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CHAPTER

The Cultural Transmission of Technological Skills

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Abstract

Human adaptation relies on the multigenerational transmission and accumulation of both skills and knowledge. Nonetheless, there is currently no agreement on which factor, or combination of factors, explains our peculiar ability to do so. Theoretical and empirical work, however, has identified many candidates that operate at both the individual and population levels. This chapter starts by giving a brief overview of these factors that support cultural transmission before highlighting the relative lack of research on the cultural transmission of skills. The chapter characterizes skills as behaviours that rely on fine motor control and knowledge as mental states that guide behaviours. Many behaviours require both complex knowledge and skilled actions to be effective. Nonetheless, the chapter argues that the field of cultural evolution has largely studied the transmission and evolution of knowledge, as opposed to skill, raising the possibility that it presents an incomplete picture of human adaptation. Drawing on evidence from anthropology and economics, the chapter suggests that the cultural evolutionary dynamics of skill are likely to differ from those of knowledge. Specifically, it argues that (i) skills are less reliant on language for transmission than is knowledge; (ii) skills are more costly to transmit than knowledge; (iii) skills are transmitted along different pathways than is knowledge, and are more often limited to vertical transmission; and (iv) as a result, skills are likely to evolve more slowly than does knowledge. The chapter concludes that a full picture of human adaptation requires an increased focus on skill, alongside knowledge.

Keywords: [skill](#), [technology](#), [cultural evolution](#), [social learning](#), [cultural transmission](#), [cumulative culture](#), [cultural evolutionary dynamics](#)

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Introduction

A central feature of our species is our unprecedented ability to develop sophisticated technologies that have allowed us to colonize and permanently occupy environments for which we are poorly suited genetically (Boyd et al., 2011). Knives, spears, slings, bows, kayaks, and clothes, along with large-scale constructions like houses, weirs, and drivelines are only a few examples of the myriad technologies that sustain humans in almost every terrestrial environment on Earth.

These technologies, and the skills to use them effectively, are not developed in isolation by especially gifted individuals but result from a cumulative cultural evolutionary process in which skills and knowledge are gradually accumulated across many generations (Boyd et al., 2011; Henrich, 2015; and see Creanza, this volume). As we shall see in this chapter, our ability to transmit and accumulate skills and knowledge results from a combination of factors that operate at the individual and population levels (see Caldwell, this volume). In what follows, we start by giving a brief overview of these factors that support cumulative cultural evolution, before highlighting the relative lack of research on the cultural transmission of skills. We describe examples of experimental work that, at first glance, might appear to investigate the cultural transmission of skills but that we argue actually study the transmission of knowledge. Drawing on evidence from anthropology and economics, we suggest that the cultural evolutionary dynamics of skills are likely to differ from those of knowledge. We conclude that the current focus on knowledge is likely to present an incomplete picture of human adaptation and so a fuller picture requires an increased focus on skill.

Factors Contributing to the Transmission of Cultural Information

There is currently no agreement on which factor, or combination of factors, explains our peculiar ability to transmit and accumulate skills and knowledge. Theoretical and empirical work, however, point to two main factors: individual capacities that promote cultural transmission and population characteristics that buffer against cultural loss and foster innovation.

At the individual level, there has been much focus on cognitive abilities supporting high-fidelity social learning. Factors that promote faithful cultural transmission include teaching, language, and prosociality (Laland, 2017). Many studies have investigated this topic using a variety of different methods, including theoretical models and experiments. For instance, Morgan et al. (2015) found empirical support for the transmission-enhancing effects of teaching and language in the context of modern humans learning to make Oldowan stone tools. Across experimental conditions, participants who were taught, as opposed to learning via passive observation, produced more tools, did so more quickly, and made more efficient use of raw materials. These benefits were further enhanced by verbal, as opposed to gestural, teaching. Such results, however, have not consistently replicated across tool types (Pargeter et al., 2022; Putt et al., 2014; Whiten, 2015) and it is important to note that while teaching and language may enhance transmission, they are unlikely to be strictly necessary (Snyder et al., 2022). Furthermore, the extent to which they help cultural transmission has been shown to vary with tool complexity (Lucas et al., 2020).

