An investigation into the social learning of cooperation in children: individual, social, and cultural comparisons

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Abstract

Humans' unique cooperative and social learning skills have contributed to the evolution of human cumulative culture, fostering the creation and transmission of knowledge and the formation of social institutions. This thesis aimed to understand how children learn from others to collaborate in coordinated interactions with different roles and outcomes, and the influence of cultural, social, and individual factors on children's cooperative behaviour. It is organised in four experimental studies. The first study investigated how different collaborative actions are copied and transmitted between three- and four-year-old children. The second study investigated the adoption of different types of social information by six- and seven-year-old children in a collective social dilemma. The third study investigated the effects of age (four- and five-year-olds versus eight- and nine-year-olds), gender, social class and culture (Brazil versus England) on the cooperation and sharing of resources between children, in a task with unequal outcomes. The fourth study investigated whether the mothers' social preferences and the children's individual characteristics affect the cooperation and sharing of resources among children in the same task from the previous study. These studies yielded important findings regarding the diverse effects of contextual factors on the development of children's collaborative skills. It has been shown that young children can copy peers by observing them in collaborative tasks, and are willing to collaborate with each other across different situations. However, when the tasks present potential conflicts of interest, children will rely on contextual cues to decide whether cooperate or not between themselves. Finally, older children showed better skills

towards negotiation and coordination involving sharing of resources, across different sociocultural groups. This thesis contribute to the discussion of the role of contextual variables on the development and learning of cooperative behaviours from an evolutionary perspective.

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Declaration

All data and other material have not previously been submitted by me for a degree in this or in any other institution. The study reported in Chapter IV was a product of joint work with two collaborators from Brazil. The theory, experimental design and analyses were all proposed and performed by me; Natalia A. C. Boccardi helped with data collection and contributed to the paper. Maria Emilia Yamamoto contributed to the paper and helped fund part of the research. Any references to or use of the work of others has been acknowledged.

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Chapter I

General Introduction

The two overarching questions within this thesis ask whether, and, if so, how children learn to cooperate with peers. Thus, this thesis primarily addresses these questions by examining the development of cooperative strategies across the early and middle childhood. The development of cooperation has been explored across a variety of fields (e.g. developmental psychology: Eisenberg, Fabes, & Spinrad, 2006; cognitive psychology: Piaget, 1932; cross-cultural psychology: Rogoff, 2003; Tudge & Rogoff, 1989; educational psychology: Slavin et al., 1985; comparative psychology: Tomasello, 2018). By taking a developmental perspective, I attempt to understand how children adopt cooperative actions to solve problems that require coordination and negotiation of interests, and as a result learn from each other how to solve these problems.

Cooperation makes human societies work, and ultimately is considered one of the core features by which humans succeeded in habiting regions across the Earth (Burkart et al., 2014; Tomasello, Melis, Tennie, Wyman, & Herrmann, 2012). It is linked to the origins of social norms, institutions, and cultural practices, such as education, technology and science (Chudek & Henrich, 2011); and it is also considered by some authors as the basis for human morality (Tomasello & Vaish, 2013; Turiel, 2006). Cooperation is a blanket term that refers to a variety of phenomena, and it has many synonyms such as: prosociality, altruism, helping, sharing, bargaining, coordination, mutualism, reciprocity, inequity aversion, fairness, justice, and morality. Therefore, it is necessary to clarify the definition of different forms of cooperation across the studies presented in this thesis.

Defining Cooperation

Cooperation is often used interchangeably with terms such as altruism and prosociality in both developmental (Eisenberg et al., 2006) and evolutionary theories (Nowak, 2006). However, altruism usually refers to costly behaviour intended to benefit others (Boyd & Richerson, 2009), while cooperation may refer to acts (costly or not) of an individual or a group of individuals that benefit other people, as well as joint actions performed by partners (Tomasello, Carpenter, Call, Behne, & Moll, 2005). In addition, prosociality refers to any behaviour intended to benefit others, thus including both altruism and cooperation (Eisenberg et al., 2006). Therefore, the adoption of prosociality, cooperation and altruism as interchangeable terms might be confusing because in many situations it is either clear that both the actor and the recipient benefit from the interactions, or it is difficult to assess whether the actor's benefits are only delayed.

