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The Cultural Transmission of Technological Skills

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12 **Abstract**

13 Human adaptation relies on the multigenerational transmission and accumulation of both
14 skills and knowledge. Nonetheless, there is currently no agreement on which factor, or
15 combination of factors, explains our peculiar ability to do so. Theoretical and empirical work,
16 however, has identified many candidates, that operate at both the individual and population
17 levels. In this chapter, we start by giving a brief overview of these factors that support cultural
18 transmission, before highlighting the relative lack of research on the cultural transmission of
19 skills. We characterize skills as behaviors that rely on fine motor control, and knowledge as
20 mental-states that guide behaviors. Many behaviors require both complex knowledge and
21 skilled actions to be effective. Nonetheless, we argue that the field of cultural evolution has
22 largely studied the transmission and evolution of knowledge, as opposed to skill, raising the
23 possibility it presents an incomplete picture of human adaptation. Drawing on evidence from
24 anthropology and economics, we suggest that the cultural evolutionary dynamics of skill are
25 likely to differ from those of knowledge. Specifically, we argue that (1) skills are less reliant on
26 language for transmission than is knowledge, (2) skills are more costly to transmit than
27 knowledge, (3) skills are transmitted along different pathways than is knowledge, and are
28 more often limited to vertical transmission, and (4) as a result, skills likely evolve more slowly
29 than does knowledge. We conclude that a full picture of human adaptation requires an
30 increased focus on skill, alongside knowledge.

31

32 **Introduction**

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

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

53

54 **Factors contributing to the transmission of cultural information**

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

60 At the individual level, there has been much focus on cognitive abilities supporting
61 high-fidelity social learning. Factors that promote faithful cultural transmission include
62 teaching, language, and prosociality (Laland, 2017). Many studies have investigated this topic
63 using a variety of different methods, including theoretical models and experiments. For
64 instance, Morgan et al (2015) found empirical support for the transmission enhancing effects
65 of teaching and language in the context of modern humans learning to make Oldowan stone
66 tools. Across experimental conditions, participants who were taught, as opposed to learning
67 via passive observation, produced more tools, did so more quickly, and made more efficient
68 use of raw materials. These benefits were further enhanced by verbal, as opposed to gestural,
69 teaching. Such results, however, have not consistently replicated across tool types (Putt et al.,
70 2014; Whiten, 2015; Pargeter et al., 2022) and it is important to note that while teaching and
71 language may enhance transmission, they are unlikely to be strictly necessary (Snyder et al.
72 2022). Furthermore, the extent to which they help cultural transmission has been shown to
73 vary with tool complexity (Lucas et al. 2020).

74 From a theoretical perspective, Fogarty et al (2011) examined the conditions under
75 which teaching, defined as a costly ability to increase the efficacy of transmission, will evolve.
76 They found it did so when the inclusive fitness benefits of helping the learner outweigh the
77 personal costs of being a teacher. As a result, teaching evolves when the information being
78 transmitted is neither too easy nor too hard to learn, but rather falls in a middle ground of

79 learnability. This is because easily-learned information would likely be invented anyway,
80 whereas difficult-to-learn information is unlikely to be successfully transmitted even with
81 teaching, and so in both cases the inclusive fitness benefits are small.

82 At the population level, demography is widely considered as a key factor for the stability
83 of cultural information. The main idea behind demographic models of cultural evolution is that
84 our social learning abilities subtly interact with demography to affect the maintenance of
85 cultural traits (Henrich, 2004; Powell et al., 2009). More specifically, it has been shown that
86 the size of the population within which information is shared can buffer the risk of losing
87 cultural information. Indeed, models have shown that, when populations are large enough,
88 individuals' propensity to learn from successful cultural models creates a selective force that
89 promotes the transmission of beneficial cultural traits and outweighs the degrading effects of
90 learning errors (Henrich, 2004). The plausibility of demographic models has been tested using
91 real-world ethnographic and archaeological data. However, results from studies looking for a
92 correlation between toolkit size and population size have been mixed. Some studies support
93 the hypothesis (Powell et al., 2009; Kline & Boyd, 2010; Collard et al., 2013; Marquet et al.,
94 2012), but others do not (Collard et al., 2005; Collard et al., 2013b; Collard et al., 2013c;
95 Buchanan et al., 2015).

