitation processes – there is some amount of selection that occurs, but then they keep the acquired information. As Richerson and Boyd (2005: 12) write, "[i]n many kinds of environments, the best strategy is to rely mostly on imitation, not your own individual learning ... then the lucky or clever of the next generation can add other tricks." There are, of course, other cases when the information is not kept. For instance, in the condition where the tool use became irrelevant there was further selection towards the always irrelevant step, causing children to leave out that step during second re-enactment. Nonetheless, situations might occur where there is imitation without selection. The question is, however, if there really is such a thing as 'blind' imitation.

An alternative possibility opposed to our above-argued emulation hypothesis is that children include a particular step 'just to be on the safe side' if the relevance of something is opaque, or if the imitation itself becomes the goal (e.g., in the case of social norms) – not a 'social goal,' but, because of the social situation, it becomes a relevant step. This, then, results in cases where the observer might just have this in mind: "I trust you. There has to be a reason why we do it."

Then again, regarding the always irrelevant step, it is possible that if the tool use itself is irrelevant during demonstration, then infants label the whole event as 'irrelevant' and code everything in this frame. Remarkably, they leave out tool use during immediate re-enactment if it is irrelevant, but they still keep the other irrelevant step. These two steps differ in the opacity of their function. In the case of tool use, it might be easier to detect its necessity for reaching the goal, but there is no explicit information about the other irrelevant step, hence its relevance is opaque – this might explain why more infants keep this step than the tool use. But it is still a question why those infants leave out this step in the second testing, when the tool use was relevant during demonstration and immediate re-enactment (first testing). It is possible that, when they try out the action for themselves, the causal relations become more obvious, and it becomes clear that the irrelevant step is not necessary, hence a second selection occurs between the first and the second testing. However, it is interesting that these children, despite the possible 'enlightenment' about the causal structure of the scene, do not leave out the tool use itself at the second re-enactment, even though all they would need to do is use their hands instead of a slightly complicated procedure of the tool use.

This again means that memory processes play a role in the type of behavioral answer that occurs: the overall goal manifested by communication alters what is marked as generalizable, semantic knowledge, and, therefore, kept in the child's memory. The informational content influences the perceived form of re-enactment, whereas the more detailed semantic content seems to reflect high-fidelity imitation (Király 2008). An everyday example is that, even though certain things would be much easier to eat with our hands, it depends on the cultural circumstances (for instance, if we are having a Hungarian meal at home, or enjoying an Indian dinner at our colleague's place) whether we stick to our socially accepted way of eating and using cutlery. In any case, we rely on our social scripts, thus on our socially constituted generic knowledge.

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Potential effects of memory processes on cultural transmission

In Simpson and Riggs's (2011) experiments, children showed a rather different pattern: during immediate reenactment, they imitated the actions faithfully, and after a delay, they imitated the necessary action steps selectively and left out the causally irrelevant step. The authors refer to Heyes and Bird (2007), who suggested that these two forms of copying could be explained by two separate types of mechanisms. While overimitation can be explained by sensorimotor models, where sensory input representations are directly linked to motor representations and hence enable the copying of meaningless actions, selective imitation involves a process where, between sensory and motor representations, there are higher level, conceptual representations (such as representations of the action goal) that enable goal emulation. Simpson and Riggs (2011) argue that the most plausible explanation is that, when children observe the demonstrated behavior, they form two kinds of representation: one sensorimotor and one conceptual. While the conceptual one remains strong, the sensorimotor representation fades away, and this leads to emulation in the long term. We sense a contradiction here: if the sensorimotor representations arise because the conceptual, higher-level representations cannot be formed, then how is it possible to form both types at once? Another question is what decides during immediate re-enactment which 'form' will win? According to Simpson and Riggs's (2011) data, sensorimotor representations 'win,' and this leads to the imitation of the irrelevant steps. But this suggests that the simple, sensorimotor representation is more dominant than the conceptual one, and that the conceptual representation could only exert influence if the sensorimotor has already faded.

In contrast with this, our data suggest that, already at immediate re-enactment, the conceptual representation would be in charge. The semantic content of encoding depends on both the cognitive opacity of the situation and the communicative signal present at modeling. These two factors induce in children the identification of the information that is worth learning. Inherently, when infants are guided to be able to reason according to their physical and functional knowledge, they select the semantic content by the help of their instrumental knowledge base. On the other hand, when children are guided by pedagogical settings to encode the cognitively opaque aspects of the situation as relevant, they select more elements (or all of the elements) as generalizable social knowledge, that is, semantic, generic elements as well. In the first case – since instrumental, efficiency guided reasoning was responsible for the encoding of the content – the semantic information is associated with the functional, instrumental domain. Yet, in the case of cognitively opaque contents labeled as relevant by pedagogical settings, the learnt semantic information could be associated with the social domain.

Based on this differentiation, it can be further supposed that the instrumental domain can be used not only for encoding, but children can also apply their efficiency based interpretative schemas to update the information. However, in the social domain, these efficiency based interpretative schemas do not apply, so that is why they do not update the information within this domain. The information which was introduced in a social learning situation, and which was signaled as 'culturally' relevant seems to be sensitive only to social refinement cues, and not to efficiency cues. This could be the reason for their inflexibility in performance. This inflexibility represents the guiding role of high-fidelity imitation and a selection bias during the learning phase (during encoding) in the case of contents that are signaled as

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relevant and also generalizable pieces of cultural information. It could also be a developmental issue, since Simpson and Riggs (2011) tested older children, hence there might be a fundamental difference between 2-year-olds on one hand, and 3- and 4-year-olds on the other. The question, however, is: what is it that changes? It can be supposed that already at the age of 2 children form conceptual representations even during immediate re-enactment. These representations can be part of 2 domains: instrumental and social. Regarding the social domain, we do not expect flexibility since there is no clear-cut inferential principle that could guide the updating. In the instrumental domain, it seems that 3-year-olds are ready to flexibly retrieve additional information according to the needs of the situation, resulting in a different strategy in re-enactment. However, at the age of 2 they are not yet able to do so.

Another factor in our results could be that the immediate re-enactment after demonstration would have an effect on children's strategy after the delay. But even if motor reinforcement is so strong that it leads children to stick to their original strategies (that is, if they would switch flexibly if there was only a delayed test and no immediate re-enactment), it leaves us with a puzzle. Is motor reinforcement, having performed a task once in a certain way, stronger than infants' conceptual and causal understanding of events? Once we do something in a particular way, will we not be able to change our way of doing it? One could argue that a second demonstration (before the delayed re-enactment) could help infants to correct their strategies – but they do not even always follow the demonstrator in the first place (i.e., they overwrite the demonstrator's strategy in the tool use irrelevant condition).

Our claim is that cultural transmission is a mixture of propagating knowledge from the instrumental and social domains. When a situation 'delivers' knowledge in the instrumental domain, even children and infants use their individual learning strategies and reasoning skills to optimize the content, and they learn an efficient way to attain a functional, instrumental goal. The learning is flexible, selective online, and probably also flexible during memory retrieval, later in development. However, when the pedagogical setting induces that the delivered knowledge is social in essence, for instance, it is a socially accepted way of attaining a goal, a social rule or a social norm, infants encode it as an important subgoal. The result of this encoding process is inflexibility since social norms do not necessarily follow efficiency criteria. Since the social content cannot be inferred with the help of reasoning principles, this inflexibility holds on.

We agree with Richerson and Boyd (2005: 8) on the notion that "individual psychologies determine which ideas are likely to be easy to learn and remember and which kinds of people are likely to be imitated" in the sense that the domain of the conceptual knowledge in question (whether it is social or instrumental) also influences the dynamic way of re-enactment in imitative situations. We claim that cognitive processes strongly influence cultural transmission; moreover, there is a mutual correspondence between cognitive processes acting on the potential knowledge domains and the cultural contents transmitted. This dynamic relationship determines where fidelity remains, promoting stability of culture in the form of the matrices of social norms and rules, and where we can give space to invention and creativity. And finally, this is how imitation can be mixed with the influence of individual learning, resulting in the population adaptation outreaching any individual achievement possible.

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THE NAÏVE PSYCHOLOGY OF CHILDREN: CONSTRUCTING A CULTURAL MIND THROUGH LANGUAGE AND SOCIAL PRETEND PLAY

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Naïve psychology (or theory of mind) develops in gradual sequence during the early childhood years. Naïve psychology encompasses diverse conceptual understanding, including pretence, desires, emotions, perceptions, intentions, and beliefs. Nevertheless, the ability to attribute false belief, the recognition that a person can possess beliefs which do not represent the true state of affairs, is often widely taken as a hallmark ability of a representational understanding of mental states. It is important to recognize that culture shapes individual minds and behaviors. Culture also influences the development of language skills and social competence – these are important aspects in children's developing understanding of mind. While the development of different naïve psychology concepts during the early childhood years has been studied extensively in the Western cultures, the majority of non-Western studies focus on false-belief understanding. There has been relatively little research that compares children's developing understanding of various naïve psychology concepts in different cultural contexts. This chapter focuses on the longitudinal development of children's naïve psychology within different socio-cultural contexts. It draws on the results of a large-scale longitudinal comparative study of naïve psychology development between children from the United Kingdom (UK) and Singapore. For the purpose of this chapter, this cross-cultural research will be referred to as the *UK–Singapore study.*[1]

This chapter begins by discussing children's developing understanding of various naïve concepts in Western contexts. Then the focus is on the four dominant theoretical interpretations relating to the development of young children's naïve psychology, which are often drawn upon the same empirical evidence. This is followed by an overview of children's acquisition of naïve psychology concepts in non-Western contexts. A synthesis of the key findings of the longitudinal UK–Singapore study is then presented. This leads to a discussion on the implications for current theories of naïve psychology and the important role of culture in influencing the impact of social environmental factors on children's naïve psychology development. The chapter concludes by identifying key issues and avenues for future research.

Children's naïve psychology development in Western cultures

Children in Western cultures have been shown to acquire knowledge of pretence and desires before visual perceptions, followed by beliefs. The different naïve psychology concepts, as will be discussed, develop gradually from rudimentary to sophisticated understanding.

An extensive body of literature has documented the developmental change of children's gradual mastery, from elementary to complex understanding, of pretence in Western cultures. Through manipulation and interaction, infants discover the functional uses of everyday objects in their daily experiences. From 18 months of age, they learn to use other objects as substitutes for the real things, such as using a banana as a phone (e.g., Leslie 1987, 1989, 1994, 2005), and they attribute pretend properties to objects, such as pretending to feed a baby doll (e.g., Nielsen and Dissanayake 2004). Empirical evidence shows that as children approach their second birthday, they become more competent in understanding simple pretence stipulations and transformations, and in describing successive sequences and consequences in the pretence episodes by giving non-literal descriptions and producing appropriate pretend actions (e.g., Harris and Kavanaugh 1993; Harris et al. 1994; Walker-Andrews and Harris 1993). A number of studies that focus on children's ability to distinguish between pretend and real acts, on the one hand, have found that 3-year-old children are able to distinguish fantastical events from real ones (e.g., DiLalla and Watson 1988; Golomb and Galasso 1995; Samuels and Taylor 1994; Sharon and Woolley 2004). Other studies, on the other hand, have explored children's ability to differentiate between imagined and real *entities*. For example, Woolley and Wellman (1990: Study 2) found that 3-year-old children are able to explicitly grasp the difference between reality and non-realities for pictures, toys, and pretence. Some research has investigated whether children understand pretence in terms of actions (acting-as-if, or behaving-as-if), or of mental states. In a series of experimental studies, Lillard (1993, 1996, 1998b) demonstrated that children below 5 years of age do not seem to understand the mental representational nature of pretence. Lillard's results showed clear developmental trends with children acquiring an adult-like understanding that pretence involved the mind by 8 years of age. In contrast, Leslie (1987) argues that the emergence of pretence marks the onset of children's understanding of their own and others' pretence. He claims that since pretence and other mental states share similar mental structure, one cannot engage in pretend play without the simultaneous understanding of the mentalistic nature of pretence (Friedman and Leslie 2007; Leslie 1987). It is important to note that adults' beliefs in the importance of pretend play in children's development vary across cultures. Moreover, the socialization process shapes children's play behavior. However, there is limited published evidence of children's pretence understanding in different cultures.

During the early childhood years, children also acquire a good knowledge of other aspects of naïve psychology, particularly of desires and perceptions. At around 18 months of age, when children develop a psychological understanding of subjective desires, they know that desired objects give happiness, and undesired objects may cause negative feelings (Repacholi and Gopnik 1997). This demonstrates that infants understand that others can have desires, and these desires might be different from their own desires. Research has shown that by 2 years of age, children know that people will feel good if they get what they want, and they will feel sad if they do not get it (Wellman and Woolley 1990). By 2 years of age, children acquire knowledge of level-1 perspective-taking when they

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understand that someone else may see something that they themselves do not (Moll and Tomasello 2006).

More sophisticated naïve psychology concepts are developed during the preschool years. At around 4 years of age, children understand that another person could see something in a different way than they do (Flavell et al. 1981; Masangkay et al. 1974). For example, a turtle in a picture may appear standing on its feet to them, but it may appear to be lying on its back to someone sitting on the opposite side of the table. In addition, 4-year-old children are able to distinguish between the appearance and reality of an object's identity (Flavell 1986, 1993; Flavell, Flavell and Green 1983; Flavell, Green and Flavell 1986). When given a deceptive object such as a candle that looks like an apple, they are likely to say that the object looks like a candle and really is a candle, or it looks like an apple and really is an apple.

Passing the false-belief task is often taken as a gold standard for determining whether a child has acquired a representational naïve psychology. In the classic unexpected transfer 'Maxi' task (Wimmer and Perner 1983), Maxi leaves some chocolate in a blue cupboard. While he is away, his mother removes it and puts it in a green cupboard. Children are then asked where Maxi looks for the chocolate. Children below 3 years 5 months tend to make the classic error by predicting Maxi's actions based on the true state of reality, whereas children at 4 years and above are able to predict Maxi's behavior based on his false belief (e.g., Wellman et al. 2001). There is evidence to suggest that infants attribute false belief in a modified non-verbal spontaneous-response task (e.g., Baillargeon et al. 2010; Onishi and Baillargeon 2005; Surian et al. 2007). Nevertheless, there is controversy over whether infants can truly represent false belief, either implicitly or explicitly (see discussions in Leslie 2005; Ruffman and Perner 2005; Stack and Lewis 2008). The majority of the findings suggest that the ability to attribute false belief develops between the ages of 3 years 5 months and 5 years (e.g., Wellman et al. 2001; Wimmer and Perner 1983).

In summary, 18-month-old children in the Western cultures acquire knowledge of rudimentary aspects of pretence and discrepant desires. By 2 years of age, children understand level-1 visual perspective-taking. At 3 years old, children develop a mentalistic understanding of pretence. At around 4 years of age, children exhibit understanding of level-2 visual perspective-taking, appearance–reality distinction, and false-belief prediction. Nevertheless, do children growing up in other cultures follow a similar sequence of development in naïve psychology? Parental support for children's understanding of pretence, desires, perceptions, and beliefs through everyday discourse about mental states may vary from culture to culture. More research is needed to elaborate on the degree to which the age of onset of children's understanding of naïve psychology concepts varies between different cultures. Furthermore, the gradual change from rudimentary understanding by 2 years of age to more sophisticated understanding at around 4 years of age is of interest to both theorists and education practitioners. However, there is no cross-cultural work that compares the developmental changes across this age range. The UK–Singapore study attempted to fill this gap by comparing naïve psychology development between two cultures.

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Theories of naïve psychology

How children acquire their naïve psychology concepts has been a topic of intense theoretical debate. There are four dominant theoretical accounts of the development of naïve psychology, namely modularity theories, 'theory theory' approaches, representational change accounts, and simulation theory.

Modularity theorists propose that children's naïve psychology has innate foundations and comprises of a series of domain-specific modules that come 'on-line' at some point in the course of development as a result of brain maturation (e.g., Fodor 1992; Leslie 1994). Metarepresentation and pretend play are two central concerns in Leslie's (1987, 1989, 1994) modular theory. Leslie defines metarepresentational ability as the capability to decouple a primary representation into a metarepresentational context. According to Leslie, metarepresentation and pretend play emerge from a Theory of Mind Mechanism (ToMM), which is a specialized neurocognitive mechanism that develops at about 18 to 24 months of age. As the ToMM matures, children develop an early understanding of pretend and desire representation in the second year of life, and an understanding of belief representation in their third year (Leslie 2005; Scholl and Leslie 1999). Leslie (1994) argues that 'pretend' and 'believe' belong to the same representational systems. An additional piece of processing component, the 'selection processor' (SP), is included in the ToMM model to explain the time lag between understanding pretence and belief (Leslie and Thaiss 1992). Minimal input is required from the SP when understanding pretence, whereas more input is required when understanding false belief. At 3 years old, children have difficulty with false-belief tasks is due to limitations in this component. The SP matures at around 4 years of age, and it is responsible for appropriate identification and selection of input for specific inference processes.

In contrast, 'theory' theorists propose that children's understanding of mind is characterized in terms of theory formation (e.g., Gopnik 1998; Gopnik and Meltzoff 1997; Wellman and Gelman 1992). According to proponents of 'theory theory,' infants are born with initial innate abilities that undergo revision as children are confronted with new evidence leading to the acquisition of new theories and elaboration of existing theories (Gopnik 1996, 2003; Gopnik and Meltzoff 1997; Gopnik and Wellman 1992, 1994). Understanding of own and others' mental states emerges at the same time as a result of children's theory development. Wellman (1990) suggests two distinct theoretical shifts in early naïve psychology development. At the age of 2, children acquire a simple desire psychology comprising an understanding of simple desires, emotions, and perceptions, which is mentalistic and non-representational. The first theory shift occurs at 3 years of age when children change from a simple desire psychology to a desire–belief psychology. At 3 years old, children understand both fictional representation (e.g., imagination) and reality-oriented representation (e.g., belief). However, they conceptualize beliefs as direct 'copies' of reality that represent the true state of the world. They do not understand that belief may not always be consistent with reality. The second theory shift occurs at 4 years of age when children acquire a belief–desire psychology. At this age, children understand that people's actions and behavior are guided by their desires, thoughts, and beliefs.

