Psychological Review

Beyond Newton: Why Assumptions of Universality Are Critical to Cognitive Science, and How to Finally Move Past Them

Ivan Kroupin, Helen E. Davis, and Joseph Henrich

Online First Publication, May 16, 2024. https://dx.doi.org/10.1037/rev0000480

Psychological Review

ISSN: 0033-295X

https://doi.org/10.1037/rev0000480

Beyond Newton: Why Assumptions of Universality Are Critical to Cognitive Science, and How to Finally Move Past Them

Ivan Kroupin[1, 2], Helen E. Davis[3, 4], and Joseph Henrich[2]
[1] Department of Psychological and Behavioural Science, London School of Economics and Political Science
[2] Department of Human Evolutionary Biology, Harvard University
[3] School of Human Evolution and Social Change, Arizona State University
[4] Institute of Human Origins, Arizona State University

Cognitive science is a study of human universals. This assumption, which we will refer to as the Newtonian principle (NP), explicitly or implicitly pervades the theory, methods, and prose of most cognitive research. This is despite at least half a century of sustained critique by cross-cultural and anthropologically oriented researchers and glaring counterexamples such as the study of literacy. We argue that a key reason for this intransigence is that the NP solves the boundary problem of cognitive science. Since studying the idiosyncratic cognitive features of an individual is not a generalizable scientific enterprise, what scale of generalization in cognitive science is legitimate and interesting? The NP solution is a priori—only findings generalizing to all humans are legitimate. This approach is clearly flawed; however, critiques of the NP fail to provide any alternative solution. In fact, some anti-NP branches of research have abandoned generalizability altogether. Sailing between the scylla and charybdis of NP and hermeneutics, we propose an explicit, alternative solution to the boundary problem. Namely, building on many previous efforts, we combine cultural-evolutionary theory with a newly defined principle of articulation. This framework requires work on any given cognitive feature to explicitly hypothesize the universal or group-specific environments in which it emerges. Doing so shifts the question of legitimate generalizability from flawed, a priori assumptions to being a target of explicit claims and theorizing. Moreover, the articulation framework allows us to integrate existing findings across research traditions and motivates a range of future directions.

Keywords: cognitive science, framework theories, cultural variation, cultural evolution, articulation

The power and simplicity of Newton's universal laws of physics have left a deep impression on the sciences, and, perhaps surprisingly, cognitive science is no exception. Classical cognitive science[1] has typically, if only implicitly, presupposed that the proper subject of our science is a single, universal human mind (Levinson, 2012). At the same time, a Newtonian assumption of universality is hard to square with the core role of culture in organizing human societies and minds. After all, the variety of cultural systems humans produce and the cognitive skill sets we develop within them are what allow for our unparalleled range and success (e.g., Henrich, 2016; Tomasello, 1999; Vygotsky, 1978). To paraphrase Geertz (1973): Without humans, no culture, but also without culture—no humans. The purpose of the current article is to identify a key theoretical reason the Newtonian approach to cognitive science has persisted in the face of half a century of sustained critiques and outline what it will take to finally move beyond it.[2]

Background

The tension between a universalist camp emphasizing common human cognitive features and a culturalist camp emphasizing the importance of cultural variation has been a recurring theme in the study of human behavior (see, e.g., Cole, 1996; Rogoff & Chavajay, 1995, for historical reviews). In psychology and cognitive science, specifically, the universalist position has been the subject of extensive empirical and theoretical critique by culturally focused researchers for at least the past 50 years (e.g., Ardila, 2005; Arnett, 2008; Barrett, 2020; Bender & Beller, 2013; Blasi et al., 2022; Cole, 1996; Cole et al., 1971; Greenfield, 1997; Henrich et al., 2010;

Ivan Kroupin https://orcid.org/0000-0003-3673-9918
The authors have no known conflicts of interest to declare.
Ivan Kroupin played a lead role in conceptualization, writing–original draft, and writing–review and editing. Helen E. Davis played a supporting role in conceptualization and writing–review and editing. Joseph Henrich played a supporting role in conceptualization and writing–review and editing.
Open Access funding provided by [Department of Psychological and Behavioural Science, London School of Economics and Political Science]:
Correspondence concerning this article should be addressed to Ivan Kroupin, Department of Psychological and Behavioural Science, London School of Economics and Political Science, Houghton Street, London WC2A 2AE, United Kingdom. Email: i.kroupin@lse.ac.uk

[1] That is, the field that grew out of the cognitive revolution of the 1950s and 1960s and, with roots stretching back to the late 19th century, focused on the mind as a general computational system (Gardner, 1985). This contrasts with alternative approaches developed by cultural psychology and cultural evolution, as discussed below.

[2] The authors thank Susan Carey, Brian Leahy, Heidi Keller, Doug Medin and three anonymous reviewers for their feedback during the development of this article.

Kline et al., 2018; Levinson, 2012; Nielsen et al., 2017; Rad et al., 2018; Rogoff, 1981). We do not wish to add yet another critique of the universalist position to this list. Instead, we take an etiological approach, treating this recurring conflict as a symptom and seeking to understand the underlying, unresolved theoretical tension that drives its persistence. Having identified the underlying issue, we attempt to move beyond it by proposing a series of theoretical concepts that help identify limitations, reconcile disparate findings, and illuminate important future directions. We see this work as standing firmly on the shoulders of the many theoretical and empirical critiques of Newtonian cognitive science that have come before (see, e.g., Cole, 1996; Greenfield, 2020; Sternberg & Grigorenko, 2004, as well as citations throughout this article). Our goal is to provide a novel perspective on why this problem has been so intransigent and a streamlined conceptual framework to facilitate the reunion of those approaches that emphasize universality and those that emphasize cultural diversity.

Plan of the Argument

To begin, we define the Newtonian principle (NP), review its historical origins, and discuss how it parsimoniously captures several persistent blind spots within cognitive science. The primary contribution of this article, however, begins when we explore an overlooked metatheoretical question: Why has the NP persisted in cognitive science despite (at least) five decades of compelling theoretical argument for, and empirical evidence supporting, the importance of cultural variation? We argue the NP is not an error but, in fact, acts as a lynchpin—bearing the weight of a fundamental theoretical tension in cognitive science.

Given this lynchpin status, calling for the abandonment of the NP without providing an alternative solution to these deep tensions is like proposing we fix a house by removing a rotten beam: Yes, and what will hold up the roof? In the final parts of the article, we sketch a theoretical alternative to the Newtonian position that explicitly compensates for the supporting role played by the NP, highlighting the role of cultural-evolutionary theory and proposing a replacement to the NP, namely the principle of articulation. To preview, with this principle, we propose a subtle but important change to what we think of as the units of interest in cognitive science. Namely, we propose that rather than focusing on individual cognitive features, the unit of interest should be the interrelation of these features with the environments they arose in response to. Taking such feature-environment systems, which we shall call articulations, as the basic unit of investigation allows us to synthesize work across different traditions and conclusively move beyond the NP.

A Brief Proviso

Before we continue, it is important to address a common reaction when emphasizing the role of cognitive features, which result from group-specific cultural environments. Namely, it is our experience that when we emphasize the importance of group-specific features, this is sometimes interpreted as an implicit denigration of evidence for and/or the importance of universal features. We wish to make our stance on this very clear: Universal features of the mind are obviously real, important, and necessary parts of cognitive science. Moreover, in some cases, the requisite evidence to prove this universality has already been collected, and the mechanisms by which these features provide adaptive value in the relevant (cultural) environments have already been defined. For instance, mechanisms of low-level vision provide a classic case study (Palmer, 1999). Likewise, classical cognitive science has made great progress in studying capacities that are clearly not universal, as in the case of literacy and numeracy (e.g., Dehaene, 1997, 2010). Nevertheless, we will argue that classical cognitive science all too often assumes universality. This assumption, in turn, places crucial limitations on the study of the human mind and drives a recurring conflict between universalist and culture-focused researchers.

Cognitive Features and the Scope of the Issue

As a final introductory point, it is important to outline the scope of the issue at stake and clarify our terminology. The issue of whether or not cognitive science should focus on universals boils down to the following question: Of all the possible things one could study in human cognition, what subset should be part of cognitive science? We will refer to this total set of what can be studied as the set of "cognitive features." That is, we intend cognitive features as the most general possible category, from universal edge detection in low-level visual processing to group-specific cognitive operations underpinning literacy or the idiosyncrasies responsible for Rembrandt's individual artistic genius. It is manifestly the case that not all cognitive features should be included in cognitive science. The individual genius of Rembrandt, for instance, is not a generalizable category (unless it is used as a case study of some broader set). Low-level visual mechanisms common to all mammals, in contrast, are quite clearly a universal mechanism and thus a subject for a generalizable science of cognition. The primary focus of this article is how to think about cognitive features, such as those responsible for literacy, which are generalizable but not universal.

The Newtonian Principle (NP)

> What Newton learned entered the marrow of what we know without knowing how we know it. (Gleick, 2004, p. 239)

Newtonian systems, which describe an orderly universe with a set of general regularities or laws, have proven to be attractors within the space of theories concerned with human behavior and cognition. An early example is the doctrine of "psychic unity," articulated by anthropologist Adolf Bastian and further developed by his student, Franz Boas. Psychic unity is the assumption that all humans possess a similar mental makeup that is responsible for parallels across human societies. Whether or not Bastian, Boas, or others explicitly had Newton's orderly universe in mind, the doctrine of psychic unity also strives to describe an orderly "universe," in this case of human behavior, using a limited set of regularities.

A similar doctrine emphasizing universal cognitive features emerged during the cognitive revolution (Gardner, 1985). During this period, linguists, computer scientists, and psychologists came together to produce a framework for thinking about cognition as computation or information processing. As Turing (1950) demonstrated in his landmark essay, even a very simple computer could, in principle, perform any calculation. This remarkable, domain-general characteristic of computation in principle and the increasing capacities of digital computers in practice inspired many classical cognitive scientists to study the mind as a computer that solves general problems (based on models such as Newell et al., 1959). As a result, the nascent science of cognitive systems typically emphasized features that were both universal in their presence across our species and often general in their application across all domains of content (e.g., Miller, 2003; Shepard, 2004; see Bruner, 1990, for a dissenting perspective from that era).

We propose that these historical tendencies are best captured in terms of the Newtonian principle that *the proper subject matter of cognitive science involves universal properties of the mind.* It is important to note that this principle is much more specific than a claim that cognitive science must concern itself with generalizations that can be applied to the whole of humanity. After all, claims about reliable ways in which the human mind interacts with a variety of ecological or cultural contexts can be applied to all humans. But this kind of claim about interactions assumes that (a) meaningful variation in human cognition is an important subject of study in cognitive science, and (b) cognitive science requires us to characterize the environments of cognition (as well as phylogeny and ontogeny) just as much as it requires us to characterize internal cognitive mechanisms. What we will refer to as the NP does not admit either of these two assumptions. Rather, it is the position—often tacit and unexamined—that (a) cognitive features that are worth studying are those that are reliably present in all human minds, and consequently, (b) there is no need to characterize the environments of cognition in any detail, since the features of cognition we are interested in should be present in all environments.

Crucially, we emphasize that the NP often shapes work in classical cognitive science without being held as an explicit doctrine. That is, we certainly do not claim that all cognitive scientists abide by this principle or would agree with it if asked explicitly (though some seem likely to, e.g., Miller, 2003; Shepard, 2004). However, in the next section, we will show that the NP provides a parsimonious explanation for certain persistent limitations in classical cognitive science. These limitations, in turn, help reproduce this principle and thereby reproduce the timeworn conflict between universalist and culturalist camps.

The Limits of Classical Cognitive Science as Evidence for the Newtonian Principle

In this section, we review evidence for the persistence and pervasiveness of an NP in classical cognitive science. Specifically, we consider two ongoing limitations in cognitive science research consistent with such a principle, as well as their reflection in our theoretical terminology and even our professional phenomenology.

Limitation 1: Lack of Cross-Cultural Samples Often Conceals the Distinction Between Universal Versus Nonuniversal Features

In the face of the manifest importance of culture and the equally manifest diversity across human groups, it is particularly striking that cognitive science has overwhelmingly relied on a narrow sampling of Western, educated, industrialized, rich, and democratic (WEIRD) populations (Henrich et al., 2010, see also Barrett, 2020; Blasi et al., 2022; Medin et al., 2017; Nielsen et al., 2017; Rad et al., 2018). Moreover, most articles in cognitive science do not even comment on their use of WEIRD samples. Oddly enough, those articles that do include cross-cultural samples are often expected to provide explicit justification for doing so. WEIRD samples remain, in this sense, an “unmarked default” (Medin et al., 2010; see also Blasi et al., 2022, on English as an unmarked linguistic default).

Despite the absence of representative samples, classical cognitive science abounds with claims of universality. These are typically not stated openly (though sometimes they are, e.g., Shepard, 2004). Rather, they are usually treated as another unmarked default. Perhaps the most common form of universalist claim is entirely implicit. Namely, authors often simply omit any discussion of what cultural environments this capacity is (particularly) relevant in and/or likely to have developed in response to. In the absence of such a discussion, the capacity is presupposed to arise and be applicable universally. Work on executive functions offers a representative, though not particularly egregious, example of this pattern. Executive functions (EF) are a family of top–down control mechanisms, variously referred to as “capacities” or “skills,” responsible for inhibiting prepotent responses, flexibly applying new rules, manipulating information in working memory, and so on. Given their central importance, EFs are a major focus within cognitive psychology and the subject of thousands of studies. Yet, remarkably, typical reviews of the EF literature (Cristofori et al., 2019; Diamond, 2013) contain no discussion as to which specific environments these functions may be particularly necessary in. Further, neither of the cited reviews contain a single instance of the word “culture,” much less discuss the possibility of population-level variation in the demand for different varieties of top–down cognitive control. A recent review of work on EF conducted in cross-cultural samples (Schirmbeck et al., 2020) reveals that there are only 26 studies dating back to 2006. Of these, 23 are limited to samples from major urban centers in countries with mandatory formal schooling. The remaining three included samples with limited formal schooling. No studies were found to have sampled populations without access to formal schooling, a particularly important driver of cognitive differences across cultures (Cole, 1990; Rogoff, 1981).

