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ARTICLE

Child Development Perspectives

Peer learning and cultural evolution

Sheina Lew-Levy[1] | Wouter van den Bos[2,3] | Kathleen Corriveau[4] | Natália Dutra[5] | Emma Flynn[6] | Eoin O'Sullivan[7] | Sarah Pope-Caldwell[8] | Bruce Rawlings[1] | Marco Smolla[9] | Jing Xu[10] | Lara Wood[11]

[1]Department of Psychology, Durham University, Durham, UK

[2]Department of Psychology, University of Amsterdam, Amsterdam, The Netherlands

[3]Center for Adaptive Rationality, Max Planck Institute for Human Development, Berlin, Germany

[4]Wheelock College of Education and Human Development, Boston University, Boston, Massachusetts, USA

[5]Núcleo de Teoria e Pesquisa do Comportamento, Universidade Federal do Pará, Belém, Brazil

[6]School of Psychology, Queen's University Belfast, Belfast, UK

[7]School of Psychology and Neuroscience, University of St. Andrews, St. Andrews, UK

[8]Department of Comparative Cultural Psychology, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

[9]Department of Human Behavior, Ecology and Culture, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

[10]Department of Anthropology, University of Washington, Seattle, Washington, USA

[11]Division of Psychology, Abertay University, Dundee, UK

Correspondence
Sheina Lew-Levy, Durham University, Upper Mountjoy, South Rd., Durham DH1 3LE, UK.
Email: sheina.lew-levy@durham.ac.uk

Abstract

In this article, we integrate cultural evolutionary theory with empirical research from developmental psychology, cultural anthropology, and primatology to explore the role of peer learning in the development of complex instrumental skills and behavioral norms. We show that instrumental imitation, contingent teaching, generative collaboration, and selective copying contribute to domain-specific transmission of knowledge between peers. Stages of development and characteristics inherent to the learner and model influence how and when children learn from each other. Peer learning is persistent across societies despite cultural beliefs that favor adult–child transmission in some settings. Comparative research hints at the possibility that children's greater motivation to interact with and learn from each other may set humans apart from other primates. We conclude by outlining avenues for future research, including how individual characteristics and developmental changes in social networks, motivation, and cognition may contribute to cultural evolution.

KEYWORDS

cultural evolution, peer learning, social learning

INTRODUCTION

In 2018, 15-year-old Greta Thunberg highlighted the urgent need for action on the climate crisis by striking outside the Swedish Parliament. Inspired by Thunberg, children and adolescents all over the world started their own protests, including Licypriya Kangujam in India, Vanessa Nakate in Uganda, and Xiye Bastida in New York. School strikes for climate were soon widespread, with over a million students participating in the Global Climate Strike for Future in March 2019. The global climate strikes exemplify the powerful ways in which peer

learning facilitates the rapid and effective transmission of new behaviors, beliefs, and practices.

In this article, we consider peer learning—defined here as learning between same- or similar-aged children and adolescents—from a cultural evolutionary perspective. Cultural evolutionary theory contends that social learning is central to human adaptability, giving rise to complex and diverse instrumental skills and behavioral norms that are transmitted and refined over generations (Richerson & Boyd, 2005). Since peer learning has been central to cultural evolutionary theory since its inception, we aim to complement existing theoretical models with empirical insights into the developmental trajectory of peer learning and the factors that promote or inhibit its expression. First, we review theoretical predictions regarding the adaptive advantages that peer learning offers. Then we consider these predictions in light of psychological, educational, and anthropological research on children and adolescents. Finally, we take a comparative perspective by considering how peer learning in nonhuman primates can inform our understanding of its evolution.

PEER LEARNING IN CULTURAL EVOLUTIONARY THEORY

Researchers who study cultural evolutionary theory frequently use analytical or simulated models to test a wide range of parameters and scenarios, and to generate new hypotheses when counterintuitive results are produced (Perry et al., 2022). One prominent line of research has focused on the adaptiveness of social versus individual learning (Enquist et al., 2007). To mitigate the cost of learning irrelevant or outdated information, social learning must be used selectively based on contextual or content cues (Kendal et al., 2018). Selective social learning is evidenced by biases toward attending to observable cues in a demonstrator (e.g., success), a trait (e.g., frequency), or a state (e.g., uncertainty). Such biases may be combined hierarchically based on cues such as success and conformity (McElreath et al., 2008). Relevant to our work here, a *copy older individuals strategy* may be a relatively low-cost learning bias because older age is usually associated with greater experience and skill (Wood et al., 2013).