Although Perner (1991) is not a theory theorist, he shares the view that children construct their understanding of mind in a theory-like manner due to developmental changes in representational ability. Perner (1991) proposes two distinct stages of theory development. He

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identifies 2- and 3-year-old children as having a 'situation theory' of behavior. Children of these ages understand mental states such as pretence and desires as situations in the world, but they do not have a representational understanding of mind. Rather than a radical change of the situation theory, Perner (1991: 252) suggests that the change involves "theory extension," which is a relatively minor change to the early situation theory. At around 4 years of age, when children acquire a 'representation theory of mind,' they recognize mental states as representational and not simply as true state of affairs. Taking a domain-general view, Perner (1991) explains that children's false-belief understanding depends on their knowledge of representation as representation (i.e., metarepresentation). Support for the domain-general view comes from a study showing that 3- and 4-year-old children encountered equal difficulties with false-sign (i.e., object is moved but the signpost misrepresents current reality) and false-belief tasks (Leekam et al. 2008). This suggests that children have a general difficulty understanding representation rather than mental states specifically.

A fourth theoretical account is offered by simulation theory. Simulation theorists propose that children are aware of their own mental states, and they make use of this awareness to deduce the mental states of another person through a simulation process (e.g., Gordon 1986; Harris 1992, 1994). In other words, they put themselves in the mental shoes of another when predicting the other's behavior. Simulation theory places much emphasis on the role of pretend play and imagination in naïve psychology development. Between 2 and 3 years of age, children can set aside their own mental states and mentally simulate the mental states of another person (Harris 1992, 1994). For example, children begin to attribute mental states such as desires, perceptions and emotions to dolls at an early age. Between 3 and 4 years of age, the simulation process offers children the flexibility to gain insight into the psychological process (mental states, actions, speech) of another person or character during their role play, thus helping them to enact what another person or character might do in a given situation (Harris 2000). The improvement in the accuracy of their simulation enables children to imagine a situation that is in conflict with the current state of reality. With greater imaginative flexibility, 4- and 5-year-old children can solve false-belief problems by setting aside their own mental states and the reality of a situation while imagining the mental states of another person.

It is worthwhile to keep in mind that the four theoretical approaches are not mutually exclusive. A similarity can be found between theory theory and modularity theory. Both modularity and theory theorists hold that infants are born with innate theories which undergo revisions in the early years. While modularity theorists argue that children acquire the mental abilities as their brains mature, theory theorists, representation change theorists and simulation theorists consider social experience to play a role in children's naïve psychology development. In contrast to theory theorists, simulation theorists argue that since children understand others' mental states through a simulation process, their ability to understand their own mental states should develop before the ability to understand others' equivalent mental states. That is, they understand their own desires before understanding others' desires, and their own beliefs before others' belief. Furthermore, pretence is a defining feature in Leslie's (1987) modularity and Harris's (1994) simulation accounts of naïve psychology development, but it is less prominent in theory theory and representational change theory.

The four theoretical frameworks have been written by Western psychologists on the basis of research conducted largely in the West. Critics of the four approaches argue that they fo-

cus too heavily on within-individual development, with social experience playing no more than a triggering role (e.g., Astington 1996; Hughes and Leekam 2004). There is a lack of attention paid to the process of how children acquire their naïve psychology concepts within the cultural and social milieu (e.g., Astington 1996; Carpendale and Lewis 2004; Garfield et al. 2001; Lillard 1998a).

Children's naïve psychology development in non-Western cultures

Is naïve psychology development universal? A few non-Western studies have demonstrated that the development of naïve psychology concepts such as false belief and the appearance–reality distinction follows a similar marked shift between 3 and 5 years of age in a variety of different cultures (e.g., Avis and Harris 1991; Flavell et al. 1983b). The majority of these studies examining the influence of culture on the development of naïve psychology have been conducted in Africa (e.g., Avis and Harris 1991), Asia (e.g., Flavell et al. 1983b; Lee et al. 1999; Naito et al. 1994; Tardif and Wellman 2000), and the Middle East (e.g., Yazdi et al. 2006). The findings of these studies were usually compared with existing research conducted in the Western cultures (e.g., Brown and Dunn 1996; Gopnik and Astington 1988; Gopnik and Slaughter 1991; Moses and Flavell 1990; Perner et al. 1987; Siegal and Beattie 1991; Wellman and Bartsch 1988). A limited number of direct cross-cultural comparisons have reported universal development. For example, in a cross-cultural comparative study of false-belief understanding in Canada, India, Peru, Samoa, and Thailand, Callaghan et al. (2005) found consistent patterns with children passing the false-belief task at approximately 5 years of age. A meta-analysis of 178 studies of children's false-belief task performance, conducted by Wellman et al. (2001), showed that children's understanding of beliefs develops similarly across a number of countries/cultures, including Australia, Austria, Canada, Japan, Korea, UK, and the United States.

In contrast, a host of other studies have found cultural variations revealing that culture plays an essential role in children's cognitive development. Joshi and Maclean (1994) found that Indian girls between 4 years 2 months and 5 years 3 months performed better than English children of the same age in the real-apparent emotion distinction task. Vinden's (1996) results showed poor performance on false-belief and representational change tasks among children in Peru compared to Western norms. In a comparative study of 4 groups of children living in Papua New Guinea (Western children, and non-Western children from 3 cultural groups, i.e., Mofu, Tolai, and Tainae), Vinden (1999) found a 1-year time lag in false-belief performance among the non-Western children. Moreover, the Western cohort showed a lag of a year behind typical Western norms. Vinden (1999) reported that the Western cohort showed a gradual progression from 4 to 6 years of age rather than the usual 3 to 5 years of age. Similarly, Vinden (2002) reported that Mofu children in Cameroon showed a delay in false-belief understanding compared to Western norms.

Cultural differences have often been observed among cultures located on opposite ends of the individualism–collectivism spectrum. According to Triandis (1996), in individualist cultures such as Western Europe and North America, on the one hand, personal goals are given priority over group goals, and attitudes shape social behavior. In collectivist cultures such as Asia and Africa, on the other hand, individual goals conform to group goals, and

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social behavior is guided by norms, duties, and obligations. The majority of non-Western studies to date have investigated false-belief understanding in children aged 3 years and above, comparing collectivist cultures such as Japan and China with Western cultures. In contrast to Western norms, Naito (2003) reported poor performance among 5-year-old Japanese children in inferring another's false-belief. Ruffman et al. (1998: Experiment 4) found that Japanese children performed more poorly on false-belief and understanding of sources of knowledge gained by seeing or feeling in comparison to British and Canadian children. Naito and Koyama (2006) revealed that Japanese children only acquired an understanding of false belief at around 6 to 7 years of age, a year and a half later than Western samples. Much of the non-Western research has focused on children's false belief understanding. To date, there is no published longitudinal cross-cultural work that directly compares children's naïve psychology development between the ages of 2 to 4 years.

Differences were also observed between Chinese and Western cultures. In a meta-analysis of 196 experimental conditions in published and unpublished studies from mainland China and Hong Kong as compared to 155 conditions from North America, Liu et al. (2008) found similar patterns of performance on the false-belief task. Nonetheless, systematic cultural differences were also found, with children from North America performing at above-chance levels up to 2 years before children from Chinese cultures. Given the Western influences in Hong Kong, it was somewhat surprising that children from mainland China passed the task significantly earlier than children from Hong Kong in this study. In contrast, Sabbagh et al.'s (2006) findings revealed that although preschoolers in China outperformed their U.S. counterparts from a previously studied sample (Carlson and Moses 2001) on executive function tasks, there was no cross-cultural difference in performance on false-belief, deception, and appearance–reality tasks. It is important to highlight that these results were based upon cross-sectional data, and it remains unclear whether the acquisition of naïve psychology concepts are culturally-specific at different time points in development between two diverse cultures.

The inconsistent pattern of findings between Western and Eastern cultures is further complicated by the fact that, even within Western cultures, performance on naïve psychology tasks is not uniform within age (e.g., Freeman, Lewis and Doherty 1991; Lillard 1998b; Robinson and Mitchell 1992; Wellman and Estes 1986). Lecce and Hughes (2010) matched 5- to 6-year-old children in the UK and Italy in terms of chronological age (CA), verbal mental age (VMA), gender, and maternal education. Their results indicated that British children outperformed Italian children in the mean aggregate scores for first-order and second-order false-belief understanding. Even within Western cultures, differences in socialization goals, parent–child interaction, children's conversational styles, and education system might have contributed to variations in naïve psychology development (Lecce and Hughes 2010). This is also likely to be the case within Eastern cultures. For example, differences were observed in imaginary–reality distinction ability between affluent and deprived Indian children (Wahi and Johri 1994). Hence, it would be unwise to regard all Eastern cultures as homogeneous. The likelihood that these factors may also vary markedly across cultures should not be ignored.

Researchers have often relied on cultural dimensions such as individualism and collectivism to identify traits that might contribute to the differences in children's understanding of others' beliefs. Some explanations to account for the variations in naïve psychology

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development between Eastern and Western cultures include differences in language structure such as bilingualism and specific linguistic markers (e.g., Kobayashi et al. 2007, 2008; Lee et al. 1999), social differences such as socio-economic status, parental factors, family composition, and child-rearing practices (e.g., Liu et al. 2008; Wellman et al. 2006), differences in cultural experiences (e.g., Naito and Koyama 2006; Vinden 1996), and cultural differences in executive function ability (e.g., Chasiotis et al. 2006; Sabbagh et al. 2006).

In summary, extensive research in both Western and Eastern cultures has focused on comparing the difference between 3- and 4-year-old children's ability to understand false belief. The similar age of onset of false-belief understanding across some culture groups lends support to the view that naïve psychology is a universal ability. It is important to highlight that cultural and social factors shape children's pattern of development. Literature has emerged that offers contradictory findings about the onset of false-belief understanding (e.g., Jenkins and Astington 1996; Liu et al. 2008; Naito and Koyama 2006), suggesting the possibility of intracultural and intercultural differences in development. Hence, there is a need to embrace a socio-cultural approach when studying children's naïve psychology development.

Language skills and children's naïve psychology development

The development of naïve psychology is closely tied to children's language skills. Language not only aids children's ability to meet naïve psychology task demands but also plays a major role in children's naïve psychology development (e.g., Astington 2001; Astington and Baird 2005; Milligan et al. 2007). Some researchers suggest that the linguistic complexity of the false-belief task accounted for 3-year-old children's difficulty with understanding false belief (e.g., Chandler et al. 1989; Moses 1993). Children's ability to pass the false-belief task depends on a certain level of linguistic ability in order to understand the narratives of the story and make correct predictions and judgments (Astington and Jenkins 1999). In the standard unexpected transfer task, as children listen to the story being narrated, they have to follow the story sequence, understand the test questions and provide appropriate answers. If the task demands require less linguistic ability by engaging children in acting out the role of the character, 3-year-old children show better performance (Freeman et al. 1991).

Prior research on the role of language in false-belief understanding has involved the measurement of language competence using receptive vocabulary, general language, semantics, syntax, and memory of complements measures (see meta-analysis conducted by Milligan et al. 2007). Correlations between receptive vocabulary measured using either the British Picture Vocabulary Scale (BPVS; Dunn et al. 1997), or Peabody Picture Vocabulary Test – revised (PPVT-R; Dunn and Dunn 1981), and naïve psychology concepts have been reported in the literature (e.g., Cutting and Dunn 1997; Hughes and Dunn 1997). Happé (1995) demonstrated the link between VMA as measured by BPVS and false-belief understanding for both typically developing children (CA range: 3 years 1 month to 4 years 9 months) and children with autism (CA range: 6 years 3 months to 18 years 7 months). In a study of the relation between individual differences in pretence and naïve psychology development of children aged 3 years 4 months to 4 years 8 months in North America, Taylor and Carlson (1997) reported that children's knowledge of mental states was significantly

correlated with PPVT-R scores. Taken together, the existing findings highlight that language ability, as measured by receptive language skills, is important for aspects of naïve psychology understanding.

In cross-cultural research which compares children from different linguistic backgrounds, like the UK–Singapore study, it is important to acknowledge that variations in native and second languages might influence naïve psychology development in children. Studies have found that the mental state terminology of particular languages may facilitate children's false-belief understanding. In the false-belief paradigm, the test questions are phrased using belief terms such as *think* and *believe.* In English, these mental verbs are considered neutral (Tardif et al. 2007), whereas equivalent verbs of *think* such as *yiwei, dang* and *xiang* in Mandarin carry a certain degree of false-belief connotations (Lee et al. 1999). Evidence suggests that the use of the explicit false-belief verbs *(yiwei* and *dang),* but not the more neutral verb *(xiang),* facilitated children's false-belief understanding in China (Lee et al. 1999). These results underscore the possible influence of linguistic background on false-belief understanding. Exposure to these mental state terms in their daily conversations may have an effect on children's naïve psychology development. Hence, it is important to document and take into account children's linguistic ability.

Children's language skills and naïve psychology development develop in synchrony with their social interaction skills during the early childhood years. In other words, with greater language skills and understanding of others' mental states, children are able to participate in more sophisticated linguistic interactions with other people in social contexts such as pretend play and gain a deeper understanding of others' behaviors, feelings, and thoughts.

Social pretend play and children's naïve psychology development

Some Western studies which combined both observational and experimental approaches have provided support for the premise that shared pretend play is associated with children's naïve psychology development. In what follows, evidence that pretend play behavior influences the acquisition of naïve psychology concepts is first discussed and followed by evidence for the reverse relationship.

Studies have shown that individual differences in naïve psychology development are related to complexity of pretend play behavior. A few studies have observed children playing with their peers in preschool settings. Schwebel et al. (1999: Experiment 2) observed 31 preschoolers aged 3 to 5 years during free play in a day-care setting in the U.S. Their cross-sectional data revealed that children who engaged in more jointly constructed pretend play and were rated highly on transformation skills performed better on the appearance–reality task. Furthermore, joint pretend play was a significant predictor of children's knowledge of the appearance–reality distinction, after CA and VMA were taken into consideration. However, no relationships were found between solitary pretend play and naïve psychology concepts. Neither were any pretend play behavioral measures associated with false-belief understanding.

Nielsen and Dissanayake (2000) observed 40 children, aged between 36 and 54 months, playing with each parent in 2 sessions in a laboratory setting in Australia. The researchers conducted correlation analyses to test their hypothesis that children's pretend play behavior

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would be associated with their ability to pass the false-belief tasks. Their results revealed significant associations between false-belief understanding and certain components of pretend play (object substitution, role assignment, and exhibition of imaginary object pantomimes – e.g., children acted as if they were really holding a toothbrush), but no relation with other categories of pretend play (imaginary transformation, attribution of animacy, role play, and joint proposals).

Using longitudinal data from naturalistic settings, Dunn and colleagues examined the casual link between social pretend play behavior and false-belief understanding of 50 children in a 7-month study in the U.S. (Dunn et al. 1991; Youngblade and Dunn 1995). The researchers reported that children who had engaged in more role enactment at the age of 33 months were better able to explain actions based on false beliefs at 40 months of age. This research studied a group of children at two time points, but because the children came from only one cultural setting it is difficult to discern the impact of diverse socialization experiences of children from different cultural backgrounds on the relationship between pretend play behavior and naïve psychology development.

As regard the reciprocal relation, the results of Hughes and Dunn's (1997) study of 25 friendship dyads of 4 years of age in the UK revealed that naïve psychology (false-belief and deception) task performance was significantly associated with frequency of pretend play and mental state talk. Furthermore, children's task performance predicted frequency of mental state talk, after age was accounted for. Importantly, children who displayed frequent talk in pretend episodes referred to mental states more often in general than children who engaged in less overall talk. This research suggests that children talk about mental states to initiate and foster shared pretend play. Alternatively, children's experience in shared pretend play may enhance their awareness of mental states.

Further evidence of the causal relation between pretend play and naïve psychology development comes from a training study in Australia. Dockett (1998) demonstrated that 4-year-old children trained in a series of learning experiences, including setting up a pretend play pizza restaurant corner, achieved significant improvement in post-test performance on false belief, appearance–reality, and representational change. However, another training study conducted by Rakoczy et al. (2006: Study 2) in Germany did not produce a transfer effect of developments in pretend play behavior and pretence understanding to tasks that tapped children's understanding of false belief and appearance–reality distinction.

The research overviewed thus far examines how development of early pretend play behavior facilitates children's later naïve psychology development. In contrast, though, relatively few studies have explored the reverse relationship between children's early naïve psychology development and their subsequent competence to engage in complex forms of pretend play. A small-scale longitudinal observational study of 20 children between 34 to 45 months of age in Canada found predictive relations between early naïve psychology concepts (false belief and appearance–reality distinction), and frequency of pretend play behavior (joint planning and role assignment) 7 months later, after CA and VMA were taken into consideration (Jenkins and Astington 2000). The relationship was not symmetrical. That is, there was no evidence that social behaviors in pretend play predicted later naïve psychology development. In explaining the differences in results compared to Youngblade and Dunn's (1995), Jenkins and Astington (2000) noted that role enactment (the child acting out a role), which involves mental representation of action, would precede and enhance false-belief

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understanding. However, role assignment, which involves a more sophisticated level of representing two conflicting states (who the child really is, and the character being enacted), would develop after children acquire false-belief understanding.

Taken together, the link previously found between some aspects of early pretend play behavior and later acquisition of some naïve psychology concepts suggests a positive relationship. Regarding the reverse relationship, children's ability to consider contrasting perspectives and beliefs simultaneously will enhance their capacity to engage in complex forms of shared pretend play, which involves planning of pretend scripts, negotiation of roles and themes, and resolution of conflicts for the continuation of the pretend episodes. It is noted that some of these studies identified social pretend play behavior with peers as a promising avenue for exploring the relation between pretend play and naïve psychology development. Culture and cultural variants are transmitted not only from parents to child but also between peers (Newson et al. 2007; Richerson and Boyd 2005).

