# Evolutionary Approaches to Understanding Children's Academic Achievement

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## Abstract

There are evolved cognitive biases that influence what people pay attention to (e.g., faces, not rocks) and how they interpret this information (e.g., underlying intentions). These cognitive biases are organized to help us understand ourselves and other people (folk psychology), other species (folk biology), and the physical world (folk physics). Human cultural advances have resulted in the development of evolutionarily novel concepts (e.g., natural selection) and skills (e.g., reading) that are built from this evolved core. The basic architecture of folk cognitive biases is universal and adapted to nuances in local conditions as children play, interact with other people, and explore the environment. The learning of evolutionarily novel competencies is necessary for success in today's economy but children do not learn these as easily as they adapt folk knowledge nor are they as motivated to engage in the associated activities. This is because learning academic competencies requires adapting folk systems for tasks for which they did not evolve. The associated activities (e.g., direct instruction) are very different from the activities (e.g., play) that foster the adaptation of folk abilities to local conditions. Schooling thus involves the society-wide organization of children's activities so they learn competencies that would not otherwise emerge. This perspective allows us to better understand the importance of working memory, a motivational focus on effort, and the need for explicit, organized instruction for children's learning in school.


## INTRODUCTION

Darwin's (1859) natural selection is the organizing framework for all of the biological sciences, and yet many social and educational scientists continue to ignore or actively resist the insights that can be achieved by viewing human behavior and cognition from an evolutionary lens. Focusing the evolutionary lens on children's learning and motivation in school has great potential to expand our understanding of these processes and to develop better ways to ensure that children are well prepared for the demands of living in today's modern world. We provide a brief introduction to evolutionary educational

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psychology, and then highlight current research efforts in the field and issues that remain to be addressed.

## FOUNDATIONAL RESEARCH

The foundational insight is that there are critical differences between what children have evolved to easily learn in natural environments and what they are expected to learn in school (Geary, 1995). The distinction is important because nearly all of school-taught academic material is evolutionarily novel in that these were developed only recently; in fact formal schooling is an evolutionary novel cultural innovation (Geary, 2007). Universal schooling is necessary because navigating life in the modern world requires learning the novel skills of reading, writing, and arithmetic, to name only the basics. If children learned these skills as easily as they learn language or how to interpret the facial expressions of other people, for instance, formal schooling would not be necessary.

To understand evolutionarily novel or biologically secondary competencies, it is first necessary to understand the evolved or biologically primary foundation upon which these are built. This foundation of core domains coalesces around folk psychology, folk biology, and folk physics (Atran, 1998; Gallistel, 1990; R. Gelman, 1990; S. Gelman, 2003; Pinker, 1994), as shown in Figure 1. These are universal in that humans have an inherent bias to process and organize information in these domains, although the extent to which they are elaborated and aspects of the surface features (e.g., language) of the domain can vary across cultures.

Folk psychology is organized around the self, other individuals, and group dynamics. The first includes awareness of the self as a social being and of one's relationships with other people. The individual-level system processes information that guides one-on-one social dynamics and supports dyadic relationships. The group-level systems enable individuals to break their social world into categories of people. Folk biology supports the ability to develop taxonomies of other species and acquire knowledge about these species that is critical to the survival of people in traditional societies. Folk physics enables navigation, generation of mental representations of physical space, the construction of tools, and an implicit understanding of magnitude and time.

### EVOLUTION AND COGNITIVE DEVELOPMENT

Children are biologically prepared to learn in folk domains and are inherently motivated—for example, the "fun" associated with peer play is an evolved reward that ensures engagement in these activities—to seek out experiences