In this thesis, cooperation is defined as either joint and mutually beneficial actions, or costly decisions to benefit others. Hence, two types of cooperative interactions were considered. The first type is *collaboration*, which is defined as mutual interactions between two or more partners that require the collaborators to establish common goals and coordinate their actions (Tomasello et al., 2005) and is synonymous to mutualism and coordination in the acquisition of resources. The second type is *sharing*, which refers to any situation where an individual who is in possession of resource must decide to give part of these resources to other people (Wu & Su, 2014), and its definition is drawn from the literature on distributive justice, sense of fairness, and inequity aversion (McAuliffe, Blake, Steinbeis, & Warneken, 2017). Both concepts are discussed in more detail in chapters II and V. The next section gives

an overview of the contextual variables that were investigated across the studies presented in this thesis.

The role of context on children's collaborative decisions

Recent findings on young children's early cooperative skills have supported the argument that humans have a universal propensity to help, cooperate and share with others (Tomasello & Vaish, 2013; Warneken, 2018). In addition, children grow up in groups that share similar cultural practices, and acquire information from their interaction with others, through various processes, such as tutoring, observation, collaboration and conflict (Flynn & Whiten, 2012). Furthermore, humans' unique social learning and cooperation skills have contributed to the development of human culture as a cumulative phenomenon, fostering the construction and transmission of knowledge and the formation of social institutions (Boyd & Richerson, 2009; Tomasello et al., 2005). However, it remains unclear how this natural propensity to cooperate interacts with social learning processes, and further studies are necessary to understand the effects of contextual factors on children's learning of cooperative behaviour.

Evolutionary and developmental theories are often concerned with the emergence of general patterns of behaviour, that can be observed across a variety of social groups and cultures. This focus has been criticised both in developmental (Nielsen, Haun, Kärtner, & Legare, 2017) and cultural psychology (Kline, Shamsudheen, & Broesch, 2018), for two reasons. First, these theories are often drawn from limited samples, mostly children and families from middle and upper middle classes, from United States, Canada and European countries, hence obscuring which characteristics are universally similar or subjected to local

variations. Second, human cooperative skills might have evolved in response to changing physical environments and increasingly demanding social contexts (Richerson, Boyd, & Henrich, 2003), therefore leading to the evolution of flexible behaviour, which are quickly adaptable to local influences. Thus, the development of cooperative behaviours should be investigated in relation to environmental (i.e. contextual) influences, in tandem with the investigation of more general patterns across different social and cultural groups.

Although cooperation can be defined as the joint action of two or more individuals to achieve a common goal, it can be also seen as a type of strategy to obtain resources at one end of a continuum with competition at the opposite end (Green & Rechis, 2006). Individuals in interaction adopt strategies according to a number of factors, such as the requirements of the situation, the relationship between the participants, individual goals or interests, and the sociocultural background (Green & Rechis, 2006; House et al., 2013). In social activities, the partners' interests can be aligned or not, which means that the partners in a joint activity can achieve their goals at the same time or not. Cooperation is fairly simple when the partners' goals are aligned, because cheating is unlikely to happen in this scenario. However, when the partners' goals are not aligned, cooperation is riskier, since there is a chance that the partner will defect after being rewarded.

Regarding the management of partner's interests, evidence points towards an early understanding of commitment to joint actions in humans and a sensitivity to proportional sharing after collaboration (Hamann, Warneken, Greenberg, & Tomasello, 2011; Warneken, Lohse, Melis, & Tomasello, 2011). Three-year-old children help partners or share their rewards with them more often when they are committed to a joint activity. For instance, Warneken et al. (2011) investigated young children's sharing after collaboration and they have

showed that children share even when the rewards are clumped together and can be monopolized by one of the partners. In Hamann et al., (2011), children had to work together in pairs to retrieve individual rewards; however, the experiment was set up to make one of the children always receive their reward first than the other. It was found that three-year-old children kept collaborating until their partners achieved their rewards, which means that children understand their commitment to a joint task and are not only using the other as a "social tool". These and other findings were interpreted as evidence for the early emergence of children's comprehension of the normative dimensions of collaborative tasks, which is in part responsible for humans' success in cooperating and sharing resources.