Opportunity costs (time, energy, access) and benefits (accrued knowledge) are also associated with learning at different developmental stages (Gurven et al., 2020). Learning pathways are classified as *vertical* (from parents to offspring), *oblique* (from nonparents of the older generation to younger individuals), and *horizontal* (among peers; Cavalli-Sforza & Feldman, 1981). Theoretical models suggest that horizontal transmission is part of an optimal learning schedule (Gurven et al., 2020; Reyes-García et al., 2016). Because children are accessible models, potentially more tolerant of other children than are adults, and often only slightly more proficient in a skill than an observer, horizontal transmission may facilitate stepwise learning (with increasing complexity) and sequential learning (easier skills followed by harder skills) by middle childhood. Such peer-to-peer transmission may also reduce the opportunity costs suffered by adults by allowing adults to prioritize other complex tasks (e.g., hunting, digging tubers; Gurven et al., 2020). Once baseline competencies have been reached, nonparental adults can transmit novel or more specialized knowledge to adolescents.

Horizontal transmission may also confer advantages during episodes of environmental and demographic change. In a simple two age-class (parents and offspring) cultural learning model with vertical and horizontal transmission, the latter can be crucial in fluctuating environments, such as those with seasonal variation in the availability of resources (Acerbi & Parisi, 2006; Aoki et al., 2012). This is because as "imperfect" cultural models who are themselves still learning, peers provide a source of variation that can allow the innovation or refinement of behaviors.

A similar model permitting more than two age classes shows that a bias toward copying older individuals is beneficial in stable environments (Deffner & McElreath, 2022). Conversely, learning from younger agents is beneficial in quickly changing environments because younger agents are more likely to use individual learning that generates up-to-date adaptations, resulting in a successful copy-the-young strategy (Deffner & McElreath, 2022). Age classes in cultural evolution models can also help explain domain-specific transmission pathways (Fogarty et al., 2019). For example, if fertility norms are transmitted purely vertically and parents with low-fertility norms also have fewer offspring, this norm would ultimately disappear. Thus, horizontal transmission alongside norms that favor weak conformity to the majority are required for low-fertility traits to spread.

PEER LEARNING IS EFFECTIVE AND GENERATIVE

Empirical research suggests that peer learning can support high-fidelity, effective, and efficient transmission. In studies of transmission chains, British children as young as age 3 successfully transmitted and acquired behaviors, such as specific methods to solve puzzle boxes, across several generations. This included solutions taught by adults (Flynn & Whiten, 2008) and by other children (McGuigan & Graham, 2010). Children also parsed out redundant behaviors modeled by peers, suggesting that they can quickly omit irrelevant actions to achieve a goal, which reflects instrumental imitation (Flynn, 2008).

Similarly, in studies of diffusion, over time, groups of 2- to 4-year-olds in the United Kingdom converged on a

single puzzle box solution even when group members initially reached multiple solutions, suggesting a potent role of social learning to establish group norms (Whiten & Flynn, 2010). Furthermore, peers who were older, more popular, and more dominant were observed and copied more than were peers who were younger, less popular, and less dominant (Flynn & Whiten, 2012). In studies conducted primarily in Europe and North America, children were effective teachers, with contingent teaching evidenced by age 7 (reviewed in Strauss & Ziv, 2012; see also Qiu & Moll, 2022). Peers may be highly effective teachers precisely because they are children; their demonstrations may be more repetitive, more exaggerated, and more easily duplicated than are demonstrations by adults (Lewis, 2005).