In sum, work on EF is typical in that it often assumes that the cognitive features being measured develop in the same way and are important for life outcomes in the same way across all human environments, around the world, and back into history. Whether or not this is the case, however, is clearly an outstanding empirical question and certainly not something to be ruled out by an unmarked presupposition (Schirmbeck et al., 2020; see also Doebel, 2020, for a theoretical account of why EF may be expected to vary by context). This same pattern of presupposed universality in the face of observed variation holds across a wide range of cognitive domains (for cross-cultural reviews, see Apicella et al., 2020; Ashton, 1975; Barrett, 2020; Blasi et al., 2022; Cole, 1996; Henrich et al., 2010; Kline et al., 2018; Rogoff, 1981).

The trend of unmarked universality continues in the description and use of methods: Tasks are typically described as “assessments of X,” where X is the capacity in question (executive function, theory of mind, etc.). This phrase not only imports the unmarked universal assumption regarding the capacity but further adds an unmarked assumption that the task itself is a universally applicable metric of this capacity. Yet, as with the nonuniversality of samples, the nonuniversality of methods across cultural contexts has been amply demonstrated. For instance, extensive evidence has shown that only participants from formally schooled, industrialized environments have experience with anything like the context of a laboratory task (i.e., something like school testing, see Ardila, 2005; Greenfield, 1997; Lave, 1997; Sharp et al., 1979).

This is even true of apparently simple forms of measurement such as Likert scales (Hruschka et al., 2018).

How, then, can we explain this systematic lack of sample diversity in the face of such extensive countervailing evidence? Of course, convenience has some role to play in this pattern (a "law of least effort," which we discuss below). However, convenience is obviously inadmissible as an argument for generalizing to the human species from a particular sample. Instead, typical studies will refer to implicitly universal categories such as "children" or "people" or "measures" and so forth when describing their samples, methods, and results. These descriptions only make sense as applied to nonrepresentative samples given an NP, under which the cognitive features being studied are universal. In this sense, a lack of cross-cultural samples is not only evidence for an NP, but it also helps reproduce this principle across time by keeping evidence of cultural variation out of sight and out of (our theories of the) mind.

Limitation 2: Environments Are Not Characterized, Limiting Our Ability to Interpret Results and Generalize to Nonlab Contexts

The flip side of a lack of cross-cultural sampling is a failure to characterize the environments, including cultural environments,[3] in which cognition emerges and operates. Unlike the former issue, which has been the subject of numerous critiques, this lack of environmental characterizations has largely been overlooked by critiques of universalism in recent decades. Yet, this issue is no less a critical, structural barrier preventing our advancing toward a cultural cognitive science.

For instance, while studies in non-WEIRD populations, especially in small-scale societies, typically provide some details of the cultural environment in question, this is almost never the case for studies with WEIRD populations. That is, in their explanations for cognitive patterning, almost no cognitive studies within WEIRD, or even urban industrialized populations outside the West, cite or discuss ethnographic material on the sampled populations in their explanations of observed patterns. To illustrate: Apart from statements of location and relative socioeconomic status, when was the last time you encountered ethnographic or sociological details about a sample of children from Boston, Paris, or even Beijing? What kind of challenges do these children face in their day-to-day lives? What opportunities and demands does their environment provide? Are these different across countries or socioeconomic groups? Does the pattern of results described in this study reflect culturally specific environments? Why or why not? and so forth.

Once we make them explicit, it is hard to imagine that the answers to these questions are so trivial that they do not warrant comment in interpreting the results of WEIRD studies. Yet, they are almost never discussed within classical cognitive science. The action of an implicit NP helps make sense of this peculiar state of affairs. After all, if we presuppose the universality of the features we study, the particular environments in which our participants live their lives should be of limited importance. In fact, if findings with WEIRD populations are assumed to be universal, we may expect that any deviation from these findings would generate demand for some external, environmental explanation. Sure enough, "environmental" explanations are often used only for "peculiar" findings from non-Western or even low-socioeconomic status Western samples that deviate from patterns of performance presupposed to be universal. We scarcely need to stress again how unsustainable this presupposition of universality is, given the overwhelming evidence that cultural context plays an enormous role in shaping cognition across many domains. In sum, while neither cultural sampling nor environmental descriptions are necessary under an NP, both are necessary beyond it.

Limitation 3: Newtonian Terminology

As we have seen so far, the NP systematically passes over in silence details of the (cultural) environments in which cognitive features emerge and operate, whether through the neglect of cross-cultural sampling or of any descriptions of the environments themselves. This pattern is evident likewise in the absence of any standard terms to express the relationship between a given cognitive feature and the environmental factors to which it is an adaptation. More often than not, mention of this relationship is omitted entirely. When addressing this relationship does become necessary, the terminology typically employed once again removes any specific environment from view. That is, terms like "reliably-developing," "innate," or "culturally-constructed" place the cognitive feature being described on one side or another of a dichotomy between those that are influenced by culture and those that are not. This does not mean we cannot describe the environments that produce these features or in which they are useful, but it certainly does not imply the need for us to do so.

As with the previous limitations, this pattern is consistent with an active, if implicit, NP in classical cognitive science, and, once again, it helps to both reproduce this principle and provoke repeated confrontations with culturalist researchers. Below, we propose an alternative terminology that forces us to systematically address the relation between cognitive features and (cultural) environments.

Newtonian Principle in Our Professional Phenomenology

> Everybody knows.
>
> Leonard Cohen and Sharon Robinson

Yet another source of evidence for the NP comes straight out of our experience, as researchers, of reading the Participants sections of empirical articles. That is, in addition to shaping our research and theory, the NP is also a very concrete piece of cultural–cognitive software. Specifically, the set of presuppositions that lead to the limits described above is also consistent with a rapid set of inferences that emerge when we read empirical reports in cognitive science. For instance, when an article simply refers to "children" or "people," we usually experience no sense of incoherence, like one would feel hearing the phrase "she won the Olympic gold in sports" (in what sport?).

Instead, the automatic inference is often that "children" or "people" refers to all humans in the specified age or category. At the same time, imagine being asked, "What would be your best guess as

[3] The environments human children emerge and develop in are overwhelmingly structured by and around humans and their social relations (e.g., Henrich, 2008); we refer to cultural environments in order to highlight this fact. That being said, the same logic applies throughout to features of the environment not shaped by humans, as we discuss below.

to what the population in this study was like?" Doubtless, we would find the safest bet to be a relatively advantaged group from environs of the labs in which the research was conducted or from a set of online participants with typical demographics. To see the NP in action, suppose a researcher collected data among monolingual Matsigenka children in the Peruvian Amazon but did not mention this in her Methods section, simply referring to them as "Peruvian children" within certain age categories. Presumably, any researcher worth their salt would immediately experience this omission as problematic for the interpretation of the resulting data. Yet, at the same time, thousands of studies referring simply to, for example, "U.S. children" have passed and continue to pass peer review in the most prestigious journals (and claims about "human-like" performance of AI models pass peer review, presupposing Western, educated performance as a universal benchmark, Atari et al., 2023). We propose that this is possible as a result of an internalized NP, which renders the inference from certain samples to all children across the history of our species unproblematic. Moreover, without specifying the group, also failing to specify the group environment is simply a matter of internal coherence. The absurd alternative would be to give an ethnographic account of Western children's environments and then make claims about research with this sample providing evidence about implicitly universal "child development." In sum, it is essentially impossible to have gone through an education in cognitive science and not have developed a set of automatic inferences consistent with an NP—though it is certainly possible to become aware and critical of them (as, indeed, a great many researchers have done before us). We believe this automatic set of presuppositions helps the NP to reproduce tacitly across academic generations.

Forestalling Some Objections

By no means do we wish to say that theoretical factors are the only cause of the observed biases. Any scientific discipline is a social endeavor, and all such endeavors are prone to developing structural biases toward certain groups and ideas. Likewise, any social endeavor is advanced by individuals who are prone to their own biases, which may include a "law of least effort," leading some to avoid resource-intensive deviations from a universalist norm.[4] Understanding these biases within cognitive science is a crucial subject in its own right. Existing work highlights, among other things, a lack of support in funding and publishing for cross-cultural work as well as systematic social and racial inequalities in multiple areas of research (e.g., Medin et al., 2010).

However, if we take seriously the idea that the trajectory of science is in some meaningful way determined by both the implicit and explicit theoretical commitments of scientists, then one important strategy for overcoming this bias as a field is to confront it in theory and update said theoretical commitments. After all, these commitments help structure and justify the system that reproduces the political/material status quo. In this sense, we see the current article as part of a broader effort that must also include concrete action at the level of individuals and institutions, a point we return to in our closing discussion.

We also wish to reiterate that we are not claiming that all or even most researchers in the classical cognitive science tradition explicitly adopt the NP. Nor do we, in any sense, wish to lessen the importance of cognitive features, which are demonstrably universal in our species. In fact, the framework we develop below explicitly integrates such features alongside culturally specific ones. The point so far has been to identify certain clear empirical and theoretical deficits in our field and posit the NP as a parsimonious explanation for their presence and persistence, as well as the presence and persistence of the universalist–culturalist divide. Next, we turn to the question of why the NP itself has persisted in the face of at least half a century of countervailing evidence and culturalist critique.

No Mere Error: The Newtonian Principle Persists as an Answer to the Boundary Problem

If God did not exist, it would be necessary to invent him.

Voltaire

We propose that one of the reasons why the NP persists, despite decades of theoretical and empirical counter-examples, is that it provides a solution to a tension at the core of cognitive science. That is, even if the Newtonian bias did not exist, the need to solve this tension would require us to invent it or something like it.

The Boundary Problem of Cognitive Science

If the NP is a solution, what is the underlying tension which it resolves? Working backward, the NP involves assuming that a universal mind should be the subject of cognitive science. If this assumption resolves some tension, the tension itself must have to do with defining whether our subject matter is universal, that is, defining its boundaries.

In fact, there is a fundamental tension regarding the boundaries of our subject matter inherent in cognitive science. This stems from the fact that, unlike electrons, humans are not identical. Consequently, we need to make a decision regarding what portion of humanity our scientific generalizations should span. In fact, this is the same issue we encountered already in defining cognitive features: By our general definition, cognitive features include any properties of cognition that it is possible to study—including those that are universal, not just in humans but in most cognitive systems (e.g., visual edge detection), but also those that are totally specific to some individuals (e.g., Rembrandt's genius in painting). Defining (a) the scope of legitimate generalization, that is, which groups a finding must generalize to in order to be a part of cognitive science and (b) the subset of all possible cognitive features that are of interest to cognitive science, are thus two sides of the same coin.

In either formulation, this is far from a trivial challenge. Our species exhibits systematic variation across an indefinite number of temporal and geographical scales, from individuals to single families to communities to nation-states and beyond. If we are to study human cognition, then how are we to properly bound our inquiries? That is, what scope of generalization across these many scales of variation will count as part of our science?

Clearly, the idiosyncratic cognitive features of some individuals—Devon from Essex County, for example—are not of interest to a science of human cognition (unless, say, they are an exception to some rule or case study for some broader theory). In contrast, facts

[4] The authors thank Douglas Medin for pointing out this particular possibility in a review.

about the cognition of all humans, of course, constitute a valid and crucial scope of generalization. However, as we can, see at least in the examples of research on literacy and numeracy, universal statements about the mind are clearly not the only valid ones. So where, between just Devon and all *Homo sapiens* past and present, do we draw the line of permissible generalization?

This boundary problem of cognitive science reflects a tension at the core of any effort to study human cognition. The NP resolves this tension through an a priori assumption that the correct scope of generalization is one that applies to all humans. This is attractive not only in its simplicity but also in its mimicry of "hard" science, where such universal laws are, in fact, the norm (see Shepard, 2004, for an explicit appeal to physics in this vein).

We Cannot Simply Remove the Newtonian Principle (or Ignore the Boundary Problem)

Having defined the boundary problem and the way in which it is solved by the NP, we begin to see why the latter may have been so resistant to decades of work arguing for the importance of cultural variation. After all, if we simply remove the lynchpin of the NP, we also lose the solution to the boundary problem, which our field has explicitly or tacitly appealed to at least since the cognitive revolution of the 50s and 60s (and plausibly since the early days of psychophysics more than a century and a half ago, e.g., Fechner, 1860). In other words, simply removing the NP is not any more sustainable than persisting with it, perhaps even less so since it leaves us in danger of a "postmodern holiday."

Dangers of a Postmodern Holiday

Specifically, a failure to solve the boundary problem is a threat to cognitive science qua generalizable science. If we fail to define a meaningful scope of generalization, we are open to the possibility of all levels of generality being equally legitimate subjects of study. Even just Devon from Essex County. If all possible levels of generalizations are legitimate, each level of generalization is liable to find those who would defend its importance. This leaves cognitive science in danger of departing on the same "postmodern holiday" (Levinson, 2012), which saw cultural anthropology stop engaging with generalizable research altogether (D'Andrade, 2000).

In other words, simply jettisoning the NP's a priori approach brings us to a different, but equally a priori, solution to the boundary problem. Namely a hermeneutic approach, that is, assuming that the proper scope for a science of human cognition is at the level of case studies, with limited scope for generalization across them. This threatens not only our ability to engage in generalizable science but also our ability to engage with previous and ongoing work in this tradition.

Losing Connection to Existing and Ongoing Work

Simply disposing of the NP is not just a danger to cognitive science prospectively; it compromises our access to the vast bodies of systematic work that have and continue to be generated under its auspices. After all, once we take away the plank of the NP, we suddenly find ourselves in deep water. Which groups exactly do studies of "children" or "people" inform us about? How can we interpret these findings at all given their reliance on a NP we reject?

This is not an imagined problem. The exact process described above has happened within living memory: A first wave of cross-cultural research began just at the dawn of the cognitive revolution (e.g., Cole et al., 1971; Gay & Cole, 1967; Greenfield & Bruner, 1966). This work initially operated within the same theoretical framework as classical cognitive science but found the universalism of this approach impossible to sustain given the evident cultural variation they saw emerging from their field studies. A split between universalist and culturalist camps ensued, with the latter replacing computational cognitive science with Vygotskian activity theory, developing their own ecosystem of journals, and, in some cases, drifting into hermeneutics entirely (see Bakhurst, 2009; Rogoff & Chavajay, 1995, for historical reviews). This led some (though certainly not all) major figures in this tradition to reject the meaningfulness of results from standard experimental measures altogether. A particularly striking case comes from Sharp et al. (1979), where the authors report a many-year, multihundred-participant study of the effects of formal schooling on cognition in the Yucatan Peninsula, only to conclude that their own data and, moreover, most data collected with standard experimental methods were largely meaningless.

