



Original Article

How does competition affect the transmission of information? ☆

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ABSTRACT

The use of social information is a prerequisite to the evolution of culture. In humans, social learning allows individuals to aggregate adaptive information and increase the complexity of technology at a level unparalleled in the animal kingdom. However, the potential to use social information is related to the availability of this type of information. Although most cultural evolution experiments assume that social learners are free to use social information, there are many examples of information withholding, particularly in ethnographic studies. In this experiment, we used a computer-based cultural game in which players were faced with a complex task and had the possibility to trade a specific part of their knowledge within their groups. The dynamics of information transmission were studied when competition was within- or exclusively between-groups. Our results show that between-group competition improved the transmission of information, increasing the amount and the quality of information. Further, informational access costs did not prevent social learners from performing better than individual learners, even when between-group competition was absent. Interestingly, between-group competition did not entirely eliminate access costs and did not improve the performance of players as compared with within-group competition. These results suggest that the field of cultural evolution would benefit from a better understanding of the factors that underlie the production and the sharing of information.

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1. Introduction

The ability to gather and use information provided by the behaviors of others, namely social learning, is a prerequisite for the evolution of culture. From an evolutionary perspective, the use of social information is commonly considered to be profitable because it allows the avoidance of the costs of trial-and-error-learning in terms of the effort and risks (Boyd & Richerson, 1985). Experimental studies have shown that humans use social information in many manners and under various conditions (Mesoudi, 2011; Morgan, Rendell, Ehn, Hoppitt, & Laland, 2012). The particularly developed human capacity to learn socially allows information to flow between individuals, which results in an accumulation of adaptive information. Consequently, humans possess a complex technology that no individual could possibly invent alone (Boyd & Richerson, 2005).

However, the possibility to use social information is closely related to its availability. From the perspective of the copied individuals (designated as models), social learners are parasites because they exploit information without contributing new information themselves (Kameda & Nakanishi, 2002; Laland, 2004; Rogers, 1988). Thus,

models are most likely reluctant to share information unless they have an incentive to share. One may object that many behaviors can be copied by simple visual contact without implying close proximity to the models. However, even in relatively simple material cultures, such as those of hunter-gatherers, the processes or skills that allow the construction of an item are generally not readily deduced from the object itself (Ohmagari & Berkes, 1997). In this case, the opacity of the objects prevents social learners from constructing an equally efficient copy using simple visual contact (Acerbi, Tennie, & Nunn, 2010; Derex, Godelle, & Raymond, 2013).

There are many ethnographic examples of information withholding, oriented sharing or secrecy for all types of information. For instance, among the adze makers in the village of Langda in Indonesian Irian Jaya, the craftsmen report that they instruct only close relatives because of the great value of the skill (Stout, 2002). Additionally, among the Asabano from Papua New Guinea, older men enjoy the status associated with religious knowledge and control its oral dissemination (Lohmann, 2001). More generally, ethnographic studies suggest that information is commonly treated as a good, which is traded between models and learners, with low-status individuals giving gifts or deference to high-status individuals in exchange for their expert knowledge (Henrich & Gil-White, 2001).

The wide majority of cultural evolution studies assume that cultural learners are free to use social information (Caldwell & Millen, 2008; Kameda & Nakanishi, 2002; Kameda & Nakanishi, 2003; Kempe, Lycett, & Mesoudi, 2012; Mesoudi, 2011). However, a more

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realistic setting would be to allow models to impose costs in exchange for information. Only one study has looked at the consequence of allowing informational access cost (Mesoudi, 2008). In this experiment, players had to virtually design an arrowhead by the modification of 5 attributes and were allowed to set access costs that other participants had to pay them in order to view their arrowhead design. Under this setting, successful players tend to offer their information only for a high price, thus preventing other group members from socially collecting useful information (Mesoudi, 2008). A consequence of this restricted information access is to prevent the transmission of the adaptive information necessary for the evolution of cumulative culture and make social learners unable to invade the population.