From a theoretical perspective, Fogarty et al. (2011) examined the conditions under which teaching, defined as a costly ability to increase the efficacy of transmission, will evolve. They found it did so when the inclusive fitness benefits of helping the learner outweigh the personal costs of being a teacher. As a result, teaching evolves when the information being transmitted is neither too easy nor too hard to learn but rather falls in a middle ground of learnability. This is because easily learned information is likely to be invented anyway, whereas difficult to learn information is unlikely to be successfully transmitted even with teaching, and so in both cases the inclusive fitness benefits are small.

At the population level, demography is widely considered as a key factor for the stability of cultural information. The main idea behind demographic models of cultural evolution is that our social learning abilities subtly interact with demography to affect the maintenance of cultural traits (Henrich, 2004; Powell et al., 2009). More specifically, it has been shown that the size of the population within which information is shared can buffer the risk of losing cultural information. Indeed, models have shown that when populations are large enough, individuals' propensity to learn from successful cultural models creates a selective force that promotes the transmission of beneficial cultural traits and outweighs the degrading effects of learning errors (Henrich, 2004). The plausibility of demographic models has been tested using real-world ethnographic and archaeological data. However, results from studies looking for a correlation between toolkit size and population size have been mixed. Some studies support the hypothesis (Collard et al., 2013c; Kline & Boyd, 2010; Marquet et al., 2012; Powell et al., 2009), but others do not (Buchanan et al., 2015; Collard et al., 2005, 2013a, 2013b).

The difficulty with testing demographic models using real-world data is that human populations are typically embedded within extended networks of cultural exchange, making it difficult to gather meaningful estimates of population size (Derex & Mesoudi, 2020). For this reason, cultural evolution researchers have turned to lab experiments, in which groups of participants are tasked to improve a piece of technology in order to test predictions from theoretical models. Most experiments provide support for a positive effect of group size on the accumulation of cultural information (Derex & Boyd, 2015; Derex et al., 2013; Kempe & Mesoudi, 2014; Muthukrishna et al., 2014; Wisdom et al., 2013; but see Caldwell & Millen, 2010; Fay et al., 2019). One study, for instance, exposed naïve participants in groups of two, four, eight, and 16 to demonstrations showing how to produce virtual arrowheads and fishing nets and tracked the efficiency of those tools across time (Derex et al., 2013). The larger the group, the less likely tools were to deteriorate, the more likely they were to improve, and the more likely a diversity of tool types was to be maintained. These studies illustrate how decreases in effective population size may result in a loss of technologies and/or skills and can help explain non-monotonical trends in cultural evolution.

Along with studies about population size, an increasing number of studies have started to investigate how the structure of the population impacts the transmission and accumulation of cultural information. Human populations are typically embedded within extended networks of cultural exchange and recent work suggests that differences in rates of connectedness strongly affect the transmission and accumulation of cultural information (Derex & Mesoudi, 2020). For instance, experimental studies that assume that existing traits can not only be refined but also combined with other existing cultural traits have shown that cultural accumulation can benefit from lower levels of connectedness (Derex & Boyd, 2016). This is because high levels of connectedness make individuals more likely to converge on similar solutions, which results in lower levels of cultural diversity and slower rates of innovation compared with less connected groups. When the risk of cultural loss is considered, simulation models show that optimal rates of accumulation are reached for intermediate levels of connectedness (Derex et al., 2018). This is because low levels of connectedness increase the risk of cultural loss by decreasing access to demonstrators, while high levels of connectedness reduce opportunities to innovate by homogenizing cultural behaviours. At intermediate levels of connectedness, groups can accumulate cultural information while remaining culturally distinct, which keeps fuelling innovation (Derex & Mesoudi, 2020).

The Relationship between Knowledge and Skill in Technology

While the above highlights the progress made in understanding the transmission and accumulation of cultural information, we will now suggest that it has failed to account for how technologies are manifest as complex motor actions, what we will call *skills*. In particular, we suggest that much existing work can be better characterized as studying the transmission of knowledge, as opposed to skill. Let us begin by briefly outlining how we feel these two concepts differ.