The UK–Singapore study

The UK–Singapore study is a 3-phase longitudinal study that combined both experimental tasks and naturalistic observations to explore children's developing understanding of various aspects of naïve psychology at 2½, 3 and 3½ years of age in 2 different cultural contexts, namely, Edinburgh in the UK, and Singapore. Edinburgh is the capital of Scotland, and it is a cosmopolitan UK city. Singapore is a multiethnic and multilingual nation located in Southeast Asia. The majority of residents are monolingual in Edinburgh, whereas Singapore has embraced an official bilingual education policy since independence in 1965. Although English is the administrative language and is used as the medium of instruction in schools in Singapore, pupils have to acquire a compulsory second language (Chinese [Mandarin], Malay, or Tamil). The blend of Eastern and Western influences and the use of English as the first language in Singapore offer a unique culture for comparative study. As a result of globalization, Singaporean children are exposed to norms, values, and ideas from Asia, America, and Europe. Singaporean children are raised with childcare practices influenced by Asian values of collectivism, conformity to norms and filial piety, as well as by Western theories of child development. With rapid commercialization, Singaporean children have been exposed to a variety of media such as television programs and advertisements featuring Western toys, sweets, fast food, and cartoons. Despite these Western influences, the UK and Singaporean families differ widely in their family experiences.

A total of 87 children were recruited in the UK ($M = 28.60$ months, $SD = 1.90$) and Singapore ($M = 29.89$, $SD = 2.76$) in the first phase of study. Of the initial sample, 36 children ($M = 42.75$, $SD = 1.84$) in the UK cohort and 38 children ($M = 43.68$, $SD = 2.79$) in the Singapore cohort participated in all 3 phases of the study. The UK cohort predominantly included children of Caucasian background, whereas the Singapore cohort comprised of children from diverse ethnic backgrounds, including Chinese, Malay, and Indian. While the UK and Singapore cohorts were similar in terms of first language spoken, birth order, and number of siblings, they differed from each other in some respects. The majority of the mothers in the Singapore cohort engaged in full-time employment, whereas a greater number of mothers in the UK cohort worked part-time. Consequently, the number of preschool hours and the

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number of hours cared for by non-parental caregivers were higher for the Singapore cohort compared to the UK cohort. Children were assessed on the British Picture Vocabulary Scale (BPVS; Dunn et al. 1997) at 2½ and 3½ years of age in order to ascertain their VMA and ensure that their language was in line with their CA.

The UK–Singapore study employed a repeated-measures design, incorporating a wide variety of standardized experimental tasks that tapped 4 main aspects of naïve psychology, namely, children's understanding of pretence, desires, visual perceptions, and beliefs. The task battery included: (1) attribution of pretend properties, (2) object substitution, (3) pretend transformation, (4) discrepant desires, (5) level-1 visual perspective taking, (6) level-2 visual perspective taking, (7) appearance–reality distinction, (8) mental representation in pretence, (9) pretend–reality distinction, (10) false-belief question in the appearance–reality task, (11) false-belief prediction, (12) false-belief explanation, and (13) imaginary–reality distinction. The methodology of this study has been described in detail elsewhere (Lim 2011a).

Semi-structured naturalistic observations of spontaneous social interactions during free play with peers were collected. A subsample of 26 children from each culture, matched by gender (13 boys and 13 girls), CA, and VMA were selected to examine the role of pretend play behavior in children's naïve psychology development. Only children who participated in all 3 phases of the study and played with same-gender partners in all observations were included. 5 categories of pretend play behavior, which were derived from the literature (Gosso et al. 2007; Howes 1980, 1985; Howes and Matheson 1992; Howes et al. 1989; McLoyd et al. 1984; Miller and Garvey 1984; Youngblade and Dunn 1995) and from preliminary observations of children's play, were coded continuously off video recordings of the play sessions using The Observer XT 9 (Noldus Information Technology 2009). These included peer play scale, types of social bids, pretend play themes, types of pretend role play, and modes of transformation. Different pretend play behaviors were further identified under each category. The detailed description and discussion of the specific procedural steps used to differentiate between different pretend play behaviors have been described in Lim (2011a, 2012a).

The longitudinal results showed cultural similarities in children's performance on several pretence understanding, the level-2 visual perspective-taking, the appearance–reality distinction and the false-belief explanation tasks. However, cultural differences were observed in the developmental patterns of some aspects of naïve psychology. The UK cohort performed significantly better than the Singapore cohort in the unexpected transfer false-belief prediction task at 3½ years of age, after VMA and gender were treated as covariates. Moreover, the UK cohort achieved significantly higher total mean for the level-1 visual perspective-taking task across the 3 phases and the mental representation in pretence task across 3 and 3½ years of age. In contrast, the Singapore cohort scored significantly higher in total mean for the discrepant desires task across the 3 phases. The majority of children from both the UK and Singapore had difficulty justifying their predictions or explaining the character actions at 3 and 3½ years of age. While the UK cohort employed significantly more mental state terms in their false-belief justification/explanation at 3 years of age, the Singapore cohort rarely referred to the desires and epistemic states of the characters in explaining action for either the prediction or the explanation task. The baseline and longitudinal comparative results of children's naïve psychology and belief understanding (including true-belief ascription,

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knowledge–ignorance attribution, false-belief prediction, and false-belief explanation) are reported in Lim et al. (2010a, 2010b) and Lim (2011b, 2012b).

Partial correlation analysis, with gender partialed out, was conducted to examine the relation between phases I and III VMA and task scores where variations between cultures have been found. It is important to consider language measures at the 2 time points because of the parallel development of language and naïve psychology. Several cross-cultural similarities emerge from the correlation analysis of language data. For both cohorts, there were significant concurrent (within phase) positive correlations between VMA and level-1 visual perspective-taking in phase I, between VMA and level-1 visual perspective-taking in phase III, and between VMA and false-belief prediction in phase III. In addition, longitudinal positive correlations between phase I VMA and phase III false-belief prediction were found for both cohorts. Early level-1 visual perspective-taking (phase I) was positively correlated with phase III VMA for both cohorts. There were no significant associations among VMA, action prediction, discrepant desires, and phase II mental representation in pretence task scores in either cohort. Given the mixed findings, it is difficult to establish a clear reciprocal relationship between VMA and naïve psychology in the present study.

More correlations, however, were observed for the Singapore cohort than the UK cohort. For the Singapore cohort alone, there were longitudinal positive associations for early VMA (phase I) with later level-1 visual perspective-taking (phase II) and mental representation in pretence (phase III). Longitudinal positive correlation between phase II level-1 visual perspective-taking and phase III VMA was also found. Moreover, there were concurrent positive associations between VMA and mental representation in pretence in phase III. Furthermore, there was a fairly strong positive correlation between phases I and III VMA. It was notable that these correlations were not found for the UK cohort.

Partial correlations, controlling for the effect of phase III VMA and gender, were employed to examine the relation between pretend play behavior and naïve psychology concepts. The correlation results revealed significant associations between some early social pretend play behavior and later acquisition of some naïve psychology concepts for both cultures. These results, as will be discussed in specific detail in the next section, provide partial support for the proposition that social pretend play behavior is an early marker of understanding mental representation. There were no significant relationships between non-social pretend play behavior and naïve psychology concepts for both cultures. The reciprocal relationships between some pretend play behavior and some naïve psychology concepts for the Singaporean children alone provide partial support for the premise that pretend play behavior and naïve psychology are closely related and intertwined. The cross-cultural comparative observational data of children's pretend play behavior and its relation with naïve psychology development are reported in Lim (2011b, 2012a).

Taken together, these findings extend our understanding of the cultural similarities in the gradual development of various naïve psychology concepts between the UK and Singapore, a hybrid culture. Nevertheless, there were substantial cross-cultural differences in the onset of some aspects of naïve psychology. The roles of language and social pretend play behavior in children's naïve psychology development cannot be fully understood without considering culture as a frame of reference.

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A cultural perspective of naïve psychology development: Evidence from the UK–Singapore study

The findings from the UK–Singapore study add to existing theoretical discourse by confirming the cultural universality of some naïve psychology concepts in Singapore and the UK. The four dominant theoretical frameworks of the development of naïve psychology, as will be discussed, can be applied to explain some but not all aspects of developmental changes in naïve psychology concepts between UK and Singaporean children.

Rather than an innate ability with the modules coming 'on-line' over the course of development as suggested by modularity theory (e.g., Leslie 1987, 1994), the development of children's naïve psychology might differ due to cultural variations in social experiences. The findings from the UK–Singapore study provide evidence of divergence in some aspects of naïve psychology at 2½, 3, and 3½ years of age between the two cultures. The disparity in the specific behavior exhibited by children of the same age in different cultures underscores the importance of considering cultural influences in children's development (Tomasello 1999). Moreover, development does not occur within "the individual, the sole child" (Bruner 1986: 149). The modularity theory could still hold, though not assessed within the UK–Singapore study, because infants may be born with innate knowledge of some rudimentary naïve psychology concepts.

The developmental patterns of naïve psychology concepts in both cultures lend some support to Wellman's (1990) model of theory formation: 2-year-old children acquire simple desire psychology, 3-year-old children are characterized as desire–belief psychology, and 4-year-old children are described as belief–desire psychology. Therefore, the first theory change occurs from 2 to 3 years of age, and the second change occurs from 3 to 4 years of age. The data also fit Perner's (1991) representational model where 2- and 3-year-old children's understanding of mind is considered as a 'situation theory' of behavior. By 4 years of age, children develop a representational understanding of mental states. However, as Lewis and Carpendale (2011) have noted, rather than developing in a theory-like manner, children's performance reflects different levels of cognitive loads or linguistic demands imposed by different naïve psychology tasks. Even if naïve psychology concepts tend to be acquired at similar age, an emphasis on the influences of cultural and social factors on children's growing understanding of mind should not be ignored. The focus of children's naïve psychology development should be on the processes and contexts that can affect understanding and conceptual change rather than age of emergence. Carpendale and Lewis (2004, 2006) propose that early social interactions account for the 'gradualism' observed in children's developing understanding of various aspects of naïve psychology.

In partial support of the simulation theory, the results of the UK–Singapore study indicate that pretend role play, and not pretend play in general, supports children's understanding of mental representation. For the UK children, role enactment at 2½ years of age was significantly correlated with false-belief prediction at 3 years of age and appearance–reality distinction at 3½ years of age. For the Singaporean children, role enactment at 2½ years of age was significantly associated with appearance–reality distinction at 3 years of age, and mental representation in pretence at 3½ years of age. In addition, significant correlation between role play at 3 years of age and mental representation in pretence at 3½ years of age was observed for the Singaporean children. Of note, there were no significant correlations

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for role enactment and role play with some aspects of naïve psychology. The simulation theorists overlook the fact that cultural diversity in pretend play or imagination may lead to differences in naïve psychology development.

There are some results observed in the UK–Singapore study that the current dominant theoretical approaches cannot explain. It is worthwhile highlighting that the results of the UK–Singapore study do not rule out the proposition that cultural values, practices, and beliefs contribute to the developmental process of children's acquisition of naïve psychology concepts. While theory theory, representational change theory, and simulation theory have acknowledged the role of early social experiential factors, these theoretical frameworks fail to fully consider the enculturation process that shapes children's developing understanding of various naïve psychology concepts. According to Miller (2005), the aim of cultural psychology is not to refute universals and the importance of innate drives or to presume that psychological theories must be constructed differently in every culture, but it is to recognize the cultural process as playing a fundamental role in influencing the pattern of development. Appreciating cultural and social influences as factors contributing to a mix of universality and diversity in development is the key to understand children's naïve psychology.

How is culture shaping the mind and behavior? Culture is a body of information acquired through social learning experiences such as teaching and imitation (Richerson 2011). Culture plays a part in shaping children's socialization experiences; therefore, it plays an active role in influencing every aspect of naïve psychology development from birth through preschool years and even in adulthood. Cultural influences are reflected in childrearing beliefs and practices. Parental knowledge of child development and expectation of appropriate and acceptable behaviors vary across cultural settings. Within a culture, members use information to regulate their own behavior and interpret the behavior of other individuals for meaningful social interaction (Blount 1982). For example, in collectivist cultures, acquiring social competence (goals, attitudes, and values) requires children to learn to cooperate and work in harmony with others (Keats 1997). Therefore, children acquire culturally related ways of not only understanding their own pretence, desires, perspectives, beliefs, and behaviors, but also adopting others' mental states and differentiating between their own and others' mental states.

The results of the UK–Singapore study indicating universal development in some aspects of naïve psychology do not preclude the fact that culture has a formative role in contributing to these similarities. Globalization may result in transcultural transmission of ideas and values. However, resistance to external influences (from within a culture) may lead to variations in the development of some aspects of naïve psychology. Hence, it is necessary to appreciate the extent to which cultural diversity might unfold within universal development (Astington 2006). While culture is a form of inheritance, it is very different in details from genes (Richerson 2011). Children do not blindly imitate their parents or another person but select among cultural variants (Richerson 2011). The results of the UK–Singapore study showed that the UK cohort achieved better performance in level-1 visual perspective-taking tasks across the 3 phases compared to the Singapore cohort. This finding contrasts with Wu and Keysar (2007), who found that American adults who grew up in an individualistic culture that promotes independence and places less emphasis on other-orientation were less able to interpret actions from another person's perspective than Chinese adults who grew up in a collective culture that values interdependence. With rapid globalization, attributing

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traits according to individualistic and collectivistic constructs might be somewhat arbitrary. Elements and traits of both individualism and collectivism may exist in the UK or Singapore. Hence, it is important that culture is not reducible to drawing a distinction between Western individualistic and Eastern collectivist dimensions. Cultural diversity may occur due to differences in religion, race, ethnicity, language, and geographic location.

The development of children's naïve psychology should be viewed as a process rather than age of attainment of conceptual understanding. In the majority of non-Western studies on children's false-belief understanding, the tendency is generally to evaluate children's responses as right or wrong without trying to explore the thought processes that children engage in to arrive at their conclusion. The UK–Singapore study demonstrates that there are culturally varied ways of how children justify their predictions and explain the behavior of a naïve character who has a false belief. This finding is consistent with those of Naito and Koyama (2006: Experiment 2), who found a tendency for Japanese children to incorrectly justify action based on behavioral and situational cues rather than provide desire-based explanations to account for the character's false belief. Taken together, these results suggest that children's thinking might be guided by cultural beliefs, norms and values.

Language plays a critical role in naïve psychology development (e.g., Astington 1996; Bruner 1986; Carpendale and Lewis 2004). The acquisition of sophisticated language skills allows successful interactions with other people. Culture and language are inseparable. Language is "a socially-conduced kind of cultural transmission" and is acquired locally through social interaction (Enfield 2011: 50). It is impossible to understand cultural phenomena (including language, ritual practices, and practical knowledge) and conventionalized social behavior without making reference to mental states (Enfield 2011). Within a culture, there are culturally specific ways of how people use language to share thoughts, feelings, perspectives, and beliefs. Even though children in the UK and Singapore cohorts speak English as their first language, there is cultural and linguistic diversity in terms of the usage of English in their daily conversations. Acquisition of specific naïve psychology concepts might depend on different aspects, or more than one aspect, of language abilities. In other words, it is important to determine which language and which aspects of the language influence which aspects of naïve psychology.

Children's naïve psychology concepts develop gradually in the context of social interaction (Carpendale and Lewis 2004). The non-significant findings between non-social pretend play behavior and naïve psychology concepts, but significant associations between some social pretend play behavior and some naïve psychology concepts suggest that naïve psychology development takes place in a social context. Children appear to be social learners, adapting their learning in different social environments. Joint attention and imitation first appear during infancy (e.g., Meltzoff 1988a, 1988b; Tomasello and Haberl 2003). Children gradually acquire the ability to engage in more complex social interactions with others during the preschool years. Joint activities in play provide a channel through which enculturation and socialization take place. In the UK–Singapore study, the cultural differences in the significant associations between some early pretend play behavior and later acquisition of some aspects of naïve psychology reveal that culturally-specific pretend play behavior might be linked to different aspects of naive psychology development. The results suggest an interplay of biological, cultural, and social influences. Nevertheless, this does not discount the role of innate factors in the early emergence and development of play behavior.

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Conclusion

There are both cross-cultural similarities and culturally-specific developmental patterns in children's naïve psychology. Despite the contrasting cultural backgrounds of the UK and Singaporean children, the similarities in the age of emergence of various naïve psychology concepts provide evidence for a universal development. Nevertheless, there are important cultural differences in the development of some naïve psychology concepts. Cultural values, norms, and practices, as well as parental beliefs, and the knowledge of children's development might be important sources of variability in the timing of onset of naïve psychology concepts. This is an important issue that cross-cultural research needs to address in the future. Language and social interactions, which play fundamental roles in shaping some aspects of naïve psychology development, must be recognized.

In conclusion, research in children's naïve psychology should move away from simply documenting age-related changes to studying how developmental patterns vary with different cultural and social experiences. It is essential that the dominant theories of naïve psychology development should consider the socio-cultural factors in shaping a mixed pattern of similarities and differences in children's developing understanding of naïve psychology concepts.