The transmission and enforcement of social norms within groups regulate and promote cooperative behaviours, especially when there is potential conflict of interests, and these norms may differ from one culture to another (Guzmán, Rodríguez-Sickert, & Rowthorn, 2007; Henrich, 2004). Thus, there might be differences in cooperative and competitive behaviour of children across cultures, especially during middle childhood (Carlo, Koller, Eisenberg, Da Silva, & Frohlich, 1996; Carlo, Roesch, Knight, & Koller, 2001; Haidt, Koller, & Dias, 1993; House et al., 2013; Kagan & Madsen, 1972; Knight & Kagan, 1981; Madsen, 1967, 1971). For instance, children from more collectivistic cultures, such as those from Mexico and China, are predicted to be more cooperative than children from more individualistic cultures, such as those from United States. Furthermore, there is an indication that observed differences in children's behaviour are not limited to the differences between urban and rural settings (House, 2017).

According to Hofstede, Hofstede, & Minkov (2010), culture is the set of thoughts and collective practices that differentiate one group from the other and affect the meaning people

attach to different aspects of their lives, and that are reflected in the institutions of society. These authors proposed six cultural dimensions that characterize different societies: power distance, individualism, masculinity, uncertainty avoidance, pragmatism and indulgence. Although similar in dimensions of masculinity, pragmatism and indulgence, Brazil and England differ from each other in the dimensions of power distance, individualism and uncertainty avoidance. Brazil has higher scores on power distance and uncertainty avoidance; hence, Brazilians tend to respect social hierarchies, to accept social inequality and to value signals of status and power. Conversely, the country has lower individualism scores; people are integrated early to strongly cohesive groups, whether in family or in the workplace, and they tend to build strong bonds of loyalty and exchange of favours. Britain has the opposite scores to each of these dimensions, indicating that it is a more individualistic society, focusing on individual independence and pursuit of personal goals, but also flexible for the future and with few but effective laws. Such dimensions may significantly affect how people cooperate and follow rules in these societies (Gächter & Herrmann, 2009). Therefore, cooperative behaviour has been predicted to differ between children from these two cultures.

In addition to culture, this thesis investigated the effects of two other variables: the families' socio-economic status, and the social preferences of children's mothers in social dilemmas. Regarding the participants' socio-economic status, the information was collected across all studies, and tested in three of them (Chapters IV, VI, and VII). The first reason to collect this information was to characterise the sample's demographics. The second reason was to test for possible interaction between the effects of socio-economic status and culture. In this thesis, socio-economic status was assessed in two ways: indirectly, by sampling children from different types of schools; and more directly, by asking the children's mothers

to fill questionnaires about their socio-economic status. These methods are described in more detail within the empirical chapters (more specifically, Chapters IV and VI).

The social preferences of the children's mothers were assessed in both countries, across three hypothetical social dilemmas, which are experimental economic games that simulate real potential conflicts of interest in the distribution of resources. The evidence on the relationship between parents' and their children's prosocial behaviour is mixed (Bauer, Chytilová, & Pertold-Gebicka, 2013; Bryan & London, 1970; Bryant & Crockenberg, 1980; Carlo, Koller, Raffaelli, & Guzman, 2007; Evans, 2004; Hoffman, 1975; NICHD Early Child Care Research Network, 2003), in part because it is difficult to parse out the multiple factors that can explain this relationship, such as genetic factors, educational level, environmental scarcity, among others (Bugental & Grusec, 2007; Eisenberg et al., 2006; Pepper & Nettle, 2017). This work attempted to indirectly assess the relationship between mothers' propensity to adopt cooperative behaviours and their children's collaborative actions towards peers. Contributions and limitations of this method are discussed in more detail in Chapter VI.