The core of our distinction is that skill emphasizes actions while knowledge emphasizes mental states. For instance, the creation of a colonial knot (as opposed to, say, a French knot) in cross-stitch requires quite fine motor control to perform highly specific actions and, as such, it is a skill. On the other hand, the ability to read a map and use it to navigate to your destination successfully requires understanding the conventions of map creation (scale, contour lines, location symbols) but does not require any particularly challenging actions, and so it is an example of knowledge.

This is not a dichotomy: in the vast majority of cases both skill/action and knowledge/mental state are at work (you need to *know* how to make a French knot, and holding a map involves *actions*). The interaction between knowledge and action has long been stressed by archaeologists who clearly recognize that both contribute to activities such as tool-making (Pargeter et al., 2020). Improvements in skill require increased precision of selected actions which leads to higher replicability in achieving a desired goal (Crown, 2001; Stanley & Krakauer, 2013). Individuals, then, may be poorly skilled because they perform appropriate actions with poor precision or because they perform inappropriate actions. Becoming a skilled hunter, for instance, requires more than developing fine motor control and depends on knowing facts about the local environment and animal behaviour. Kawabe (1983), for instance, has shown that among the Gidra from south-west Papua New Guinea, adolescents vary in hunting success rate because of difference in environmental knowledge. Nonetheless, certain tasks may rely on skills more so than knowledge and so are better characterized as tasks of skill or knowledge.

The way in which we are using the terms knowledge and skill here has considerable overlap with the archaeological terms *connaissance* and *savoir-faire* (Pelegrin, 1993) commonly translated as knowledge and know-how, and which refer to the mental images of possible actions and the ability to perform those actions, respectively. There is also similarity with the notions of public/behavioural and private/mental culture (Tamariz, 2019), where the public performance of a behaviour is distinguished from its mental representation. Despite this overlap, the intention behind the work is different. Here, we argue that tasks can be characterized as relying to various degrees on skill and/or knowledge.

With the difference between skill and knowledge in mind, let us note that not all technologies (the focus of this chapter) emphasize skill. For instance, the use of programming languages is at the heart of a vast array of contemporary technological developments and learning these languages is a key part of modern-day cultural inheritance. Nonetheless, the successful use of these languages relies almost entirely on an individual's mental state as opposed to their ability to perform certain actions, and so we suggest that a successful programmer is better characterized as *knowledgeable* as opposed to skilled.

Despite this, skills are critical to the ecological success of the human species. Compared to chimpanzees that obtain 95 per cent of their calories from foods that they gather by hand, human foragers obtain 32 per cent of their calories from extracted resources and 60 per cent from hunted resources (Kaplan & Robson, 2002). Technologies that support this subsistence strategy require huge amounts of skill, and this can occur both at the level of production and at the level of use. As one example, consider the bow hunting of caribou by the Netsilik living along the Arctic coast of North America (Balikci, 1970). To produce a bow requires the skilled manipulation of a musk-ox horn handle and antler limbs, as well as antler splits and blocks, along with sinew to bind them all together. Once a bow is made, several hunting techniques can be implemented to use the produced tool efficiently. One in particular, stalking on open terrain, requires the hunter(s) to approach their prey by standing bent at the waist and imitating the gait of a grazing caribou in order to approach the animal without scaring it off. This approach can last for several hours, and once sufficient proximity is achieved the hunter would suddenly stand upright and quickly release an arrow. While knowledge is critical to this hunting technique, its successful execution also relies on highly complex motor actions making it a skill.

Cultural Evolution Typically Studies Knowledge and Not Skill

With the distinction between knowledge and skill in mind, we can now return to studies of cultural transmission and ask to what extent the two are present.

For practical purposes, experimental tasks used in cultural evolution tend to be simple and straightforward to solve compared to the ecological problems solved by human cultures (Derex, 2022; Miton & Charbonneau, 2018). Limiting the complexity of tasks is important to study cultural transmission effectively over a relatively short period of time. However, it carries the risk of leading to an incomplete understanding of the mechanisms at work, as well as of the resulting cultural evolutionary dynamics. In this section, we argue that most current work focuses extensively on knowledge transmission, leaving relatively little known about the transmission of skill.