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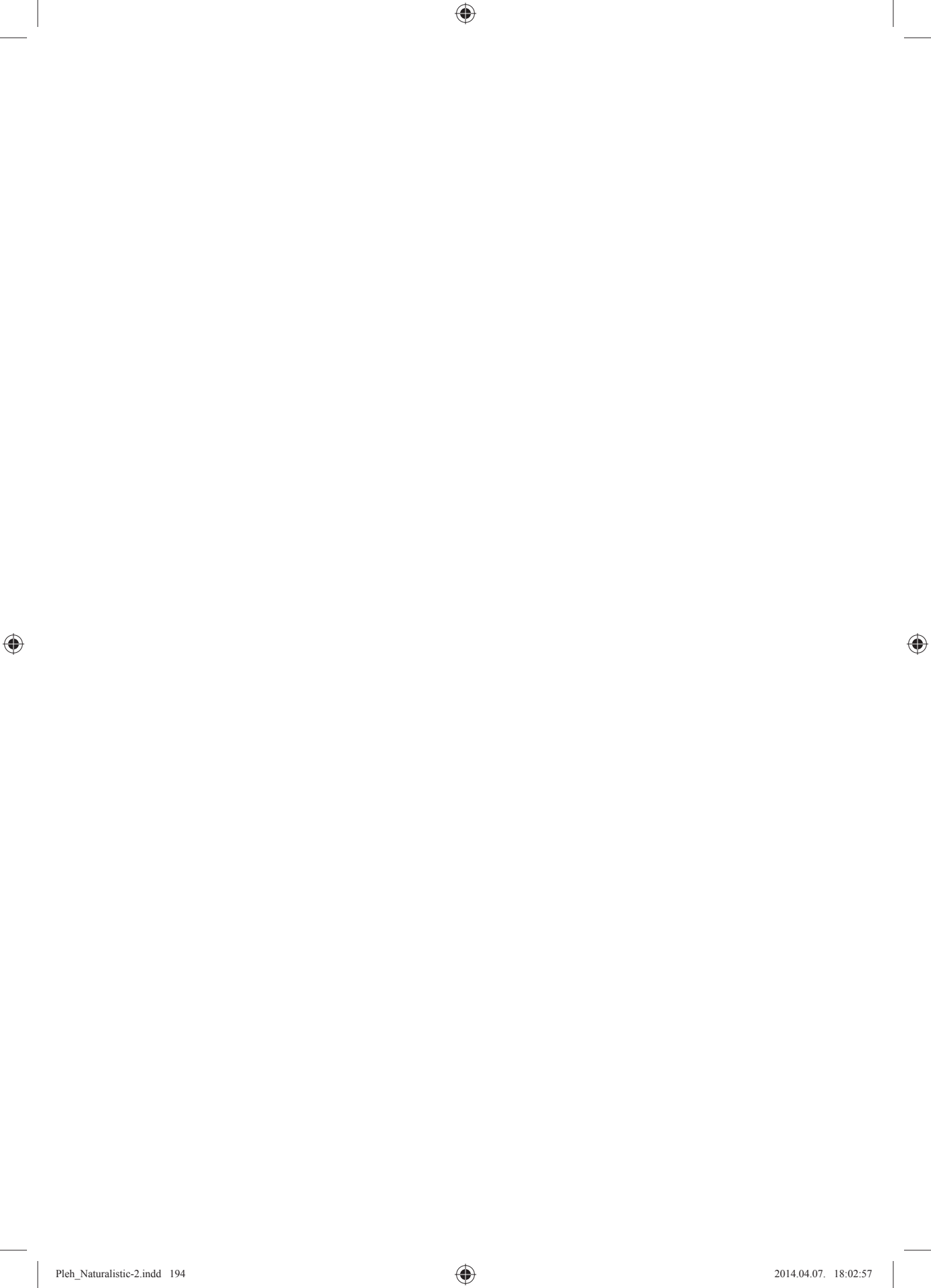
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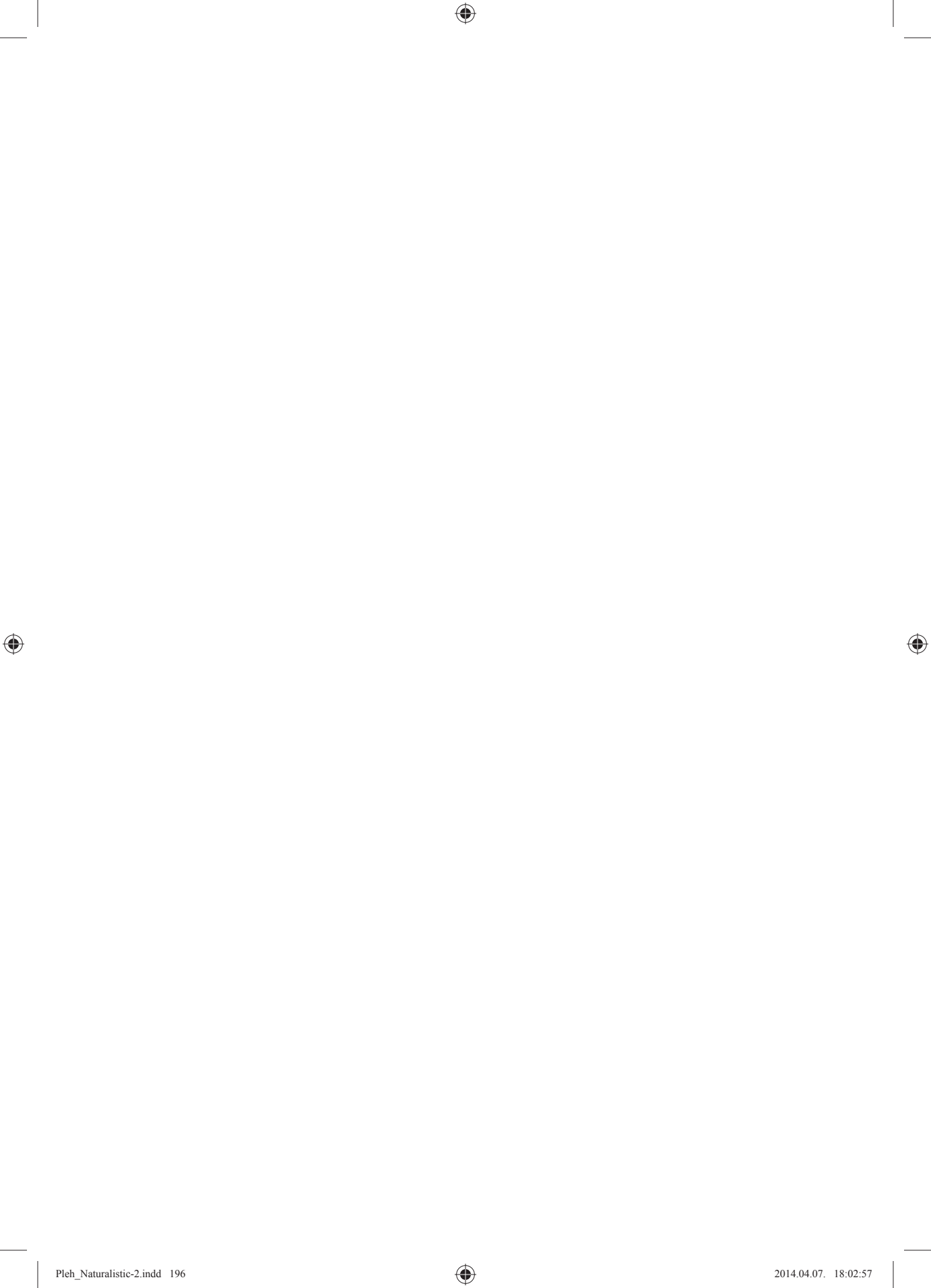
TRANSMISSION BIASES IN THE CULTURAL EVOLUTION OF LANGUAGE: TOWARDS AN EXPLANATORY FRAMEWORK

N. J. Enfield

Introduction[1]

In any natural, causal account of linguistic and other cultural transmission, an important role is played by the biases that regulate the process at various levels. These biases ultimately regulate the historical, cumulative transmission of culture. One reason for wanting to understand these biases is that they are phenomena of interest in themselves. In addition, while the discussion here presupposes the prior evolution of a capacity for cumulative culture in our species, our interest in transmission biases should ideally also give us some insight into that initial phylogenetic transition. In this chapter, I discuss some of the biases that have been described in previous work relating to cultural change, including the historical evolution of language, and I will point to the need for a coherent conceptual framework within which to explain just why we observe the biases we observe. After sketching a proposal for such an explanatory framework, I conclude by pointing toward some lines of research that this opens up.

Cultural epidemiology

In the cultural evolution of language, that is, the diffusion, maintenance, and change of linguistic practices in historical communities, it is often assumed or implied that the unit of analysis is the language system as a whole. But the replication and transmission of whole language systems is not causally conducted at the system level. It is an aggregate outcome of a massive set of much simpler and much smaller concrete speech events that operate on the elements which form *parts* of any language, such as a word or a piece of grammar (Hudson 1996). Language systems only exist because populations of linguistic items replicate and circulate in human communities, where these items are directly observable as elements of spoken utterances (Croft 2000; Enfield 2003, 2008). A causal account of language evolution focusing on the transmission of linguistic items can be termed an epidemiological view of language change, following Sperber (1985, 1996), and in a similar spirit to Keller (1994)

and Croft (2000). In an item-based account, the pieces of a language or other cultural system can change independently from other pieces, and they can be picked out and borrowed from one system to another, as for example when we borrow a word.

Of course, the notion of *item* is an abstraction. An item in the sense intended here does not refer to a bounded physical object. Even when such objects are implied (e.g., a cultural tool like a hammer), the item is always defined by sets of relations. Thus, a hammer is only a cultural item when we include not just the object but its relation to the human body and the functions it is designed for fulfilling (e.g., banging in nails). So, even the simplest items must be understood to be packages of relations. And of course all sets of relations are embedded in further such sets, and again in further such sets, and so on seemingly without limit, as any ethnographer or grammarian well knows. This is why an item-based account must also ultimately be linked to higher-level linguistic systems or grammars (see Enfield 2014). But we must avoid the temptation to treat these coherent systems as if they were organisms with bodies. Cultural systems are not organisms. They are observed aggregates of behavior, distributed in patterns of cognition, action, and material structure in the form of cultural items and the interrelations between those items. While ultimately we need a causal account for why it sometimes seems like we *can* treat languages as if they were organism-like systems (e.g., when we write grammars), it is first necessary to define the basic underlying causal anatomy of item-based language transmission. Here I outline the basics of a *transmission biases* approach to the historical evolution of languages.

Biased transmission

The diffusion of cultural items is best understood in terms of a *biased transmission* model of the distribution of cultural knowledge and practice within human populations and across generations, following a general framework of cultural epidemiology (Sperber 1985, 1996; Boyd and Richerson 1985, 2005; Enfield 2003, 2008). In a biased transmission model, the question of whether fashions of cultural practice in a population spread, decline, transform, or remain as they are will be determined by the cumulative effect of a range of biases which ultimately serve as filters or pumps on cultural practices in a competition for social uptake.

Linguistic and other cultural items are not confined to the mind, or to perceptible performance, but are simultaneously manifest in mental and material domains, *and* in *relations between* these domains. At any given moment, a human population is abuzz with a virtual mesh of ongoing causal chains that constitute continuous trajectories of production and comprehension of item-level patterns of behavior. I am referring to all of the situated courses of behavior in which people carry out goal-directed action by means of words, tools, body movements, and other cultural items. These trajectories of behavior are the contexts in which the natural histories of cultural and linguistic items are played out. They constitute causal chains with links from mind (I know a word; I understand a tool) to usage (I utter the word in a communicative act; I use the tool for a purpose), to mind (my addressee learns or recognizes the word; an onlooker builds or confirms an understanding of the tool's function, attributing a goal to my behavior), to usage, to mind, to usage, to mind, to usage, and on. We may call this type of causal trajectory a chain of *iterated practice,* or a cognitive causal chain (Sperber 2006). See Figure 1 for a simplified illustration.
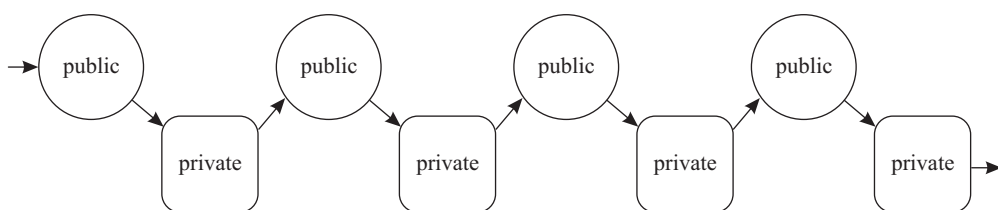
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Figure 1. Simplified illustration of iterated practice, or a social cognitive causal chain
(after Sperber 2006: 438)

Figure 1 is not the same as the "iterated learning" chains presented by Kirby and colleagues (2004; 2008), Christiansen and Chater (2008), among others (see below). Those iterated learning depictions resemble Figure 1, but they are not the same. In iterated learning, each arrow from public to private may represent an entire learning process such as a child's learning of a language. Each link in the chain is effectively a single macro-level 'state change' in ontogeny (e.g., the move from not knowing the language to knowing the language). This is shorthand for a great set of small events and small associated state changes. Learning a language involves not one event but many iterations of exposure and reproduction, and in each occasion of exposure and reproduction there is feedback that comes from others' reactions to our usage of words for communicative goals in context. This feedback plays an essential role in learning.

The iterated learning model abstracts away from these details (not without practical reason), while the iterated practice model in Figure 1 attempts to capture them directly and explicitly. While iterated learning focuses on the ontogenetic or biographical timescale, iterated practice focuses on the *enchronic* timescale, that is, the timescale of moves and counter-moves in sequences of human interaction (Enfield 2009: 10; 2013: Ch. 3). In Figure 1, each link in the chain from private–public–private does not represent a generation of individuals in a human population (by contrast with the comparable figure in Christiansen and Chater 2008). It represents a generation of individuals in a population of *items,* that is, one local cycle of instantiation of a practice, such as a single use of a word, a single performance of a ritual, or a single occasion of making bacon and eggs for breakfast.

The schema in Figure 1 draws our attention to a set of little bridges that a bit of culture has to cross if it is to survive a cycle of iterated practice. What are the forces that facilitate the passage across those bridges, and what are the forces that inhibit it? These forces are called *transmission biases* (following Boyd and Richerson 1985, 2005). This kind of account assumes a standard model of Darwinian evolution (variation of heritable characters in a population), but where the variation is guided in a specific way. As Boyd and Richerson (1985) formulate it, variation of cultural items is guided by the properties of human agents. If, for example, a certain way of doing something is easier to learn than some other functionally equivalent way (e.g., doing maths on an abacus versus a calculator), then this greater ease is likely to increase the frequency of the easier variant in the population, and, all things being equal, this variant will also in turn increase in frequency simply because it is already higher in frequency. Christiansen and Chater (2008) use this idea in arguing that the properties of

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the human brain, e.g., for language learning and processing, favor certain linguistic variants over others, leading to the view that language is the way it is because it is 'shaped by the brain,' and thus not because the evolution of a language faculty has caused the human brain to change in some fundamental way as a result of how language is.

Assuming this model of guided variation, the question then becomes: What are the forces that serve to guide variation in this way, and that operate upon different variants within a population, ultimately determining whether they become, or remain, conventional in the population? We now consider some of the known biases.

Some previously described transmission biases

Variants of cultural behavior compete for adoption by individuals in human populations. Different researchers have described different biases, sometimes in quite specific terms, sometimes in broader terms. For example, Chater and Christiansen (2009) describe four factors that mostly have to do with properties of the individual human body, especially the brain: (1) perceptuo-motor factors, (2) cognitive limitations on learning and processing, (3) constraints from mental representations, (4) pragmatic constraints. These factors can affect the likelihood that one linguistic variant is selected over another, though the social mechanisms that are also a necessary part of the process are left implicit by these authors. By contrast, Boyd and Richerson (1985) introduce distinctions that are broader in kind. They illustrate this with an example from table tennis. For the function of hitting the ball, one may choose between holding the bat with a pencil grip or a handle grip. Choosing one of these variants necessarily precludes choosing the other. They discuss different biases that might cause a person to select one grip over the other. A *direct bias* concerns the relationship between the variant and the adopter, and thus it concerns affordances (Gibson 1979). An individual should choose variant A if it is somehow more advantageous than variant B for a proximate function in a given context. Thus, by a direct bias we should choose the grip that is easier, more effective, feels better, and gives better results. An *indirect bias* works with reference to a notion of social identity, assuming that the variant a person selects will be seen by others and that this will lend a certain status to both the adopter (as the kind of person who adopts that variant) and the variant (as a variant that is adopted by that person or someone like that). We adopt variants of behaviors not only for their proximate efficacy but also with some notion of how we will be seen by others when we make that choice. So by an indirect bias we should choose the same grip as people who we identify with or want to emulate. Finally, a *frequency-dependent bias* favors variants that are more frequent.

Similar biases have been described in a vast literature in sociology on the diffusion of innovations (Rogers 2003). Here, we can discern three sets of conditioning or causal factors in the success or failure of a practice. First, *sociometric factors* concern the network structure of demographic groups. Different individuals are differently socially connected, especially in terms of the number of their points of connection to others in a social network, as well as the quality (e.g., intensity) of these connections. A practice is more likely to spread if it is being modeled by someone who is widely connected in a network, simply because he or she will expose a greater number of people to the practice. Gladwell (2000) refers to this as *the law of the few.* Second, *personality factors* concern differences between individuals in the population that can have consequences for the success or failure of an innovation. Some

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people are more willing than others to innovate and to adopt others' innovations (early adopters versus laggards). And these differences may correlate with social categories such as age, class, and subculture. Some people are better known or better admired in their social milieu and may thus be more likely to be imitated. Third, there is the sheer *utility* of an innovation, more or less what Boyd and Richerson (1985) mean by direct bias, outlined above. The innovation will take off if it is more advantageous to potential adopters.

The biases that we have just reviewed might be seen as a somewhat unstructured, ad hoc list. It is clear that they each play an important role in the mechanisms of transmission that drive the circulation of bits of culture in human populations. But how to explain them? Where do these biases come from, and how are they related to each other? How can we limit this possibility space? Can we motivate these biases by locating them directly in the causal anatomy of transmission? What predictions are possible?

One way to motivate and constrain the possibility space of transmission biases is to develop an explanatory framework that is grounded in the basic structure of iterated practice shown in Figure 1. Let us now see how this structure gives us a way of locating and characterizing the biases. If we examine the elements of transmission illustrated in Figure 1, we see at the heart of it a repeating, four-stroke cycle of transmission consisting of the following steps:

1) *Exposure:* A process of going from public to private, made possible by a mind and body coming into contact with, and perceiving/engaging with, the public instantiation of a bit of culture.
2) *Representation:* The storing and organizing of a private construct based on (1), and the private product of this process.
3) *Reproduction:* A process of going from private to public, made possible in part by an individual's motivation to cause the same public event as in (1).
4) *Material:* The material instantiation of the result of an event of reproduction of a cultural item.
5) Stages (3 & 4) can then lead to another round by exposing another person to the cultural item in question – feeding into a new stage (1).

Figure 2. Loci for transmission biases. A four-stroke engine model

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Each of the four steps is a bridge or existential threshold for any bit of culture to succeed or fail in the competition for uptake in a human population. If people are not exposed to it, it will die. If it is difficult to represent mentally, or if in the course of mental representation it is radically altered, it will die or effectively die. If people are not motivated to reproduce it, no further exposure will happen, and with the biological death of those individuals who have mental representations of the practice in question will come the historical death of the practice, as happens for example with language extinction. And if the material realization of the practice is not available to the perception of others, the transmission process will stall. Failure on any of these four loci of transmission causes a break in the chain and may cause the variant to no longer exist.