Of course, not all of the researchers in this tradition arrived at conclusions as strong as those of Sharp and his colleagues. And there is no question that this tradition has produced work of enormous value and insight into cognition and culture (see, e.g., Cole, 1996; Lancy et al., 2010; Rogoff, 2003, for some overviews). Nevertheless, dropping the NP without an alternative solution to the boundary problem that is compatible with work in classical cognitive science leaves us in danger not only of an enormous loss of intellectual resources but also of alienating most practitioners working within standard experimental paradigms to date (i.e., nearly all of the field). Needless to say, this is not an optimal state of affairs. Ensuring commensurability of data between paradigms is standard in the other sciences. For instance, in the shift from Newtonian to relativistic physics, all reliable observations made under the former must also be accounted for under the latter.

Summary: What Will It Take to Move Beyond Newton?

Etiologically speaking, we propose that the need to solve the boundary problem is the underlying cause that produces the recurring symptom of universalist–culturalist conflicts, signposted by (at least) half a century of theoretical and empirical skirmishes. We propose that the dynamics of these conflicts come down to the fact that each side adopts, to some extent, one of two incompatible a priori answers to the boundary problem: The first is that the correct scope of generalization is across all *Homo sapiens* (the NP). The second a priori answer emphasizes the legitimacy of cultural variation but also stands in danger of legitimizing any level of generalization (hermeneutics). As ever, we do not claim that any researcher explicitly adheres to either of these two positions (though it is quite possible some do). The point is that the implicit structure of the conflict is organized around these two poles, and that until we make an explicit and concerted effort to find an alternative solution to the boundary problem, the basic pattern will continue to reemerge.

In sum, a primary goal of this work is to illustrate how fundamental limitations within classical cognitive science can emerge as a product of the NP, itself a solution to the boundary problem that ultimately drives the cycle of conflict between universalist and culturalist camps. We argue that such a systemic, etiological approach is liable to be more productive than further, complementary criticisms of universalist research as culturally limited and of culturalist work as insufficiently generalizable.

Next, we develop a proposal for moving beyond the NP—in two parts: First, we lay out how a cultural evolution framework can address the boundary problem. After this, we introduce the notion of articulation as a step toward developing the necessary theoretical architecture to systematically incorporate cultural environments into our theories of cognitive features.

Cultural Evolution: Priors on Boundaries

The boundary problem in cognitive science is that there is an infinity of possible groups over which we may make generalizations about cognitive organization. The NP and hermeneutics provide simple, though ultimately unsustainable, a priori solutions to this problem. What is the alternative to such a priori solutions? The case is a general, practically etymological one: For any situation with an infinity of possibilities and no a priori basis for selection, we must select them on some priori basis, that is, rely on some set of priors to guide our choices. Cultural evolution provides a framework in which such systematic priors may be developed over various human groups and their cultural traits, drawing on empirical and theoretical resources across history and the behavioral sciences.

Cultural Evolution: A Source of Systematic Priors

Moving from a catalog of individual animals to evolutionary biology requires a theory of evolution operating over certain individuals and groups. In the same way, systematically motivating the study of cross-cultural variation requires a theoretical framework that takes the organization and development of cultural traits as its primary subject matter. Cultural evolution provides just such a framework and is in fact constructed such that it emerges naturally from genetic evolution (Boyd & Richerson, 1985; Cavalli-sforza & Feldman, 1981; Henrich, 2016; Muthukrishna & Henrich, 2019). Specifically, cultural evolution provides a framework for theorizing the origins of variation in cultural traits and explains how cultural environments change across time and produce observed cross-cultural variation. For instance, Henrich (2020) used this logic extensively in studying the emergence of a peculiarly WEIRD psychology in Europe, making theoretically motivated selections of subgroups (e.g., different religious communities exposed to specific institutions prohibitions and prescriptions) within the framework of a larger cultural-evolutionary theory. Likewise, Muthukrishna et al. (2021) illustrated how historical records from across the globe provide invaluable empirical support for hypotheses regarding the emergence and role of specific cultural environments and their effects on individual cognition across time. Crucially, under some conditions, theories in cultural evolution predict continuously varying cognitive features along a particular spectrum due to some feature of the environment (e.g., rooted in religion, institutions), not sharply bounded groups.

Of course, the variable, empirically grounded solution*s* to the boundary problem provided by cultural evolution are less clean-cut than a priori universalist or hermeneutic ones. Indeed, there is no general answer to the boundary problem provided by cultural evolution. Rather, cultural evolution "solves" the boundary problem in the same way any problem in science is solved: It offers a framework in which we can formulate and test local hypotheses regarding which cultural environments are likely to be important subjects of study, variously suggesting geographic, demographic, and temporal boundary conditions. This case-by-case approach is an inevitable consequence of treating cultural systems as the subjects of independent study that interact with human cognition in systematic ways. It seems to us that treating cultural systems as a subject of study is manifestly more rigorous and realistic than the a priori rulings of the NP or hermeneutic approach. It is only by taking a systematic, theory-based approach that the cultural variation that lies "at the heart of the human phenomenon" (Levinson, 2012) can be incorporated into a generalizable cognitive science.

Integrating Environments and Cognitive Features

So can we call it a day now that we have cultural evolution as the source of alternative solutions to the boundary problem? Not quite. Recall that the NP is the assumption that the proper subject matter of cognitive science is the universal properties of the mind. Cultural evolution, on the other hand, is a theory addressing how features of culture have been and continue to be organized and transmitted. Since the proper subject matter of cognitive science cannot be cultural features alone (even if some features of the mind are clearly cultural), it follows that we still lack some crucial theoretical notion linking particular environments to the cognitive features that emerge in adaptive relation to them. After all, as we discussed above, a major limitation of classical cognitive science is the lack of concepts and accompanying terminology that would make this connection. Any theory that would move beyond the NP, integrating solutions to the boundary problem from cultural-evolutionary theory, needs an explicit replacement for this principle and a set of concepts derived from it that would capture the relation between cognitive features and environments.

Beyond Newton: The Principle of Articulation

Here, we sketch the principle of articulation as an explicit replacement for the NP. The principle of articulation builds on the solution to the boundary problem provided by cultural evolution, providing a theoretical foundation for both a distinction between universal and group-specific properties as well as the integration of cultural environments with individual cognition.

Defining the Principle of Articulation

Articulation

Given that cognitive features are part of our adaptive biological system, it follows that there is some environment to which any given cognitive feature is adapted (whether in the process of phylogeny or ontogeny). In fact, this follows a well-established principle in cognitive science: Marr (1982) famously argued that understanding a cognitive mechanism depends on an understanding of the computational problem that this mechanism is designed to solve. That is, cognitive features emerge over phylogeny and/or ontogeny to solve some particular problem that exists in the environment of the organism at the time of this emergence. (As a reminder, by "cognitive feature," we mean any stable property of cognition—whether universal, group-specific, or wholly idiosyncratic. At issue is the question of what subset of these features is the proper concern of cognitive science).

We will use the term articulation to refer to the adaptive interrelation between features and the affordances and demands provided by the environment(s) in which they emerge, drawing on the original sense of articulation as referring to a joint (from Latin *artus*, "joint"). We may say that cognitive features supporting literacy are articulated with an environment in which written materials are present and reading is advantageous (e.g., a classroom where children are taught to read in the first place).[5]

Environments of Articulation

We may call the environment in which a given cognitive feature is articulated the environment of articulation (EOA) for this feature (Henrich, 2008).[6] That is, the EOA for a cognitive feature is a set of environmental properties that made the feature in question adaptive when it originally emerged across phylogeny or ontogeny. As we shall see, for certain features, the EOA is also the environment of evolutionary adaptedness (Tooby & Cosmides, 1992). Specifying the EOA is central to the understanding of why the cognitive feature in question emerged in the first place and in what contexts it is designed to operate effectively (i.e., identifying the problem it is designed to solve, as in Marr's computational level). Notice that this is not the same as the environment of behavior, as evident at least in the obvious misfirings of cognitive features in the face of perceptual illusions or probability distributions we were unlikely to encounter in our evolutionary environment (e.g., Gigerenzer, 2008; Kahneman et al., 1982). These "errors" showcase cognitive features operating outside of their EOAs.

Defining any given EOA in detail is often a challenging task and one that demands theory. After all, cognitive features are gradually shaped by changing contexts, and defining these environments and their temporal or geographic extents is not trivial, to say the least. Theoretically, the mathematical tools and approaches, sometimes labeled "cultural niche construction," offer rigorous ways to think through the EOA and build theory in which the EOA evolves dynamically over time (Creanza et al., 2012; Kendal, 2011). Empirically, detailed studies of child development across human societies that integrate ethnographic, experimental, and statistical tools offer the best approach to studying EOAs (e.g., Deffner et al., 2022; House et al., 2020). We return to the challenges and strategies of characterizing EOAs in greater detail in our discussion of future directions. A first and crucial step, however, is a very general characterization of EOAs—whether they are experienced by all humans or only some. We outline this distinction presently after introducing the more general principle that centers EOAs in our approach to cognitive science.

The Principle of Articulation

The principle of articulation is that the proper subject matter, or the basic units of investigation, in cognitive science are the articulations between cognitive features and (cultural) environments.[7] That is, in order to constitute a theory in cognitive science, one must both describe the cognitive feature and the EOA for this feature. For instance, under an NP, there is no problem describing executive functions as reliably developing features of the mind that allow for inhibitory control, cognitive flexibility, and so on. Under the principle of articulation, in contrast, such a description is fundamentally incomplete since it indicates no EOA. In other words, to conform to the principle of articulation, an account of any cognitive feature requires some claim regarding the phylogenetic and/or ontogenetic environments that are required for this feature to emerge and in which it is (particularly) adaptive. This principle does not inherently privilege universal or culturally specific features of the mind. As we shall see below, it allows us to naturally distinguish and incorporate both the universal features privileged by the Newtonian approach and important nonuniversal features. Neither does it require any detailed knowledge of the relevant EOAs. The point is simply that we always make assumptions about the environments that produced the cognitive features we are studying, at least in that we assume them to be shared by all humans or only some group. The principle of articulation simply mandates that we state these assumptions openly, however limited our data regarding them may be.

Articulation as a Generalization Within a Rich Theoretical Tradition

As will be apparent to readers familiar with work in cultural psychology and related disciplines, the notion of articulation provides a new definition and label within a venerable and much-discussed space of ideas. A wide range of researchers throughout the history of cognitive science and beyond have emphasized, in various ways, the necessity of a deep interrelation between cultural context and cognitive structure (Bourdieu, 1977; Bruner, 1990; Geertz, 1973; Greenfield, 2009; Lave, 1997; Luria, 1976; Sternberg & Grigorenko, 2004; Tomasello, 2019; Tooby & Cosmides, 1992; Vygotsky, 1978; see in particular Sternberg & Preiss, 2005, for a series of relevant pieces discussing the relationship of cognition, culture, and technology). In fact, the discussion of this issue dates back at least to Aristotle and was elaborated by Humboldt, Mill, Wundt, Levy-Bruhl, and many others (see Cole, 1996, for a historical review). Within philosophy, Hegel (1807) and Heidegger (1927) provided particularly lasting theoretical pictures of the deep interrelation of cultural organization and cognitive structure. By the same token, we have already described how articulation is related to Marr's (1982) computational level of analysis. Theories by the likes of Vygotsky (1978) and Bronfenbrenner (1981) go further than most in centering the relation of cognitive features to local environments. Likewise, cultural-evolutionary theory in general (e.g., Henrich, 2016) and the "collective brain" hypothesis (Muthukrishna & Henrich, 2016) in particular propose that in our cultural species,

[5] This combined term is especially relevant since the articulation relationship can involve causality in both directions: The environment shapes the cognitive feature, but the cognitive feature can also shape the environment to the extent that it drives niche-construction. For instance literate people are liable to transform their environment so that it contains (more) written materials.

[6] The acronym "EOA" was used in previous work (Henrich, 2008) to refer to an "environment of ontogenetic adaptedness." Environments of articulation expand on this concept to include environments of phylogenetic adaptedness (e.g. those which produced edge-detection in our visual systems).

[7] Notice how this definition relies on cultural-evolutionary solutions to the boundary problem, that is, identifying which cultural environments are important to study.

many of the cognitive features we are able to measure in fact reflect adaptations to a particular cultural environment (the eponymous collective brain).

A general review of these concepts is a worthy future project, but outside of our scope here. The point we wish to make is that our goal is certainly not to claim conceptual novelty in the face of this rich history. Rather, the principle of articulation generalizes from and provides a label for a family-resemblance of ideas in previous work. Specifically, it posits that understanding a cognitive feature requires understanding the environment it is articulated with. Or, more exactly, it proposes that the subject matter of cognitive science must be the combination of features and environments, that is, the articulation between the two. The minimalism of this principle means that it is compatible with a range of traditions and, as we shall illustrate below, allows us to both integrate across their bodies of work and motivates a range of new directions. First, however, we illustrate how even a minimalist principle of articulation provides a natural distinction between universal and culturally specific cognitive features.

Articulation Provides a Natural Distinction Between Universal and Group Features

Recall that under the NP, terms distinguishing universal and nonuniversal features omit reference to the environments in which these features emerged and were adaptive (e.g., "reliably-developing," "culturally-constructed"). This, in turn, is consistent with the omission of cultural variation in theories and samples and the reproduction of the universalist–culturalist conflict. Working from a principle of articulation, in contrast, provides a natural distinction between universal and group-specific features by appealing to the relevant environments in both cases.

In fact, strictly speaking, it makes this sharp division redundant. To give an analogy, by now it is clear that specific cutoffs such as the notorious $p < .05$ can be dangerously misleading on their own (Greenland, 2023; Greenland et al., 2016; Wasserstein & Lazar, 2016). This does not, of course, mean that reality does not have interpretable structure. Rather, it means that hypotheses must be assessed more holistically and may not benefit from a reduction to binary categorization (see McElreath, 2020, for an excellent and accessible discussion).[8] Ultimately, we hope that the principle of articulation can foster this more holistic kind of reasoning when it comes to detailing articulations between cognitive features and their environments. Namely, understanding that the distinction between universal and culturally specific is less useful than specific, case-by-case analysis of cognitive features and their environments. Nevertheless, since the universal–local distinction has been a key point in the literature thus far, we can show how this can be naturally expressed in terms of articulations.