As an example, consider an experimental investigation of the transmission of Oldowan stone knapping techniques (Morgan et al., 2015), finding transmission was enhanced by teaching (in particular when gestural teaching was combined with speech). The controlled production of stone tools undoubtedly requires a considerable amount of skill and precise motor control. Indeed, a study comparing the knapping ability of experts (with more than 20 years of experience in stone knapping) against intermediate knappers (several years of experience) and novices (little to no experience) found clear differences between the groups, with only experts being able to precisely predict and control the outcome of strikes (Nonaka et al., 2010). Nonetheless, although the experiment involved such a technology, we suggest it is likely that it did not study the transmission of skill because the experimental time frame was too short. The expertise study mentioned above shows that the skills underlying stone knapping develop slowly, continuing to improve over decades of practice. The transmission study, however, took under an hour of a given participant's time, with no more than 30 minutes spent making tools. We suggest this time is too short for the meaningful transmission of skill. Indeed, a more recent study involving two hours of knapping was still unable to detect increases in skill (Pargeter et al., 2022). Instead, what was likely to have been transmitted was basic knowledge concerning stone knapping—how to hold the materials, the general characteristics of suitable strike locations, how hard to hit, and so on—which participants put into practice as best they could. Such knowledge allowed participants to make a number of viable flake tools, but their *skill* as knappers is likely to have remained poor.

Similar arguments could be made about most experimental tasks that are commonly used in the cultural evolution literature. Making paper airplanes so that they fly as far as possible or building towers so that they are as tall as possible involves relatively straightforward actions in which individuals are already competent prior to the experiment (such as folding a piece of paper; Caldwell & Millen, 2008). Therefore, cultural transmission in those studies is likely to have concerned knowledge and not skill. The unintended focus on knowledge that we aim to highlight in this chapter is not limited to experimental studies. For instance, one of the rare field studies looking at the interaction between social structure and cultural transmission among traditional populations focused exclusively on the transmission of knowledge (Salali et al., 2016).

That these studies investigate the transmission of knowledge, as opposed to skill, does not mean they are poor studies. The transmission of knowledge is itself a critical part of culture and worthy of study. Experimental studies of knowledge transmission have proved useful tests of theoretical predictions about how individuals learn in groups (Mesoudi, 2011; Morgan et al., 2012) and field studies are extremely valuable to reveal the pathways through which knowledge might flow within actual populations (Migliano et al., 2017). Nonetheless, this work leaves untouched the cultural transmission of skills and we should be cautious about the extent to which current findings generalize.

The Cultural Evolutionary Dynamics of Skill Are Likely to Differ from Those of Knowledge

The broad focus of the cultural evolutionary literature on knowledge is only problematic to the extent that knowledge does not capture the full spectrum of cultural evolution. Whether the cultural evolutionary dynamics of skills differ to those of knowledge is an empirical question that remains yet to be addressed.

Some findings from the cultural evolutionary literature are likely to be valid regardless of the cultural content involved. For instance, consider the influential finding of theoretical models that population size and connectedness critically affect the transmission and maintenance of cultural traits by buffering the risk of cultural loss (Creanza et al., 2017; Derex & Boyd, 2016; Henrich, 2004; Powell et al., 2009). Although experiments supporting the role of population size on the proper transmission of cultural information have mostly involved the cultural transmission of knowledge (Derex et al., 2013; Kempe & Mesoudi, 2014; Muthukrishna et al., 2014), we should expect to observe similar effects when skills are involved. Indeed, both knowledge and skills are at risk of cultural loss due to our limited learning abilities, and while the magnitude of the risk may differ, it is plausible that fewer learners will increase the risk of losing cultural information in both cases. Nonetheless, there are multiple reasons to suppose that the cultural evolutionary dynamics of skill might differ from that of knowledge and we shall describe a few examples here.