It is important not to get the impression that a single such chain represents the entire historical trajectory of a cultural item. It is only the tiniest strand. At any moment, there is a thicket of equivalent chains of iterated practice that keep a practice alive and evolving in the kind of sizable human population that would constitute a historical cultural community.

As discussed above, the key question that a biased transmission approach to linguistic epidemiology seeks to answer is: What are the filters, pumps, and transformers in an item's career? On the present proposal, we can posit four functionally-defined loci at which any bias may have an effect. Each locus is defined by the function it serves in accelerating, braking, or altering the transmission of practices in human populations through social–cultural interaction (i.e., at an enchronic level). While there may be a long, if not open, list of possible biases, they all should be definable in terms of how they operate upon one of the four transmission loci, exhaustively defined by the basic causal structure represented in Figures 1 and 2 above: exposure (world-to-mind transition), representation (mind structure), reproduction (mind-to-world transition), and material (world structure). Within the framework of these basic causal loci for transmission (1–4), different specific biases may affect the transmission of a practice in qualitatively different ways. As sketched above, some of these biases will have to do with facts about social networks, some with individual personality traits, some with properties of human perception, attention, memory, and action, some with the shape of the human body, some with the culture-specific means and ends that come with culturally evolved structures of activity, some with the organization of complex information in cognition. Let us now briefly consider how some of the previously described specific biases fit within the framework of these minimal loci for cultural transmission.

Exposure

Exposure, relating to the world-to-mind transition, is where biases can affect the likelihood that a person will come into contact with, and pay attention to, the practice.

Connectedness

All people are situated in social networks, but they are situated in different ways. One type of difference between people concerns the number of other people we come into contact

with. So-called connectors have a large number of social ties (Granovetter 1973), and so are more likely to be involved in an encounter with an innovation. Those who have few social network connections will have a lower chance of being exposed to a given practice.

Salience

Once one is in the presence of a behavior or kind of innovation, one may or may not pay attention to it. Things that stand out are more likely to be attended to. The definition of 'stand out' is clearly a matter of perception in the classical sense of affordances, that is, a matter of the relationship between a person and the practice. Some things are more likely to be noticed because of the nature of our perceptual apparatus in relation to the world. Other things are more salient to us because we are on the lookout for them, often because our language or culture encourages or requires it.

Identity

Who is the person carrying out the practice when it is encountered? If it is somebody who I want to 'be like' in some way, then I am more likely to pay attention to what the person is doing and how. If it is someone I have no affinity with, or desire to imitate, I will be less likely to inspect their behavior. In this way, social identity can play a role in exposure biases, by affecting the extent to which someone will attend, or carefully attend, to the practice when encountered.

Representation

Representation, relating to mind structure, is where biases can affect the likelihood that, or the manner in which, a practice will be learnt or stored by a person, or how the psychological or otherwise private component of a practice will be structured.

Once we have come into contact and at least noticed a practice, we can learn it. We form a representation of it, attributing to it some meaning or function, and we incorporate that representation in a framework of existing representations or knowledge. Some innovations are more memorable than others. Of two things we may notice, one will be more easily internalized. The reasons for this difference concern cognitive propensities that are either known from psychological science or that are on that research agenda. There are other differences in how things are learnt. The modality of an input (seen, heard, felt, or some combination of these) can have consequences for how a thing is interpreted, learnt, and understood (Enfield 2009). This then affects in turn how the knowledge is used in practice (e.g., it may account for how an agent decides that a practice is an appropriate means for certain ends in a particular context).

There are effects of the psychological context into which a practice is embedded. Practices are partly constituted by knowledge – knowledge that is caused by, and in turn causes, public behavior and associated states of affairs. Like any structured domain, knowledge is

characterized by structured patterns that include part–whole relations, hierarchical relations, and other sorts of dependency among items in a system. When we learn something, we relate it to other things we know, at the very least because it stood in relation to other things in the context in which we learnt it. As an example, if I learn a new word such as *unfriend,* I relate it to other words I already know, both in terms of similarity *(untie, undo, unfold)* and association (e.g., the fact the *unfriend* is a verb and is used with specific grammatical roles in English sentences). Or if I learn about the possibility of downloadable ringtones, I will naturally contextualize this in terms of my existing knowledge of mobile phones and internet access. Through this *context bias,* I am more readily able to learn and psychologically represent those things that have an existing place or slot in my current knowledge.

In language, items are structured into conceptual frames, systems of categorization, templates, conceptual metaphors, structural paradigms, and syntagms. While these systems often display a degree of symmetry, consistency, and simplicity, change is always taking place. It is in the nature of systems that when something happens in one place it will have effects in another place. In the densely structured linguistic systems of lexicon and grammar, such system-internal relational perturbations sometimes give rise to a certain "psychological shakiness," as Sapir (1921) put it, which can lead to reorganization of a system, in the private, mental realm, and then potentially in the public realm.

In the broadest sense of meaning, capturing everything from the arbitrary meanings of words in languages to the affordance-grounded functions of tools (Kockelman 2006), we benefit from what can be called *natural meaning.* If a word or grammatical expression is compatible with other information, for example by having iconic properties, it is better learnt and remembered. Similarly for technology, if there is a good match between affordances and functions, then we are more likely to understand the practice, it will be easier to learn, and indeed what needs to be stored representationally is reduced because the relevant information can be stored materially (Norman 1991). This kind of *content bias* pertains to learning, storage, and reduction of load on cognition, thus illustrating some ways in which 'representation' is a functional locus for transmission biases, both in language and in culture more generally.

Reproduction

Reproduction, relating to the mind-to-world transition, is where biases can affect the likelihood that a person will employ the practice themselves.

One way to think of this sense of reproduction is whatever causes a person to turn the private representation of a practice into action whose production and effects are then perceptible by others.

What motivates us to turn knowledge into action? Daily life involves goal-directed behavior that is motivated by our beliefs and desires (see e.g., Davidson 2006; Searle 1983; Fodor 1987). I may want to get something done for which I need another person's cooperation. One way to secure this is to produce an utterance using some selection of words and grammatical constructions. Depending on my specific goals, I will select certain words and will thereby select against all the other words I could have chosen. This is the competition among words and grammatical forms invoked in Darwin's (1859, 1871: 60) quote of Max

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Müller (1870): "A struggle for life is constantly going on amongst the words and grammatical forms in each language." The competition among different cultural practices operates in the same way. I have a goal, I have certain beliefs about how it can be attained, and I have certain knowledge that allows me to set courses of action in motion where certain effects are foreseen. All this points to a powerful bias under the reproduction rubric, concerning functional needs and means to ends.

Boyd and Richerson's *content bias* fits partly under this rubric. As discussed above, a content bias favors a practice that is more beneficial in some way to the one selecting it. As Boyd and Richerson (1985, 2005) point out, some aspects of these biases are "direct," others are "indirect." A direct bias is in operation when the benefit concerns the greater functional payoff, or reduced cost, of the practice, in terms of the primary effects it brings about. In the table tennis example, a direct bias would favor the pencil grip if the pencil grip were lower in cost or greater in benefit than the handle grip, that is, in terms of its efficacy for getting the ball back over the net and, ultimately, winning matches. An indirect bias is about the effects of whom you identify with (or against) by virtue of choosing a practice.

In language, there is an extensive literature on this phenomenon in the field of sociolinguistics. Speaking English, I might say *guy* in one context and *bloke* in another. It may be that there is a slight meaning difference between these two words (thus invoking a direct content bias), but these differences may be minimal compared to the effect of identifying myself with certain subcultural groups by virtue of this choice between different word forms with near-identical meanings. Clearer examples concern pronunciation: whether I choose to say *working* or *workin'* has more to do with who I identify with (an indirect bias) rather than what meaning I convey (a direct bias). In the cultural realm, both a Rolex and a Tagheuer will tell the time for a high price but the choice may depend on whether you want to identify with Roger Federer versus Tiger Woods (or, indeed, tennis versus golf). And there is perhaps most often some combination of the two. Do I choose to drink this brand of beer over all the rest because it tastes better (a direct bias), or because by doing so I identify with some person or group of people (an indirect bias)? It could be both. In any case, the mechanisms at play will serve to bias a person's motivation for selecting one practice over all the others that he thereby does not select.

The indirect bias is also sometimes described as a *model bias*. There is an important distinction to be made here depending on the age of the person concerned. How does a child select which variants of a practice to adopt? A conformity bias favors those practices that "everyone else" adopts (Boyd and Richerson 1985; Gergely and Csibra 2006). Another term for this bias is docility (Simon 1990), that is, an adaptive propensity to do more or less unquestioningly what other members of your group do. For the infant, this group will also tend to consist of the people to whom one is genetically most closely related. The effect is that cultural practices tend to (but need not) have similar histories as genes.

As a person becomes socialized to the point that they are regarded a full member of a cultural group, they will encounter a greater range and number of cultural items (i.e., they continue learning), and they may find themselves therefore with new choices. This may be because they encounter other ways of doing things than the way 'my people' do things, through their contacts with other groups, for instance in trading, ritual, and other kinds of intergroup social interaction. Different people will have different degrees of mobility, sometimes as a result of personality, sometimes as a result of gender (men often travel more

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widely than women), age, or subculture. At a later age, there is a greater degree of choice and therefore greater competition between choices. We may or may not consciously deliberate about such choices. But as adults we may be more aware of the meanings of the different options. Here is where the indirect bias looks more like the model bias exploited in advertising and also active in any other diffusional process as a low-level favoring of those practices that are modeled by more admired or charismatic people.

Material

Material, relating to world structure, is where biases can affect the manner in which a practice will be instantiated in the perceptible world.

Material biases concern the affordances of a cultural item for exposure and reproduction. Material biases can affect exposure biases in some obvious ways. Speech, for instance, as a result of a particular reproduction process (vocalization), has the property of being instantiated in fleeting form. A fact about the material of speech is that it is perceptible at the time of production, but then it is gone. But when a reproduction process involving language is carried out through writing, this evanescence is dramatically lessened, and the dynamics of transmission are significantly affected. Outside of language, we see similar contrasts. Forms of activity such as adopting a certain grip for table tennis are temporally fleeting and are only available for exposure simultaneously with the reproduction process that potentially constitutes the transmission event (photos, etc., aside). The table tennis bat itself, however, has a more persistent physical existence. Material biases concern the specific nature of the 'publication' of cultural practices such that they may continue to play a role in the exposure–reproduction cycle described above under the rubric of iterated practice.

Conclusion

The purpose of this chapter has been to address the need for an explanatory framework in the study of transmission biases in cultural epidemiology, focusing mostly on the case of language. A proper account of the cultural evolution of language must be explicit about the causal anatomy of the process. Previous work has usefully identified and described transmission biases, but one might ask: Why these biases? What other biases might we predict that are possible? How many might there be? I submit that we can answer these questions with reference to the basic causal anatomy of social transmission in human populations. Cultural epidemiology is powered by a four-stroke engine, a causal chain from exposure to representation to replication to material instantiation, back to exposure, and round again. When we talk about transmission biases, we mean any force that serves as a filter or pump for this process, by virtue of its effects on any of the links in this potentially open-ended chain of iterated practice.

Subsequent research should now turn to the tasks of, firstly, seeing if we can account for all of the currently known and understood biases within this four-stroke engine framework, and secondly, articulating predictions made by the framework such that we may empirically test them. In addition, such research should ultimately connect to research on the initial

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evolution in our species of the capacity for cumulative culture, a capacity that is so strongly pronounced in humans, and so weak, if present at all, in our closest relatives, the other apes. A first place to look for clues here would be to consider the known biases in connection with what is known about the cognition and social structure of other species. While we can readily assume that other animals are engaged in goal-directed courses of action, and that they select from among different means for certain ends in both the social and material realms, their selection of means for ends is relatively less flexible than that of humans. We might assume that a chimpanzee, say, will be guided in its selection of a behavioral strategy by a strong content bias, incorporating a basic min-max payoff logic. But if its repertoire of strategies is, on the whole, not being acquired by learning from others, then transmission biases will have no traction. That said, a topic for research could be to look and see the extent to which other apes possess the cognitive prerequisites for social transmission of the kind described here. While the biggest differences between us and them are known to be in social cognition, they are nevertheless intensely social species with textured social worlds. Many of the key cognitive and sociometric ingredients for biased transmission may have been in place before the evolution of our species, allowing the processes to kick in as soon as culture was being transmitted at all.

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DEVELOPMENTAL SCIENCE AND THE NATURE–NURTURE ISSUE: THE CASE OF LANGUAGE

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For the last five decades, the study of language, especially its ontogeny, has been one of the most important arenas for the nature vs. nurture debate, i.e., the question of whether human knowledge comes from the species' genetic endowment (nature), or whether most of it is learned from the environment through experience (nurture). Nurture-type theoretical positions dominated the first half of the 20th century, grounding natural languages in culture and in the acquisition in stimulus-response cycles. After the cognitive revolution in psychology in the 1950s and with the advent of developmental neuroscience, naturalistic approaches emerged and became dominant in the field, although nurture-type accounts did not disappear. The last 10–15 years have witnessed the appearance of a new synthesis, whereby innate mechanisms, learning and experience, perception, as well as social factors have all been acknowledged to play an important role in the development of language. In this new perspective, the question is shifted from a simple nature vs. nurture dichotomy to exploring exactly what mechanisms are responsible for what aspect of language acquisition, and how these mechanisms interact with one another.

Introduction

The origins of linguistic knowledge have long puzzled scholars of the human mind. We know of no human society that lacks language, suggesting that it is rooted in our biology in the same way as dancing is genetically endowed in bees or barking in dogs. Yet, human societies use languages that vary greatly, much like cultural artifacts. This two-faceted – universal, yet variable – nature of language has lead to opposing theoretical accounts, emphasizing one aspect over the other. Nurture-type theoretical positions dominated the first half of the 20th century. They saw natural languages as infinitely variable and different from one another, hence a product of culture (Boas 1940). Language acquisition was accounted for in terms of stimulus-response cycles, learning by reinforcement (Skinner 1957), and imitation (Mowrer 1960). Naturalistic approaches, dominant in the second half of the 20th century, viewed linguistic variation as superficial compared to the considerable amount of language universals. Therefore, they emphasized the genetic predisposition for language (Chomsky 1959; Guasti 2002; Lenneberg 1967; Pinker 1984).

Recently, advances in our understanding of epigenetics, i.e., how environmental factors influence gene expression at the level of the individual (Weaver et al. 2004) and of the biological roots of culture (Csibra and Gergely 2009; as well as the articles in the current vol-

ume) have lead to a re-evaluation of the relative roles of 'nature' and 'nurture,' highlighting their complementarity and synergy rather than their exclusivity.

Accordingly, the last two decades have witnessed the emergence of a synthesis in the domain of language acquisition, whereby innate mechanisms, learning and experience, perception, as well as social factors have been acknowledged to interact (Gervain and Mehler 2010; Gervain and Werker 2008). In this new perspective, the question is shifted from a simple nature vs. nurture dichotomy to exploring exactly what mechanisms are responsible for what aspect of language acquisition, and how these mechanisms interact with one another.

In this perspective, the initial state of the language faculty, i.e., the abilities and predispositions that human infants bring to the task of language acquisition, is of particular importance. Here, I will review the most recent advances regarding newborns' and young infants' speech and language abilities and argue that biological predispositions interact with experience from the earliest acquisitions.

The initial state

Readiness for language and/or prenatal learning?

The auditory system of fetuses is functional by about the 24th week of gestation (Moore 2002). Though the womb filters out most of the fine details of speech, like individual phonemes, some of the more general properties, such as prosody or rhythmicity, are preserved, transmitted through the amniotic fluid and serve as babies' first linguistic input. Indeed, fetuses respond preferentially to their mother's voice and their native language at 33–41 weeks of gestational age (Kisilevsky et al. 2009). Similarly, newborn infants recognize their mother's voice (DeCasper and Fifer 1980) and prefer the language(s) spoken by their mothers during pregnancy over other languages (Byers-Heinlein et al. 2010; Mehler et al. 1988; Moon et al. 1993). This confirms that learning about speech and language starts prenatally.

Interestingly, newborns can also discriminate two languages they never heard before, if those are rhythmically different from each other, such as English and Japanese (Nazzi et al. 1998; Ramus et al. 2000). They show universal phoneme perception, discriminating most phoneme contrasts that appear in the world's languages (Eimas et al. 1971). They can detect the acoustic cues that signal word boundaries (Christophe et al. 1994), discriminate words with different patterns of lexical stress (Sansavini et al. 1997) and distinguish between function words (articles, pronouns, prepositions, determiners, etc.) and content words (nouns, verbs, adjectives, adverbs, etc.) on the basis of their different acoustic characteristics (Shi et al. 1999). These abilities are not based on linguistic knowledge acquired in utero as they pertain to aspects of the speech signal that are filtered out by the womb, e.g., phoneme identity, etc. Rather, they show an early readiness for speech/language processing.

Is speech special?

What is it about speech that triggers these sophisticated processing mechanisms already before birth? Speech has been considered a special signal for humans (Liberman et al. 1967;

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Eimas et al. 1971; Pinker and Jackendoff 2005). It is our species-typical vocalization, producible only by a human vocal tract. Human listeners can thus recognize speech, but not other sounds, as the auditory signal they themselves can produce.

Following the motor theory of speech perception, human infants might be born with some kind of template that allows them to identify the physical/acoustic properties of speech. Indeed, neonates have been shown to prefer speech (in an unfamiliar language) over equally complex non-speech analogs (Vouloumanos and Werker 2004, 2007), or speech played backwards (Pena et al. 2003). But interestingly, newborns show equal preference for speech and rhesus monkey vocalizations (Vouloumanos et al. 2010). It is only at 3 months that they prefer speech to monkey calls. At 5 months, they can match speech to human faces and monkey calls to monkey faces (Vouloumanos et al. 2009). It seems, then, that the category 'speech' is initially broadly tuned, encompassing features that forward-going human speech and rhesus vocalizations share, but specific enough to exclude backward speech. Indeed, this latter is not producible by the human vocal tract, as some segments, e.g., stop consonants, cannot be reversed. Rhesus monkey vocalizations, by contrast, show important similarities with human speech, e.g., distinctive formant structure. These features might in turn be related to similarities between the functioning of the human and the rhesus vocal tracts, involving laryngeal phonation and rich articulation in the oral cavity. Future research will need to explore exactly which physical/acoustic properties of speech, broadly defined, play a role in infants' early preference.