Peer collaboration can also promote problem-solving, intellectual discovery, and creative thinking in children (Tomasello, 2019). This is because "peer interactions can introduce children to the process of generating ideas and solutions with equals in an atmosphere of mutual respect" (Damon, 1984, p. 335). Peer collaboration stimulates reciprocal interactions and the establishment of mutual goals, and involves learning as part of typical routines as well as in social play (Ramani & Brownell, 2013; Rogoff, 1998). For example, U.S. 6- and 7-year-olds were presented with conservation tasks related to length, mass, and quantity (e.g., children were given two identical dishes of water and the contents of one dish were poured into a short glass; Ames & Murray, 1982). Pairs of children who disagreed about the transformation (e.g., whether the glass contained less water, an equal amount, or more water than the dish) were told to discuss the item and agree on an answer. In comparison with other conditions (role playing, imitation, control), children in the peer collaboration condition had higher conservation posttest scores, suggesting that sharing judgments and reasons with a peer contributed to cognitive growth. Similarly, generative collaboration has been observed among U.S. and British children in domains including mathematical concepts (9- to 10-year-olds; Phelps & Damon, 1989), moralistic reasoning (7- to 10-year-olds; Kruger, 1992), spatial coordination (5- to 8-year-olds; Emler & Valiant, 1982), and instrumental problem-solving (2- to 3-year-olds; Ashley & Tomasello, 1998).

PEER LEARNING IS SELECTIVE AND CHANGES THROUGHOUT DEVELOPMENT

Reflecting age-related social learning biases, in experimental studies conducted primarily in the postindustrialized West, young children preferentially copied adults more than they did other children in instrumental domains. Such selective copying included British and German children as young as 14 months reproducing novel actions (Seehagen & Herbert, 2011; Zmyj et al., 2012), U.S. 3- and 4-year-olds labeling novel objects (Jaswal & Neely, 2006), and British 5-year-olds selectively reproducing causally irrelevant actions (Wood et al., 2012). In studies conducted in the United States, children preferred adults over peers as sources of knowledge about the nutritional value of food (3- to 5-year-olds; VanderBorght & Jaswal, 2009) and the reality status of a novel entity (4- to 8-year-olds; Woolley et al., 2021). However, in some of these studies, the selective copying of adults over peers was contingent on other contextual cues, including time delays, exposure to peers (Seehagen & Herbert, 2011), familiarity with the action (Zmyj et al., 2012), and reliability of the model (Jaswal & Neely, 2006).

Furthermore, evidence for adult-biased social learning may be restricted to instrumental contexts in which a correct solution can be identified. In a free-play setting, Canadian 4-year-olds imitated peers as many as 14 times an hour (Abramovitch & Grusec, 1978). Naturalistic studies have also evidenced biased copying of peers with context playing a role: Whereas U.S. 1- and 2-year-olds generally imitated adults over children when motor skills were demonstrated, they tended to selectively copy affective behaviors (e.g., laughing) from siblings and peers over those behaviors in adults (Kuczynski et al., 1987). Experimental studies conducted in the United States that involved knowledge of toys (VanderBorght & Jaswal, 2009) and play (Ryalls et al., 2000) have identified similar biased copying of peers over adults in 3- to 5-year-olds and 14- to 18-month-olds, respectively. In another study, U.S. 3-year-olds also preferred peers over adults when endorsing clothes, toys, games, and food (Shutts et al., 2010). Biases toward peers may be adaptive because children are similar to each other and therefore can provide more relevant information. Alternatively, a peer may be considered the expert in certain contexts related to children's cultures (Corsaro & Eder, 1990) or imitating peers may occur as a result of a social motivation (Over & Carpenter, 2012).

Between the beginning of adolescence and early adulthood, peer attachment grows significantly (e.g., longitudinal data from Spain; Malonda et al., 2019). Studies have hypothesized that peers become more important sources of social learning during this time (Fuhrmann et al., 2015; Molleman et al., 2022). Dutch, British, Italian, and Singaporean adolescents favored the opinions of their peers when complying with rules (Westhoff et al., 2020), subjectively evaluating risk (Knoll et al., 2017) and sharing (Ruggeri et al., 2018). Yet in other areas—such as in estimating tasks where objectively correct responses were possible (Molleman et al., 2019), hunting (Lew-Levy et al., 2021), and acquiring innovations (Hewlett, 2021)—Indian, BaYaka (Republic of the Congo), Aka (Central African Republic), and Chabu (Ethiopia) adolescents preferred to learn from adults. Together, these findings suggest that adolescent learning depends on the domain being transmitted. Adolescents

may prefer to learn from adults in instrumental domains where accrued objective knowledge of tasks is necessary for success. In normative domains, where the motivation to learn primarily reflects the desire to belong to a peer group, adolescents may instead prefer to learn from peers.