The Role of Language

One difference between skills and knowledge is that the transmission of skills is potentially less reliant on, or derives less benefit from, language. For instance, the complex actions involved in skills may be more difficult to put into words, meaning language struggles to transmit them. Similarly, while knowledge is difficult to demonstrate directly (although it can be manifest in behaviours), it may be readily put into words and expressed verbally. As such, without language, knowledge transmission may have been more challenging than skill transmission. However, the evolution of language may have reversed this relationship by greatly facilitating the transmission of knowledge. This suggests that simpler social learning mechanisms, such as imitation, may be more conducive to the transmission of skills than language.

The difficulty of transmitting skills verbally is illustrated by an experiment that compared the acquisition of stone tool-making skills among learners who were taught using speech alone (unassisted by gesture), gesture alone, or 'full language' (gesture plus speech) (Cataldo et al., 2018). Comparisons of flintknapping performance indicate that individuals who were taught using speech alone performed poorly compared to individuals instructed through either gesture alone or 'full language', suggesting that language in the absence of demonstration was poorly suited to transmitting an understanding of the process of tool-making.

Costs of Transmission

Skills and knowledge are also likely to vary in terms of costs associated with their transmission. Indeed, since skills can be difficult to put into words, they are more likely to require demonstration from teachers. This should be particularly the case for skills that are complex and/or more hazardous. Ethnographic studies, for instance, have shown that complex extractive subsistence skills such as big game hunting and multicomponent tool-making typically involve direct instruction even within populations where direct, active teaching is relatively rare (Lew-Levy et al., 2017). Thus, even though simpler skills such as trapping small game and pounding grain can be acquired through observation and participation to daily activities, skills involving risks (such as the risk of being harmed or the processing of rare raw material) will tend to involve substantial costs of transmission.

Another difference between skills and knowledge is that skills require extensive practice. To some extent, practice is likely to benefit the transmission of knowledge as well. For instance, in a knowledge-based experiment in which learners received lengthy cultural demonstration on how to build a virtual fishing net by selecting different materials and pointing and clicking on a grid to arrange the materials, 100 per cent of fishing-net builders failed at the first trial (Derex et al., 2013). This illustrates the importance of multiple demonstrations and multiple attempts in the proper acquisition of knowledge (see also Flynn & Whiten, 2010). Yet ethnographic and experimental evidence indicate that skills are acquired through long apprenticeships during which motor control is progressively developed (Kaplan & Robson, 2002; Pargeter et al., 2020). As noted above, knappers continue to improve their fine control over flaking outcomes over the course of decades. Similar learning curves are seen in bows and atlatls (Whittaker, 2013). The role of practice in the acquisition of skills is also exemplified by return rates of ache hunters who become proficient years after reaching their peak strength (Walker et al., 2002). Moreover, experimental archaeology studies have showed that learners' inability to produce stone tools is largely accounted for by a failure to execute intended actions properly rather than a failure to conceptualize appropriate goals (Pargeter et al., 2020). A consequence of this is that skills may take much longer to transmit successfully, while knowledge, although not instantaneous by any means, will often be faster to transmit.

The fact that skills require extensive practice creates specific demands for learners and might have led to the emergence of unique mechanisms to support their proper acquisition (Sterelny, 2014). One example is the production of miniature toys by adults that allow children to emulate adult activities. Many ethnographical studies have revealed that adults facilitate skill acquisition by providing children with toy or small hunting weapons at an early age. For instance, at the Par-Tee site in Oregon, children were provided with miniature atlatls for them to practice with (Losey & Hull, 2019). Other examples include miniature baskets, digging sticks, and spears which support the acquisition of subsistence skills such as harvesting and small-game hunting (Lew-Levy et al., 2017).