96 The difficulty with testing demographic models using real-world data is that human
97 populations are typically embedded within extended networks of cultural exchange, making it
98 difficult to gather meaningful estimates of population size (Derex & Mesoudi, 2020). For this
99 reason, cultural evolution researchers have turned to lab experiments, in which groups of
100 participants are tasked to improve a piece of technology, to test predictions from theoretical
101 models. Most experiments provide support for a positive effect of group size on the
102 accumulation of cultural information (Derex et al., 2013; Wisdom et al., 2013; Muthukrishna

103 et al., 2014; Kempe & Mesoudi, 2014; Derex & Boyd, 2015, but see Caldwell & Millen, 2010;
104 Fay et al., 2019). One study, for instance, exposed naïve participants in groups of 2, 4, 8 and
105 16 to demonstrations showing how to produce virtual arrowheads and fishing nets, and
106 tracked the efficiency of those tools across time (Derex et al., 2013). The larger the group, the
107 less likely tools were to deteriorate, the more likely they were to improve, and the more likely
108 a diversity of tool types were to be maintained. These studies illustrate how decreases in
109 effective population size may result in a loss of technologies and/or skills and can help explain
110 non monotonical trends in cultural evolution.

111 Along with studies about population size, an increasing number of studies have started
112 to investigate how the structure of the population impacts the transmission and accumulation
113 of cultural information. Human populations are typically embedded within extended networks
114 of cultural exchange and recent work suggests that differences in rates of connectedness
115 strongly affect the transmission and accumulation of cultural information (Derex & Mesoudi,
116 2020). For instance, experimental studies that assume that existing traits can not only be
117 refined, but also combined with other existing cultural traits have shown that cultural
118 accumulation can benefit from lower levels of connectedness (Derex & Boyd, 2016). This is
119 because high levels of connectedness make individuals more likely to converge on similar
120 solutions, which results in lower levels of cultural diversity and slower rates of innovation
121 compared with less connected groups. When the risk of cultural loss is considered, simulation
122 models show that optimal rates of accumulation are reached for intermediate levels of
123 connectedness (Derex et al., 2018). This is because low levels of connectedness increase the
124 risk of cultural loss by decreasing access to demonstrators, while high levels of
125 connectedness reduce opportunities to innovate by homogenizing cultural behaviors. At

126 intermediate levels of connectedness, groups can accumulate cultural information while
127 remaining culturally distinct, which keeps fueling innovation (Derex & Mesoudi, 2020).

128

129 ***The relationship between knowledge and skill in technology***

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

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

143 This is not a dichotomy: in the vast majority of cases both skill/action and
144 knowledge/mental state are at work (you need to *know* how to make a French knot, and
145 holding a map involves *actions*). The interaction between knowledge and action has long been
146 stressed by archaeologists who clearly recognize that both contribute to activities such as
147 toolmaking (Pargeter et al., 2020). Improvements in skill require increased precision of
148 selected actions which leads to higher replicability in achieving a desired goal (Crown, 2001;
149 Stanley & Krakauer, 2013). Individuals, then, may be poorly skilled because they perform

150 appropriate actions with poor precision or because they perform inappropriate actions.
151 Becoming a skilled hunter, for instance, requires more than developing fine motor-control and
152 depends on knowing facts about the local environment and animal behaviour. Kawabe
153 (1983), for instance, has shown that among the Gidra from southwest Papua New Guinea,
154 adolescents vary in hunting success rate because of difference in environmental knowledge.
155 Nonetheless, certain tasks may rely on skills more so than knowledge and so are better
156 characterized as tasks of skill or knowledge.

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

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

172 Despite this, skills are critical to the ecological success of the human species.
173 Compared to chimpanzees that obtain 95% of their calories from foods that they gather by

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

188

189 ***Cultural evolution typically studies knowledge and not skill***

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

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

198 focusses extensively on knowledge transmission, leaving relatively little known about the
199 transmission of skill.