Finally, gender may also influence peer learning. U.S. 3- to 6-year-olds preferred trying novel objects, activities, and food that had been selected by peers of the same, rather than a different, gender (Frazier et al., 2012; Shutts et al., 2010). In another study, of British 13- to 17-year-olds, boys selectively copied other boys, girls showed no such own-gender bias, and adult gender-based selective copying corresponded to competence-specific gender stereotypes (Cunningham et al., 2023). More work is needed to understand how socialization and gender-based stereotypes influence peer learning throughout development.

PEER LEARNING VARIES ACROSS CULTURES

Cross-cultural research indicates that social structures such as demography, cultural values, labor divisions, and historical transitions affect the prominence of peer learning. For example, cultural beliefs about the importance of horizontal ties and vertical/hierarchical ties in children's learning vary across contemporary China, Japan, and South Korea (Chapin & Xu, 2023). Korean educators place a strong emphasis on peer learning and peer equality (Jung & Ahn, 2021). In comparison, vertical/hierarchical ties, such as teachers' teaching and parents' training, assume a more prominent and central role than child-to-child ties in Chinese views of education and childrearing (Xu, 2017). Yet despite the prevalent ideology emphasizing the role of parenting in shaping children's behavior in mid-20th century Taiwan, children younger than 12 living in industrializing villages spent most of their playtime with other children, including their siblings, without adult supervision (Xu, 2022). Furthermore, in Chinese classrooms today, peer comparison, evaluation, and criticism are widely used to discipline and mobilize young children, and to shape them into socially acceptable and valued members of society (Xu, 2019).

In subsistence societies, children are expected to participate in household activities (Lancy, 2012; Nsamenang, 2006) and child care (Weisner et al., 1977), tasks that are usually carried out with peers. By age 5, Yasawa (Fiji), Huatasani (Peru), and Aka (Central African Republic) children spent most of their time in the company of other children (Broesch et al., 2021). The peer group can be an important setting for teaching; for example, three quarters of subsistence teaching of both BaYaka (Republic of the Congo) and Hadza (Tanzania) forager children ages 3–18 years was done by other children (Lew-Levy et al., 2020). Similarly, in the context of play, older Mayan (Mexico) 3- to 11-year-old caretakers showed their 2-year-old siblings how to carry out routine tasks, such as washing and cooking (Maynard, 2002).

The composition of the peer group may be determined by a variety of individual and demographic factors. For example, Kispigis pastoralist (Kenya) children primarily played in mixed-gender groups until age 6 (Harkness & Super, 1985). However, between ages 6 and 9, children increasingly segregated into single-gender groups, likely reflecting increased freedom to choose play partners, as well as the growing expectation that children participate in gender-typed chores. In challenging urban environments, such as those inhabited by youth younger than 15 living on the streets in the Dominican Republic, peer socialization is especially important for knowledge transmission (Wolseth, 2010).

Socialization practices not only influence how much children learn from each other, but also how they do so. For example, in a U.S. study that examined how 6- to 10-year-old sibling pairs collaborated during a planning task, Mexican Indigenous-heritage children collaborated more fluidly by building upon each other's ideas than did middle-class Euro-American children, who were more likely to divide tasks and do them independently (Alcalá et al., 2018). In a U.S. study of how pairs of 9-year-old Navajo and Euro-American children taught a game to a 7-year-old peer, paired Navajo teachers were more likely to support or extend upon the information provided by their teaching partner than were paired Euro-American teachers, who tended to provide identical or unrelated information (Ellis & Gauvain, 1992). Considering the aforementioned research on collaboration and problem-solving, differences in collaboration styles may also affect children's propensity to generate new behaviors and technologies across cultures.