Transmission Pathways

The fact that the transmission of skills is likely to incur larger costs to demonstrators compared to knowledge suggests that their respective transmission pathways might differ. In particular, the costs associated with the transmission of skills may disincentivize teaching toward non-kin and limit learning opportunities (see Buckley, this volume). Reviews of the ethnographic literature confirms that skills are mostly transmitted vertically. For instance, Shennan and Steele (1999) have reported that craft and tool-making traditions are predominantly transmitted from father to son or mother to daughter. A recent meta-ethnographic review studying how children learn subsistence skills also suggests that same-sex vertical transmission is one of the major ways by which children learn various foraging skills (Lew-Levy et al., 2017). To some extent, this is true of knowledge transmission as well. Studies looking at the distribution of knowledge in hunter-gatherer populations have also showed that not all knowledge is equally shared despite being cheaper than skills to transmit. For instance, field studies have showed that knowledge about medicinal plants was mostly shared between spouses and kin, while knowledge about plants that serve other functions was shared more widely. This illustrates that transmission networks are content specific even in the case of simple pieces of knowledge that can be transmitted at low cost. Nonetheless, because the transmission of skills requires more effort on the part of the demonstrator, skilled individuals should be more inclined to teach kin because of inclusive fitness benefits (see Buckley, this volume).

The fact that skills tend to be passed on vertically does not mean they are exclusively transmitted in this way. For instance, ethnographic studies have showed that hunting skills are sometimes taught by uncles, grandfathers, and other elders (Puri, 2006; Wallace & Hoebel, 1986). In some cases, like among Ethiopian Chabu, adolescents even choose their teachers, preferring to go on hunts with knowledgeable individuals (Dira & Hewlett, 2016). Yet for teaching toward non-kin to occur it must be supported by informal or formal

institutions that compensate the teachers for their efforts. For instance, cultural evolution scholars have argued that learners use deference to buy access to skilled models (Henrich & Gil-White, 2001).

Economists have long stressed the role of institutions in providing an enforcement mechanism that incentivize cultural transmission of skills (de la Croix et al., 2017). Within families, no enforcement mechanism is required because parents and relatives are inclined to teach kin because of inclusive fitness benefits. However, outside the family, skills are often passed from knowledgeable individuals to learners in return for help with routine tasks and menial assignments. For complex tasks, transmissions mechanisms often take the form of an apprenticeship, which is a relation linking a skilled individual (typically an adult) to a learner (typically a child or adolescent). The duration of apprenticeships can vary, but it typically increases with the complexity of the skill involved (de la Croix et al., 2017). Research among stone-adze makers of Langda in Indonesian, for instance, has shown that tool-making skills are traditionally transmitted through semi-formal apprenticeships that began around age 12 and last several years (Stout, 2005). In exchange for being trained, learners must often commit to defer to the teacher and follow the tradition precisely. Teachers also evaluate the commitment of potential learners and might evaluate their potential by asking them to perform activities relevant to the skill that they wish to acquire (Stout, 2005). Studies investigating the transmission of skills in pre-industrial modern Europe have also found that parents often paid premiums, with the amount depending on the prestige of the teacher. Premiums could also vary depending on the physical strength of learners, with strong individuals paying less than weak individuals (de la Croix et al., 2017).

Thus, compared to knowledge, the high costs associated with skill transmission are likely to require specific mechanisms that mitigate or eliminate the moral hazard problem in the teacher–learner relationship. It is likely that informal and formal institutions that compensate teachers for their effort are key determinants of the dissemination of skills.

Resulting Evolutionary Dynamics

The difference between skills and knowledge suggest that the cultural evolutionary dynamics of skill might differ from that of knowledge in significant ways. First, limited learning opportunities will make skills more prone to cultural loss than knowledge. Moreover, difficulty of transmitting skills relative to knowledge may render their persistence across generations increasingly fragile. Evidence of this can be seen in the Polar Inuit who, following an epidemic in the 1820s that killed many elder group members, rapidly lost the ability to make and use kayaks, leisters, and bows and arrows (Boyd et al., 2011). These technologies were regained through contact with migrating Inuit from Baffin Island, but in the meantime the Polar Inuit were unable to make and use these tools even though many of them would have grown up surrounded by their use and undoubtedly understood the general principles behind their creation and use. Nonetheless, given the historical nature of this account it is unclear the extent to which the Polar Inuit suffered from a loss of knowledge or skill.