Other variables that can moderate the development of cooperative strategies are individual characteristics, such as temperament and social skills. Individuals vary from an early age across the dimensions of those characteristics (Rothbart, 2007), which are considered predictive of children's performance in cooperative interactions (Eisenberg, Van Schyndel, & Spinrad, 2016; Endedijk, Cillessen, Cox, Bekkering, & Hunnius, 2015). However, most of the evidence on the relationship between these characteristics and children's prosocial behaviour in general were built upon reported measures or observations of children's free play (Endedjik et al, 2015). Experimental research that has investigated the relation between children's disposition towards cooperation in interactive settings, based on

their temperament and social skills, are rare. Thus, it is relevant to consider the relations between culture (between-group variable) and individual factors (within-group variables), which is rarely done in cross-cultural studies (Carlo et al., 2001). Given the influence of the contextual variables illustrated above, this thesis sought to understand how cultural and social factors mediated children's decisions in collaborative interactions.

Summary of Experiments

Three experimental approaches were chosen to study the mechanisms of cultural transmission of cooperative interactions in children. The first approach was adopted to test children's sensitivity to other peers as models and the impact of different collaborative contexts on cultural transmission of cooperation between peers (Chapter III). It is a recent empirical paradigm called diffusion or cultural transmission studies, which has contributed to a better understanding of social learning by investigating behaviour spread across groups (Flynn & Whiten, 2008, 2012; Hopper, Flynn, Wood, & Whiten, 2010; Horner, Whiten, Flynn, & Waal, 2006; Mesoudi, 2007; Wood, Kendal, & Flynn, 2012). These studies can take many forms; for the study presented in Chapter III, the diffusion chains paradigm was chosen, which examine spread of behaviour (or not) along a linear chain of children, A to B to C to D, etc. Children spend many hours in the company of their peers, and learn a great deal from those interactions. A task that explicitly requires collaboration can help us to understand better the processes of social learning among peers and the development of cooperation and cultural transmission in humans.

The second approach involved the application of an economic game to the investigation of how children choose social information from their peers (Chapter IV).

Economic games simulate social dilemmas, situations where two or more players interact and have to make decisions that may end up in a conflict of interests. Hence, one can apply an economic game as a method to measure cooperative interactions where people are tempted to cheat and to increase their rewards at the expense of others. The public goods game is particularly useful since it involves coordination between players and the dilemma between cooperating to maximise the gains of the group versus not cooperating and maximising the individual gain (Kollock, 1998). This design makes it possible to investigate both collaboration and sharing in a context where rewards are contingent on people's decisions. Economic games have been applied successfully with children to the study of development of cooperation, trust, fairness and moral behaviour (Gummerum, Hanoch, & Keller, 2008). However, to my knowledge, the use of these models to study cultural transmission processes among children has never been undertaken. In Chapter IV, children had to decide whether to copy or not social information from peers in a game that entails conflicts of interest.

The third approach aimed to understand the effect of a number of factors on children's cooperation and sharing, in a collaborative task with unequal outcomes (Chapters VI and VII). It has focused on the influence of culture, age, and social class and the interaction of these variables with children's temperament and social skills, and their mothers' social preferences regarding sharing of resources. In support for this approach, the literature on children's sharing decisions in collaborative contexts is reviewed in Chapter V, with focus on the effects of contextual variables on those decisions.

Structure of the Thesis

The main purposes of this thesis are to investigate whether children copy collaborative actions and transmit between them in different conditions, and how children from different sociocultural groups cooperate and share when their goals are not aligned. To accomplish these goals, this thesis presents a critical overview of the state of art in experimental approaches to the development of collaboration and sharing. It also proposes, across four studies, a combined approach involving a variety of methods, to address specific gaps identified in the literature. More specifically, this work attempts to integrate evolutionary, developmental and experimental paradigms to explain the influence of contextual variables on children's collaboration and sharing decisions.

This thesis is organised into two reviews (Chapters II, and V) and four empirical studies (Chapters III, IV, VI, and VII), which are summarised below. Chapter II provides a review of the theory and evidence on cultural transmission of collaboration between children. It shows that direct tests of mechanisms related to this phenomenon are rare, although evidence from naturalistic and experimental studies in developmental and educational psychology indicate that early skills probably support the cultural transmission of collaborative actions between children. Chapter III introduces a study that investigated how different collaborative actions are copied and transmitted between young children (three- and four-year-olds). In Chapter IV, a second study is described, which investigated the adoption of different types of social information in a public goods game by six- and seven-year-old children. Chapter V presents a review of the contextual variables that moderate the relationship between collaboration and sharing in children across early and middle childhood. In Chapters VI and VII, two related studies are described, which investigated how cultural,

