

## **Peer learning and cultural evolution**

**Abstract:** In this article, we integrate cultural evolutionary theory with empirical research from developmental psychology, cultural anthropology, and primatology to outline the role of peer learning in the development of complex instrumental skills and behavioural norms. We show that instrumental imitation, contingent teaching, generative collaboration, and the application of selective social learning biases contribute to high-fidelity domain-specific transmission of knowledge between peers. Further, peer learning is persistent across cultures despite norms which favour adult-child transmission in some settings. Comparative research further suggests that children's greater motivation to interact with and learn from each other sets us apart from other primates. We conclude by outlining avenues for future research, including how individual characteristics, social networks, motivation, cognition, and developmental changes in these may contribute to cultural evolution.

**Key words:** peer learning, cultural evolution, social learning

**Word count:** 3186

## **Introduction**

In 2018, fifteen-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 from all over the world started their own protests; Licypriya Kangujam in India, Vanessa Nakate in Uganda, Xiye Bastida in New York. School strikes for climate were soon widespread, with over one 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 behaviours, beliefs, and practices.

In this paper, 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 the complex and diverse instrumental skills and behavioural norms which are transmitted and refined over generations (Richerson & Boyd, 2005). Considering that peer learning has been central to cultural evolutionary theory since its inception, here we aim to complement existing theoretical models with empirical insights into peer learning’s developmental trajectory, and the factors which promote or inhibit its expression. We first review theoretical predictions regarding the adaptive advantages that peer learning offers. We then 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 non-human primates can inform our understanding of its evolution.

## **Peer learning in cultural evolutionary theory**

Cultural evolutionary researchers 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 (Richerson & Boyd, 2005). One prominent line of research has focused on the adaptiveness of social versus individual learning (Kendal et al., 2018). To mitigate against the cost of learning irrelevant or out-dated information, social learning must be deployed selectively based on contextual or content cues (Kendal et al., 2018). Selective social learning is evidenced by biases towards attending to observable cues in a demonstrator (e.g., success), a trait (e.g., frequency), or a state (e.g., uncertainty). Further, such biases may be combined hierarchically based on cues such as success and conformity. Relevant to the present paper, a ‘copy older individuals’ strategy may be a relatively low-cost learning bias because increased 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; Reyes-García et al., 2016). Learning pathways are classified as vertical (from parents to offspring), oblique (from non-parents 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). Because children are accessible models, potentially more tolerant of other children than adults, and often only slightly more proficient in a skill than the observer, horizontal transmission may facilitate stepwise (with increasing complexity) and sequential (easier skills followed by harder skills) learning by middle childhood. Such peer-to-peer transmission may also reduce the opportunity costs suffered by adults by allowing them to prioritise other complex tasks (e.g., hunting, tuber

digging) (Gurven et al., 2020). Once baseline competencies have been reached, non-parental adults can transmit novel or more specialized knowledge to adolescents.

Horizontal transmission may also confer advantages during episodes of environmental and demographic stochasticity. 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 resource availability (Acerbi & Parisi, 2006; Aoki et al., 2012). As ‘imperfect’ cultural models who are themselves still learning, peers provide a source of variation that can allow the innovation or refinement of behaviours. Similar models allowing for more than two age classes show that a bias towards copying older individuals is beneficial in stable environments, where increasing age is usually associated with greater relevant experience (Wood et al., 2013). Conversely, learning from younger agents is beneficial in quickly changing environments because they are more likely to use individual learning which generates up-to-date adaptations, resulting in a successful ‘copy-the-young’ strategy (Deffner et al., 2020; Fogarty et al., 2019). 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. Horizontal transmission alongside norms which favour weak conformity to the majority is thus 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. Transmission chain studies have shown that British children as young as three years can successfully transmit and acquire behaviours, such as specific methods to

solve puzzle boxes, across multiple generations. This includes solutions seeded by adults (Flynn & Whiten, 2008) and by other children (McGuigan & Graham, 2010). Children also parse out redundant behaviours modelled by children, suggesting that children can quickly omit non-instrumental actions to achieve a goal (Flynn, 2008). Similarly, diffusion studies have shown that over time, groups of young children in the United Kingdom will converge on a single puzzle box solution even if initially multiple solutions are innovated by group members, suggesting a potent role of social learning to establish group norms (Whiten & Flynn, 2010). Further, peers who are older, more popular, and more dominant are observed and copied more than solvers who are younger and less popular and dominant (Flynn & Whiten, 2012). Various studies demonstrate that children are effective teachers, with contingent teaching evidenced by seven years of age (Strauss & Ziv, 2012). Peers may be highly effective teachers precisely because they are children; their demonstrations of actions may be more repetitive, more exaggerated, and more easily duplicated than adult demonstrations (Lewis, 2005).