If such a template is present in newborns, it could only develop through phylogeny, as young infants cannot yet produce speech sounds, and they hence could not have developed a template for speech on the basis of the movement of their own articulators. However, recent results suggest that at least some aspects of speech might be producible even by neonates. It has been shown that newborns' communicative cries already resemble the intonational patterns of their native language, i.e., the one they were exposed to prenatally (Mampe et al.). French-exposed neonates' cries thus exhibit a rising contour, those of German-exposed infants a falling one. It is, therefore, not impossible that while young infants cannot produce the full adult repertoire of speech sounds, the features that they are able to reproduce, i.e., prosody, contribute to identifying speech, or more specifically, the native language, as a special auditory signal. It is interesting to note in this regard that the familiar prosody of the native language and of the mother's voice might also serve as an identifying cue for the mother's face. It has been shown (Sai 2005) that newborns only recognize their mothers' faces if the mothers had talked to them previously. Otherwise, recognition is delayed. Thus, prosody might provide a cue to the intermodal matching of speech and talking faces.

The brain: Pre-wired for language or driven by the signal?

The majority of the right-handed adult population shows a left hemisphere advantage for the processing of language structure and a right hemisphere advantage for the processing of speech prosody and melody (Frost et al. 1999; Pujol et al. 1999; Zatorre and Gandour 2008). Exploring the neural correlates of speech and language processing in infants can determine what role language experience and innate predispositions play in the development of this functional specialization.

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At birth, infants show larger left hemispheric brain activity in the temporal areas when listening to their native language played forward than backward (Pena et al. 2003). Similar results have been observed at 3 months of age, with the involvement of the left planum temporale, the left superior temporal gyrus, and the left temporal pole in response to forward and backward native speech pooled together, and with the left angular gyrus responding more to forward than to backward native speech (Dehaene-Lambertz, Dehaene and Hertz-Pannier 2002). This suggests that a speech processing network similar to those of adults is operational at birth and soon afterwards. However, the above studies tested native language stimuli, leaving open the possibility that prenatal experience already shaped the brain and gave rise to the functional specialization observed. Recent studies testing the processing of artificial grammars and non-native languages at birth have yielded equivocal results.

Exploring whether newborns are able to learn simple repetition-based structural regularities in a series of NIRS studies, Gervain et al. (2008, 2012) found an increased response to repetition-based AAB (e.g., *babamu, nanape*) and ABB (e.g., *mubaba, penana*) patterns as compared to random ABC controls (e.g., *mubage, penaku*) in the bilateral temporal areas, with a somewhat stronger response in the left hemisphere, as well as in the left frontal regions. When initial and final repetitions, i.e., AAB vs. ABB, were directly contrasted, the differential response was localized in the left frontal region. The stimuli used in these studies were synthesized sequences with flat prosody, whereby the only distinctive feature was structure – the presence or absence of repetition, and its sequential position. The processing of structural regularities thus appears to be clearly left-lateralized at birth.

When natural language stimuli are used, complete with prosody, meaning, etc., a somewhat different picture emerges. A study comparing the processing of native Japanese and non-native English speech stimuli in Japanese neonates has reproduced the left hemisphere advantage for forward Japanese as compared to backward Japanese, but found no hemispheric differences between forward and backward English (Sato et al. in press). In general, the processing of Japanese, forward as well as backward, was left lateralized, whereas the processing of forward and backward English was bilateral. Further, a left hemisphere advantage for forward Japanese over forward English was observed. By contrast, another study comparing native English with the rhythmically different non-native language Tagalog found no hemispheric differences for either language, but an overall advantage for the native language over the non-native one (May et al.). In this study, stimuli were low-pass filtered to mimic the attenuation of the speech signal by the womb. A more recent study using the same design with non-filtered English (native) and Spanish (non-native), again two rhythmically distinct languages, similarly obtained bilateral activation for both languages and once again an advantage for the native language over the non-native one, carried by increased activation to forward English, but no such asymmetry was found for Spanish (May et al.). At the moment, it is not clear what might account for the differences found in the above-mentioned studies. One possibility is that it is not only familiarity that triggers lateralization, but also the specific acoustic features of the stimuli used, or of the languages involved, e.g., more or less intonation, the infant-directed nature of the stimuli, etc. Further work, in particular, detailed acoustic analysis, is needed to clarify this issue.

That the physical properties of auditory signals might, at least in part, drive hemispheric specialization is not a new idea. Imaging studies in adults have provided relevant evidence (Hickok and Poeppel 2007; Poeppel 2003; Zatorre and Belin 2001; Zatorre and Gandour

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2008). This body of work has given rise to two, somewhat different conceptualizations of the issue. According to the multi-time-resolution hypothesis (Poeppel 2003), the left hemisphere is, or in the revised version of the hypothesis (Poeppel et al. 2008), both hemispheres are, responsible for processing short, fast-changing events or narrow time windows, while the right hemisphere processes and integrates over larger windows. Under this view, then, language processing would be generally left lateralized due to the fast transitions between phonemes and syllables, except for the processing of prosody, computed over longer speech units, and hence right lateralized. Another view (Zatorre and Belin 2001) argues that the left hemisphere is responsible for precise temporal processing, whereas the right hemisphere is in charge of spectral information. While adult data exist to support both hypotheses, these cannot shed light on the *origins* of the processing biases. Recently, however, both hypotheses have been tested in young babies. In an EEG–NIRS co-recording study (Telkemeyer et al. 2009), temporally modulated noise stimuli were presented to newborns. The stimuli comprised segments that varied at 12 msec (fast), 25 msec (fast), 120 msec (slow) or 300 msec (slow). The auditory evoked potentials, positive deflections peaking at around 800 msec after stimulus onset, were not different for the four stimulus types. By contrast, the hemodynamic response was greatest for the 25 msec modulation in both hemispheres (but was not significantly different from baseline for the 12 msec modulation). The two slower stimuli were preferentially processed in the right hemisphere. A follow-up study with 3- and 6-month-old infants (Telkemeyer et al. 2011) documented a similar pattern: bilateral activation for fast modulated stimuli, and a right hemisphere advantage for slowly modulated sounds. A study testing the temporal vs. spectral hypothesis with NIRS in neonates (Minagawa-Kawai et al. 2011b) employed three types of sounds: a temporal stream with fast sound changes (~31 msec) between two tones that were an octave apart (shortest segment being 21 msec), a spectral stream with slow sound changes but several tones close together in frequency, and a control with slow changes and the two tones an octave apart. Bilateral activation was found for the temporal condition, but no significant response was observed in the spectral and control conditions. Taken together, the three studies suggest that at birth, temporally modulated sounds changing at around 25–35 msec are responded to preferentially but evoke more symmetrical activation than in adults. The 25–35 msec time range seems to be particularly relevant for speech, as it is the window in which phonemic information is encoded.

In sum, the left hemisphere advantage for speech was observed in some, but not all newborn studies investigating natural language processing, and it was completely absent in newborn studies looking at signal-driven processing. Whether it arises later, possibly as a result of language experience, or whether it is present at birth but not successfully captured by the stimuli used by the experiments remains a question for further research.

Attuned to the native language(s)

The initial preparedness for speech and language is broadly based, but it already shows the impact of learning. However, it is not until a few months later, during the second half of the first year of life that attunement to the native language(s) truly begins. This attunement, concomitant with a gradual loss of plasticity, is observable at all levels of speech perception from phonemes to prosody.

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Reorganization of the phonemic space

The reorganization of the phonemic space and the loss of sensitivity to non-native phoneme contrasts is the best-known attunement phenomenon. Infants, like adults, show categorical phoneme perception, discriminating the same acoustic difference better when it spans the boundary between two phonemes than when it falls within the same phoneme category (Eimas et al. 1971; Liberman et al. 1957). As noted above, initially, infants can discriminate most phonemes that appear in the world's languages. However, after several months of experience with the native language phoneme inventory, infants' ability to discriminate sounds that do not belong to it is gradually lost. For instance, infants growing up with English are able to discriminate between the retroflex /D/ and the dental /d/, a phoneme contrast found in Hindi, but not in English, at 6-8 months. At 10-12 months, they are no longer able to perform this discrimination, just as English-speaking adults cannot (Werker and Tees 1984). Hindi infants and adults, by contrast, maintain the discrimination throughout their lives. Since this first finding, the same loss of discrimination for non-native contrasts has been replicated for different languages and phonemes (for a review, see Gervain and Werker 2008; Saffran et al. 2006). In general, then, 'learning' the native phoneme inventory means that among the categories initially present, the ones that are used in the native language are maintained, others are lost or weakened. A few cases of improved discrimination or refinement of existing categories have been reported, however (Maye et al. 2008; Narayan 2010). It has also been observed that some non-native contrasts, in particular those that fall far outside the native phoneme space, such as click sounds, are not completely lost (Best et al. 1988).

What drives this attunement process? Phonemes are the smallest units that discriminate meaning. The sounds /l/ and /r/, for example, are separate phonemes in English as they distinguish between minimal word pairs like *low* and *row*. In Japanese, there are no /l/–/r/ minimal pairs; consequently, the two sounds constitute the same phoneme. Therefore, knowing minimal pairs such as *low* and *row* can help English-exposed infants establish two separate sound categories. Indeed, 9-month-old English infants have been shown to treat the dental /d/ and retroflex /D/ sounds as separate phonemes if they are consistently paired with distinct objects, i.e., the dental /d/ with one type of object, the retroflex /D/ with another type of object, but as the same phonemes if the pairing is inconsistent, i.e., both are paired with both types of object (Yeung and Werker 2009). While this mechanism undoubtedly plays a role, infants know too few words at the beginning of the attunement process, i.e., between 6–12 months, for it to provide an exclusive explanation. Rather, it has been proposed that infants track the relevant native categories in the statistical/distributional structure of the speech input they receive. Different accounts have been proposed (Best and McRoberts 2003; Kuhl 1993, 2004; Maye et al. 2002). One experimental demonstration (Maye et al. 2002) has shown that if 6-8-month-old infants are exposed to a bimodal distribution along an acoustic continuum, i.e., if two distant instances of the continuum appear very frequently (as would be the case for the retroflex /D/ vs. dental /d/ in Hindi), then they can discriminate the endpoints of the continuum. If, however, the distribution is unimodal, i.e., two similar instances in the middle of the continuum appear frequently (as the /d/ in English), the endpoints are no longer discriminable. This suggests that infants have formed two categories in the former and one in the latter case.

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Learning the shape of words in the native language

While learning the phonemic repertoire of their mother tongue, infants also start to grasp what words sound like in their native language. They begin to extract possible word forms (Swingley 2009), and they even start to associate meaning to at least the most frequently encountered word candidates (Bergelson and Swingley 2012). How do they extract words from continuous speech and what is it exactly that they learn about them?

Infants' first strategy to segment the continuous speech stream into words is statistical, just as in the case of phoneme learning. 8-month-old infants (Saffran et al. 1996), newborns (Teinonen et al. 2009) and, in fact, even monkeys (Hauser et al. 2001) and rodents (Toro and Trobalon 2005) are able to exploit the fact that phonemes and syllables within a word are statistically more coherent than sounds spanning word boundaries. Thus, the subsequent sounds in a word typically predict each other with higher probability than sounds across a word boundary. This universal property of language allows young infants to start segmenting continuous speech, positing word boundaries where statistical coherence is low, without any knowledge of what a typical word sounds like in their native language.

However, infants soon extract enough word forms to start discovering the phonological properties that characterize the words of their native language, such as typical stress patterns, phonotactics, etc. English-learning infants, for instance, develop sensitivity to the trochaic, i.e., stress-initial pattern typical of English (e.g., 'doc*tor,* 'can*dle*) between 6 and 9 months (Jusczyk et al. 1993; Morgan 1996; Morgan and Saffran 1995), German-exposed infants, German also being a predominantly trochaic language, show the same preference already between 4 and 6 months (Höhle et al. 2009). By contrast, infants learning French, a language with no word-level stress (and iambic stress at the level of clitic groups), show no preference for either stress pattern at 6 months (Höhle et al. 2009). A stress-based segmentation mechanism, called the Metrical Segmentation Strategy (Cutler 1994; Cutler and Carter 1987), has been shown to underlie 7.5-month-old English-learning infants' recognition of familiar words. When presented with trochaic words, English-exposed infants of this age prefer to listen to passages containing these words over passages that do not contain them and over passages that only contain the initial stressed syllable (e.g., dock, can**)** (Jusczyk 1999). By this age, English infants also use language-specific stress cues to segment words from the ongoing speech stream. When presented with a continuous stream of CV syllables where every third syllable was stressed, 7- and 9-month-olds treated as familiar only those trisyllabic sequences that had initial stress (SWW). Infants showed no recognition of trisyllabic sequences that were not trochaic (WSW or WSS; Curtin et al. 2005). Interestingly, when stress and statistical information are contrasted, 6-month-olds follow statistics (Thiessen and Saffran 2003), while 8-month-olds rely more on stress (Johnson and Jusczyk 2001). This clearly indicates a shift from universal to more language-specific strategies, reflecting infants' growing knowledge of the specifics of their native phonology.

A second language-specific cue to segmentation is phonotactics. A learner can posit word boundaries if she knows that in English, the sequence /br/ is frequent word-initially, /nt/ word-finally. Indeed, Saffran and Thiessen (2003) found that 9-month-olds can learn phonotactic constraints in the laboratory and use them in a statistical-learning type segmentation task. By the same age, infants also show evidence that their knowledge of the phonotactic constraints of their native language guides their word learning (Mattys et al. 1999). When

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familiarized with nonsense CVCCVC words, in which the CC cluster was either frequent word-internally, but infrequent across word boundaries in English (e.g., /ŋk/), or vice versa (e.g., /ŋt/), infants segmented the nonsense words into two monosyllables for word-internally infrequent clusters, but not for frequent ones (Mattys and Jusczyk 2001).

The distribution of allophones in different positions within words provides a third type of language-specific cue. In English, aspirated stop consonants appear in the initial position of stressed syllables (Church 1987), their unaspirated allophones appear in all other positions. Aspirated stops are thus good cues to word onsets. Infants as young as 2 months are able to discriminate between the allophones of a phoneme (Hohne and Jusczyk 1994), so they might use them as segmentation cues. Jusczyk et al. (1999) have indeed found that 9-month-olds are able to posit word boundaries (e.g., *night rates* vs. *nitrates*) based on allophonic and distributional cues together, and 10.5-month-olds can rely on allophonic cues alone.

Neural reorganization

This perceptual commitment to the native language is accompanied by the reorganization of the underlying brain circuitry. The perception and discrimination of certain phonological properties, which were initially acoustic, become linguistically based over the first year of life. This is accompanied by an increased lateralization of the corresponding neural processing, approaching the characteristic adult pattern (i.e., left hemispheric dominance for most aspects of speech and language, except prosody/melody, which is right lateralized; for a detailed review of this issue, see Minagawa-Kawai et al. 2011a).

A good example of this neural attunement comes from a cross-sectional NIRS study with infants, investigating the discrimination of vowel length. Adult native Japanese speakers are sensitive to the contrast between short and long vowels, given the moraic rhythm of their native language, and show a left-lateralized response (Minagawa-Kawai et al. 2002). When 3-4-, 6-7-, 10-11-, 13-14- and 25-28-month-old infants were tested, discrimination at the neural level was found at 6-7 months, 13-14 months and 25-28 months. This was interpreted as a U-shaped developmental trajectory, the discrimination arising by 6 months, disappearing at 10-11 months as a result of neural reorganization and reappearing afterwards. Interestingly, this differential response was bilateral at 6-7 months, but left-lateralized in the two older age groups, suggesting that the short-long vowel contrast is initially processed as an acoustic/physical difference and becomes linguistic by 13 months.

The processing of Japanese lexical pitch accent shows a similar trajectory. Behaviorally, both 4- and 10-month-old infants can differentiate low-high and high-low pitch accent patterns when carried by bisyllabic words. However, the corresponding brain response is quite different at the two ages. Young infants show a bilateral response when the pitch accent is carried by words or by pure tones. Older infants, however, showed a left-lateralized response when the contrast was implemented over words, and a right-lateralized response over pure tones, suggesting that the neural processing of (native) linguistic and non-linguistic sound contrasts diverges by this age.

In general, it seems that over the first few years of life, the initial language network, already in place at birth, extends and becomes more lateralized, developing the adult pattern. This corresponds to an attunement to the native language, with certain perceptual distinc-

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tions turning from merely acoustic into linguistic features. As a result of this neural commitment to the native language, the initial plasticity is gradually reduced, with a critical or sensitive period for native-like speech perception and production closing during childhood or early puberty (Johnson and Newport 1989; Kuhl et al. 2005; Lenneberg 1967; Newport et al. 2001). Whether all aspects of language have a sensitive period, when this period ends and under what circumstances (amount and type of input, etc.) are still heatedly debated. The exact neural and cellular mechanisms underlying critical period effects are also only now beginning to be elucidated, mostly in animal models (Barkat et al. 2011; Hensch 2003, 2005). Some recent results in the visual cortex of rats and other animals suggest that sensitive periods might be re-openable using specific drug treatments (Hensch et al. 1998; Hensch 2005). Whether such findings are applicable to the human language faculty is an exciting new avenue for research, with considerable impact on education policy, intervention for developmental disorders such as dyslexia as well as for therapy in case of brain injury, etc.

Conclusion

It has long been recognized that language belongs as much to human biology as it does to human culture. Recent advances in research on early language acquisition suggest that the two facets of language, nature and nurture, or, biology and culture, are not exclusive. Rather, they interact in intricate ways during normal human development. The focus of current and future investigations is, therefore, to identify exactly how genetically endowed and environmental mechanisms interface to foster the uniquely human ability of language.