Universally Articulated Features

Some cognitive features are articulated with properties of the environment that are experienced by all humans or were experienced by all humans at some point during the course of our evolutionary history. For instance, the EOA for cognitive features supporting binocular vision includes a three-dimensional world (see Shepard, 1984, for a discussion of invariants in visual experience and their cognitive expressions). Given that all human populations exist in a three-dimensional world, we can say that the cognitive features supporting binocular vision have a universal EOA and that the features themselves are universally articulated. As such, it is maladaptive for individuals to lose binocular vision. The NP, therefore, can be expressed as an assumption that only universally articulated cognitive features are legitimate subjects for cognitive science, with the corollary that specifying EOAs is generally not necessary. (As usual, we emphasize that the study of universally articulated features is necessary for cognitive science, just not sufficient given the cultural nature of our species).

Locally Articulated Features

As we have emphasized throughout, not all cognitive features worth studying are universally articulated. Literacy and numeracy, for instance, are the subjects of well-developed research programs in classical cognitive science (Dehaene, 1997, 2010). Given the principle of articulation, we can say that the cognitive features supporting literacy have a group-specific or local EOA, and the features themselves are locally articulated, that is, articulated with respect to an environment peculiar to some group(s). Or, to use the terms of Shepard (1984; drawing, in turn, on Gibson, 1979), locally articulated features capitalize on invariant affordances that are present only in the environment of a specific group or groups. This makes clear the way in which evidence for the presence of a cognitive feature in a group (or species) is evidence for invariant properties of the environments that this group inhabits. Moving back and forth between characterizations of cognitive and environmental structure in this way is a core motivation for formulating the principle of articulation.

While the distinction between universally and locally articulated features may (hopefully) be clear in theory, in practice it requires some additional criterion that would define when a feature stops being simply widespread and should be considered universal. As we mentioned above, we think that this dichotomy is ultimately not the most useful for thinking about cognitive features and their environments. That being said, given that the debate thus far has often been structured around a universal v. local dichotomy, we believe it is useful to propose some criterion that could be of some use (if used with appropriate caution, again on analogy to statistical criteria). Specifically, we propose a functional criterion: For a given feature, if the level of development required for adaptive functioning in one environment is maladaptive in another environment, this feature is locally articulated. To be more precise, a cognitive feature is locally articulated if the typical level of performance in one population would leave an individual unable to perform normal functions (for their age, gender, etc.) in another.

This functional criterion captures not only those cognitive features which exist only in certain groups (e.g., literacy) but also qualitatively different degrees of development in some features as a response to local affordances and demands. An example of this latter kind of locally articulated feature is spatial navigation: Adults from the Twa (Davis et al., 2021) and Tsimane (Davis et al., 2023) communities who must travel long distances from home by foot

[8] And in fact, cutoffs were never intended as self-sufficient: Nuzzo (2014) aptly captured Fisher's original purpose for the .05 criterion as "just one part of a fluid, nonnumerical process that blended data and background knowledge to lead to scientific conclusions" (p. 151).

display approximately double the precision in a standard spatial navigation task compared to adults from the United States and Italy whose environment presents no such demands (Barhorst-Cates et al., 2021; see Henrich et al., 2023, for a review). It is plausible to assume that if a given Twa or Tsimane individual had spatial navigation skills half that of their peers, this would significantly impede their ability to perform typical tasks. In fact, support for the functional role of this capacity comes from work showing that, in the Twa at least, spatial ability is related to reproductive success (Vashro & Cashdan, 2015). Thus, we can say that performance on spatial navigation is driven by locally articulated features in both populations, with the consequence that it would be meaningless to make normative comparisons of scores across groups (though of course this remains a productive avenue for future research). At the same time, it is obvious that these features are built upon some universal features that facilitate navigation (e.g., common visual mechanisms, at least). This underlying universality not only does not reduce the locality of these features, it is a necessary aspect of them, as we discuss in the next section.

Results from work on the effects of formal schooling reveal a plethora of similar effects. For instance, Tsimane children attending school showed reliable improvements in Raven's matrices performance (a paradigmatic test of IQ) across ages 8–18. In contrast, their peers who did not attend school showed no change in performance across this age range. It follows that whatever cognitive features are tapped by Raven's matrices, they include some locally articulated features that emerge only with experience of formal schooling (Davis et al., 2020). We return to this and other examples in detail below.

Important Properties of Locally Articulated Features

Before we move on, several further properties of locally articulated features are important to highlight, as they will be central to applying universally/locally articulated distinction to existing theory and patterns of data.

Locally Articulated Features Depend Upon Universally Articulated Features

Notice that just as all of our cultural history is predicated on our evolutionary history, all locally articulated features depend upon universally articulated features for their operation. For instance, English is a locally articulated set of features built upon universally articulated language capacities. Literacy in any language likewise depends on these universally articulated language features, while chess heuristics depend on universal pattern recognition mechanisms, and so on. Locally articulated features may, of course, also depend on other locally articulated features (e.g., solving algebraic equations depends on performing addition).

Locally Articulated Features Can Drive Stable Patterns of Data and Life Outcomes

The examples of literacy and numeracy (e.g., Dehaene, 1997, 2010), among many others, illustrate that locally articulated features are just as capable of producing reliable patterns of behavior as universally articulated features. Moreover, locally articulated features are just as capable of predicting/driving life outcomes in their EOA: Literacy is paradigmatically locally articulated (in environments with written materials), yet the presence and degree of development of this cognitive feature is a crucial factor in life success in literate societies (less so in societies without any written materials). By the same token, it is perfectly possible that Raven's matrices predict life outcomes within schooled societies but not outside of them.

Both Universally and Locally Articulated Features Show Heritability

Evidence of heritability does not provide any guarantee of universal articulation. After all, heritability is shaped by cultural environments (Uchiyama et al., 2022). Indeed, heritability evolves culturally: More valued cognitive abilities increase in heritability over time because adaptive cultural evolution reduces environmental variation. There are also clear cases of genetic traits being altered by exposure to particular cultural practices, such as differences in genotype and physiology associated with better diving abilities in the Bajau people (Ilardo et al., 2018; see also Laland et al., 2010, for a general review of culture–gene interactions). It follows that evidence of heritability is simply not equivalent to evidence of universal articulation, though of course it may be *part* of an argument in favor of it (see also Heyes, 2018, for related discussion).

Both Universally and Locally Articulated Features Are Expressed in the Brain

The structure of the brain is significantly altered by cultural environments (e.g., Kitayama & Park, 2010), with the acquisition of literacy being a particularly clear example (Dehaene, 2010). For instance, if a child in a WEIRD culture never learns to read or is delayed in learning is generally a sign for serious concern, in part because brain areas responsible for literacy may not be developing in a typical way. In a context with limited or no formal schooling, however, limited or no reading skill is hardly a reason to suspect atypical neurodevelopment.

A less obvious example comes again from work on EF: Card sorting tasks in which participants have to switch between sorting rules have been shown to relate to particular areas of the prefrontal cortex in WEIRD populations (e.g., Barceló & Knight, 2002; Milner, 1963). Likewise, success on card sorting tasks during childhood has been shown to be a sensitive measure of cognitive development in WEIRD populations (e.g., Doebel & Zelazo, 2015).

At the same time, performance on such tasks in populations with limited access to formal schooling shows radically different patterns of development. For instance, Legare et al. (2018) showed that while children in a U.S. sample improved dramatically on card sorting between ages three and six (considered a key period of executive function development), children in a South African sample with limited formal schooling showed no change at all across this age range.

It is plausible, then, that card sorting taps a locally articulated cognitive feature that is grounded in universal executive functions. This would explain how card-sorting ability may be at the same time an indicator of healthy prefrontal cortex functioning in WEIRD populations and bears a limited relationship with typical development in groups existing in some other cultural environments. Further research is, of course, required to confirm this possibility, but it serves to illustrate that the relationship between some cognitive features and particular brain regions (or reliable patterns of development) is in no way decisive evidence in deciding whether this feature is universally or locally articulated.

Articulation and Biological Evolution

It is worth clearly delineating the relationship between articulation and the shaping of the mind via biological evolution, which is often the focus of evolutionary psychology. Specifically, we review two key concepts from this tradition, outlining how their overlaps with and distinctions from articulation as we have defined it here. Briefly, we see each of these as types of hypotheses or approaches about the origins and nature of cognitive features within our larger framework.

Evoked Culture

As we have discussed, it is trivially true that there are always some universally articulated features supporting any locally articulated one (e.g., literacy requires language). For a cognitive feature to be an example of evoked culture (Tooby & Cosmides, 1992) involves the stronger claim that certain group-specific patterns of behavior are produced by a single, universally articulated cognitive feature reacting in genetically programmed ways to differences in the environment (to environmental cues). It is certainly the case that some cognitive features will conform to this description. However, there is no general answer to the question of whether any given behavioral pattern is due to a locally articulated feature or, in some meaningful way, a variation on a universally articulated one. Each case must be evaluated on its own merits, that is, deciding whether the evoked culture hypothesis (that some set of behavioral variations can be explained by a single universally articulated feature) is theoretically motivated and/or provides any additional explanatory power relative to assuming a locally articulated feature. The fact is that there are universally articulated features and there are locally articulated ones, and that in many cases, distinguishing between the two is a difficult but unavoidable challenge for theory and experimental work.

Cognitive Gadgets

Cognitive gadgets are "distinctively human cognitive mechanisms … that have only been shaped by cultural evolution and remain untouched by genetic evolution" (Heyes, 2018, p. 1). Whether a cognitive feature is shaped by cultural or genetic evolution is strictly speaking orthogonal to whether it is universally or locally articulated. After all, there may be some forms of cultural experience that are or were at some point universal across our species (see, e.g., Heyes' proposals on language), making any resulting "gadgets" universally articulated.

In sum, biological evolution certainly produces articulations as the human genetic and epigenetic systems adapt to demands and affordances of certain environments. Our terminology complements existing concepts in this space, emphasizing the need to define the relationship between cognitive features and specific environments in every case, regardless of whether the features emerge from biological evolution, cultural evolution, individual learning, or all of the above.

Case Studies

Here, using two case studies, we show how applying the articulation perspective helps resolve theoretical confusion and empirical limitations that emerge from a Newtonian approach and close by emphasizing how articulation allows us to integrate across existing patterns of data.

Case Study 1: Raven's Matrices

"Some people are cleverer than others" (Deary, 2012, p. 454). This opening line of a major review of work on intelligence could hardly be a better illustration of an unmarked universal: Intelligence, whatever it may be, is presupposed to generally determine the "cleverness" of individuals, omitting all context in true Newtonian fashion. Of course, this Newtonian approach to intelligence has for many decades been disputed by researchers who argue for intelligence as variable and culturally bound (e.g., Ceci, 1991, 1996; Greenfield, 2020; Sternberg, 2019; Sternberg et al., 2023; Sternberg & Grigorenko, 2004; Tomasello, 2019).

While the literature on intelligence is too vast for us to engage with fully here, we will draw on an argument developed by Muthukrishna and Henrich (2016) to illustrate how working from a principle of articulation can help organize and clarify findings from a particular measure and at the same time remove the need to appeal to unmarked universal terms. Raven's matrices are a common measure of fluid intelligence (J. C. Raven, 1938, 2000). Fluid intelligence, in turn, is a hypothesized set of cognitive features thought of as a universal capacity for generalized processing and problem solving, often tied to particular brain regions (e.g., Gray et al., 2003; Kane & Engle, 2002). In quintessential Newtonian style, the cognitive features tapped by Raven's matrices (call them CF-RM) are typically not connected to any distinct environment in which they are likely to be (particularly) adaptive, with work generally referring to performance on Raven's matrices as a "measure of fluid intelligence" tout court.

Under a principle of articulation, however, we do not have a theory of what Raven's matrices measures without some account of the EOA for CF-RM (tallying with certain long-standing proposals in the intelligence literature, e.g., Sternberg, 2019; Sternberg & Grigorenko, 2004). Thus, our first question is: What is the EOA for RM? Recent cross-cultural work provides crucial evidence on this point: Davis et al. (2020) have shown that, within a culturally homogenous Amazonian population (the Tsimane), equivalent across various demographic variables and market access, only those children who attended formal school showed a reliable increase in performance on Raven's matrices from ages 8 to 18. Children who did not attend school from this same population showed no increase in performance across the same decade of childhood.

Under a Newtonian account, we would at best be forced to explain how the "fluid intelligence" that nonschooled children develop is not the same fluid intelligence required in school, at which point the value of the term fluid intelligence becomes increasingly unclear. At worst, we would be compelled to make the absurd assumption that unschooled children simply do not become any more generally "clever" from middle childhood to early adulthood.

Under a principle of articulation, in contrast, it becomes apparent that CF-RM is a locally articulated feature whose EOA includes the presence of formal schools. Muthukrishna and Henrich (2016) developed precisely this hypothesis, arguing that formal schooling is part of the package of features particularly well-developed in the WEIRD collective brain and that group increases in IQ reflect adaptation to such a cultural environment (see also Flynn, 2009, for a similar argument). The dramatic rise in IQ over the 20th century was also likely accompanied by an increase in the heritability of IQ: As cultural evolution made the relevant cultural features (including high-quality formal schooling) increasingly ubiquitous, variation in culture becomes reduced as a proportion of variance in performance, leaving heritability an increasingly strong role for heritability (see Uchiyama et al., 2022).

The effects of schooling and WEIRD society make sense if CF-RM is a cognitive feature that facilitates the kind of rapid manipulation of abstract, arbitrary information within a self-contained set of rules that every trial of Raven's matrices presents. After all, starting from birth, individuals in urban (post-)industrial contexts will encounter hundreds of activities with idiosyncratic rules that may or may not have been encountered by previous generations and may not be readily inferred from other cultural experiences (e.g., bureaucratic procedures, laws and regulations, dozens or hundreds of board games, video games, sports, computer applications) Formal schooling, in particular, emphasizes the need to learn new activities abstracted from the rest of everyday life. Consider, for instance, a child moving in Day 1 from learning grammar in English, algebra in mathematics, musical notation in choir, and handball in the gym. Moreover, the same lessons on the very next day could involve handwriting, trigonometry, vocal exercises, and field hockey, respectively. The same demand for rapidly learning the rules of novel, unrelated activities appears less present in rural, nonindustrialized societies where activities (from games to rituals to resource acquisition) are often conceived of through a common set of understandings and remain relatively stable both in daily life and across generations (see Scribner & Cole, 1973, for a discussion of formal vs. informal schooling contexts; Bourdieu, 1977, for work on highly interrelated conceptual systems; and Davis et al., 2020, for further discussion of Raven's matrices specifically).