social and individual factors affect children's cooperative and sharing behaviour in a situation where the resources cannot easily be divided into equal parts. The goal of the study presented in Chapter VI was to investigate the effects of age (four- and five-year-olds versus eight- and nine-year-olds), social class and culture (Brazil versus England) on cooperation and sharing of resources among children in a task with unequal rewards. In Chapter VII, I investigated whether mothers' social preferences and children's individual characteristics affect children's cooperative and sharing behaviour in the same task, and whether and how these factors interact with culture and social class. The thesis is concluded with a general discussion in Chapter VIII, discussing the theoretical and methodological contributions of the four studies and the two reviews introduced above.

This thesis contributes to the current developmental theories of human cooperation and increasing evidence on the early emergence of children's collaborative skills. It addresses a number of gaps identified in the literature regarding the effect of contextual variables (characteristics of the task, number of resources available, conflict of interests, social and cultural environments, social interaction, and individual characteristics). Therefore, it provides a better understanding of the role of interaction (mutual influence) in the cultural transmission and maintenance of cooperation between children, and whether the quality of the interaction is moderated by contextual and individual factors, with partners of similar level of skill.

Chapter II

Investigating the cultural transmission of collaboration between children

This chapter focuses on reviewing the experimental literature on how children learn to collaborate with peers, and proposing new approaches to investigate questions related to this type of learning. This chapter will not be submitted for publication.

Introduction

Humans are adapted to live in unique collaborative cultural environments (Rogoff, 2003; Tennie, Call, & Tomasello, 2009). The ability and motivation of humans for cooperation with others is one of the factors that makes human culture possible, and allow humans to possess unique skills for cultural creation and transmission (Tomasello, 1999, 2009). Conversely, once the ability of humans to create and enforce cultural institutions has evolved, it also has reinforced humans' original propensity to cooperate, thus boosting the evolution of human cooperation (Richerson et al., 2003). Therefore, the evolution of cooperation is strongly connected to the evolution of human culture, making both unique when compared to other species (Burkart et al., 2014).

The relationship between human cooperation and culture can be seen across human development (Chudek & Henrich, 2011; Moll & Tomasello, 2007; Rogoff, 1990; Tomasello, 2009; Vygotsky, 1978). Although comparative psychology between children and other primates has allowed researchers to come to certain conclusions about the evolution of cooperation (Tomasello, 2018; Tomasello & Vaish, 2013), only recently evolutionary developmental studies have started to address the processes of cultural learning of collaboration between peers, beyond the level of dyadic interactions and across different social and cultural groups (Nielsen & Haun, 2016). This sort of investigation is difficult because it requires more intricate experimental designs, greater sample sizes, and more complex analyses involving the interaction between participants.

This review focuses on the acquisition of cooperative behaviours that involve coordination between peers. Particularly, it addresses how evolutionary theories of human culture and cooperation can inform the investigation of the development of collaborative

skills in children. It discusses the progress of experimental research on the development of peer collaboration from infancy until the middle childhood in the psychological literature, and it attempts to show that these experiments have failed to address hypotheses regarding cultural processes and cooperative skills because the paradigms adopted often do not take in account particularities of either phenomena. In addition, three experimental approaches to the study of cultural creation and transmission of cooperative behaviour between children will be presented and discussed: economic games, cultural transmission, and cross-cultural comparisons. Particularities and difficulties related to the application of these methods to reciprocal interactions among children will be addressed. Finally, I argue in favour of experimental paradigms with greater complexity to tackle hypotheses on the social learning of collaborative interactions between children.