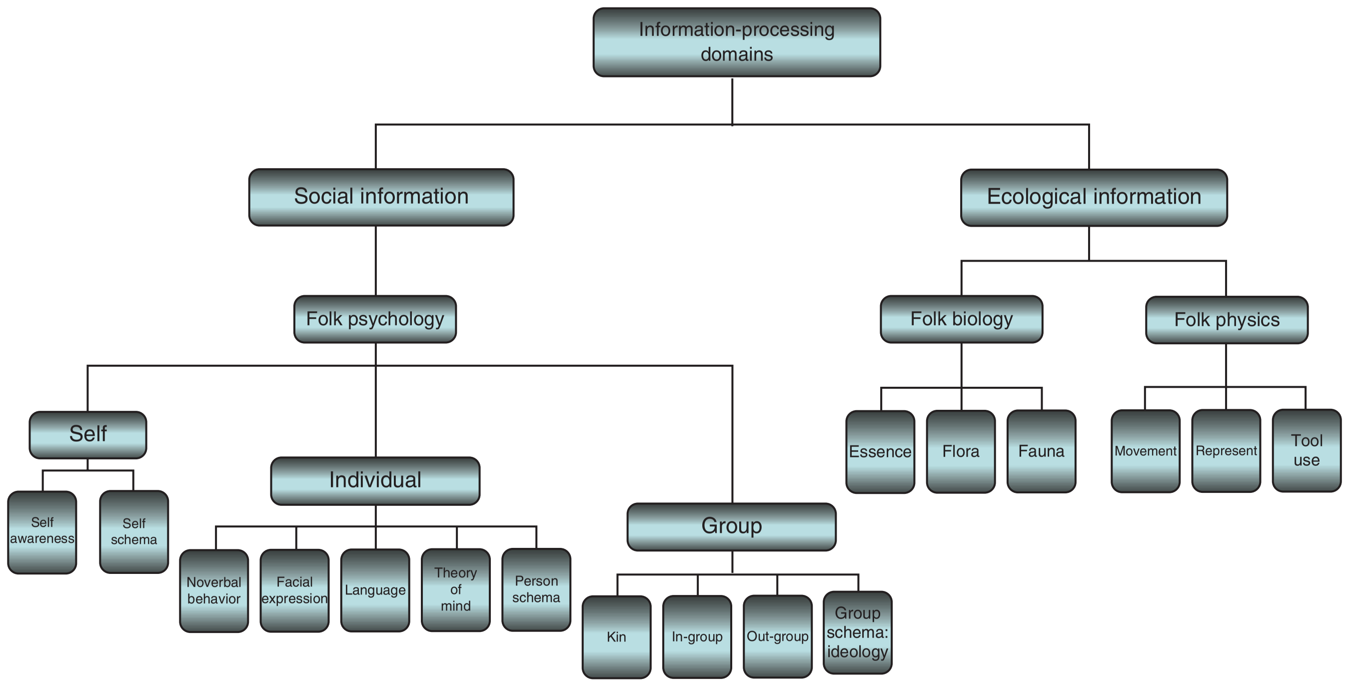


**Figure 1** Biologically primary folk domains. *Source*: Adapted from "*The origin of mind: Evolution of brain, cognition, and general intelligence*," by D. G. Geary, 2005, p. 129. Copyright 2005 by American Psychological Association.

that will facilitate the fleshing out and adapting of folk knowledge to local conditions (R. Gelman, 1990; Scarr, 1992). Play, social interactions, and exploration of the environment and objects appear to be the ways in which children generate the experiences that result in this adaption. Children are neither explicitly aware they are learning about the social, biological, and physical world as they play nor do they need to engage in effortful processing for this learning to occur.

### Cognitive and Academic Development

Humans clearly have the ability to create and learn evolutionarily novel concepts and skills, but this does not come as easily as fleshing out folk competencies (Geary, 2005). One reason is that the skeletal structure of folk systems is essentially implicit knowledge about core aspects of these domains. Infants orient and react to other humans, not because they are explicitly aware that they are members of the same species but because folk systems include features that are sensitive to human biological motion, human facial features, and so on. There is no corresponding knowledge for understanding the base-10 Arabic number system. Another reason is that folk domains will allocate attention to key features of the context, as in making eye contact during a conversation. When first exposed to books, toddlers sitting in their parents' lap do not automatically attend to the words their parents are reading to them. Finally, almost all children are motivated to engage in activities that will flesh out folk competencies. A universal motivation to engage in the activities that will result in mastery of academic domains is not likely. Many children will attempt to emulate adults' and older children's reading, but this will not result in the basic word decoding skills needed to actually read. Many people will read for its own sake, but this is driven by interest in the content of what is being read—often evolutionarily salient social themes—and not the act of reading itself.

## CUTTING-EDGE RESEARCH

Recent research and theoretical advances concerning both the implications of an evolutionary perspective for instructional science and the evolutionary origins of pedagogy are likely to shape future approaches to improving children's academic achievement.

### Cognitive Load Theory of Instruction

Although the evolutionary perspective is not ready for direct translation into school curricula, it can be used to generate testable hypotheses about the potential effectiveness of alternative instructional methods (Geary, 2008). That said, it must be acknowledged that the vast majority of empirical studies in instructional science have not been informed by evolutionary premises or principles. A notable exception has been the work of John Sweller and colleagues, whose studies of effective instructional strategies are founded on cognitive load theory (CLT), which espouses an evolutionary perspective. A predominant approach to the design of instructional techniques, CLT claims that human cognitive architecture and the manner by which both its structures and functions have evolved are analogous to the evolution of biological structures and functions (Sweller, 2004). A central tenet is that the limited capacity and duration of working memory constrains learners' acquisition of novel information. Consequently, a fundamental instructional objective of CLT is to develop techniques for reducing working memory load during learning.

Until recently, it has been assumed that the capacity limitations of working memory apply to the acquisition of all information (Paas & Sweller, 2012). However, building upon the important distinction between biologically primary and biologically secondary knowledge, Paas and Sweller (2012) have recently amended this perspective. They point out that because humans have evolved to process biologically primary information, the demands made on working memory during this processing are minimized. This is not the case with the learning of biologically secondary information, which is normally difficult to acquire owing to the sizeable working memory load imposed by this kind of information, especially during initial learning.