PEER LEARNING MAY BE PHYLOGENETICALLY WIDESPREAD

Our close phylogenetic kin, nonhuman primates (hereafter referred to as *primates*), show perhaps the most extensive cultural repertoire outside of humans, so comparative research can provide insights into how peer learning contributes to the acquisition of cultural information, and whether the human propensity for peer learning differs from that of closely related species. In the wild, young primates spend a disproportionate amount of time with their parents in the early years, so they have ample opportunity to learn from adults (Whiten & van de Waal, 2018). However, research with wild populations suggests opportunities for peer learning in a range of species, including monkeys and apes (see Table 1).

One of the most famous examples of an innovation spreading through a nonhuman primate group was initially driven by horizontal transmission (Kawai, 1965).

TABLE 1 Findings demonstrating opportunities for peer learning in monkeys and apes in the wild.

Articles	Species	Key results
Barrett et al. (2017); Coelho et al. (2015); Perry et al. (2017)	Capuchin monkeys (*Cebus capinus*)	Capuchins are more likely to learn from older individuals. However, younger individuals are more likely to innovate behaviors that may later be socially learned by group members
Grampp et al. (2019)	Vervet monkeys (*Chlorocebus pygerythrus*)	Juveniles prefer to attend to older monkeys but will attend most often to those they affiliate with (same-aged peers and kin)
Kawai (1965)	Japanese macaques (*Macaca fuscata*)	A novel potato-washing innovation was spread through a wild troop in part through peer learning
Lee et al. (2022)	Javan gibbons (*Hylobates moloch*)	Juveniles are more likely to be in proximity to immature siblings when collecting difficult-to-forage fruit, potentially leading to peer learning from individuals with similar physical constraints
Biro et al. (2003); Mitani et al. (2002)	Chimpanzees (*Pan troglodytes*)	Male chimpanzees of the same age class are likely to affiliate. Juvenile chimpanzees attend to older and same-aged models when cracking nuts; infants attend to juveniles and adults

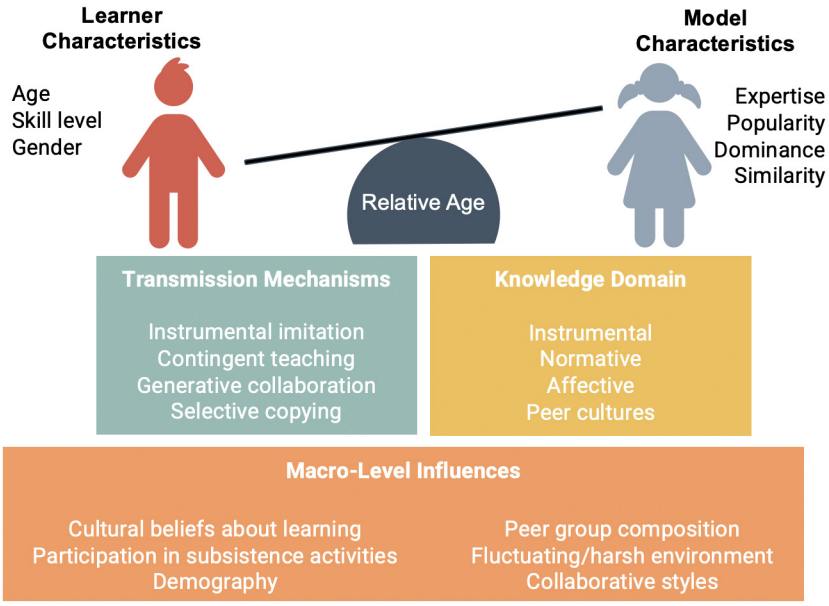

FIGURE 1 Synthesis and framework for understanding how, from whom, and in what contexts peer learning occurs, and the macro-level influences that shape its distribution across societies.