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

220 Similar arguments could be made about most experimental tasks that are commonly
221 used in the cultural evolution literature. Making paper airplanes so that they fly as far as

222 possible or building towers so that they are as tall as possible involve relatively straightforward
223 actions in which individuals are already competent prior to the experiment (such as folding a
224 piece of paper; Caldwell & Millen, 2008). Therefore, cultural transmission in those studies
225 likely concerned knowledge and not skill. The unintended focus on knowledge that we aim to
226 highlight in this chapter is not limited to experimental studies. For instance, one of the rare
227 field studies looking at the interaction between social structure and cultural transmission
228 among traditional populations focused exclusively on the transmission of knowledge (Salali et
229 al., 2016).

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

238

239 ***The cultural evolutionary dynamics of skill likely differ from those of knowledge***

240 The broad focus of the cultural evolutionary literature on knowledge is only problematic to the
241 extent that knowledge does not capture the full spectrum of cultural evolution. Whether skills
242 have different cultural evolutionary dynamics to knowledge is an empirical question that
243 remains to be addressed.

244 Some findings from the cultural evolutionary literature are likely to be valid regardless
245 of the cultural content involved. For instance, consider the influential finding of theoretical

246 models that population size and connectedness critically affect the transmission and
247 maintenance of cultural traits by buffering the risk of cultural loss (Henrich, 2004; Powell et
248 al., 2009; Creanza et al., 2017; Derex & Boyd, 2016). Although experiments supporting the
249 role of population size on the proper transmission of cultural information have mostly involved
250 the cultural transmission of knowledge (Derex et al., 2013; Kempe & Mesoudi, 2014;
251 Muthukrishna et al., 2014), we should expect to observe similar effects when skills are
252 involved. Indeed, both knowledge and skills are at risk of cultural loss due to our limited
253 learning abilities, and, while the magnitude of the risk may differ, it is plausible that fewer
254 learners will increase the risk of losing cultural information in both cases. Nonetheless, there
255 are multiple reasons to suppose that the cultural evolutionary dynamics of skill might differ
256 from that of knowledge and we shall describe a few examples here.

257

258 *The role of language*

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

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

277

278 *Costs of transmission*

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

289 Another difference between skills and knowledge is that skills require extensive
290 practice. To some extent, practice is likely to benefit the transmission of knowledge as well.
291 For instance, in a knowledge-based experiment in which learners received lengthy cultural
292 demonstration on how to build a virtual fishing net by selecting different materials and

293 pointing and clicking on a grid to arrange the materials, 100% of fishing-net builders failed at
294 the first trial (Derex et al., 2013). This illustrates the importance of multiple demonstrations
295 and multiple attempts in the proper acquisition of knowledge (see also Flynn & Whiten, 2010).
296 Yet, ethnographic and experimental evidence indicate that skills are acquired through long
297 apprenticeships during which motor control is progressively developed (Kaplan & Robson,
298 2002; Pargeter et al., 2020). As noted above, knappers continue to improve in their fine
299 control over flaking outcomes over the course of decades. Similar learning curves are seen in
300 bows and atlatls (Whittaker, 2013). The role of practice in the acquisition of skills is also
301 exemplified by return rates of ache hunters who become proficient years after reaching their
302 peak strength (Walker et al., 2002). Moreover, experimental archeology studies have showed
303 that learners' inability to produce stone tools is largely accounted for by a failure to properly
304 execute intended actions rather than a failure to conceptualize appropriate goals (Pargeter et
305 al., 2020). A consequence of this is that skills may take much longer to successfully transmit,
306 while knowledge, although not instantaneous by any means, will often be faster to transmit.

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

316

317 *Transmission pathways*

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

337 The fact that skills tend to be passed on vertically does not mean they are exclusively
338 transmitted in this way. For instance, ethnographic studies have showed that hunting skills
339 are sometimes taught by uncles, grandfathers and other elders (Puri, 2006; Wallace &
340 Hoebel, 1986). In some cases, like among Ethiopian Chabu, adolescents even choose their

341 teachers, preferring to go on hunts with knowledgeable individuals (Dora & Hewlett, 2016).
342 Yet, for teaching toward non kin to occur it must be supported by informal or formal institutions
343 that compensate teacher for their efforts. For instance, cultural evolution scholars have
344 argued that learners use deference to buy access to skilled models (Henrich & Gil-White,
345 2001).