A locally articulated hypothesis is also consistent with the fact that performance on the task correlates poorly with how intelligence is understood by at least some non-WEIRD groups (e.g., Grigorenko et al., 2001; see also Serpell, 2011). Since these alternative conceptions of intelligence constructs were developed prior to the advent of formal schooling, it makes sense that the adaptive cognitive features they refer to have a limited relation to CF-RM.

Thinking of CF-RM as a locally articulated feature tied to rapid, arbitrary processing also fits well with the reliable findings of an increase in fluid intelligence across generations (i.e., the "Flynn effect," e.g., Flynn, 1987; Pietschnig & Voracek, 2015). From this perspective, the Flynn effect emerges as a result of cultural environments changing and diversifying over time. That is, the EOA at one period of time need not remain stable, and new generations may experience significantly different environments from their parents (or children). These new EOAs, in turn, drive changes in cognitive features (see Flynn, 2009; Muthukrishna & Henrich, 2016, for parallel arguments). As an analogy, as literacy spreads across a society, it is likely that the number of written materials increases, as does their importance in day-to-day interactions. This, in turn, motivates a further increase in literacy, which is liable to further increase the presence/importance of written materials, and so on.

Thus, all that we need to explain the Flynn effect at this point is the plausible assumption that cultural environments across the world have been changing to facilitate cognition of the kind required by Raven's matrices. Specifically, a change such that the affordances and demands that environments present make processing relatively abstract information in self-contained systems with their own rules an increasingly adaptive form of cognition to engage in. This tracks with a description of the world as increasingly technological and mobile, with both different forms of technology and experience of new locations requiring the learning of new sets of rules (see, e.g., Henrich, 2020). Flynn (2009) himself endorsed a similar environmental proposal and evidenced that gains in fluid intelligence across generations are driven by environmental factors is likewise consistent with this hypothesis (Bratsberg & Rogeberg, 2018).

Finally, as we discussed above, the local articulation of CF-RM is entirely consistent with this construct (and other constructs related to fluid intelligence) reliably developing, predicting life outcomes, and consistently mapping on to certain brain regions in schooled populations. In the same vein, it is not only plausible but entirely expected that CF-RM is underpinned by some universally articulated feature since this is the case for all locally articulated features. Speculation regarding what these universal features may be, however, is beyond the scope of this work.

We do not wish to make any conclusive claims about the nature of CF-RM, fluid intelligence, or the Flynn effect here. Our point has been to illustrate how an articulation approach gives us a way of thinking about cognitive features such as CF-RM that does not require endless modifications of the term "intelligence" and avoids the unmarked universals that currently bedevil the term. Instead, stepping back and defining the nature of the articulation between a set of cognitive features required for success on Raven's Matrices (CF-RM) and some cultural environments allows us to naturally incorporate a range of evidence and sidestep the problematic use of unmarked universals.

Case Study 2: Attachment

Emotional development and interaction are just as core to human cognition as more detached forms of reasoning. Attachment theory (Bowlby, 1953), in turn, is a cornerstone of work in (the development of) emotional cognition. Attachment is conceptualized as the stable relationship that a child forms with their caretaker, primarily their mother, early in life and that serves as a model for regulating their own stress and relationships with others. This relationship came to be assessed by a standard measure known as the "strange situation," in which the parent leaves the young child alone in a room with an unfamiliar experimenter (Ainsworth et al., 1978). Attachment theory proposes that a crucial determinant of the way in which the child reacts to this situation is their internal working model of relationships, a cognitive feature that is then carried forward into their adult life (e.g., Sroufe & Waters, 1977). Specifically, the child's behavior is interpreted as evidence for their internal model of relationships falling into one of several categories, all of which are considered problematic for later life with the exception of the "secure" type (Ainsworth et al., 1978). This basic model integrating an unmarked universal attachment with strange-situation assessments has persisted to this day (R. Thompson, 2017).

Such a universalist approach conflicts with exhaustive cross-cultural research showing that the normative caretaker–child relationships described in attachment theory are not universal (e.g., Gaskins et al., 2017; Quinn & Mageo, 2013). This results in children from certain societies systematically responding to the strange situation protocol in ways standard theory interprets as maladaptive (Keller, 2018). As Keller reviewed in detail, this Newtonian approach has led to all-too-real consequences for non-WEIRD families subject to assessments and regulations based on a Newtonian attachment theory, up to and including the legal separation of children from their parents (Keller, 2018). This is not to say attachment theorists ignore cultural variation altogether (see, e.g., Mesman et al., 2016), but there remain clear disagreements regarding the degree of universality that should be attributed to attachment types and internal working models.

The purpose of highlighting this example is not to make any pronouncements regarding the ongoing debate regarding universal and culturally specific features of attachment. Our point is to highlight the advantage of an articulation framework as an explicit alternative to the NP way of organizing this debate. For instance, it forces us to immediately define the EOA with which the internal working model of relationships is articulated. If this EOA is defined as “all family contexts,” then any test of these features should rely on universal features of family contexts—which the strange situation does not. At the same time, an articulation framework makes it very clear that locally articulated features can be extremely important within their EOAs. This means that, if the strange situation (as it is typically coded) reflects locally articulated features, they may still be important and predictive of life outcomes for certain EOAs.

To put it another way, thinking in terms of articulations demands answers to a series of questions that have both proven highly relevant within attachment theory and, at the same time, have no place in the Newtonian framework. For instance, what EOAs does the strange situation reflect? To what extent are these EOAs culturally specific v. universal? If they are culturally specific, which groups should or should not be assessed using this measure? If there are groups whose EOAs are not well reflected by the strange situation, what measures may be useful for assessing early relational development? and so forth. In other words, an articulation framing helps move the debate regarding universality and the influence of (cultural) environments from the periphery of work on attachment (see Keller, 2018; Quinn & Mageo, 2013, for discussions of this peripheral status) to being a core part of the project.

Summary: Advantages of Articulation

Using two case studies, we have illustrated the advantage of moving beyond an NP, which (often implicitly) treats cognitive features and their measures as universally applicable toward a principle of articulation, which requires some hypothesis regarding the environments in which these features emerge and are adaptive. In both cases, an articulation approach coincides with existing arguments in the field (e.g., Flynn, 2009; Keller, 2018). The marginal benefit lies in providing a framework and terminology that naturally fit with these adaptationist proposals and integrate anthropological, biological, and cognitive data. The principle of articulation also allows us to push back against the use of unmarked universals while maintaining the importance of marked universal properties, which inevitably underlie locally articulated ones. Next, we review a range of future directions that are motivated by taking an articulation perspective.

Review and Next Steps

Here, we have proposed the NP as a parsimonious way of understanding the resistance of classical cognitive science to cultural variation and the recurring cycle of conflict between universalist and culturalist camps, a principle that persists because it provides a solution to the boundary problem of cognitive science. There has doubtless been much progress under the auspices of this principle. Yet, it is ultimately unsustainable in the face of the need to systematically incorporate cultural variation into the study of the human mind. After all, the development and success of human individuals and groups are impossible without cultural systems, systems which are themselves inherently variable as a result of their adaptive, evolutionary nature.

The way forward, we argue, is through a systematic integration of cultural-evolutionary theory, which provides priors for solving the boundary problem, with work in cognitive science (and related disciplines). To this end, we develop the notion of articulation, which draws our attention to the environments neglected under the NP by compelling us to include accounts of these environments in our theories of cognitive features. Thinking in terms of articulations stands to both more accurately reflect the source of regularities in our experimental work as well as to motivate and integrate work on the nature of various cultural environments.

There is an important sense in which we agree both with the culturalist critiques of the universalist research program and classical cognitive science’s adherence to a generalizable solution to the boundary problem: We see the need for incorporating cultural variation into cognitive science while at the same time having a robust theoretical framework for generalizing our findings. In the remainder of this section, we sketch further directions that we believe can continue to bring together these camps and avoid yet another cycle of division on the way toward an integrated, cultural, and cognitive science.

Future Directions

Moving beyond an NP to an understanding of human cognition as articulated with culturally evolved environments motivates at least four interrelated directions for future empirical work, some of which are under active development while others are just beggining to be explored.

Direction 1: Cultural Environments and the Boundary Problem

Significant and increasing amounts of empirical research have been devoted to identifying which forms of cultural variation are liable to have significant effects on individual cognition. Relevant research has stretched across the first wave of cross-cultural research (e.g., Cole et al., 1971; Greenfield, 1974; Lave, 1977) to work in the cultural evolution framework and related traditions (e.g., Gelfand et al., 2011; Greenfield, 2009; Henrich, 2020; Thomson et al., 2018). Further work in this area is needed if we are to provide compelling answers to the boundary problem of which human groups we should expect to show important variation in cognitive features.

More generally, the principle of articulation assumes that the subject matter of cognitive science includes both the cultural (and other environmental) contexts in which cognition emerges and the cognitive mechanisms themselves. However, at present, the archives of cognitive science have vastly more systematic data and theory regarding internal cognitive mechanisms than they do regarding the environments that shape and are shaped by these mechanisms. In this impoverished context, an important first step is generating hypotheses regarding the locality v. universality of EOAs for cognitive features of interest, even if these hypotheses are initially very speculative. Ultimately, however, we should be aiming to provide more detailed models of EOAs (including their systematic changes across time). Thinking in terms of articulation facilitates redressing this imbalance by highlighting the necessity of characterizing the latter just as much as the former.

Looking ahead, the major endeavors here are both theoretical and empirical. Theoretically, researchers need to consider how institutions (e.g., family structure), norms, technologies, games, languages, songs, schools, and routine practices (as well as features of the environment not structured by humans) might shape cognitive development, including what people attend to, what they care about, and how they process information. Empirically, cognitive scientists need to measure the EOAs across diverse societies by attending to how people live their lives and what cognitive process the worlds they confront require. Among other patterns, research should attend to which cognitive features lead to local success, respect, and attention from others, thereby influencing transmission to subsequent generations. Promising lines of research are exploring variation in EOAs and their articulation with cognitive features in the context of language learning (Blasi et al., 2022), visual experience (Deręgowski, 2017; Segall et al., 1963), family organization (Enke, 2019; Schulz et al., 2019), norms (House et al., 2020), economic demands (Talhelm et al., 2014), literacy (Dehaene, 2010), teaching (Kline, 2015), and music (Singh & Mehr, 2023). Such enterprises should integrate experimental tools from the cognitive sciences with both qualitative and quantitative anthropological approaches, which include observational and ethnographic methods (e.g., Cole et al., 1971; Greenfield et al., 2003; Lancy et al., 2010; Lave, 1977; Rogoff, 2003). Crucially, the projects should be designed using the best available statistical and simulation techniques to optimize the chances for causal identification (Deffner et al., 2022). This is especially important given that unconventional (i.e., non-WEIRD, nonconvenience) groups and data sets may not be amenable to conventional research and sampling designed in conventional ones.

One major motivation to appeal to unconventional sources of data is that cultural-evolutionary hypotheses about cognition often require inferences about past EOAs. To accomplish this, we need to integrate data from diverse societies, including data from foragers (e.g., Lew-Levy et al., 2018, 2020), with historical, archaeological, and genetic data. For example, contemporary analysis might suggest an articulation between a certain form of family structure and some cognitive features. To assess how common those family structures were in the past, we might turn to ancient DNA. Particular kinship practices, for example, leave "marks" in the genome, allowing us to look deep into our evolutionary history using ancient DNA. Indeed, analysis of contemporary data confirms that anthropological data on kinship practices like cousin marriage correlate with "runs of homozygosity" from genetic data (Bahrami-Rad et al., 2022). Focusing on historical eras, new approaches to extracting psychological measures and other sorts of information from textual data offer us longitudinal data spread across space and time (Atari & Henrich, 2023; Martins & Baumard, 2022; Muthukrishna et al., 2021). Contemporary correlations between benchmark measures from psychology and text-based measures suggest the latter often performs remarkably well (see also Bail, 2014, for discussion of other big data sets in the study of cultural environments).

Finally, we note that the principle of articulation applies equally to the "psychology" of generative AI. Despite claims that generative AI models can give "human-like" responses on psychological and cognitive measures, it turns out that large language models like ChatGPT are cognitively WEIRD, sitting somewhere between Germany and New Zealand in global surveys (Atari et al., 2023). Indeed, while more research is required, the top hypothesis is that the training data used—the large language models' EOA—are heavily biased toward WEIRD populations. Worse, this electronic EOA by definition reflects only content created by literate individuals, which narrows the sample to a minority of humans in our species' history coming from a very limited set of historical eras.

Direction 2: What Is Cognitive Development Like Outside of WEIRD, or Even Outside of Industrialized, Schooled Environments?

As many scholars have noted (see, e.g., Kline et al., 2018), the lack of cross-cultural samples means that we are liable to miss patterns of development outside of WEIRD contexts altogether. This is unsustainable if we wish our work to be a study of *Homo sapiens* and not a form of WEIRD ethnoscience (Barrett, 2020). Fortunately, large-scale efforts to study cognition across diverse populations are under way (e.g., Klein et al., 2018), including interdisciplinary efforts in the cultural evolution tradition (e.g., Muthukrishna et al., 2018; Purzycki et al., 2016; White et al., 2021). Particularly crucial is work in cultural contexts that are neither industrialized nor have widespread formal schooling. After all, neither of these environments (industrialization, formal schooling) were present in the overwhelming majority of societies in our species' evolutionary history. Yet, samples from industrialized, schooled populations make up almost all of cognitive science. If we wish to distinguish which of our existing findings apply to the human mind v. the industrialized, schooled mind, we need to address this imbalance. There is added pressure to move quickly since there are relatively few populations that have not yet been integrated into industrialized, schooled cultural systems, and it is entirely possible that there will soon be none at all.

Direction 3: What Is It That We Have Been Studying in WEIRD Populations?