It has been suggested that the uniquely human form of cooperation has played a fundamental role in human cultural evolution (Tennie, Call, & Tomasello, 2009). Humans cooperate in large groups with non-kin, even strangers, and this characteristic may substantially increase the number of transmission events among individuals. However, cooperation is not operating in every case, even if two individuals have potentially mutual benefits (e.g., by trading knowledge versus a gift). In humans, it has been shown, analytically and experimentally, that cooperation is affected by the scale of competition (West et al., 2006). Indeed, with local competition, fitness is relative to social partners, and cooperation benefits social partners. Thus, in Mesoudi's experiment (Mesoudi, 2008), most likely players had no incentive to share their information as they were in direct competition with their group members. In contrast, between-group competition favors individually costly, group-beneficial behaviors, such as cooperation and altruism (Bowles, 2006; Boyd, Gintis, Bowles, & Richerson, 2003; Darwin, 1871; Frank, 2003; Roes & Raymond, 2003). Indeed, in this case, specific conditions unite the interest of individuals and make the group more cohesive. For example, in the extreme case in which individuals cannot compete against other group members, each individual can increase its own success only by increasing the efficiency and productivity of the entire group.

The individual's possibility of conserving an advantage following the transmission of information could also improve the transmission of information. In Mesoudi's experiment, successful players had no choice to deliver partial or old information (Mesoudi, 2008): following the sharing of information, the model and the learner possess the same information, so that the model's advantage is reduced to the price of the transaction. Further, information holders (the model plus the learner) will be in competition to trade the same information, thereby reducing the value of information. Under this setting, successful individuals most likely had no incentive to share their information. However, opacity of material culture could allow more complex sharing strategies: as opacity of cultural artifacts prevents social learners from constructing an equally efficient copy using visual contact, successful individuals could trade their products, keeping the process (allowing to produce products) for themselves. More generally, individuals' strategies can be more complex than choosing between sharing and not sharing: due to the nature of cultural information, models could exhibit many subtle strategies such as delayed or partial transmission. With the possibility to withhold some information, models could share information with learners (with mutual benefits) without endangering themselves.

The aims of this study were (1) to investigate how between-group competition affects the transmission of information, (2) to examine if social learners with access costs outperform individual learners only when the competition is between groups. A complex virtual task was proposed to players with the possibility of trading their information within their group. Two treatments were considered, in which competition was either within or between groups. In all cases, players had the possibility of trading specific portions of their knowledge.

2. Methods

2.1. Participants

A total of 120 participants (64 women) were randomly selected from a database managed by the Laboratory of Experimental Economics of Montpellier (LEEM) and were recruited by email from various universities in Montpellier (Southern France). The subjects ranged from 18 to 36 years old (mean = 23 years, s.d. = 3.0). Each participant was randomly assigned to one of the two conditions of the experiment. The participants received travel fees according to the LEEM operating rule (2 € for local students, 6 € for others).

2.2. Procedure

The experiment occurred in a computer room at the LEEM. For one session, 20 players sat at a physically separated and networked computer and were randomly assigned to one group (5 players per group, 4 groups per session). The participants could not see one another and were blind regarding the purpose of the experiment and who belonged to their group. The players were instructed that communication was not allowed. The participants could read instructions on their screen regarding the rewards and goals of the game and were requested to enter their sex and birth date before the beginning of the game. The specified aim of the game depended on which of the treatments was tested (within-group competition or between-group competition, see 2.4. *Treatments*).

2.3. Game

2.3.1. Principle

The participants played a computer game (programmed in Object Pascal with Delphi 6) during which they had to achieve a complex virtual task. The aim was to construct a virtual fishing net to capture fish during virtual fishing trials. The number of fish captured and weighed by size defined the score for each trial. The players had 15 trials to improve their cumulative score. Each period of construction was followed by a transaction period, in which the content varied according to each treatment (see below). The final score of the player was their cumulative score across 15 trials plus the balance (positive or negative) associated with the purchases and sales performed by the player.

2.3.2. Construction period

During the construction period (limited to 180 s), the participants had access to several virtual tools. First, they had to choose a squared grid on which to build the net using two parameters: the number of attaching points (from 3×3 to 7×7) and the spacing between the attaching points (see (Derex et al., 2013) for complete details). Once the frame was chosen, the players had access to different types of ropes and knots. A rope could be set between any pair of attaching points, and a knot could be tied to any attaching point, in any order. There were three different types of ropes available (thick/red, medium/blue and thin/green), and three different types of knot.

During each of the fifteen trials, the players could construct a new fishing net; in this case, the manufactured product and associated process were added to his toolbox. After the first trial, the individuals could view the net that they had previously constructed and its associated score and could also review the process in detail. Subsequently, the participants had the option to construct a new net, reuse a net from their toolbox or rebuild a net according to a previously developed process.

2.3.3. Construction rules

The participants were unaware of the links between the construction parameters of a net and the expected score; however,

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