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Culture–gene coevolutionary psychology: cultural learning, language, and ethnic psychology

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While most psychologists recognize the importance of genes and culture in shaping human cognition, few theoretical perspectives in the field offer a framework for understanding their relationship and for deriving predictions about the structure of the variation we see across space and time. Here we argue that culture–gene coevolutionary (CGC) frameworks have such potential, and can unite disparate fields across the social sciences and sub-fields within psychology. We illustrate the power of this functionalist evolutionary approach by reviewing recent research on three interlinked topics; cultural learning rules, language cognition, and reasoning about ethnic social groups. We show how CGC approaches complement, and contrast with, traditional approaches in psychology on these topics. Furthermore, this theoretical framework has already been fruitful in drawing new predictions and pointing to new directions of inquiry.

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It is uncontroversial that both genes and culture shape human psychology. However, recent evolutionary approaches go one step further in formalizing the selection processes whereby BOTH genetic and cultural traits can change through time and produce functional psychological mechanisms for facing adaptive challenges. Moreover, these are not independent: Culture–gene coevolutionary (CGC) approaches explore the feedback between these two inheritance systems [1–3]. This approach allows researchers to formally develop theories about (1) the origins and functions of cognitive mechanisms that shape cultural learning and thus allow cultural evolution, and (2) the cultural evolutionary processes that generate cross-cultural patterns of psychological variation. This conceptualization clarifies that cultural capacities are integral components of human biology and that cultural psychological differences are not static monoliths, but rather the products of interacting individual minds that change across history and space.

Studies of the human genome show culture's ability to shape genetic evolution [4,5]. For example, in the last 10 millennia, cultural elements related to alcohol-making, herding, high-latitude farming have driven the spread of genes for alcohol tolerance, milk-drinking and pigmentation in particular populations [5]. Here, cultural evolution explains extant patterns of genetic variation and associated behaviors. Pushing deeper into our species' evolutionary history, there is increasing evidence that culture has been driving human evolution for at least hundreds of thousands of years [6]. Technologies such as cooking, food processing techniques, cutting tools, water containers, and projectile weapons, have shaped our stomachs, colons, teeth, sweat glands, and much more [6–8].

Effectively linking psychology to culture and institutions, this framework has spawned productive research programs on social norms [9,10,11•,12], cooperation [13,14,15•], religion [16–19], theory of mind [20•,21], teaching [22] and marriage [23]. Here, we focus on three areas of research that illustrate the full co-evolutionary process between genes and culture in domains that are likely to be of interest to psychologists: (1) cultural learning mechanisms [24–27], (2) language acquisition [28,29•], and (3) reasoning about ethnic groups [30•,31]. These three domains also reflect an evolutionary sequence of events; cultural learning mechanisms allow the evolution of complex and variable language structure, and language in turn co-evolves with cultural systems of social norms to become a pervasive and privileged marker of ethnic group membership. This pathway illustrates the potential of a CGC framework to unite disparate fields of social science and psychology.

Cultural learning mechanisms

Culture–gene coevolutionary approaches dissolve the false dichotomy between 'learning' and 'biological' accounts by turning the power of evolutionary theorizing on the question of how humans learn. Of course, psychologists have long studied these topics [32–34], but CGC theory provides (1) a rigorous way to build theories and generate predictions about the 'when, what and from whom' of adaptive learning [35–39], and (2) a cumulative framework seated within evolutionary theory that organizes insights from across the social sciences as well as subfields of social and developmental psychology [40,41].

To illustrate this, we review recent empirical work showing the extent to which people use some of the best theorized cultural learning rules: (1) skill, success and prestige biases and (2) conformist transmission [42].

Adaptive learners can improve the quality of the information they acquire from others by being selective about whom they learn from. Everyone from infants to adults uses such model-based biases, for example, attending to cues of greater skill and success in directing their cultural learning. Recent work in developmental psychology shows how children, as young as 12 months, use cues of competence and reliability in learning tool-use, word-meaning and novel practices [6,41,43–45]. Learners can also use prestige cues—such as the visual attention of others — to zoom in on whom to learn from [46,47]. In a recent laboratory study [48], for example, researchers show that 3–4 year old children use the visual attention of others to guide their imitation in selecting a novel food, drink and means of using an artifact. Similarly, Atkisson *et al.* [49] find that adults use prestige cues as much as biases for copying successful individuals, despite the latter's higher payoffs in the task.