Peer collaboration can also promote problem solving, intellectual discovery, and creative thinking. 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 in everyday routine and in social play (Ramani & Brownell, 2013; Rogoff, 1998). For example, six- and seven-year-olds were presented with conservation tasks related to length, mass, and quantity (e.g., children are presented with two identical dishes of water; one dish is poured into a short glass) (Ames & Murray, 1982). Pairs of children who disagreed about the transformation (e.g., whether the glass contains less

water, an equal amount, or more water than the dish) were told to discuss the item and to agree on an answer. In comparison with other conditions (role-playing, imitation, and control), children in the peer collaboration condition had higher conservation post-test scores, suggesting that sharing judgements and reasons with a peer contributed to cognitive growth. Similar outcomes have been observed in domains including mathematical concepts, moralistic reasoning, and causal learning (Damon, 1984).

### **Selective peer learning changes throughout context and development**

Reflecting age-related social learning biases, experimental studies primarily conducted in Europe and the US suggest that young children preferentially copy adults over other children in instrumental contexts. Such selective copying includes the reproduction of novel actions in children as young as fourteen-months-old (Seehagen & Herbert, 2011; Zmyj et al., 2012), the labelling of novel objects in three- and four-year-olds (Jaswal & Neely, 2006), and five-year-olds' selective reproduction of causally irrelevant actions (Wood et al., 2012). Adults were also preferred over peers for sources of knowledge of the nutritional value of food (VanderBorghet & Jaswal, 2009) and the reality status of a novel entity (Woolley et al., 2021). However, the selective copying of adults over peers is contingent upon other contextual cues, including time delays, exposure to peers (Seehagen & Herbert, 2011) action familiarity (Zmyj et al., 2012), and model reliability (Jaswal & Neely, 2006).

Further, evidence for adult-biased social learning may be restricted to instrumental contexts in which a correct solution can be identified. Abramovitch and Grusec (1978) observed that in a free-play setting, four-year-old children imitate peers up to 14 times an hour. Naturalistic contexts have also evidenced biased copying of peers with context playing a role; Kuczynski et al. (1987) found that whereas one- and two-year-olds generally imitate adults over children

when motor skills are being demonstrated, they tended to selectively copy affective behaviours (e.g., laughing) from siblings and peers over adults. Similar biased copying of peers over adults is found in experimental contexts involving knowledge of toys (VanderBorghet & Jaswal, 2009) and in play (Ryalls et al., 2000). Young children also use the preference of peers rather than adults when endorsing clothes, toys, games, and foods (Shutts et al., 2010). Biases towards peers may be adaptive because the peer is more like the child and therefore can provide more relevant information. Alternatively, the peer may be considered the expert in certain contexts related to children's cultures (Corsaro, 1990). Or, there may be a social motivation to imitate peers (Over & Carpenter, 2012).

Between the beginning of adolescence and early adulthood, peer attachment grows significantly (Malonda et al., 2019), and it is hypothesized that peers also become more important sources for social learning during this time (Fuhrmann et al., 2015; Molleman et al., 2022). Currently, the evidence is mixed regarding the relative importance of horizontal versus oblique sources, with some studies showing that adults are more important (Molleman et al., 2019), and others suggest that peers have more weight (Knoll et al., 2017). It is likely that the development of the balance between vertical, horizontal, and oblique transmission in adolescence depends on early life stress, knowledge domains, and cultural values.

### **Peer learning varies across cultures**

Cross-cultural research indicates that social structures such as demography, cultural values, labour divisions, and historical transitions affect the prominence of peer learning. For example, ideologies about the respective roles and meanings of horizontal ties and vertical/hierarchical ties in children's learning are diverse across contemporary China, Japan, and South Korea (Chapin & Xu, n.d.). 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 behaviour in mid-20th century Taiwan, children living in industrializing villages spent most of their playtime with other children, including their siblings, without adult supervision (Xu, 2022). Further, in Chinese classrooms today, peer comparison, evaluation and criticism remain a widespread method to discipline and mobilize young children and a powerful mechanism to shape children into socially acceptable and valued members of society (Xu, 2019).