The authors provide several examples of how biologically primary information can be of assistance when a learner is acquiring biologically secondary skills, accounting for a number of demonstrated instructional effects. One interesting example is the "modality effect." Numerous studies have shown that instructional formats using two sensory modalities yield learning superior to equivalent formats that use only a single modality. For example, studying a pictured (visually presented) object accompanied by a spoken (auditorily presented) description yields better learning than when the pictured object is described by written (visually presented) text. The classic explanation for this outcome based on CLT is that working memory capacity is increased by using two different sensory channels as compared with only one. However, from an evolutionary perspective, this enhanced learning of a biologically secondary skill may be more appropriately attributed to the assistance of biologically primary skills. That is, the use of this kind of dual-mode instructional approach is beneficial because humans have evolved to listen to a description of an object while looking at it, not to read a description of it (a biologically secondary skill itself) while looking at it (Paas & Sweller, 2012).

### THE EVOLUTIONARY PRECURSORS OF TEACHING

Some exciting theoretical developments have emerged over the past several years regarding the evolutionary history of pedagogy itself. For example, Csibra and Gergely (2009, 2011) have hypothesized that a type of human communication they call *natural pedagogy* arose during hominin evolution to facilitate the transmission of generic technological knowledge and skills between individuals. This adaptation is proposed to have evolved to enable "fast and efficient social learning of cognitively opaque cultural knowledge that would be hard to acquire relying on purely observational learning mechanisms alone" (2009, p. 148). Furthermore, according to Tehrani and Riede (2008), a review of the archaeological record suggests that pedagogy has been vital for accurately transmitting skills across generations. In contrast, after reviewing the ethnographic record of traditional societies, Lancy (2010) concluded, "Teaching has been largely superfluous in the process of cultural transmission throughout human history" (p. 97). Although Sterelny (2012) agrees that the role of teaching was frequently quite limited in traditional societies, he also points out that "adults can and do structure and engineer the learning environment, even without explicit teaching" (p. 36).

A recent review of these and other perspectives on the evolution and ontogeny of teaching has led some researchers to conclude that teaching is both species typical—universal across cultures—and species unique, that is, not evident in nonhuman species (Strauss & Ziv, 2012). Of course, these conclusions depend in part on how one defines teaching. For example, a definition based on cognitive components stipulates that teaching is an intentional activity for increasing the understanding of another who is judged (via a so-called theory of mind) to either lack knowledge or possess a false belief (Ziv & Frye, 2004). Certainly, adopting such a definition would rule out nonhuman animals as being capable of teaching. Nonetheless, the point here is that an evolutionary perspective can inform the study of proximate or immediate factors that influence the development and acquisition of teaching skills, and thus may yield unique insights into how humans have evolved to transmit (teach), as well as learn, novel culturally important information.

## KEY ISSUES

Children's natural interest in novelty and their motivation to learn their culture may get them started in school but is not likely to maintain long-term academic learning. One possibility may be to capitalize on the fuzzy boundary between primary and secondary domains during the early years of schooling and children's motivation to learn culturally important knowledge and to use these to build academic self-efficacy and other beliefs that will help to maintain effort in school learning in later years.

There may be an excess reliance on "internal" motivation for academic learning, at the expense of focusing on the utility of the learning. If we assume that children are inherently motivated to learn in academic domains and learn as effortlessly as they learn in folk domains, then we risk undervaluing the importance of focus and effort for secondary learning. Without an explicit assumption that learning will require effort, we put children at risk for making attributions (e.g., they do not have the ability to learn the material) that may undermine their engagement with school when academic material becomes difficult.

## CONCLUSION

An evolutionary approach to children's academic learning and motivation in school can explain why learning to read is more difficult than learning a native language, among many other primary–secondary contrasts (Geary, 2007), and why many children are more motivated to socialize with their friends than to learn algebra. This perspective has profound implications for how to design instruction to address these differences and to better understand and address the motivational and attributional (e.g., that learning requires effort) factors that will influence long-term engagement in academic learning.

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Dr. **David C. Geary** received a BS in psychology from Santa Clara University, an MS in child clinical/school psychology from California State University, and an MA and PhD in developmental psychology from the University of California, Riverside. Upon completion of his PhD in 1986, he held faculty positions at the University of Texas at El Paso and the University of Missouri, first at the Science and Technology campus and then in Columbia. Dr. Geary served as chair of his department from 2002 to 2005 and as the University of Missouri's Middlebush Professor of Psychological Sciences from 2000 to 2003. He is currently a Curators' Professor and Thomas Jefferson Fellow. He has published nearly 250 articles, commentaries, and chapters across a wide range of topics, including three sole-authored books; *Children's mathematical development*, *Male, female: The evolution of human sex differences* (now in second edition, 2010), and *The origin of mind: Evolution of brain, cognition, and general intelligence* as well as one co-authored book, *Sex differences: Summarizing more than a century of scientific research*. He served as a member of the President's National (US) Mathematics Advisory Panel and Chaired the Learning Processes subcommittee, is a recipient of a MERIT award from the National Institutes of Health, and was appointed by President G. W. Bush to the National Board of Directors for the Institute for Education Sciences. He currently directs NIH- and NSF-funded studies on young children's and adolescents' mathematical cognition and learning, as well as various projects in evolutionary psychology.

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