Adaptive learners can also take advantage of the wisdom of crowds to extract information from groups. Frequency-dependent biases are social learning rules that exploit the relative proportion of traits in the population, when considering whether to adopt a belief, motivation or behavior. Models of conformist transmission lead to specific predictions about when individuals should disproportionately weigh the majority trait rather than rely on other learning heuristics. Lab experiments confirm many theoretical nuanced predictions [50,51], including most recently that a conformist strategy is more common with larger model sets [52] and larger numbers of possible traits to copy [53•]. See Ref. [54] for a review of recent developmental research showing other mechanisms that make humans cultural learners.

Languages

The cultural learning machinery described above allowed the unique human capacity for complex language — perhaps the best-studied cognitive adaptation arising from culture–gene co-evolution. Recent evidence from developmental psychology shows that children use many of the cultural learning biases described above for learning word meanings [55]. These cultural transmission events in interaction with human-specific psychological mechanisms facilitated the development of complex communication systems, and their cross-cultural diversification into languages [28].

The long running debate over the nature of cognitive mechanisms for acquiring syntactical structures continues [56–58]. There is increasing evidence that cultural evolutionary processes can produce complex linguistic structures that facilitate coordination and make languages more learnable [28,59,125] even in the absence of genetic evolution. So languages can evolve culturally to fit brains. However, the resulting language structures plausibly selected for better cognitive capacities, for example for recursive computation [60–62]. Alternatively cognitive capacities for linguistic recursion may have co-evolved with, or been exapted from, cultural and genetic capacities for complex tool-making [6,63,64].

Perhaps less appreciated is the fact that both phoneme and morpheme repertoires can be analyzed as culturally-evolved tools for communication with consequences for natural selection. Human laryngeal morphology, neural circuits for motor control and greater memory capacities likely reflect natural selection acting on human bodies and brains in response to the need to produce more distinct sounds and words [65]. There is also evidence that cultural evolution has patterned the current variation in languages' sound and word repertoires [6,66,67]. For example, larger populations where phonemic distinctions facilitate intelligibility, and those with less history of population bottlenecks that cull variation, have larger phonemic repertoires [68–70], although this is still debated [71–73]. Similarly, lexicon size — for example, number of color words — is associated with cultural complexity [74]. At the individual-level color lexicon is correlated with gray matter in the visual cortex [75] and has cognitive effects on color discrimination tasks [76]. Similar findings in the domain of numerical and spatial cognition suggest the importance of culturally-evolved language structures as aids to human thought [77,78]. A cultural evolutionary approach provides a mechanism whereby lexically and phonemically rich languages co-evolve with institutions in large-scale societies, thus patterning several aspects of plastic psychological variation. Correlations between particular genetic variants and the use of tonality in languages suggest that even some language-driven genetic evolution may be underway in response to culturally-evolved variation [79]. However, we should stress that the extant linguistic variation is unlikely to have fedback much on natural selection at the population-level, as evidenced by the fact that adopted children will easily learn any language they are raised with.

Thinking about ethnic groups

Humans universally mark their membership in culturally-structured groups, often using the linguistic variation described above to do so. We refer to symbolically marked boundaries associated with cultural traits as ethnic. Ethnic boundaries then is the product of individuals' social interactions given their suite of cognitive mechanisms — for example, for cultural learning, intergroup behavior, categorization, among others. However, cognitive heuristics likely evolved in response to these culturally-constructed social boundaries. For example, if individuals from different groups have dissimilar cultural expectations and

therefore have difficulty coordinating, natural selection can favor motivations for ingroup preferences and for marking one's group membership [80]. Preferential imitation of members of successful groups can also favor altruistic cooperation on the basis of arbitrary tags [81]. Such approaches hypothesize an evolved psychology in response to culturally-constructed social worlds.

Psychologists have long studied human group perception [82–84], but they often conflate functionally distinct phenomena such as stereotyping, implicit attitudes, essentialism, ingroup preference and prejudice [85–87]. Instead we argue that several of these ethnic phenomena are functionally distinct, but may co-occur because they are triggered by social landscapes where the relevant structures culturally co-evolved [88]. This framework allows us to derive predictions about when we expect ethnic phenomena to co-occur and which interventions are likely to work. Furthermore, much social psychology collapses their analysis of functionally different kinds of social groups [89,90], whereas a functionalist theory helps us parse the kinds of groups processed by specific mechanisms. For example, ethnicity, gender, and political coalition membership are likely inputs to different mechanisms given they cross-cut each other and are relevant for different tasks [91,92]. While ethnic membership may provide a basis for making predictions about someone's norms, gender and coalitional affiliation are unlikely to do so. On the other hand, gender is informative about a person's availability as a mate, and coalitional membership is useful for inferring cooperation networks. Below we review recent work suggesting that humans privilege arbitrary symbolic markers and linguistic cues as delineators of social boundaries that they stereotype and essentialise. These biases only make sense if ethnic markers like language, culture and our social categorization psychology co-evolved throughout human evolution.