In subsistence contexts, children are expected to participate in household activities and childcare, tasks which are usually conducted in the company of peers. By five years, children across diverse subsistence societies were found to spend most of their time in the company of other children (Broesch et al., 2021). The peer group can be an important setting for teaching; Lew-Levy et al. (2020) showed that three quarters of subsistence teaching by both BaYaka and Hadza forager children was between children and/or adolescents. Similarly, Maynard (2002) demonstrated that in the context of play, older Mayan sibling caretakers showed younger siblings how to engage in everyday tasks, such as washing and cooking. In challenging urban environments, such as those inhabited by Dominican street kids, peer socialization is especially important to knowledge transmission (Wolseth, 2010). The composition of the peer group may be determined by a variety of individual and demographic factors. For example, Kispigis pastoralist children primarily played in mixed-gender groups until the age of six years (Harkness & Super, 1985). Between six and nine years, however, children increasingly segregated into single-gender groups, likely reflecting increased



freedom to choose play partners, as well as the increasing expectation that children will participate in gender-typed chores.

Socialization practices not only influence how much children learn from each other, but also how they do so. For example, Alcalá et al. (2018) examined how siblings collaborated during a planning task. Mexican Indigenous-heritage children collaborated more fluidly by building upon each other's ideas than middle-class Euro-American children. In contrast, the latter were more likely to divide tasks and undertake them independently. Similarly, Ellis and Gauvain (1992) investigated how Navajo and Euro-American children taught a game to a younger peer, finding that Navajo child teachers were more likely to support or extend upon the information provided by their teaching partner than Euro-American child teachers, who tended to provide identical information. Considering the aforementioned research on collaboration and problem solving, differences in collaboration styles may also affect children's propensity to generate new behaviours and technologies across cultures.

### **Peer learning may be phylogenetically widespread**

As nonhuman primates (hereafter primates) show perhaps the most extensive cultural repertoire outside of humans, 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. Recent findings regarding the opportunity for peer-learning in certain primate species (Grampp et al., 2019), and famous examples of peers driving the spread of innovative behaviors (Kawai, 1965), suggests an underexplored role for peers in the transmission of primate behaviour. Several primate species have been found to identify conspecifics of different age classes (Sato et al., 2012), and in the wild, types of social interactions vary depending on the age of the

individuals involved (Grampp et al., 2019; Lee et al., n.d.). Young primates spend a disproportionate amount of time with parents in their early years, and so the opportunity to learn from adults in infancy is greater. For example, in the wild, young chimpanzees' (*Pan troglodytes*) acquisition of termite-fishing skills is mediated by the learning opportunities provided by their mothers (Lonsdorf, 2005).

However, in many species, individuals tend to spend more time with conspecifics of the same age as they mature, whether kin and/or non-kin (Grampp et al., 2019; Lee et al., n.d.). While there is some evidence that capuchin monkeys (*Cebus capuchinus*) prefer learning from the behaviour of older individuals (Coelho et al., 2015), younger capuchins were more likely than older ones to innovate foraging, investigative, and self-directed behaviours, some of which were transmitted to other group members (Perry et al., 2017). Recent work with vervet monkeys (*Chlorocebus pygerythrus*) found that while juvenile monkeys had no preference to attend to same-aged individuals, peers nonetheless received the highest levels of attention because juveniles were more likely to spend time with individuals of the same age (Grampp et al., 2019). In Javan Gibbons (*Hylobates moloch*), juveniles were more likely to be in proximity to immature siblings when collecting difficult-to-forage fruit, potentially because juveniles have similar physical constraints and thus, could more effectively learn to overcome these constraints from each other (Lee et al., n.d.). When learning nut-cracking behaviours, chimpanzees favour older or same-aged individuals (Biro et al., 2003). Potato washing in groups of Japanese Macaques on Koshima Island, one of the most famous examples of socially transmitted behaviour in wild primates, was observed to be originally driven by social learning between same-aged individuals (Kawai, 1965).