Second, skills may evolve more slowly than knowledge. There are two reasons to suppose this might be the case: (i) as already discussed there are reasons to suppose that skills transmission is a slower process than knowledge transmission, if true, and assuming that both transmit with similar fidelity, then skill evolution will also be slower than knowledge evolution; and (ii) the evidence reviewed above suggests that complex skills (due to the cost of their transmission) are disproportionately transmitted vertically. Such a process will slow the spread of innovations within and between populations and cause cultural evolution to approximate genetic evolution which is slower than cultural change (Perreault, 2012). Buckley & Boudot (2017), for instance, reported that loom designs and weaving techniques (that are mostly transmitted from mother to daughter through a lengthy apprenticeship) exhibit low rates of innovation. An additional reason why skills might evolve slowly is that teachers are often concerned with detecting and correcting errors in

learners' techniques. These corrections, however, not only concern actual errors but also deviation from the traditional way of performing the technique (Buckley & Boudot, 2017). This is likely to increase the fidelity of transmission between generations but will ultimately reduce opportunities for innovation.

Due to the conservative way in which skills are transmitted, mechanisms are likely to be required to promote the diffusion of innovations between families. One such mechanism is marriage. Weavers, for instance, often move from the parental household to their spouse's household (Buckley & Boudot, 2017). Yet because innovation rates are low, skills are often uniform within communities with no variation between household. Another mechanism that has been put forward by anthropologists is ritual relationship, which has been shown to promote interactions between communities (Hill et al., 2014). For instance, quantitative analyses of interaction rates have revealed that ritual relationship is a more important predictor than kinship for different types of interaction, including opportunities for cultural transmission (such as observing tool-making skills). However, it is not entirely clear whether occasional episodes of observation are sufficient to enable the transmission of complex skills.

Apprenticeships may also help diffuse skills beyond single families. Economists, for instance, have argued that because semi-formal and formal apprenticeship are independent of family ties, they allow learners to acquire skills from larger populations (de la Croix et al., 2017). For instance, they have argued that, compared to China where training was provided by family members, pre-industrial Western Europe had a formal system of apprenticeship organized by guilds that were better at disseminating techniques and innovations. One interesting feature of guilds is that they introduced journeymanhood (Lis et al., 1994). Journeymen were considered competent craftsmen and were authorized to work in the field in which they have been trained but could not yet work as self-employed master craftsmen. Rather they had to travel to another city to acquire additional skills, which exposed them to a broader range of skills and fostered the spread of new techniques. (De la Croix et al. (2017) compared their status to postdoctoral researchers in scientific fields). It is likely that regions that relied on institutions such as extended families and clans may have experienced lower rates of innovations than regions where learners could sample from larger pools of skilled teachers.

Conclusion

Human adaptation relies on the cultural accumulation of both skills and knowledge. Theoretical and empirical work indicate that our ability to transmit cultural information results from a combination of factors that operate at the individual and population levels. In this chapter, we briefly reviewed these factors and have argued that most cultural evolutionary work has studied the transmission of knowledge. Yet humans extract resources and exploit technologies that require high level of skill. As we have argued, skills and knowledge differ along many dimensions, and we should be cautious not to assume that findings about the transmission of knowledge necessarily generalize to skills. Compared to knowledge, the transmission of skills might occur via different learning mechanisms, over longer periods of time, and might involve different transmission pathways. Understanding how cultural transmission differ between skills and knowledge is critical for debates about the relationship between of humans' unique social structure and the transmission and accumulation of cultural innovations. Indeed, it has been argued that humans live in large networks of unrelated individuals that might be conducive to the spread and accumulation of cultural information (Hill et al., 2014). Yet actual measurements of cultural transmission in natural populations remain scarce and little is still known about how skills, in particular complex ones, spread in natural populations. Due to the features of skills, it seems unreasonable to assume that large social networks will automatically result in large skills transmission networks. Additional mechanisms such as semi-formal and formal institutions have probably been key to promote the dissemination and accumulation of skills. A more detailed understanding of the cultural transmission of skills, alongside and interacting with knowledge, will provide a more general basis for understanding cultural evolution and human adaptation.

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