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

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

369

370 *Resulting evolutionary dynamics*

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

383 Second, skills may evolve more slowly than knowledge. There are two reasons to
384 suppose this might be the case: (1) as already discussed there are reasons to suppose that
385 skills transmission is a slower process than knowledge transmission, if true, and assuming
386 that both transmit with similar fidelity, then skill evolution will also be slower than knowledge
387 evolution, and (2) the evidence reviewed above suggests that complex skills (due to the cost
388 of their transmission) are disproportionately transmitted vertically. Such a process will slow

389 the spread of innovations within and between populations, and cause cultural evolution to
390 approximate genetic evolution which is slower than cultural change (Perreault, 2012). Boudot
391 and Buckley (2017), for instance, reported that loom designs and weaving techniques (that
392 are mostly transmitted from mother to daughter through a lengthy apprenticeship) exhibit low
393 rates of innovation. An additional reason why skills might evolve slowly is that teachers are
394 often concerned with detecting and correcting errors in learners' techniques. These
395 corrections, however, not only concern actual errors but also deviation from the traditional
396 way of performing the technique (Buckley & Boudot, 2017). This is likely to increase the fidelity
397 of transmission between generations but will ultimately reduce opportunities for innovation.

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

409 Apprenticeships may also help diffuse skills beyond single families. Economists, for
410 instance, have argued that because semi-formal and formal apprenticeship are independent
411 from family ties, they allow learners to acquire skills from larger populations (de la Croix et al.,
412 2017). For instance, they have argued that, compared to China where training was provided

413 by family members, preindustrial Western Europe had a formal system of apprenticeship
414 organized by guilds that were better at disseminate techniques and innovations. One
415 interesting feature of guilds is that they introduced journeymanship (Lis et al., 1994).
416 Journeymen were considered competent craftsmen and were authorized to work in the field
417 they have been trained at but could not yet work as self-employed master craftsmen. Rather
418 they had travel to another city to acquire additional skills, which exposed them to a broader
419 range of skills and fostered the spread of new techniques. (De la Croix et al., 2017 have
420 compared their status to postdoctoral researchers in scientific fields). It is likely that regions
421 that relied on institutions such as extended families and clans may have experienced lower
422 rates of innovations than regions where learners could sample from larger pools of skilled
423 teachers.

424

425 ***Conclusion***

426 Human adaptation relies on the cultural accumulation of both skills and knowledge.
427 Theoretical and empirical work indicate that our ability to transmit cultural information results
428 from a combination of factors that operate at the individual and population levels. In this
429 chapter, we briefly reviewed these factors and have argued that most cultural evolutionary
430 work has studied the transmission of knowledge. Yet, humans extract resources and exploit
431 technologies that require high level of skill. As we have argued, skills and knowledge differ
432 along many dimensions, and we should be be cautious not to assume that findings about the
433 transmission of knowledge necessarily generalize to skills. Compared to knowledge, the
434 transmission of skills might occur via different learning mechanisms, over longer periods of
435 time and might involve different transmission pathways. Understanding how cultural
436 transmission differ between skills and knowledge is critical for debates about the relationship

437 between of humans' unique social structure and the transmission and accumulation of
438 cultural innovations. Indeed, it has been argued that humans live in large networks of
439 unrelated individuals that might be conducive to the spread and accumulation of cultural
440 information (Hill et al., 2014). Yet, actual measurements of cultural transmission in natural
441 populations remain scarce and little is still known about how skills, in particular complex ones,
442 spread in natural populations. Due to the features of skills, it seems unreasonable to assume
443 that large social networks will automatically result in large skill transmission networks.
444 Additional mechanisms such as semi-formal and formal institutions have probably been key
445 to promote the dissemination and accumulation of skills. A more detailed understanding of
446 the cultural transmission of skills, alongside and in interaction with knowledge, will provide a
447 more general basis for understanding cultural evolution and human adaptation.

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