How social learning and cultural transmission affect collaborative behaviour

Culture can be defined as information acquired by learning from other individuals, through mechanisms such as imitation or teaching, which is usually transmitted across generations and leads to different behavioural patterns among genetically similar groups (Danchin, Giraldeau, Valone, & Wagner, 2004; Richerson et al., 2003). That is, culture is anything that accounts for differences between groups of the same species that cannot be explained only by genetic variation, demography or the physical environment. According to this definition, a variety of animals have culture, such as many species of songbirds, cetaceans and non-human primates (Danchin et al., 2004). However, although relying on social mechanisms, this definition of culture does not necessarily require any cooperative skills. Moreover, although animal culture can change across generations (Tomasello, 1999), they do

not tend to accumulate modifications over time, as happens in human technology. In this sense, human culture is unique because of humans' abilities to accumulate information and transmit across generations and to create social norms and institutions through cooperation (Tomasello, 2009).

Based on the assumption that human culture is, in part, the product of collaborative efforts between members of social groups, theorists have addressed both cultural evolution and the evolution of cooperative behaviour as intertwined phenomenon. For instance, Richerson et al. (2003) argued that social institutions and social preferences evolved at the same time as human culture. Once culture turned into an evolutionary process, social institutions and preferences changed over time as products of cultural change. Tomasello and colleagues (Tomasello, 2009; Tomasello & Vaish, 2013) added that the evolution of human culture was only possible due to the evolution of social cognition that underlies humans' ability to cooperate and share resources with others. Thus, human children have special skills and motivations regarding collaboration with partners, which they call 'shared intentionality'. Human's unique cooperation skills led to the emergence of cumulative cultural evolution (Moll & Tomasello, 2007), while the ability of humans to create and enforce cultural institutions also reinforced humans propensity to cooperate, and may have contributed also to the evolution of human cooperation (Boyd & Richerson, 2009).

Cultural transmission is "the process of acquisition of behaviours, attitudes, or technologies through imprinting, conditioning, imitation, active teaching and learning, or combinations of these" (Cavalli-Sforza, Feldman, Chen, & Dornbusch, 1982, p. 19). Therefore, social learning processes are the mechanisms by which cultural transmission occurs. This transmission can occur either vertically (from parents to the offspring),

horizontally (among peers), or obliquely (from older generations to the younger ones without direct relatedness). Human cultural transmission relies on the combination of two mechanisms: faithful imitation and innovation (Tennie et al., 2009). Faithful imitation allows people to reproduce the exact actions a model performed to achieve some result, allowing the spread and maintenance of a cultural trait within a group. An innovation is a change introduced in the current behaviour, which, if successful, can replace the previous behaviour and, subsequently, spread across the group. This system allows cultural traits to accumulate modifications over time and across generations.

Cooperation in the context of cultural transmission is an important behaviour to make people conform and behave to favour their groups, therefore improving the mechanism of faithful transmission (Tennie et al., 2009). Cooperative norms are embedded in social institutions and preferences, which determine how somebody must behave. Both cultural practices and cooperative norms can be kept stable in human groups by forms of social control and mechanisms of social learning (Guzmán et al., 2007). For instance, social rules can be established and followed by means of communication, modelling and application of rewards and sanctions. Therefore, cooperative behaviours, once stabilised, can be transmitted more or less faithfully within and across generations. In addition, by means of cultural evolution, humans (even those in the same area) could have developed different cultural institutions and norms, evolving independently over time. This process led to variation in institutions across human cultures, with different societies having different social control strategies and different sets of beliefs, values, preferences, and practices, acquired through participation in the adoption of social norms and institutions (Nisbett, Peng, Choi, & Norenzayan, 2001; Richerson et al., 2003).

The development of reciprocal interactions among children

One of the ways children learn to collaborate with others must be through witnessing and taking part in reciprocal interactions often. These reciprocal interactions start between children and their caregivers (Trevarthen, 2011), and have an important role in the development of prosocial behaviours (Cortes Barragan & Dweck, 2014). Furthermore, interactions between children and their caregivers in family routines and rituals are mechanisms by which children acquire social norms from their group (Rossano, 2012). Given that parents and other adults are the primary source of socialization for children, the literature on social learning of cooperation tend to have adults as models (Eisenberg et al., 2006).