As we have reviewed above, without work testing the relationship of cognitive features to particular environments, we are not in a position to understand these features. Given the ubiquity of unmarked universals, this is a problem for many cognitive features already identified by reliable experimental results in classical cognitive science. That is, when theoretical constructs and their measures are developed in WEIRD populations, they are all too often left as unmarked universals, despite absent or contradictory evidence from other cultural environments. In such cases, the Newtonian position leaves ambiguous whether the cognitive features we have identified are universally articulated or are, in fact, locally articulated features that are specifically adaptive in WEIRD, or at least industrialized, schooled environments.

One way of testing this issue is by examining performance on standard tasks outside of industrialized, schooled communities (e.g., see Mayer & Träuble, 2013, on theory of mind; Legare et al., 2018, on executive function; Rogoff, 1981, on formal schooling; and Berry, 1987, for further relevant discussion). The complementary approach, less often considered, involves studying the nature and diversity of the cultural environments in WEIRD societies. That is, ethnographies of WEIRD environments can identify the peculiar opportunities and demands these present to the developing mind and how they are likely to shape patterns of development we observe in WEIRD samples (see also Medin et al., 2010, 2017, for relevant discussions of the biases produced by WEIRD research).

Of particular interest may be the ways in which the continuing digitalization of society shapes both cultural environments and cognitive systems not only in WEIRD populations but also worldwide (see, e.g., Maynard et al., 2005; Vedechkina & Borgonovi, 2021, for relevant discussions). The same is true of the cultural–cognitive dynamics that have produced and continue to produce large-scale changes to the planet's climate and ecology, whose roots like in the industrial revolution of WEIRD societies (Preiss, 2022; we thank an anonymous reviewer for highlighting these two directions for future work).

Direction 4: What Are Cultural Environments?

A final direction of development is toward a formalizable theory defining what cultural environments are as a class in the same way that classical cognitive science defines cognitive systems as computational systems. Developing a more formal theory is an important step forward in systematizing the various dimensions on which cultural systems have been shown to vary and how these interact with each other and individual cognition (see, e.g., Ellis et al., 2017; Frankenhuis et al., 2016; Walasek et al., 2022, for examples of important work in this domain).

Crucially, this does not imply that features of the environment shaped by human behavior are the only relevant features of EOAs. After all, culture had nothing to do with the EOAs responsible for the emergence of low-level visual mechanisms. Understanding noncultural environments as EOAs is a crucial, ongoing task (e.g., see Battaglia et al., 2013; Ullman et al., 2017, for a proposal on how physics in day-to-day life is modeled by the mind). That being said, cultural environments are a particularly crucial form of EOA given their centrality to emergence and successes of human-unique cognition (e.g., Henrich, 2008).

Direction 5: Modeling Articulation

Important work on the mechanisms by which cognitive systems may infer structure from their environments has been done in a number of traditions focused on the process of inference. These include Bayesian (e.g., Griffiths et al., 2008; Tenenbaum et al., 2011) and free-energy (Badcock et al., 2019; Ramstead et al., 2019; Veissière et al., 2019) models of cognition, among others. In one sense, these models are highly compatible with the principle of articulation in as much as they explicitly address Marr's (1982) computational level. As we have said throughout, we absolutely acknowledge the importance of such mechanisms and research that elaborates on their structure.

However, these approaches remain in line with the NP since they are focused on characterizing universal and domain-general properties of inference. For instance, efforts to integrate either Bayesian or free-energy traditions with cultural evolution to model expected variation across cultural groups are rare. That being said, there are important exceptions (e.g., Hong & Henrich, 2021; Perreault et al., 2012; B. Thompson et al., 2016, 2022). We see no in-principle barrier to constructing such models to explicitly capture articulations—that is, both cognitive features and their environments—and suggest that it is a fruitful direction for future work.

Changing Theory, Shifting Incentives

As we acknowledged at the outset, the social endeavor that is cognitive science involves many motivations and biases outside of purely theoretical considerations. However, we would maintain that the easier it is to name a problem and trace its causes, the easier it is to mount resistance to it. Once the field has theoretical motivation to resist universal generalizations, this can shift the incentive structure such that a "least effort" approach will now involve addressing issues of culture and universality from the outset rather than facing sustained critique in, for example, journal reviews. The fact that theoretical commitments can motivate significant, and especially cross-cultural, efforts is evident at least from changes in the history of anthropology: For better or worse, the theoretical commitments of anthropology in the first half of the 20th century were such that researchers systematically traveled to remote (and often dangerous) locations to pursue their studies. As the discipline became more comfortable with considering culture as something present "back home" in Western, industrialized settings, researchers were increasingly able to avoid such resource-intensive work. To put it simply, our hope here is to add to the theoretical pressure motivating a reverse of this development in cognitive science. We do so by providing a streamlined terminology for discussing the issue of universality—its importance, problems, and potential solutions—and by shifting the emphasis from cognitive features to articulations between cognitive features and their EOAs.

Work, in theory, is certainly not just a way of shifting incentives. After all, even if we were to remove all of the practical challenges and biases that produce universalist thinking, the theoretical issues we discuss here, in particular the boundary problem, would not be solved. Thus, we see the present work as both facilitating concrete shifts in behavior and pointing the way toward a theoretically coherent status quo.

Concrete Call to Action: Marking the Universalist Default

We would like to close with a more concrete recommendation for moving beyond unmarked universals and the NP in our scientific practice. Namely, we suggest reports of empirical research state, in all cases, a hypothesis regarding the EOA and whether this environment is universal or group-specific.

Of course, we will often lack the data to make any firm conclusions in this regard. This is not a problem. The goal here is to keep environments in (our theories of) mind. As such, outlining why we may suspect the relevant feature to be universally or locally articulated, as well as what empirical evidence is required to make a determination either way, would be a major step forward. In line with our discussion above, simply being explicit about this issue marks the scope of the claim and helps correct for the NP. Specifically, this stands to make both the writer and the reader actively consider how the cognitive feature and/or experimental result under examination is related to cultural environments—and not fall prey to our automatic inferences of universality in the absence of any claim about scope.

Conclusion

In closing, we wish to emphasize again that shifting away from the NP does not entail rejecting the reality or importance of universal features. Nor does it impinge upon the reality and importance of any replicable findings produced to date. The question here is what environments the features identified by existing (and future) work are adapted to. In many ways, the framework we propose is simply an elaboration of long-standing aspects of cognitive science, from Marr's (1982) emphasis on computational problems to subsequent developments in theories of inference to developments in cultural psychology and cultural-evolutionary theory. Our call is explicitly for a unity platform from which we may move beyond an NP and the decades of conflict between universalist and culturalist camps and toward a more inclusive, better-articulated science of our cultural species.

References

Ainsworth, M., Blehar, M., Waters, E., & Wall, E. (1978). *Patterns of attachment*. Erlbaum.

Apicella, C., Norenzayan, A., & Henrich, J. (2020). Beyond WEIRD: A review of the last decade and a look ahead to the global laboratory of the future. *Evolution and Human Behavior*, *41*(5), 319–329. https://doi.org/10.1016/j.evolhumbehav.2020.07.015

Ardila, A. (2005). Cultural values underlying psychometric cognitive testing. *Neuropsychology Review*, *15*(4), 185–195. https://doi.org/10.1007/s11065-005-9180-y

Arnett, J. J. (2008). The neglected 95%: Why American psychology needs to become less American. *American Psychologist*, *63*(7), 602–614. https://doi.org/10.1037/0003-066X.63.7.602

Ashton, P. T. (1975). Cross-cultural Piagetian research: An experimental perspective. *Harvard Educational Review*, *45*(4), 475–506. https://doi.org/10.17763/haer.45.4.kpq1578t13tk0541

Atari, M., & Henrich, J. (2023). Historical psychology. *Current Directions in Psychological Science*, *32*(2), 176–183. https://doi.org/10.1177/09637214221149737

Atari, M., Xue, M. J., Park, P. S., Blasi, D., & Henrich, J. (2023). *Which humans?* PsyArXiv. https://doi.org/10.31234/osf.io/5b26t

Badcock, P. B., Friston, K. J., & Ramstead, M. J. D. (2019). The hierarchically mechanistic mind: A free-energy formulation of the human psyche. *Physics of Life Reviews*, *31*, 104–121. https://doi.org/10.1016/j.plrev.2018.10.002

Bahrami-Rad, D., Beauchamp, J., Henrich, J., & Schulz, J. (2022). *Kin-based institutions and economic development* (SSRN Scholarly Paper 4200629). https://doi.org/10.2139/ssrn.4200629

Bail, C. A. (2014). The cultural environment: Measuring culture with big data. *Theory and Society*, *43*(3), 465–482. https://doi.org/10.1007/s11186-014-9216-5

Bakhurst, D. (2009). Reflections on activity theory. *Educational Review*, *61*(2), 197–210. https://doi.org/10.1080/00131910902846916

Barceló, F., & Knight, R. T. (2002). Both random and perseverative errors underlie WCST deficits in prefrontal patients. *Neuropsychologia*, *40*(3), 349–356. https://doi.org/10.1016/S0028-3932(01)00110-5

Barhorst-Cates, E. M., Meneghetti, C., Zhao, Y., Pazzaglia, F., & Creem-Regehr, S. H. (2021). Effects of home environment structure on navigation preference and performance: A comparison in Veneto, Italy and Utah, USA. *Journal of Environmental Psychology*, *74*, Article 101580. https://doi.org/10.1016/j.jenvp.2021.101580

Barrett, H. C. (2020). Towards a cognitive science of the human: Cross-cultural approaches and their urgency. *Trends in Cognitive Sciences*, *24*(8), 620–638. https://doi.org/10.1016/j.tics.2020.05.007

Battaglia, P. W., Hamrick, J. B., & Tenenbaum, J. B. (2013). Simulation as an engine of physical scene understanding. *Proceedings of the National Academy of Sciences of the United States of America*, *110*(45), 18327–18332. https://doi.org/10.1073/pnas.1306572110

Bender, A., & Beller, S. (2013). Cognition is … fundamentally cultural. *Behavioral Sciences*, *3*(1), 42–54. https://doi.org/10.3390/bs3010042

Berry, J. W. (1987). The comparative study of cognitive abilities. In S. H. Irvine & S. E. Newstead (Eds.), *Intelligence and cognition: Contemporary frames of reference* (pp. 393–420). Springer Netherlands. https://doi.org/10.1007/978-94-010-9437-5_10

Blasi, D. E., Henrich, J., Adamou, E., Kemmerer, D., & Majid, A. (2022). Over-reliance on English hinders cognitive science. *Trends in Cognitive Sciences*, *26*(12), 1153–1170. https://doi.org/10.1016/j.tics.2022.09.015

Bourdieu, P. (1977). *Outline of a theory of practice* (R. Nice, Trans.). Cambridge University Press.

Bowlby, J. (1953). Some pathological processes set in train by early mother–child separation. *Journal of Mental Science*, *99*(415), 265–272. https://doi.org/10.1192/bjp.99.415.265

Boyd, R., & Richerson, P. J. (1985). *Culture and the evolutionary process*. University of Chicago Press.

Bratsberg, B., & Rogeberg, O. (2018). Flynn effect and its reversal are both environmentally caused. *Proceedings of the National Academy of Sciences of the United States of America*, *115*(26), 6674–6678. https://doi.org/10.1073/pnas.1718793115

Bronfenbrenner, U. (1981). *The ecology of human development: Experiments by nature and design*. Harvard University Press.

Bruner, J. (1990). Culture and human development: A new look. *Human Development*, *33*(6), 344–355. https://doi.org/10.1159/000276535

Cavalli-sforza, L. L., & Feldman, M. W. (1981). *Cultural transmission and evolution* (1st ed.). Princeton University Press.

Ceci, S. J. (1991). How much does schooling influence general intelligence and its cognitive components? A reassessment of the evidence. *Developmental Psychology*, *27*(5), 703–722. https://doi.org/10.1037/0012-1649.27.5.703

Ceci, S. J. (1996). *On intelligence: A biological treatise on intellectual development, expanded edition* (2nd ed.). Harvard University Press. https://doi.org/10.4159/9780674029316

Cole, M. (1990). Cognitive development and formal schooling: The evidence from cross-cultural research. In L. C. Moll (Ed.), *Vygotsky and education: Instructional implications and applications of sociohistorical psychology* (pp. 89–110). Cambridge University Press. https://doi.org/10.1017/CBO9781139173674.005

Cole, M. (1996). *Cultural psychology: A once and future discipline* (pp. xvi, 400). Harvard University Press.

Cole, M., Gay, J., Glick, J., & Sharp, D. W. (1971). *The cultural context of learning and thinking: An exploration in experimental anthropology*. Basic Books.

Creanza, N., Fogarty, L., & Feldman, M. W. (2012). Models of cultural niche construction with selection and assortative mating. *PLOS ONE*, *7*(8), Article e42744. https://doi.org/10.1371/journal.pone.0042744

Cristofori, I., Cohen-Zimerman, S., & Grafman, J. (2019). Executive functions. In M. D'Esposito & J. H. Grafman (Eds.), *Handbook of clinical neurology* (Vol. 163, pp. 197–219). Elsevier. https://doi.org/10.1016/B978-0-12-804281-6.00011-2

D'Andrade, R. (2000). The sad story of anthropology 1950–1999. *Cross-Cultural Research: The Journal of Comparative Social Science*, *34*(3), 219–232. https://doi.org/10.1177/106939710003400301

Davis, H. E., Gurven, M., & Cashdan, E. (2023). Navigational experience and the preservation of spatial abilities into old age among a tropical Forager-Farmer population. *Topics in Cognitive Science*, *15*(1), 187–212. https://doi.org/10.1111/tops.12602

Davis, H. E., Stack, J., & Cashdan, E. (2021). Cultural change reduces gender differences in mobility and spatial ability among Seminomadic Pastoralist-Forager children in Northern Namibia. *Human Nature*, *32*(1), 178–206. https://doi.org/10.1007/s12110-021-09388-7

Davis, H. E., Stieglitz, J., Kaplan, H., Tayo, A. M., & Gurven, M. (2020). *The formal schooling niche: Longitudinal evidence from Bolivian Amazon demonstrates that higher school quality augments differences in children's abstract reasoning*. PsyArXiv. https://doi.org/10.31234/osf.io/d3sgq

Deary, I. J. (2012). Intelligence. *Annual Review of Psychology*, *63*(1), 453–482. https://doi.org/10.1146/annurev-psych-120710-100353

Deffner, D., Rohrer, J. M., & McElreath, R. (2022). A causal framework for cross-cultural generalizability. *Advances in Methods and Practices in Psychological Science*, *5*(3). https://doi.org/10.1177/25152459221106366

Dehaene, S. (1997). *The number sense: How the mind creates mathematics*. Oxford University Press.

