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Young children's acceptance of within-species variation: Implications for essentialism and teaching evolution

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ABSTRACT

Neglecting within-species variation plays a crucial role in students' misconceptions about adaptation by natural selection. Prior research on the development of this propensity suggests that this neglect is due to a strong early-arising essentialist bias to treat species as invariant. Across two studies, we examined the strength of this bias by exploring 5- and 6-year-olds' and 7- and 8-year-olds' assumptions about variation in contexts similar to those used in a recent early educational intervention teaching adaptation. In Study 1, children heard about fictitious animals' physical and behavioral traits and their beneficial functions. They then judged whether all other species members would vary or be invariant on those traits. Across age groups, children showed a marginal essentialist tendency to reject variation. In Study 2, the same method was used, but all references to beneficial trait functions were removed. The 5- and 6-year-olds' responding did not differ from Study 1, but the 7- and 8-year-olds' acceptance of variation increased to above chance rates. Parental religious and evolution beliefs correlated with younger children's responses but not with older children's responses. Together, the findings suggest that under certain facilitative contexts children display greater abilities to represent variation than assumptions of a robust and inflexible essentialist bias would predict. By 7 to 8 years of age, children displayed autonomy from their parents' beliefs and tended to expect

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variation. However, priming their teleological intuitions undermined their non-essentialist expectations. Theoretical and educational implications are discussed.

Introduction

Adaptation by natural selection is central to the study of living organisms and fundamental to understanding why organisms possess functionally specialized traits. Despite its significance to biology and related fields, however, decades of research have shown that it is widely misunderstood (see Gregory, 2009, for review). This is in part because individuals fail to appreciate that adaptation involves a selectionist process in which species members with more beneficial traits out-live and out-reproduce other members with less beneficial traits—ultimately leading to a greater frequency of organisms with beneficial traits in the population. Instead, individuals tend to incorrectly reason that beneficial adaptations result from all species members undergoing heritable transformations in response to their survival needs (Gregory, 2009; Kelemen, 2012).

Although specific causal ideas about how individual species members transform can differ, incorrect beliefs about adaptation are largely resistant to instruction (Jensen & Finley, 1995; Shtulman & Calabi, 2013) and are observed among first-year medical students and science teachers with background training in biology (e.g., Brumby, 1984; Nehm, Kim, & Sheppard, 2009). One of the key reasons proposed for this learning challenge is that when reasoning about adaptation, students do not assume the critical feature of biological populations that allows the selectionist process of differential survival and reproduction to occur—within-species variation (Gregory, 2009; Shtulman & Calabi, 2012, 2013; Shtulman & Schulz, 2008). What, then, accounts for students' tendency to ignore within-species variation when reasoning about adaptation?

Recent developmental research gives good reasons to suppose the tendency to neglect variation may derive from cognitive biases present from early childhood, one of which is the essentialist bias (Rosengren, Brem, Evans, & Sinatra, 2012). Psychological essentialism is the implicit belief that categories such as animal species share underlying causal properties or "essences" that determine their identity (Gelman, 2003; Medin & Ortony, 1989). Although essences cannot be seen and their content may not be explicitly known, from young ages individuals make inferences indicating that they believe stable underlying essences exist and are responsible for species members' properties. For instance, 4-year-olds intuit that even if a rabbit is raised by monkeys, it will still have long ears and a preference for carrots because, despite its unusual rearing, its essential and inviolable rabbit nature remains intact (Gelman & Wellman, 1991). Importantly, essentialist assumptions displayed during early childhood, and arguably as early as infancy (Setoh, Wu, Baillargeon, & Gelman, 2013), endure into adulthood and continue to exert a strong influence on reasoning about biological categories.

If essentialist assumptions predispose individuals to represent all species members as intrinsically the same, then overt evidence of differences across individual species members (e.g., variable fur color) are likely to be overlooked in favor of noting similarities (Gelman & Rhodes, 2012; Shtulman & Calabi, 2012; Shtulman & Schulz, 2008). As a natural consequence of assuming trait homogeneity within species, the most intuitive way to think about adaptation seems to be in terms of beneficial transformational events that occur within the lifespans of individual organisms and not in terms of a population-based selectionist process dependent on within-species variation. Observations that animals undergo dramatic physical changes within their lifetimes (e.g., as a function of inevitable growth) without changing their identity (Rosengren, Gelman, Kalish, & McCormick, 1991) likely further promote transformationist views of adaptation.

Even though there is valid justification for proposing that an early arising essentialist bias may contribute to neglecting within-species variation, currently there is limited research directly examining the strength of this resistance early in development. Prior related work has explored young children's