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COGNITIVE ETHNOGRAPHY AND THE NATURALIZATION OF CULTURE

Arnaud Halloy and Olivier Wathelet

Introduction[1]

During the past two decades, cognitive anthropology (CA), as a discipline at the frontier of cognitive and social sciences, made an important contribution to the elaboration of a naturalistic approach to culture (Barrett 2004; Boyer 2001; d'Andrade 1995; Lawson and McCauley 1990; Sperber 1996; Tooby and Cosmides 1992). By developing a research program grounded on an epidemiology of ideas (Sperber 1996), one of the current mainstream cognitive approach in anthropology drew the attention of social scientists to the crucial role of 'cognitive constraints' in the elaboration and spread of (potential) cultural representations (Morin 2011). However, from an ethnographic perspective, such an approach to cultural transmission presents two important limitations. Firstly, as most naturalistic approaches to culture in biology and evolutionary psychology, it disregards or avoids dealing with the complexity and dynamics of real life situations, notably the situational factors that may play a constitutive role (and interact in an unexpected way with cognitive mechanisms) in cultural transmission. A second limitation is its focus on conceptualization processes, while emotional, attentional and perceptual factors may in fact be crucial in learning and memorizing cultural skills – cf. the so-called 'embodied cognition' approach (Varela et al. 1991; Clark and Chalmers 1998; Berthoz 2002; Shapiro 2011).

Consequently, a major issue we tackle here is how to connect the richness of ethnographic data to the ambition of CA, an ambition overtly developed in Dan Sperber's *Epidemiology of Representation,* but that has never been fully addressed by his followers. Cognitive ethnography (CE) is among the current approaches aiming to connect cognition to ethnographic work in a new way, as a major interest is given to its capacity to describe cognitive processes distributed and situated in specific places (Hutchins 1995a). First used by Edwin Hutchins, an American scholar from San Diego, to define his work in *Cognition in the Wild* (1995a: 371; see Giere and Moffatt 2003 for a prehistory of the notion), cognitive ethnography highlights the structure and dynamics of distributed *cognitive systems,* that is, how cognition is located in spaces inhabited by humans, tools, and material devices. In other words, it aims to extend cognition to a whole system larger than a single individual and to emphasize how *cognition* (Clancey 1997; Clark 1999) and *action* (Grison 2004) are closely interlinked and

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always situated. For instance, this approach sees intelligence and symbolic treatment as an emergent property of the interaction between humans and non-humans. Tools, artifacts, and the ways they are distributed into a specific location (Conein and Jacopin 1993) explain the emergence and distribution of representations (Zhang and Norman 1994). Canonical studies in the field[2] are about how airplane navigation is made possible as an interaction between actors (pilots) and complex control devices (airplane cockpit or merchant, and military ship navigation) (Hutchins 1995b; Hutchins and Klausen 1996), or about workplace studies, mostly using methods from ethnomethodology (Halverson 1995; Lahlou 2000; Suchman 2007; Licoppe 2008). As Dan Sperber rightly asserted (2001), these studies are often used to position themselves against a so-called 'cognitivist' paradigm given their tendency to exclude brain mechanisms when talking about cognition and its cultural variation.

At first glance, the opposition between these approaches appears to be irreconcilable. Broadly speaking, cognitive anthropology would highlight universal cognitive constraints and cognitive ethnography would describe situational factors relying on specific circumstances. We believe the potential gain of the collaboration between these approaches is most often underestimated, as each tends to minimize the relevance of the other side. Our view is that this opposition is not only unproductive at the academic level, but more importantly tends to mask the complex interaction at work between long-term and short-term cognition, between potentially inherited predispositions and acquired dispositions, between learning and acting.

In this paper, we would like to introduce a specific way of reconciling anthropological and ethnographic approaches of cognition by embracing a *cognitive ethnography of cultural learning* (CECL). CECL is an alternative framework for a naturalistic approach to cultural learning *from an ethnographer's point of view.* From CA, it holds to the aim of elucidating how our cognitive architecture constrains cultural transmission; from CE it promotes a situated approach to cognition, notably relying on the so-called embodied cognition. By adding the topic of cultural transmission to cognitive ethnography, our aim is to support a theoretical and methodological framework focused on learning processes, to be able to take into account the material, cognitive, emotional, and perceptual contexts of action and communication in a temporal framework at the level of activity and individual learning. By putting emphasis on ethnography, we address primarily the constraint of local activity and its specific temporality, focusing on how cognitive skills spread and emerge locally.

In the next part of this chapter, we will start with the description of what we consider as the most valuable contributions of both CA and CE to the understanding of culture – but also their respective epistemological limits. Then we will present our alternative approach to cultural learning. The last part of the chapter is dedicated to a brief illustration of CECL from both authors' fieldworks.

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[2] CE, even if firstly developed by an anthropologist, finds more followers outside social sciences, for instance in French cognitive ergonomy (Wisner 1995; Darses et al. 2004; Theureau 2004).

Epistemological background: Cognitive anthropology and cognitive ethnography

CA and CE differ in *the level of analysis* and *description* they favor as well as in *the way they conceptualize cognition.* CA focuses on identifying universal 'cognitive constraints' underpinning cultural transmission, while CE is first interested in functional constraints working at the level of "cognitive systems."

Among the best candidates to cognitive constraints in CA, we find what Pascal Boyer calls "ontological categories," which can be defined as tacit assumptions about the most general kinds of things that contain various default inferences which help us acquire new concepts (Boyer 2001). In substance, ontological categories are potentially innate 'recipes' for construing new concepts. This kind of cognitive constraint could play a crucial role in the transmission of many cultural concepts. Minimally Counterintuitive Concepts (MCIs), for example, would be "a special group of concepts that largely match intuitive assumptions about their own group of things (e.g., PERSONS, ANIMALS, TOOLS, PLANTS) but have a small number of tweaks that make them particularly interesting and memorable." (Barrett 2004: 23). For example, as Pascal Boyer (2001) defends it, if the concept of *ghost* is so widespread around the world, it is because it combines rich (intuitive) inferences associated with the ontological category of PERSON and some counterintuitive features such as invisibility, going through the walls, etc. making it particularly 'catchy' and memorable.

The extent to which these conceptual processes are context dependent is a matter of strong debate. As social psychologist Ara Norenzayan suggests (Norenzayan et al. 2006), MCIs are not cognitively salient concepts easily remembered *per se.* Instead, he draws our attention to the importance of contextual expectations, concerns, and goals of individuals dealing with MCIs. More precisely, these authors insist on taking into account a 'set of beliefs' instead of simply 'beliefs,' as the impact of MCIs is better when embedded in narratives where they are combined with intuitive concepts.

Narratives, in our view, might be a kind or part of a larger *cognitive system* able to "orchestrate" (Hutchins 2008) mental processes in specific situations. Cognitive systems include not only 'sets of beliefs,' but also the conditions and modalities of their enunciation. As Carlo Severi (2007) puts it from a pragmatist standpoint, the successful transmission of a belief depends heavily on its context of transmission, and not only on the clear understanding of its semantic content. This is particularly true in studies working on religion, showing that people involved in religious practice learn not only concepts but also the very context of their transmission (Houseman 1993, 2004; Severi 2007).

If CA and CE differ in the descriptive level they privilege, both frameworks also draw on different conceptions of cognition and cultural learning. Basically, CA sees cultural learning as based on a (modular) 'prewired' and built-in cognitive architecture while CE sees human cognition as a fundamentally cultural and social process always leaning on specific social and material situations. In our view, both conceptions of cognition and its relation to cultural learning are right, in the sense that they capture effective, distinct, and complementary dimensions of cognitive processes. But we see their respective epistemologies as too narrowly defined. Because of their focus on universal 'cognitive constraints' – i.e., potentially universal properties of human cognition –, most cognitive anthropologists *do not explore ethnographically* the impact of real-life situations on cultural learning, that is, the cognitive properties of actual cul-

tural learning systems *in the making*. And because of its focus on 'cognitive systems,' CE only *pays a slight attention to the impact of prewired cognitive constraints* on cultural learning.

As a heuristic attempt to bridge the gap between CA and CE, CECL needs to develop an analysis able to take into account, in the same description, both cognitive and situational properties. 'Cultural technologies', as we will see in the next section, are, in our view, the best level of analysis for such an enterprise.

Doing CECL: Exploring cultural technologies

By developing a CECL, we assume that ethnographic accounts about how culture and cognition are interlinked should be privileged over purely theoretical claims. Thus, relevant question becomes what should be described in the first place. We suggest that one relevant analytical elements of cultural transmission are *cultural technologies*.[3] Very concisely, a technology can be defined as an "in-between space of practice" (Belin 2002), neither totally material, nor totally subjective, where expectations and dispositions relative to an experience and skills are learnt and expressed. Cultural technologies are "cultural" as they lie down the conditions for producing and re-producing a shared experience. By way of illustration, religious rituals are powerful cultural technologies able to produce and re-produce a shared experience among people who take part in them – for example possession trance or ecstatic states as the result of an encounter between acquired and "prewired" dispositions (Cohen 2007) and a socially and materially organized environment. The success of transmission of an experience does not depend on cognitive and dispositional processes alone, nor exclusively on existing social and material environments, but precisely on their potential "orchestration" (Hutchins 2008), or configurations of shared patterns of thinking, paying attention, feeling, and behaving in specific cultural environments.

Exploring cultural technologies requires, in our view, a focus on patterns of acting, interacting, thinking, perceiving, and feeling that can be identified by the ethnographer in the field. Each category of patterns is constrained by acquired and prewired cognitive mechanisms *and* by the contextual features or conditions of its actual transmission (Halloy and Naumescu 2012). The articulation between cognitive and contextual constraints is complex, but what we insist on is that some cultural technologies are able to "hijack" (Boyer 2008) or even reframe intuitive processes of thinking, automatic emotional responses, and attentional and perceptual skills. In other words, recurrent patterns might be found not only in conceptual forms, a position defended by cognitive anthropology, but also in how cultural knowledge is performed, organized, and embodied – involving not only concepts/representations, but also spaces, artifacts, actions, interactions, and emotions (Halloy 2012; Naumescu 2012).

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[3] "Technology" is the best translation we found of the French word "dispositif". However, it differs from it in two ways. Firstly, "technology" connotes a human-made and material entity while a "dispositif" connotes the encounter between external (material, social, discursive...) and internal (dispositions, intentions, moods...) elements (Berlin 2002). As a result, not all "dispositifs" need to be human-crafted and some of them can be largely internalized. Secondly, "technology" looses the Foucauldian idea of a *system of relations*, which connects a series of heterogeneous elements (Agamben 2007: 8). In the absence of any English word for "dispositif", we will use the word "technology" as a synonym, echoing Alfred Gell's (2006) expression "technology of enchantment".

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One last important point: the framework we suggest is above all heuristic. Its central purpose consists in suggesting a conceptual "toolbox" (Houseman 2003) intended to better equip the ethnographic description. Two case studies will illustrate the CECL approach in the following pages. The first one is an ethnographic investigation of culinary skills performed by professional cooks. The second one is that study of how and why some cultic objects acquire their power in an Afro-Brazilian cult.

Case studies

Cooking cognition

One noticeable feature of cognitive ethnography is the emphasis it puts on qualitative methods focusing on lived situations (Ball and Oremerod 2000) instead of experimental settings (laboratory experience, *ad-hoc* tasks, and quantitative questionnaires) as, for example, in the classical work of cognitive anthropology on color vision (see the account of critics from Varela and Thompson 1990; Pylyshyn 2000). Observation, participation, and open interviews are common techniques, just like the use of video to produce complex traces of past activities (Williams 2006). By using videos of past activities as a medium for interviews (Clot 1999; Rix-Lièvre and Biache 2004), "the aim is to produce, within an ergonomic perspective, descriptions of the activity that are as close as possible to experience, in order to reveal and unravel the complexity of action and interaction" (Cahour and Licoppe 2010).

To study culinary skills of professional cooks working and teaching within a French Graduated Institution – Institut Paul Bocuse, located close to Lyon –, we used several techniques from classical ethnographic daily observation of mundane tasks to videotaping selected culinary situations. Among these, eight professionals and students close to completion agreed to perform two recipes written and selected with the help of one of our informants, a culinary teacher. The aim was to gain knowledge of culinary skills, describe the ways in which these are properties of a culinary system (a hypothesis of cognitive ethnography), and explain the ways these were learned (CECL's aim).

A preliminary step of the analysis was then to describe the functional properties of a specific culinary system, the one made of a professional kitchen where teachers use to cook.

The first range of observation – maybe the most obvious one – was to describe how the physical space was used to perform a complex task like cooking. For instance, time management is a critical factor of professional cooking (James 2006), relying on processes of distributed cognition (De Leon 2003b). It involves a mix of various skills like planning operation (which operations need more time than others), or developing some abilities to fasten or slow down culinary operation to allow a synchronization of several parallel processes of food transformation. To do so, chef has to make sure each ingredient is warm enough and not over- or undercooked, both criteria being inter-dependent as he knows that ingredients continue to be cooked even when they are on cold plate due to residual heat.

A third range of cognitive operation lies in the process of producing *ad hoc* "manipulative spaces" ("espace manipulatoire" in French; Conein 1990: 108, extending G.H. Mead's concept). By organizing the range of tools, raw ingredients, and other artifacts at the very beginning of the task, cooks set the basis for the following process at the scale of the whole

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system (like cutting, cooking, and combining), as well as at the micro-scale of tools and ingredients manipulation. For instance, that ingredients are usually put into small transparent boxes once they are cut into slices and bites, these boxes forming a row reproducing the order of appearance in the forthcoming recipe (see De Leon 2003a).

This simple situation illustrates one major effect of cognitive distribution through and on action. These operations extend memory within space and may reduce the effort required to remember and to perceive needed artifacts (Kirsh 1995; Clark 1997). Reducing the effort to think, perceive, and act in a kitchen is one of the explicit goals of education within the Institut Paul Bocuse. Indeed, a professional chef should be able to notice in a very short amount of time the relevant variation during the culinary process. The organization of environment structures the range of perceptual effort needed to perform efficiently. However, a second line of cognitive process is needed – some of them being outside the scope of classical cognitive ethnography – as, for instance, the perceptive skills used to judge the relevance of a line of transformation performed by ingredients in relation to an expected result. This is one of the major issues of the process of learning how to be a good cook, which convinced us to extend the framework of cognitive ethnography into CECL.

In order to understand how a cook performs perceptual skills and how attention is located in action, excerpts of the interviewed produced while watching videos of previous cooking activities shed light on major dimension of culinary cognition.

[Question: Why are perceptive skills so fundamental to cooking?]
When you are working with eighteen cooks, you need to do that [use your senses], *this is necessary. Because you have seventy order forms coming fast, seventy place settings… It implies it is just not possible to do stupid manipulation with the fish. If someone makes a mistake at the very beginning of the process, it is the whole service that is ruined. We are quite stressed all along the process; this is why we pay attention to everything that is happening.*" (Professional cook)

In a kitchen, we always keep our ears open; we always keep our eyes open, because we are never working on a single preparation, but on several ones. Many times we work on a side, the oven is not frequently in front of us; and then we always need to have a glance at our back to keep an eye on countertop. We always need to be alert. (Professional cook)

Interestingly, our informants confirm a classical claim of the anthropology of cooking: you need to experiment a day in a kitchen, most notably during a 'coup de feu' ['a rush on'], to understand how to act, perceive, and think in an appropriate way:

Somebody asked me how I got into the real restaurant business. I said it was the night fifty-two people came in, and they all ordered steaks. I learned to work the broiler that night… That is the best way to learn, though, when you have fifty-two tries at something, you've got to hit one right. (Schroedl 1988: 179)

We encounter here Tim Ingold's proposition of "education of attention" (2001) relying in this case on a guided immersion of apprentices by chefs within a rich and materially equipped sensescape. These perceptual habits depend not only on specific environments

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(Grasseni 2009), but also on negotiation between actors (Goodwin 1997). As such, informants explain how they create sensory cues during the culinary process to assess the quality of the culinary pathway as, for instance, adding a small bite of an ingredient just "*to create some witness. Here* [a chef watching the video of his own recipe] *you can see, and here it sparkles, this is the right time* [for adding another ingredient]." By creating this opportunity to hear a specific noise, the cook is then able to judge the level of temperature, and he knows when to add a new ingredient.

As suggested by our ethnographic material, sensory skills are at the intersection of the distribution of cognition within a worktop in a kitchen, the development of individual perceptual abilities leading to specific ways of conceptualizing substance (Hahn and Soentgen 2010) and variation in the perception of sensory qualities of ingredients. By connecting the mind to material environments, CECL provides a naturalistic account of how they are mutually shaped through action. Moreover, it is worth noting that the so-called coupling between mind–body environment is not a stable structure: it remains open to new configurations. To make it even clearer, space is never really the same as chefs recreate relevant conditions for perceiving by manipulating their material environment, but their acquired skills remain strong. This happens through a process of re-creating a cultural technology to allow for the reproduction of action and cognition. For instance, it is manifested in the use of the body of the cook itself. The body has been described as a central tool for cooking, allowing some cognitive operation like weighting, assessing temperature or quantity of foods (Sutton 2006; Patel 2008). In our fieldwork, one frequent operation was to touch meat while heating – more or less consciously according to the stage in the process – and assess the quality of the cooking. A well-known classification is the organization in several states like 'very rare,' 'rare,' 'medium,' 'well done,' and 'very well done.' To conduct their judgment, young students were told to compare the texture of the meat to the texture of the palm of their hand when pressing the thumb with other finger. As the texture of the palm slightly varies – due to modification in its muscular structure, it creates a sensory cue to compare the texture of the meat. This combination of a portable tool (the hand in its specific configuration) and some skills relying on representations and expectations creates an *ad hoc* prototype for sensory skills anchoring a set of behaviors into relatively stable patterns. This kind of mix between hands and skills create a cultural technology that may explain the cultural transmission of some major traits of cuisine practice in the professional universe.