Dehaene, S. (2010). *Reading in the brain: The new science of how we read* (Reprint ed.). Penguin Books.

Deręgowski, J. B. (2017). Cross-cultural studies of illusions. In A. G. Shapiro & D. Todorovic (Eds.), *The Oxford compendium of visual illusions* (pp. 38–53). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199794607.003.0002

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*(1), 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

Doebel, S. (2020). Rethinking executive function and its development. *Perspectives on Psychological Science*, *15*(4), 942–956. https://doi.org/10.1177/1745691620904771

Doebel, S., & Zelazo, P. D. (2015). A meta-analysis of the dimensional change card sort: Implications for developmental theories and the measurement of executive function in children. *Developmental Review*, *38*, 241–268. https://doi.org/10.1016/j.dr.2015.09.001

Ellis, B. J., Bianchi, J., Griskevicius, V., & Frankenhuis, W. E. (2017). Beyond risk and protective factors: An adaptation-based approach to resilience. *Perspectives on Psychological Science*, *12*(4), 561–587. https://doi.org/10.1177/1745691617693054

Enke, B. (2019). Kinship, cooperation, and the evolution of moral systems. *The Quarterly Journal of Economics*, *134*(2), 953–1019. https://doi.org/10.1093/qje/qjz001

Fechner, G. T. (1860). *Elemente der Psychophysik* [Elements of psychophysics]. Breitkopf und Härtel.

Flynn, J. R. (1987). Massive IQ gains in 14 nations: What IQ tests really measure. *Psychological Bulletin*, *101*(2), 171–191. https://doi.org/10.1037/0033-2909.101.2.171

Flynn, J. R. (2009). *What is intelligence?* (1st expanded pbk. ed.). Cambridge University Press.

Frankenhuis, W. E., Panchanathan, K., & Nettle, D. (2016). Cognition in harsh and unpredictable environments. *Current Opinion in Psychology*, *7*, 76–80. https://doi.org/10.1016/j.copsyc.2015.08.011

Gardner, H. (1985). *The mind's new science: A history of the cognitive revolution*. Basic Books.

Gaskins, S., Beeghly, M., Bard, K. A., Gernhardt, A., Liu, C. H., Teti, D. M., Thompson, R. A., Weisner, T. S., & Yovsi, R. D. (2017). Meaning and methods in the study and assessment of attachment. In H. Keller, & K. A. Bard (Eds.), *The cultural nature of attachment: Contextualizing relationships and development* (pp. 195–229). MIT Press. https://doi.org/10.7551/mitpress/9780262036900.003.0008

Gay, J., & Cole, M. (1967). *The new mathematics and an old culture: A study of learning among the Kpelle of Liberia*. Holt, Rinehart and Winston.

Geertz, C. (1973). *The interpretation of cultures*. Basic Books.

Gelfand, M. J., Raver, J. L., Nishii, L., Leslie, L. M., Lun, J., Lim, B. C., Duan, L., Almaliach, A., Ang, S., Arnadottir, J., Aycan, Z., Boehnke, K., Boski, P., Cabecinhas, R., Chan, D., Chhokar, J., D'Amato, A., Subirats Ferrer, M., Fischlmayr, I. C., … Yamaguchi, S. (2011). Differences between tight and loose cultures: A 33-nation study. *Science*, *332*(6033), 1100–1104. https://doi.org/10.1126/science.1197754

Gibson, J. J. (1979). *The ecological approach to visual perception*. Houghton Mifflin.

Gigerenzer, G. (2008). Why Heuristics work. *Perspectives on Psychological Science*, *3*(1), 20–29. https://doi.org/10.1111/j.1745-6916.2008.00058.x

Gleick, J. (2004). *Isaac Newton*. Vintage.

Gray, J. R., Chabris, C. F., & Braver, T. S. (2003). Neural mechanisms of general fluid intelligence. *Nature Neuroscience*, *6*(3), 316–322. https://doi.org/10.1038/nn1014

Greenfield, P. M. (1974). Comparing dimensional categorization in natural and artificial contexts: A developmental study among the Zinacantecos of Mexico. *The Journal of Social Psychology*, *93*(2), 157–171. https://doi.org/10.1080/00224545.1974.9923149

Greenfield, P. M. (1997). You can't take it with you: Why ability assessments don't cross cultures. *American Psychologist*, *52*(10), 1115–1124. https://doi.org/10.1037/0003-066X.52.10.1115

Greenfield, P. M. (2009). Linking social change and developmental change: Shifting pathways of human development. *Developmental Psychology*, *45*(2), 401–418. https://doi.org/10.1037/a0014726

Greenfield, P. M. (2020). Historical evolution of intelligence. In R. J. Sternberg (Ed.), *The Cambridge handbook of intelligence* (2nd ed., pp. 916–939). Cambridge University Press. https://doi.org/10.1017/9781108770422.039

Greenfield, P. M., & Bruner, J. S. (1966). Culture and cognitive growth. *International Journal of Psychology*, *1*(2), 89–107. https://doi.org/10.1080/00207596608247117

Greenfield, P. M., Maynard, A. E., & Childs, C. P. (2003). Historical change, cultural learning, and cognitive representation in Zinacantec Maya children. *Cognitive Development*, *18*(4), 455–487. https://doi.org/10.1016/j.cogdev.2003.09.004

Greenland, S. (2023). Connecting simple and precise P-values to complex and ambiguous realities. *Scandinavian Journal of Statistics*, *50*(3), 899–914. https://doi.org/10.1111/sjos.12645

Greenland, S., Senn, S. J., Rothman, K. J., Carlin, J. B., Poole, C., Goodman, S. N., & Altman, D. G. (2016). Statistical tests, *P* values, confidence intervals, and power: A guide to misinterpretations. *European Journal of Epidemiology*, *31*(4), 337–350. https://doi.org/10.1007/s10654-016-0149-3

Griffiths, T. L., Kemp, C., & Tenenbaum, J. B. (2008). Bayesian models of cognition. In R. Sun (Ed.), *The Cambridge handbook of computational psychology* (pp. 59–100). Cambridge University Press. https://doi.org/10.1017/CBO9780511816772.006

Grigorenko, E. L., Geissler, P. W., Prince, R., Okatcha, F., Nokes, C., Kenny, D. A., Bundy, D. A., & Sternberg, R. J. (2001). The organisation of Luo conceptions of intelligence: A study of implicit theories in a Kenyan village. *International Journal of Behavioral Development*, *25*(4), 367–378. https://doi.org/10.1080/01650250042000348

Hegel, G. W. F. (1807). *Phenomenology of spirit* (A. V. Miller, Trans.). Oxford University Press.

Heidegger, M. (1927). *Being and time* (J. Macquarrie & E. S. Robinson, Trans.). Martino Fine Books.

Henrich, J. (2008). A cultural species. In M. Brown (Ed.), *Explaining culture scientifically* (pp. 184–210). University of Washington Press.

Henrich, J. (2016). *The secret of our success: How culture is driving human evolution, domesticating our species, and making us smarter* (pp. xv, 445). Princeton University Press.

Henrich, J. (2020). *The WEIRDest people in the world: How the west became psychologically peculiar and particularly prosperous*. Farrar, Straus and Giroux.

Henrich, J., Blasi, D. E., Curtin, C. M., Davis, H. E., Hong, Z., Kelly, D., & Kroupin, I. (2023). A cultural species and its cognitive phenotypes: Implications for philosophy. *Review of Philosophy and Psychology*, *14*, 349–386. https://doi.org/10.1007/s13164-021-00612-y

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences*, *33*(2–3), 61–83. https://doi.org/10.1017/S0140525X0999152X

Heyes, C. (2018). *Cognitive gadgets: The cultural evolution of thinking*. Belknap Press.

Hong, Z., & Henrich, J. (2021). The cultural evolution of epistemic practices: The case of divination. *Human Nature*, *32*(3), 622–651. https://doi.org/10.1007/s12110-021-09408-6

House, B. R., Kanngiesser, P., Barrett, H. C., Broesch, T., Cebioglu, S., Crittenden, A. N., Erut, A., Lew-Levy, S., Sebastian-Enesco, C., Smith, A. M., Yilmaz, S., & Silk, J. B. (2020). Universal norm psychology leads to societal diversity in prosocial behaviour and development. *Nature Human Behaviour*, *4*, 36–44. https://doi.org/10.1038/s41562-019-0734-z

Hruschka, D. J., Munira, S., Jesmin, K., Hackman, J., & Tiokhin, L. (2018). Learning from failures of protocol in cross-cultural research. *Proceedings of the National Academy of Sciences of the United States of America*, *115*(45), 11428–11434. https://doi.org/10.1073/pnas.1721166115

Ilardo, M. A., Moltke, I., Korneliussen, T. S., Cheng, J., Stern, A. J., Racimo, F., de Barros Damgaard, P., Sikora, M., Seguin-Orlando, A., Rasmussen, S., van den Munckhof, I. C. L., Ter Horst, R., Joosten, L. A. B., Netea, M. G., Salingkat, S., Nielsen, R., & Willerslev, E. (2018). Physiological and genetic adaptations to diving in sea nomads. *Cell*, *173*(3), 569–580.e15. https://doi.org/10.1016/j.cell.2018.03.054

Kahneman, D., Slovic, P., & Tversky, A. (Eds.). (1982). *Judgment under uncertainty: Heuristics and biases*. Cambridge University Press. https://doi.org/10.1017/CBO9780511809477

Kane, M. J., & Engle, R. W. (2002). The role of prefrontal cortex in working-memory capacity, executive attention, and general fluid intelligence: An individual-differences perspective. *Psychonomic Bulletin & Review*, *9*(4), 637–671. https://doi.org/10.3758/BF03196323

Keller, H. (2018). Universality claim of attachment theory: Children's socioemotional development across cultures. *Proceedings of the National Academy of Sciences of the United States of America*, *115*(45), 11414–11419. https://doi.org/10.1073/pnas.1720325115

Kendal, J. R. (2011). Cultural Niche construction and human learning environments: Investigating sociocultural perspectives. *Biological Theory*, *6*(3), 241–250. https://doi.org/10.1007/s13752-012-0038-2

Kitayama, S., & Park, J. (2010). Cultural neuroscience of the self: Understanding the social grounding of the brain. *Social Cognitive and Affective Neuroscience*, *5*(2–3), 111–129. https://doi.org/10.1093/scan/nsq052

Klein, R. A., Vianello, M., Hasselman, F., Adams, B. G., Adams, R. B., Jr., Alper, S., Aveyard, M., Axt, J. R., Babalola, M. T., Bahník, Š., Batra, R., Berkics, M., Bernstein, M. J., Berry, D. R., Bialobrzeska, O., Binan, E. D., Bocian, K., Brandt, M. J., Busching, R., … Nosek, B. A. (2018). Many labs 2: Investigating variation in replicability across samples and settings. *Advances in Methods and Practices in Psychological Science*, *1*(4), 443–490. https://doi.org/10.1177/2515245918810225

Kline, M. A. (2015). How to learn about teaching: An evolutionary framework for the study of teaching behavior in humans and other animals. *Behavioral and Brain Sciences*, *38*, Article e31. https://doi.org/10.1017/S0140525X14000090

Kline, M. A., Shamsudheen, R., & Broesch, T. (2018). Variation is the universal: Making cultural evolution work in developmental psychology. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *373*(1743), Article 20170059. https://doi.org/10.1098/rstb.2017.0059

Laland, K. N., Odling-Smee, J., & Myles, S. (2010). How culture shaped the human genome: Bringing genetics and the human sciences together. *Nature Reviews. Genetics*, *11*(2), 137–148. https://doi.org/10.1038/nrg2734

Lancy, D. F., Bock, J. C., & Gaskins, S. (Eds.). (2010). *The anthropology of learning in childhood*. AltaMira Press.

Lave, J. (1977). Tailor-made experiments and evaluating the intellectual consequences of apprenticeship training. *The Quarterly Newsletter of the Institute for Comparative Human Development*, *1*(2), 1–3.

Lave, J. (1997). What's special about experiments as contexts for thinking? In M. Cole, Y. Engeström, & O. Vasquez (Eds.), *Mind, culture, and activity: Seminal papers from the laboratory of comparative human cognition* (pp. 57–69). Cambridge university press.

Legare, C. H., Dale, M. T., Kim, S. Y., & Deák, G. O. (2018). Cultural variation in cognitive flexibility reveals diversity in the development of executive functions. *Scientific Reports*, *8*(1), Article 16326. https://doi.org/10.1038/s41598-018-34756-2

Levinson, S. C. (2012). The original sin of cognitive science. *Topics in Cognitive Science*, *4*(3), 396–403. https://doi.org/10.1111/j.1756-8765.2012.01195.x

Lew-Levy, S., Kissler, S. M., Boyette, A. H., Crittenden, A. N., Mabulla, I. A., & Hewlett, B. S. (2020). Who teaches children to forage? Exploring the primacy of child-to-child teaching among Hadza and BaYaka hunter–gatherers of Tanzania and Congo. *Evolution and Human Behavior*, *41*(1), 12–22. https://doi.org/10.1016/j.evolhumbehav.2019.07.003

Lew-Levy, S., Lavi, N., Reckin, R., Cristóbal-Azkarate, J., & Ellis-Davies, K. (2018). How do Hunter–Gatherer children learn social and gender norms? A meta-ethnographic review. *Cross-Cultural Research: The Journal of Comparative Social Science*, *52*(2), 213–255. https://doi.org/10.1177/1069397117723552

Luria, A. R. (1976). *Cognitive development: Its cultural and social foundations*. Harvard University Press.

Marr, D. (1982). *Vision*. The MIT Press.