Like humans, a range of factors determines the relative importance of peers in primate learning, such as social structure, social tolerance, and life history. For example, the social structure of Japanese macaques affected the learning dynamics in their group. The observed novel food processing behavior was initially spread between same-aged juveniles, and then from younger individuals to older adult females. Older adult males were less likely to acquire the behavior because males become more peripheral to their groups following the juvenile period.

Experimental work directly comparing human children to other primates showcases how species differences in peer learning behaviors may support or constrain the acquisition of instrumental skills. In one study, groups of British 3- and 4-year-old children, juvenile and adult chimpanzees, and juvenile and adult capuchin monkeys were presented a puzzle box with increasingly complex solutions for more desirable rewards (Dean et al., 2012). Only children reached the final stage and thus the most desirable rewards, which the authors concluded was the result of social cognitive capabilities, including teaching, imitation, and prosociality. Similarly, across two studies, British 3- to 4-year-old children and adult chimpanzees were presented with identical puzzle boxes offering potential solutions of varied complexity (McGuigan et al., 2017; Vale et al., 2021). Children (McGuigan et al., 2017), but not chimpanzees (Vale et al., 2021), engaged in cycles of innovation and social transmission to reach more complex solutions than they did when tested alone.

Comparative work also suggests that primates strategically collaborate with peers when solving problems

(Horner et al., 2005; Melis & Tomasello, 2013, 2019; Vale et al., 2019). For instance, in a series of collaboration tasks, captive chimpanzees preferentially recruited previously successful peers over unsuccessful ones (Melis et al., 2006). However, children show a greater proclivity to engage collaboratively with peers than do other primates. When given the choice between solving problems individually or collaboratively, 2- to 3-year-old children are much more likely to elect to collaborate with peers than are 11- to 22-year-old chimpanzees (Rekers et al., 2011). Taken together, this body of work hints at the possibility that when comparing children with other primate species, children's motivation to interact with and learn from each other may underlie humans' greater capacity for cultural evolution (Rossano et al., 2022).

CONCLUSION AND NEXT STEPS

In this article, we have integrated cultural evolutionary theory with empirical evidence for peer learning across development, cultures, and primate species (see Figure 1 for summary and synthesis). Our review supports predictions derived from cultural evolutionary models suggesting that horizontal transmission is part of an optimal learning schedule. Empirical research suggests that instrumental imitation and contingent teaching are effective mechanisms for peer-to-peer knowledge transmission in early and middle childhood. Our review also suggests that when children have incomplete information, peer learning can generate new knowledge, and may be favored in challenging environments, though more research on this latter point is needed.

While cultural evolution models predict a bias toward copying adults in stable environments, we show that peer learning is persistent across societies despite cultural beliefs about learning that favor vertical transmission in some settings. This suggests that peer learning is pervasive even in stable environments. Furthermore, although children are biased toward learning from adults in instrumental domains, children attend to other demonstrator characteristics, such as expertise and gender. Evidence on the relative importance of peer versus adult transmission in adolescence suggests domain-specific learning motivations. Overall, in noninstrumental domains, such as affective behaviors, norms, and peer cultures, children and adolescents seem to exhibit a copy the young strategy. More broadly, research in primatology suggests that the human propensity to interact with peers may have contributed to our species' ability to develop complex solutions to solve instrumental problems. In summary, our review suggests that peer learning is a robust form of social learning that operates across all stages of development, and that contributes to both cultural maintenance and change.

Our review also points to several important avenues for research. Relatively little work has considered whether and how individual characteristics (e.g., personality, gender) affect children's propensity to learn from peers, how individual characteristics affect from whom others choose to learn, or how these interact and change throughout development. Interdisciplinary work should also consider how social networks and group composition may affect opportunities for peer learning across settings, cultures, and primate species. Such research can shed light on how access to peers interacts with motivation to learn from them, and, in turn, how these dynamics help or hinder the evolution of complex culture. Finally, theoretical models should draw from empirical research to consider how individuals' physiological and cognitive capabilities throughout development affect the order in which they learn cultural traits and their lifetime cultural repertoire.

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ORCID

Sheina Lew-Levy https://orcid.org/0000-0002-1250-6418
Natália Dutra https://orcid.org/0000-0002-0766-0795

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