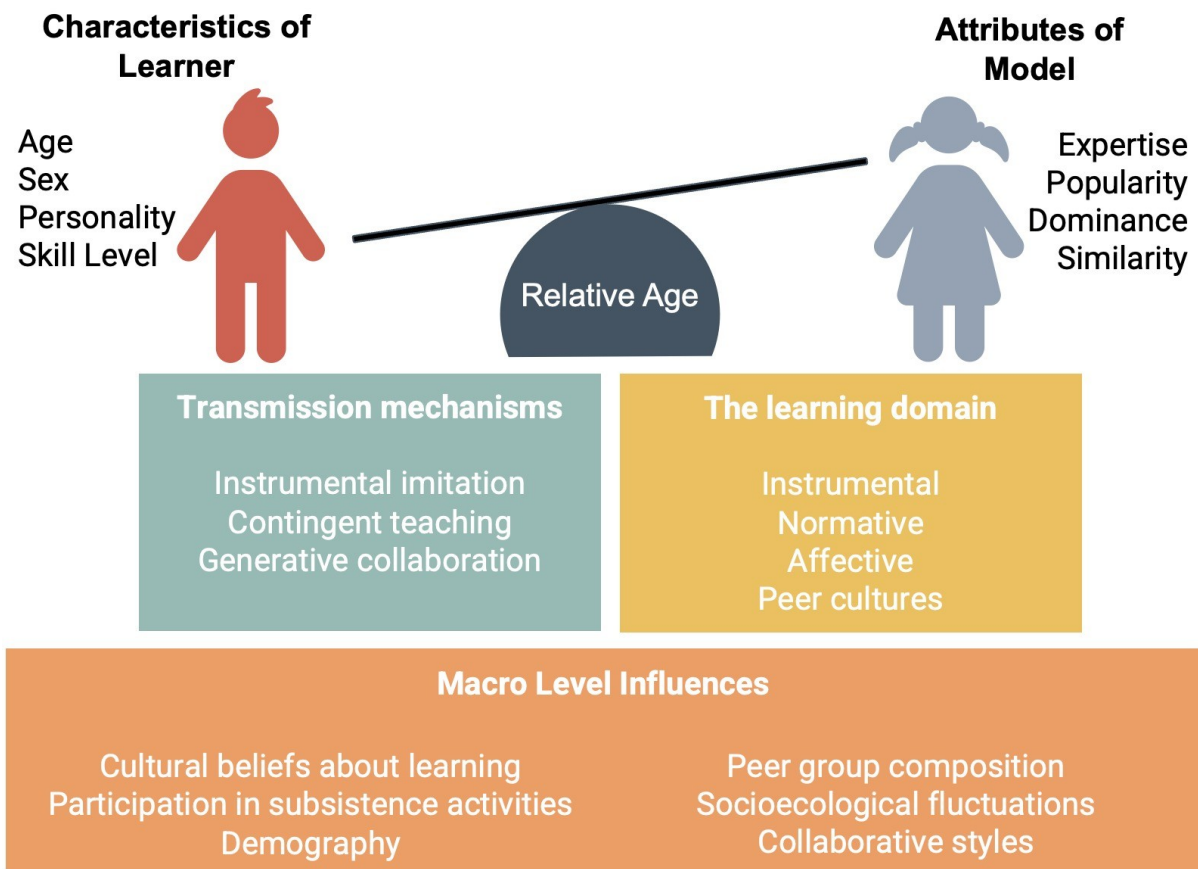
Experimental work directly comparing human children to other primates showcases how species differences in peer learning behaviours may support or constrain the acquisition of instrumental skills across species. Dean et al. (2012) presented a puzzle box with increasingly complex solutions for more desirable rewards to groups of children (3-4 years), chimpanzees, and capuchin monkeys. Only children reached the final stage and thus the most desirable rewards, which the authors concluded was due to a suite of social cognitive capabilities, including teaching, imitation, and prosociality. Similarly, across two studies, children (3-4 years) and chimpanzees were presented with identical puzzle boxes offering a range of potential solutions of varied complexity. Children (McGuigan et al., 2017), but not chimpanzees (Vale et al., 2021), engaged in cycles of innovation and social transmissions to reach higher solution levels than those in conspecific asocial conditions did not. Thus, children's greater motivation to interact with and learn from each other compared to other primate species may underlie humans' greater capacity for cultural evolution (Rossano et al., 2022).

### **Conclusion and future questions**

In this paper, we have integrated cultural evolutionary theory with empirical evidence for peer learning across development, cultures, and primate species (see Figure 1). 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. Evidence regarding the relative importance of learning from peers versus adults in adolescence is mixed, likely owing to limited research on this life stage more generally. Our review also suggests that when children possess incomplete information, peer learning can generate new knowledge, and

may be favoured in challenging environments, though more research on this latter point is needed. While cultural evolution models predict a bias towards copying adults in stable environments, we show that peer learning is persistent across cultures despite norms which favour vertical transmission in some settings. This suggests that peer learning is pervasive even in stable environments. Furthermore, although children do evidence social learning biases towards learning from adults in instrumental domains, children account for other cues for model quality when these are available. In non-instrumental domains, such as affective behaviours and peer cultures, children exhibit a ‘copy the young’ strategy. More broadly, research in primatology suggests the human propensity to interact with peers may have contributed to our species’ ability to develop complex solutions to solve instrumental problems. Overall, our review suggests that peer learning is a robust form of social learning which operates across all stages of development, and which contributes to both cultural maintenance and change.

Our review also points to several important avenues for future 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 whom others choose to learn from, nor how these change throughout development. Future 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 interact 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 carefully consider how the physiological and cognitive capabilities of an individual throughout development affects the order in which they learn cultural traits and their lifetime cultural repertoire.



**Figure 1.** Synthesis of research regarding from whom peer learning occurs, how, in what contexts, and the socioecological factors which shape its distribution across cultures.

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