Several cultural evolutionary processes mentioned in the first section, 'Cultural learning mechanisms,' can produce clustered spatial distributions of cultural traits with more similar individuals within, than between, clusters. This landscape can promote predictions about individuals based on their marked cultural category membership [31,93]. In line with this prediction, people are more likely to assume that others will have similar traits if, and only if, they share the same intentional symbolic marker, but not if they share an incidental feature like a birthmark [94]. Furthermore, children readily use novel labels to make predictions about characters and imbue visual similarity with social meaning [95], though only when stimuli refer to people rather than dolls [96]. Cross-culturally, adults also rely heavily on novel sartorial markers when making predictions about characters' rare traits [97]. There is also increasing evidence that adults privilege linguistic cues as bases for categorizing others, even when they cross-cut membership in cooperative units [98] and that children rely on these cues for making predictions about strangers, even in cultural contexts where adults do not [31].

Another common feature of ethnic reasoning is the belief that group membership is immutable within, and between, generations. We refer to these biases as 'essentialist'. The stability and inheritance patterns of many cultural identities suggest that an essentialist heuristic may have facilitated inter-temporal predictions about individuals — though see [99•,100] for theoretical issues and alternative CGC accounts. Empirically, language boundaries are often essentialized [101], and children tend to construe linguistic boundaries as stable identity markers [102•,103,104]. The early critical window for language acquisition may support such stability beliefs. However, other work shows that beliefs about identity immutability are socially transmitted [105•], are promoted by the use of generic language and noun labels [106,107•], vary across different ethnic boundaries, and are often quite low [99•,104,105•,108,109]. So, it appears that cultural evolution can strategically strengthen or suppress essentialist bias in ethnic psychology. For example, case studies show that higher ranking groups adopt more fixed beliefs about identity inheritance than low status groups do, thus keeping high status a limited resource [110,111].

Evolutionary and functional perspectives on social categorization also suggest which kinds of group boundaries are likely to motivate the above ethnic phenomena. While many psychologists do not distinguish 'racial' from 'ethnic' categories, culture–gene coevolutionary frameworks suggest reasons that the first kind of social boundary marked by genetically inherited morphological features will be treated differently from the latter kind that are marked by, and indicative of, cultural traits. Racial categories may not be as robust a motivator of ethnic phenomena as once thought since such boundaries primarily result from recent long-distance migrations, and are unlikely to have marked cultural boundaries for much of human evolution. Researchers have found race encoding decreases when cross-cut with coalitions [92], race is not universally a preferred basis of inductive inferences [112], young kids prefer same-accented friends over same-race friends [113], and essentialize language more than race, at least if they are members of the racial majority [102•].

Directions for future research and conclusions

All these domains remain active areas of research and debate. Experimentalists continue to delineate cultural learning rules in the lab and across species [114–116]. More recently social scientists have started to measure the importance of these heuristics in real-world settings [117,118] and to use models to test whether the learning rules producing macro-population patterns can be

inferred [119]. In the language domain several challenges remain including differentiating cognitive mechanisms that evolved specifically for language acquisition from those that evolved for other tasks or more general cultural learning [63,120,121]. Finally, several researchers are focusing on the ways in which psychological mechanisms for reasoning about ethnicity fit together [88,99•,122], and the markers that trigger them [97,123,124]. On the cultural evolutionary front, we are currently testing the possibility that essentialist ideologies reflect the costs and benefits to a society that facilitates immigration. Institutions like ethnic endogamy or inheritance of limited resources may have culturally co-evolved with essentialist belief systems.

Culture–gene coevolutionary theory has much to offer both biology and psychology. For psychology, CGC provides a broad evolutionary framework that explicitly incorporates cultural explanations alongside non-cultural hypotheses. As illustrated above with the co-evolution of cultural learning rules, language capacities and ethnic reasoning, free-standing research traditions within psychology immediately slot into the connective tissue provided by this framework. For cultural psychology, CGC theory not only provides a means to understanding the micro-foundation and evolution of culture, but also a means to build deductive theories that explain psychological variation.

Conflict of interest statement

Nothing declared.

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