Martins, M. J. D., & Baumard, N. (2022). How to develop reliable instruments to measure the cultural evolution of preferences and feelings in history? *Frontiers in Psychology*, *13*, Article 786229. https://doi.org/10.3389/fpsyg.2022.786229

Mayer, A., & Träuble, B. E. (2013). Synchrony in the onset of mental state understanding across cultures? A study among children in Samoa. *International Journal of Behavioral Development*, *37*(1), 21–28. https://doi.org/10.1177/0165025412454030

Maynard, A. E., Subrahmanyam, K., & Greenfield, P. M. (2005). Technology and the development of intelligence: From the loom to the computer. In R. J. Sternberg & D. D. Preiss (Eds.), *Intelligence and technology: The impact of tools on the nature and development of human abilities* (pp. xxiv, 248). Lawrence Erlbaum. https://doi.org/10.4324/9780203824252

McElreath, R. (2020). *Statistical rethinking: A Bayesian course with examples in R and Stan* (2nd ed.). CRC Press. https://doi.org/10.1201/9780429029608

Medin, D., Bennis, W., & Chandler, M. (2010). Culture and the home-field disadvantage. *Perspectives on Psychological Science: A Journal of the Association for Psychological Science*, *5*(6), 708–713. https://doi.org/10.1177/1745691610388772

Medin, D., Ojalehto, B., Marin, A., & Bang, M. (2017). Systems of (non-)diversity. *Nature Human Behaviour*, *1*, Article 0088. https://doi.org/10.1038/s41562-017-0088

Mesman, J., van Ijzendoorn, M. H., & Sagi-Schwartz, A. (2016). Cross-cultural patterns of attachment: Universal and contextual dimensions. In J. Cassidy & P. R. Shavers (Eds.), *Handbook of attachment: Theory, research, and clinical applications* (3rd ed., pp. 852–877). Guilford Press.

Miller, G. A. (2003). The cognitive revolution: A historical perspective. *Trends in Cognitive Sciences*, *7*(3), 141–144. https://doi.org/10.1016/S1364-6613(03)00029-9

Milner, B. (1963). Effects of different brain lesions on card sorting: The role of the Frontal Lobes. *Archives of Neurology*, *9*(1), 90–100. https://doi.org/10.1001/archneur.1963.00460070100010

Muthukrishna, M., & Henrich, J. (2016). Innovation in the collective brain. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *371*(1690), Article 20150192. https://doi.org/10.1098/rstb.2015.0192

Muthukrishna, M., & Henrich, J. (2019). A problem in theory. *Nature Human Behaviour*, *3*(3), 221–229. https://doi.org/10.1038/s41562-018-0522-1

Muthukrishna, M., Henrich, J., & Slingerland, E. (2021). Psychology as a historical science. *Annual Review of Psychology*, *72*(1), 717–749. https://doi.org/10.1146/annurev-psych-082820-111436

Muthukrishna, M., Henrich, J., Toyokawa, W., Hamamura, T., Kameda, T., & Heine, S. J. (2018). Overconfidence is universal? Elicitation of genuine overconfidence (EGO) procedure reveals systematic differences across domain, task knowledge, and incentives in four populations. *PLOS ONE*, *13*(8), Article e0202288. https://doi.org/10.1371/journal.pone.0202288

Newell, A., Shaw, J. C., & Simon, H. A. (1959). *Report on a general problem-solving program* [Conference session]. International Conference on Information Processing, Paris, France.

Nielsen, M., Haun, D., Kärtner, J., & Legare, C. H. (2017). The persistent sampling bias in developmental psychology: A call to action. *Journal of Experimental Child Psychology*, *162*, 31–38. https://doi.org/10.1016/j.jecp.2017.04.017

Nuzzo, R. (2014). Scientific method: Statistical errors. *Nature*, *506*(7487), 150–152. https://doi.org/10.1038/506150a

Palmer, S. E. (1999). *Vision science: Photons to phenomenology*. MIT Press.

Perreault, C., Moya, C., & Boyd, R. (2012). A Bayesian approach to the evolution of social learning. *Evolution and Human Behavior*, *33*(5), 449–459. https://doi.org/10.1016/j.evolhumbehav.2011.12.007

Pietschnig, J., & Voracek, M. (2015). One century of global IQ gains: A formal meta-analysis of the Flynn effect (1909–2013). *Perspectives on Psychological Science*, *10*(3), 282–306. https://doi.org/10.1177/1745691615577701

Preiss, D. D. (2022). Human intelligence in the time of the Anthropocene. In R. J. Sternberg & D. D. Preiss (Eds.), *Intelligence in context: The cultural and historical foundations of human intelligence* (pp. 361–391). Springer International Publishing. https://doi.org/10.1007/978-3-030-92798-1_15

Purzycki, B. G., Apicella, C., Atkinson, Q. D., Cohen, E., McNamara, R. A., Willard, A. K., Xygalatas, D., Norenzayan, A., & Henrich, J. (2016). Moralistic gods, supernatural punishment and the expansion of human sociality. *Nature*, *530*(7590), 327–330. https://doi.org/10.1038/nature16980

Quinn, N., & Mageo, J. M. (Eds.). (2013). *Attachment reconsidered: Cultural perspectives on a western theory*. Palgrave Macmillan. https://doi.org/10.1057/9781137386724

Rad, M. S., Martingano, A. J., & Ginges, J. (2018). Toward a psychology of *Homo sapiens*: Making psychological science more representative of the human population. *Proceedings of the National Academy of Sciences of the United States of America*, *115*(45), 11401–11405. https://doi.org/10.1073/pnas.1721165115

Ramstead, M. J., Kirchhoff, M. D., & Friston, K. J. (2019). A tale of two densities: Active inference is enactive inference. *Adaptive Behavior*, *28*(4), 225–239. https://doi.org/10.1177/1059712319862774

Raven, J. (2000). The Raven's progressive matrices: Change and stability over culture and time. *Cognitive Psychology*, *41*(1), 1–48. https://doi.org/10.1006/cogp.1999.0735

Raven, J. C. (1938). *Progressive matrices: A perceptual test of intelligence*. H.K. Lewis.

Rogoff, B. (1981). Schooling and the development of cognitive skills. In H. C. Triandis & A. Heron (Eds.), *Handbook of cross-cultural psychology* (Vol. 4, pp. 233–294). Allyn & Bacon.

Rogoff, B. (2003). *The cultural nature of human development*. Oxford University Press.

Rogoff, B., & Chavajay, P. (1995). What's become of research on the cultural basis of cognitive development? *American Psychologist*, *50*(10), 859–877. https://doi.org/10.1037/0003-066X.50.10.859

Schirmbeck, K., Rao, N., & Maehler, C. (2020). Similarities and differences across countries in the development of executive functions in children: A systematic review. *Infant and Child Development*, *29*(1), Article e2164. https://doi.org/10.1002/icd.2164

Schulz, J. F., Bahrami-Rad, D., Beauchamp, J. P., & Henrich, J. (2019). The Church, intensive kinship, and global psychological variation. *Science*, *366*(6466), Article eaau5141. https://doi.org/10.1126/science.aau5141

Scribner, S., & Cole, M. (1973). Cognitive consequences of formal and informal education: New accommodations are needed between school-based learning and learning experiences of everyday life. *Science*, *182*(4112), 553–559. https://doi.org/10.1126/science.182.4112.553

Segall, M. H., Campbell, D. T., & Herskovits, M. J. (1963). Cultural differences in the perception of geometric illusions. *Science*, *139*(3556), 769–771. https://doi.org/10.1126/science.139.3556.769

Serpell, R. (2011). Social responsibility as a dimension of intelligence, and as an educational goal: Insights from programmatic research in an African Society. *Child Development Perspectives*, *5*(2), 126–133. https://doi.org/10.1111/j.1750-8606.2011.00167.x

Sharp, D., Cole, M., Lave, C., Ginsburg, H. P., Brown, A. L., & French, L. A. (1979). Education and cognitive development: The evidence from experimental research. *Monographs of the Society for Research in Child Development*, *44*(1/2), 1–112. https://doi.org/10.2307/3181586

Shepard, R. N. (1984). Ecological constraints on internal representation: Resonant kinematics of perceiving, imagining, thinking, and dreaming. *Psychological Review*, *91*(4), 417–447. https://doi.org/10.1037/0033-295X.91.4.417

Shepard, R. N. (2004). How a cognitive psychologist came to seek universal laws. *Psychonomic Bulletin & Review*, *11*, 1–23. https://doi.org/10.3758/BF03206455

Singh, M., & Mehr, S. A. (2023). Universality, domain-specificity, and development of psychological responses to music. *Nature Reviews Psychology*, *2*(6), 333–346. https://doi.org/10.1038/s44159-023-00182-z

Sroufe, L. A., & Waters, E. (1977). Attachment as an organizational construct. *Child Development*, *48*(4), Article 1184. https://doi.org/10.2307/1128475

Sternberg, R. J. (2019). A theory of adaptive intelligence and its relation to general intelligence. *Journal of Intelligence*, *7*(4), Article 23. https://doi.org/10.3390/jintelligence7040023

Sternberg, R. J., & Grigorenko, E. L. (2004). Intelligence and culture: How culture shapes what intelligence means, and the implications for a science of well-being. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *359*(1449), 1427–1434. https://doi.org/10.1098/rstb.2004.1514

Sternberg, R. J., & Preiss, D. D. (Eds.). (2005). *Intelligence and technology: The impact of tools on the nature and development of human abilities* (pp. xxiv, 248). Lawrence Erlbaum. https://doi.org/10.4324/9780203824252

Sternberg, R. J., Preiss, D. D., & Karami, S. (2023). An historical causal-chain theory of conceptions of intelligence. *Review of General Psychology*, *27*(3), 320–335. https://doi.org/10.1177/10892680231158790

Talhelm, T., Zhang, X., Oishi, S., Shimin, C., Duan, D., Lan, X., & Kitayama, S. (2014). Large-scale psychological differences within China explained by rice versus wheat agriculture. *Science*, *344*(6184), 603–608. https://doi.org/10.1126/science.1246850

Tenenbaum, J. B., Kemp, C., Griffiths, T. L., & Goodman, N. D. (2011). How to grow a mind: Statistics, structure, and abstraction. *Science*, *331*(6022), 1279–1285. https://doi.org/10.1126/science.1192788

Thompson, B., Kirby, S., & Smith, K. (2016). Culture shapes the evolution of cognition. *Proceedings of the National Academy of Sciences of the United States of America*, *113*(16), 4530–4535. https://doi.org/10.1073/pnas.1523631113

Thompson, B., van Opheusden, B., Sumers, T., & Griffiths, T. L. (2022). Complex cognitive algorithms preserved by selective social learning in experimental populations. *Science*, *376*(6588), 95–98. https://doi.org/10.1126/science.abn0915

Thompson, R. (2017). Twenty-first century attachment theory: Challenges and opportunities. In H. Keller & K. Bard (Eds.), *Contextualizing attachment: The cultural nature of attachment* (pp. 301–321). MIT Press. https://doi.org/10.7551/mitpress/9780262036900.003.0012

Thomson, R., Yuki, M., Talhelm, T., Schug, J., Kito, M., Ayanian, A. H., Becker, J. C., Becker, M., Chiu, C. Y., Choi, H.-S., Ferreira, C. M., Fülöp, M., Gul, P., Houghton-Illera, A. M., Joasoo, M., Jong, J., Kavanagh, C. M., Khutkyy, D., Manzi, C., … Visserman, M. L. (2018). Relational mobility predicts social behaviors in 39 countries and is tied to historical farming and threat. *Proceedings of the National Academy of Sciences of the United States of America*, *115*(29), 7521–7526. https://doi.org/10.1073/pnas.1713191115

Tomasello, M. (1999). The human adaptation for culture. *Annual Review of Anthropology*, *28*(1), 509–529. https://doi.org/10.1146/annurev.anthro.28.1.509

Tomasello, M. (2019). *Becoming human: A theory of ontogeny*. Harvard University Press.

Tooby, J., & Cosmides, L. (1992). The psychological foundations of culture. In J. H. Barkow, L. Cosmides, & J. Tooby (Eds.), *The adapted mind: Evolutionary psychology and the generation of culture* (pp. 19–136). Oxford University Press. https://doi.org/10.1093/oso/9780195060232.003.0002

Turing, A. M. (1950). Computing machinery and intelligence. *Mind*, *LIX*(236), 433–460. https://doi.org/10.1093/mind/LIX.236.433

Uchiyama, R., Spicer, R., & Muthukrishna, M. (2022). Cultural evolution of genetic heritability. *Behavioral and Brain Sciences*, *45*, Article e152. https://doi.org/10.1017/S0140525X21000893

Ullman, T. D., Spelke, E., Battaglia, P., & Tenenbaum, J. B. (2017). Mind games: Game engines as an architecture for intuitive physics. *Trends in Cognitive Sciences*, *21*(9), 649–665. https://doi.org/10.1016/j.tics.2017.05.012

Vashro, L., & Cashdan, E. (2015). Spatial cognition, mobility, and reproductive success in northwestern Namibia. *Evolution and Human Behavior*, *36*(2), 123–129. https://doi.org/10.1016/j.evolhumbehav.2014.09.009

Vedechkina, M., & Borgonovi, F. (2021). A review of evidence on the role of digital technology in shaping attention and cognitive control in children. *Frontiers in Psychology*, *12*, Article 611155. https://doi.org/10.3389/fpsyg.2021.611155

Veissière, S. P. L., Constant, A., Ramstead, M. J. D., Friston, K. J., & Kirmayer, L. J. (2019). Thinking through other minds: A variational approach to cognition and culture. *Behavioral and Brain Sciences*, *43*. https://doi.org/10.1017/s0140525x19001213

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes* (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.). Harvard University Press.

Walasek, N., Frankenhuis, W. E., & Panchanathan, K. (2022). An evolutionary model of sensitive periods when the reliability of cues varies across ontogeny. *Behavioral Ecology*, *33*(1), 101–114. https://doi.org/10.1093/beheco/arab113

Wasserstein, R. L., & Lazar, N. A. (2016). The ASA statement on p-values: Context, process, and purpose. *The American Statistician*, *70*(2), 129–133. https://doi.org/10.1080/00031305.2016.1154108

White, C. J. M., Muthukrishna, M., & Norenzayan, A. (2021). Cultural similarity among coreligionists within and between countries. *Proceedings of the National Academy of Sciences of the United States of America*, *118*(37), Article e2109650118. https://doi.org/10.1073/pnas.2109650118

Received March 23, 2023
Revision received December 22, 2023
Accepted February 9, 2024 ■