Indeed, this use of the body as a central part of a culinary cultural technology condenses several qualities: it is personal, it is learned through a mix of imitation of chefs and of understanding oral instructions, and it does not rely solely on the verbal description of sensory perception, which is known to be the ambiguous translation of phenomenal qualities (Candau 2004). A similar learning process is performed by the use of the cook's own body to learn to evaluate temperature in general (Wathelet, 2013). In a first stage of the learning process, the temperature is assessed as minus, equal, or superior to the perceived body temperature. Progressively, stages are created in association with specific substances, and more complex classification is performed. Some cooks are experts in locating the variation of sensibility on their own body; the lips being, for instance, far more sensible than the bottom of the hand. By using a metallic tool put in contact with the food then with the lips, they are able to appreciate fine variations of temperature.

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These examples suggest that learning perceptual skills is a progressive process relying on the use of several tools, involving both 'internal' and 'external' cognition, and creating some cultural technologies aiming to create at least regularity, at best a stable structure for (efficient) performance. Shared patterns of behavior rely on a cognitive dynamics, which connects changing personal dispositions (representational and attentional ones) with changes in the structure of environment. Within these kitchens, knowledge, attentional habits, utensils, and bodies form a cultural technology attuned for the learning and refinement of perceptual skills. In other words, it is through action and the manipulation of artifacts that dispositions and expectations, on the one hand, and spatial and material organization, on the other hand, are interconnected. By pursuing a CECL of culinary expertise in various settings, we expect to find recurrent patterns in how cultural knowledge is embodied into distinctive bodily skills and states, as well as how it is enacted in performance and the manipulation of artifacts.

Empowering objects in the Xangô cult

One major benefit of CECL is the opportunity to take into account sensory and emotional relation between people and their surroundings within a cognitive framework. In our second case study, we go further in this direction by moving to the description of ritual systems leading to the 'empowerment' of religious objects in an Afro-Brazilian cult.[4] In other words, we will ask a simple but difficult question about some "cultic objects":[5] *How* and *why* do they become 'powerful' objects for their human counterpart?

By 'powerful' objects, we mean material entities able to make people think, feel, perceive and act in a way that presupposes a causal influence between them. In the Xangô cult, we suggest this 'power' of cultic objects would be the result of a mutual reinforcement of at least two categories of factors. The first category is the cultural transmission of interpretative models able to organize experience by making sense of dramatic episodes or by framing ritual interpretation where cultic objects are involved. This is particularly clear when analyzing, for example, punishment stories about the reconversion of Xangô members to Pentecostalism, where it is explicitly told that a wrong manipulation of their altar – like getting rid of it in the river or an open sewer on their pastor's advice – will attack them directly in their own body and mind. In all cases, such stories emphasize the idea of an indissoluble link between some cultic objects, the *orixás* (African deities) and their initiates. These stories feed the imagination about the 'power' of *otãs* (stones) or *ferramentas* (pieces of iron), which are the main elements of every altar (called *assentamento*[6]). This vital role could explain why

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[4] Ethnographic elements in this section draw on an extensive fieldwork in the Xangô, a possession cult of Yoruba origin located in the city of Recife, in the North-East of Brazil. In the Xangô cult, at least two African deities (*orixás*) are assigned to every initiate and materialized in personal altars composed, as we will see, of stones (*otãs*) or pieces of iron (*ferramentas*).

[5] By "cultic objects" we mean "those material artifacts that are specifically intended to a ritual function" (Moisseeff 1994: 8).

[6] Every altar is composed of a small earthenware bottle containing water and a large earthenware, wooden or ceramic plate containing the *õta* or *ferramentas,* as well as other objects associated with *orixá.*.

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many converted worshippers prefer to abandon their *assentamento* in their initiator's temple rather than destroying it. However, even if such dramatic stories may have a real impact on Xangô members's behaviour, they don't tell us how and why the intimate binding between objects, deities and humans is actually woven, why and how mere natural objects or artifacts become powerful entities? We suggest the answer is to be found in the second category of factors: the formal features of the body's and objects' treatments during ritual action.

Our central claim is that the fundamental cognitive, emotional and perceptual processes that sustain the empowerment of some cultic such as stones consist in an *ontological hybridization process* realized through their introduction and manipulation inside the ritual sphere. A first step is realized with the ontological transformation of mere objects and artifacts into 'object-gods', i.e. objects deemed to *be* an *orixá*. Physical cues such as the stones' shape, texture and color, as well as the circumstances in which they were found play an important role in guiding first presumptions of 'object-god' identification (Sansi-Roca 2005). For example, a bright-toned and smooth stone found near a river by a future initiate will be easily associated with *Oxum*, the *orixá* of sweet water and rivers, whose color is yellow. But most of the time, for *presumption* to become *conviction*, oracular consultation remains essential. The person who found the stone will bring it back to the temple and ask the cult leader to "play the shells" (*jogar búzios*), i.e. to consult the oracle that will confirm (or not) the divine nature of the stone. At this stage, however, we only have a "generic" *orixá*, what we have called an 'object-god'. A second step, which is essential for cultic objects to acquire the power they are deemed to exert over their human counterpart, consists in transforming an 'object-god' into an 'object-body'. In other words, to transform a generic object into an intimate one, connected to one person's body in particular. As we suggest, such a radical change is elicited by *formal features* of ritual action involving objects and the body of individuals for whom they are being manipulated. One aim of CECL is to identify ritual features directly at work in the Xangô cult and able to elicit, but also hijack, as we will see, evocative, emotional and perceptual resources.[7]

Ritual features and mental processes: dynamic ontologies

We can identify three main rituals where *orixás*'s altars are systematically manipulated:[8] the *amasí* or bath of leaves, which is a prophylactic and purificatory ritual that precedes the animal sacrifice; the *obrigação* or animal sacrifice and the *feitura*, which is the initiation ritual par excellence, where the initiate's head is shaved and his/her body and head are scarified (*catulagem*). If we systematize our observations of those three ceremonies, at least three remarkable and recurrent features of ritual treatments of cultic objects are to be found. We hypothesize they are at the core of the ontological hybridization of object-gods into object-bodies, which confer to them their power.

[7] For a more detailed theoretical and ethnographic description of this argument, see Halloy 2013.

[8] Those three rituals are part of the initiation process and, apart from the scarification ritual, they are reiterated every year for each initiate.

Contiguity

A first recurrent feature is contiguity: objects and body are systematically brought into physical contact during rituals of *amasí* and *feitura*. Why is that so? What might contiguity do to the hybridization process of cultural objects?

Recent experimental research on magical thinking suggests an interesting answer. Very sketchily, what we learn from these studies is that the laws of contagion and similarity described by Tylor, Frazer and Mauss more than a century ago are not a singular feature of 'primitive' thought, but should rather be conceptualized as deeply-rooted cognitive processes of the human mind (Rozin et al. 1989). For the present analysis, what interests us in the first place is the law of contagion and how it is actually mobilized in the Xangô cult. A formula grasps it elegantly: 'Once in contact, always in contact.' Magical contagion, in other words, operates as if one entity, through a physical contact with another, would permanently transfer some of its fundamental properties to the other (Rozin and Nemeroff 1990). Of course, people can react and use rationality to overcome this emotional impression, but in most cases without being able totally to suppress it.

This idea of a transfer of 'fundamental properties' from one material entity to another by physical contact fits very well with Xangô members' notions of ritual efficiency. Sacrificial blood and its ritual use, for instance, exemplify the idea. Blood is first of all a bodily substance and, as such, maybe one of the most frequent *prima materia* used in magical works all around the world. For Xangô members, blood is a highly evocative concept and is frequently associated with 'life' itself. This is why, when combined with ritual activity, Xangô members associate blood with the concept of *axé* (pronounced 'ashé), the vital force present in living things but also in many objects and substances. Ritual acts are, in their view, conceptualized as the necessary means for transferring *axé* from one body or object to the other, like some kind of 'spiritual' transfusion:

> *Why the blood, the animal? What is blood? Isn't blood life itself? Nobody lives without blood! Don't we need blood to stay alive? So what does it mean? That if we stop doing these things* [sacrifices], *something will die as a result!* (Junior, a cult chief)

People and objects involved in ritual action are thus at the center of a kind of *incremental process* of *axé*, through the spiritual transfer of fundamental properties from one entity to the other. *Otãs* and *ferramentas*, in such a process, would accumulate their power from the many substances (blood, red palm-oil, feathers, African pepper, powders, fresh leaves, water and so on) with which they are 'fed' or 'washed up', but also from the persons who manipulate them (Sansi-Roca 2005). Some *assentamentos*, especially the ones of deceased initiators, enjoy a special status and are considered as particularly powerful precisely because the material elements they are made of are literally imbued with *axé* from the numerous people and substances they have been in contact with.[9] Systematic contiguity between *otãs* or *ferramentas and* the body of the initiate during ritual activity would thus be able to

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[9] *A contrario*, we can also mention the spatial organization of *orixá*'s altars in order to avoid "spiritual pollution " with taboo substances from one *assentamento* to the other.

activate the kind of inferences associated with magical thinking, and more specifically with the law of contagion.

Heterogeneity and cognitive opacity of liturgical elements

A second common feature of many material elements involved in ritual action is their heterogeneity and cognitive opacity. By "heterogeneity", we mean the large variety of material and symbolic elements systematically associated with *otãs* and *ferramentas* during ritual activity. By "cognitive opacity",[10] we refer here to the highly evocative but intellectually hard to grasp nature of many of these material and symbolic elements.

In an inspiring analysis of aborigine cultic objects, Marika Moisseeff convincingly defends a provocative idea closely related to our own discussion: 'Everything happens as if the aptitude of cultic objects to produce meaning relied profoundly on their impossibility to give them a univocal meaning' (1994: 15, our translation). In other words, the profoundly polysemic nature of cultic objects directly contributes to the foundation of their exceptional nature (ibid).

In the Xangô cult, songs and invocations for the *orixás* seem to activating, but also to opacifying the inferential process associated with the manipulation of *otãs* and *ferramentas* during ritual activity.[11] Two features of the liturgical repertoire might induce this paradoxical process. The first one is that songs and invocations are mostly in Yoruba, an African language Xangô members do not understand, or only very partially. However, as the Brazilian ethnomusicologist José Jorge de Carvalho notes, the capacity of Xangô members to project ascribed meaning to songs for the *orixás* is very great (1993: 205). Even if they have no access to the literal meaning of these songs, 'they make their own translation, based principally on certain associations and phonetic concordances with the Portuguese language' (ibid: 205). A second relevant feature of ritual songs is not semantic but performative: songs for the *orixás* are 'much more emotional, dynamic and energetic, especially during trance occasions when the presence of the gods is celebrated with joy' (ibid: 205). In the case of the three ceremonies involving objects and body treatments, it is worth mentioning that they are all propitious for provoking possession trance, and trance, most of the time, happens while cultic objects are being manipulated. In other words, *otãs* and *ferramentas*, once incorporated into ritual action, are not only mysterious objects able to release and "blur" people's imagination about them, but they are also meant to elicit specific feelings and sensations leading to possession trance.[12]

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[10] Even if we give it our own interpretation, the concept of "cognitive opacity" is directly inspired from the seminal work of Gergely and Csibra (2006) on cultural transmission.

[11] For the sake of brevity, we will only focus on the liturgical repertoire and leave aside the analysis of the material heterogeneity of altars and body's treatments.

[12] For a fuller description of the emotional process leading to possession, see Halloy (2012, forthcoming).

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Invert isomorphism

A curious and, at first sight, insignificant ethnographic detail characterizes the way stones and pieces of iron are ritually manipulated: once introduced into the ritual sphere, they are handled with caution and attention; they must not be tossed about or knocked together, and Xangô members take care not to let them fall. In more technical terms, we can say that the object's 'affordances' are hijacked during ritual activity. Very schematically, an affordance is an intuitive or direct perception of an object's potential for action (Gibson 1979: 127). In the case of (small) stones such as *otãs*, their 'hardness' and regular shape make them 'graspable' and good candidates for being thrown, interlocked, knocked together and banged more or less violently against other objects. Depending on their size and the context of where they are encountered, they might thus be used as a tool (for driving a pile into the ground), as a toy (skipping stones on the water) or as a weapon (throwing stones at the riot police as recent events in Brazil have shown). Pieces of iron, on their part, are most of the time prospected in a local mechanic or, for more elaborated pieces, in a specialized blacksmith. Through the "consecration" process (Gell 1998), i.e. the ritual process of their introduction into the *orixá*'s altar, it is as if stones and pieces of iron acquired a new ontology, they become *otãs* and *ferramentas,* activating "a new potential for action", which Pierre Liénard nicely calls an "affordance derivée" (2003: 295). How can we explain such ontological transformation?

In a seminal paper drawing on his ethnography of Turkana sacrifice, Pierre Liénard suggests that ritual action activates specific assumptions about the difference between living things and artifacts, and "gives them a twist". Living kinds are used as tools, henceforth acquiring a function, an important feature of our understanding of artifacts. And artifacts are manipulated as if endowed with a powerful inherent quality, an essence, a central feature of our understanding of living things (2006: 343–344). Liénard also describes the cognitive and emotional consequences of such hybridization processes between ontological categories. He concludes that symbolic material such as an '*artifactual* living kind' or an '*essentialized* artifact' is 'somewhat attention-grabbing (at least for a majority in the course of its successive instantiations) and should attain great success in a cultural tradition' (ibid: 370).

We think this is precisely what happens with *otãs* and *ferramentas*. On the one hand, sacrificial animals are manipulated as mere artifacts *as* they are being categorized as members of a functional class (ibid: 352). What is of interest about them is their very materiality: their blood as the main vehicle of *axé*, and their organs as the main ingredients in offerings to *orixás*. Such a process of 'artefactualization' is also true for the initiate himself who is enclosed in the same ontological dynamic. As a matter of fact, it is as if the initiate was reduced to pure corporeity during ritual activity, and even more radically during episodes of possession. As Xangô members say, he becomes mere 'material' (*materia*) for the *orixá* to 'incorporate'. On the other hand, some objects (*otãs*, *ferramentas*) are manipulated with caution, not because they are breakable, but as if they had embedded within them an '*essential* quality', which is the constitutive quality of living kinds (ibid). "*Otãs are* the *orixá"*, as Xangô members say.

In our view, such 'essentialization' is a fundamental step in the empowering process of cultic objects. Because they are endowed with a new 'essence', they *are* an *orixá and* part of the 'distributed self' of one initiate (Strathern 1988; Gell 1998), they become objects themselves capable of manipulation. In the present case, a specific ritual feature we describe

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as 'invert isomorphism' – where living kinds are manipulated as tools and artifacts as living kinds – is a clear manifestation of the ontological hybridization of cultic objects in ritual contexts.

In substance, the initiates who see many objects and substances (heterogeneity) systematically associated with the manipulation of their head and body (concomitance and contiguity), who see – and feel – their treatment responding to very similar gestures and attitudes (isomorphism), are led to perceive these objects as their 'external organs' (Sansi-Roca 2005: 144), or as a 'composite body' (Losonczy, personal communication), or more generally as their person 'distributed' in the material environment (Strathern 1988; Gell 1998). The frequency of association between object/body manipulations and possession trance (concomitance) in the Xangô cult also strengthens the intimate connectivity between the artifact, the *orixá* and the initiate's body by blurring ontological frontiers between the three categories of entities. Ritual activity could thus be described as a cultural technology organizing a singular *cognitive mode* characterized in this particular case by a deeply-rooted belief in magical contagion, by an exacerbated and blurry evocative process, by an intense and "uncanny" emotional quality (possession and its early signs) and by a potential for action which is largely hijacked.

Conclusion

To conclude this rather wide exploration of cognitive practices, we would like to highlight three major issues of CECL at the crossroad of current major debates in the cognitive and social sciences.

First, as a heuristic framework for a naturalistic approach to cultural learning, CECL is neither pure ethnography, nor pure anthropology, but stands between these two poles. If some may observe we overemphasized CE in this chapter, this is due to the current tendency in naturalistic approaches to culture to rely on CA. In the ideal framework we discussed here, ethnographic data and the theoretical statements they produce are directly linked to fieldwork. However, they should not be seen as accounts of single events in the first place, but rather as statements talking about human nature, more generally.

The second issue is about CECL's conception of cognition. From a CECL perspective, cognition is a multifaceted and dynamic process taking place at the intersection between individual minds and cultural contexts. At the individual level, it involves pre-wired and acquired dispositions and expectations constraining cognitive processes. At the same time, cultural learning contexts are able to "hijack" (Boyer 2008) and capitalize on such dispositions and expectations by educating attention (Ingold 2001), transforming and acculturating 'crude' emotional reactions and sharpening perceptual processes (cf. Halloy 2012). As a result, cultural expectations and dispositions, rather than mental representations, should be seen as the cornerstones of what could be called *culture*. We believe this is because contexts, through participation (Lave and Wenger 1991), are constitutive elements of cultural learning: one needs not just an epidemiology of ideas to explain culture, but an epidemiology of cultural technologies and the experiences and skills they contribute to develop, in real life situations.

Our third issue is methodological. CECL is a concrete, small scale and qualitative study of cultural transmission, as it describes culture and cognition *in the making*. It may present a

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necessary counterpoint to a quantitative study of cultural transmission, based on an abstract and large scale approach to culture, as the one recently suggested by Olivier Morin (2011). In our view, developing a qualitative and small scale approach is essential for explaining cultural transmission for at least two reasons. Firstly, not only successful traditions are interesting for thinking about cultural transmission. Many local traditions, in fact, tend to arise and die without reaching a larger scale. Some of them will survive a few years, others will die prematurely, and some others will get aborted before seeing the day… But in most cases, they will leave traces of their past existence in memories, bodies, as well as spaces and artifacts. Such traces might become the building blocks for new cultures and traditions to develop, and as such deserve to be analyzed. Secondly, one of CECL's main aims consists in describing how complex systems of constraints are organized in real life situations, i.e., how, in Olivier Morin's (2011) terms, "local" and "global," or situated and cognitive constraints interact or, in our terms, how cultural technologies are designed, and how their *form* influences the form of mental representations in specific situation. This is why ethnography is, in our view, unavoidable, even if it can (or should) be enriched by experimental (Astuti and Harris 2008; Bloch 2005; Seligman and Brown 2009) or semi-experimental protocols (Robinson et al. 2008) *in the field,* as well as large scale and abstract quantitative methods (Morin 2011). By developing hybrid methods and common empirical research, CECL is an attempt to bridge the gap between ethnography and cognitive sciences, opening an alternative pathway towards a *situated* naturalistic approach to culture.

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