Typically, adults have more knowledge and power than children and organise activities in order to help children to perform tasks and learn progressively (Rogoff, 1998). However, Piaget (1932) argued that children's moral behaviour emerges from reciprocal interactions between peers. The reason for this would be that, by interacting with people of relatively equal status, children would be able to develop notions of equality and fairness. In addition to this, Vygotsky (1978) argued that cognitive skills in humans develop through interactions with more knowledgeable others (such as adults or older children), within specific social and cultural backgrounds; that is, these social and cultural factors shape the development of human social and cognitive skills (Rogoff, 1990). Children learn a great deal from coordinated activities with adults and older peers, but they also develop the necessary skills to create and maintain coordinated actions with others, such as games, conversations, problem solving and the resolution of conflicts early in their lives (Eckerman & Peterman, 2004).

Children are able to coordinate with a peer from the second year of age in simple tasks (Brownell & Carriger, 1990, 1991; Brownell, Ramani, & Zerwas, 2006), without any adult scaffolding. The sustained coordinated episodes that characterise children's cooperation in their third year develop from changes in perspective taking abilities that take place during the second year, when they learn to differentiate their own perspectives from that of others. Three-year-old children are able to coordinate and reverse complementary roles in more complex tasks, where both have specific roles at the task (e.g. one child pulls the handle while the other moves the lever; Ashley & Tomasello, 1998). They also start to appreciate the normative dimensions of collaborative problem-solving activities and commit with a partner even when they achieve their individual goal first (Hamann, Warneken, & Tomasello, 2012). In a broad sense, the development of cognitive skills that underlie the ability to coordinate actions with others is a cornerstone of children's socialization into their cultural groups. The creation and transmission of language or symbolic communication, technology, knowledge and institutions are possible because humans can coordinate their actions and understand each individual's role in social interactions (Tomasello et al., 2005).

In summary, children can learn by interacting with peers and the learning children undertake with peers is probably different from what they have with adults or more experienced partners (Piaget, 1932; Rogoff, 2003). Moreover, cooperation between peers can lead to the development of new interactions and the creation of new cultural practices (Behne et al., 2008; Tomasello, Kruger, & Ratner, 1993). However, outside specific literature restricted to educational contexts (e.g. collaborative learning: Slavin et al., 1985), the information on this ability is limited to the psychological mechanisms that underlie this assumption (Behne et al., 2008). In other words, there is not much experimental evidence on

how children create new cultural practices themselves, through collaboration. Nevertheless, ethnographic evidence points towards the existence and horizontal transmission of games between children from different age groups (Morin, 2015). Whether and how this transmission is independent from adult influence remains to be tested. Thus, a combination of imitation and collaborative tasks involving different motivations and instructions may help to understand how these factors facilitate or hinder the social learning of cooperation among children.

Despite the relationship between cooperation and culture in human development, experimental research supporting such claims does not focus on specific characteristics of cultural transmission and learning, including its accumulation over time and across generations. Although a few studies tapped into the subject, either by investigating different cultures or social learning in collaborative tasks (e.g. Ashley & Tomasello, 1998; Callaghan et al., 2011; Göckeritz, Schmidt, & Tomasello, 2014), to my knowledge there is no experimental research on how cultural transmission of collaborative actions occur from adults to children or between children themselves.

Learning to collaborate with peers: an overview of the experimental literature

Here, I present and discuss evidence regarding cooperation as specific types of social behaviour that require the interaction between two or more people; that is, mutual collaboration between partners (Richerson et al., 2003). The traditional literature on the social learning of collaboration developed two different, but complementary, approaches to the study of human reciprocal interactions: one focused on cognitive development and another focused on social and moral development. However, the effects of any social learning mechanisms

between peers was often limited to imitation and instruction. I present and discuss both approaches below.

Collaborative interactions between children have been addressed often in the context of cognitive skills, such as memorization, logic, mathematical and writing skills (for reviews: Rogoff, 1998, 2003; Tudge & Rogoff, 1989), often through the replication or adaption of Piaget's tasks. This literature provides evidence that observational learning and instruction improves young children's performance in these tasks when compared to discussion and conflict (Ashley & Tomasello, 1998; Azmitia, 1988; Azmitia & Perlmutter, 1989; Johnson-Pynn & Nisbet, 2002; Verba, 1998). For instance, Ashley and Tomasello (1998) aimed to understand the developmental origins of coordination and teaching in young children. They investigated whether children from two to four years of age would be able to learn complementary roles in a collaborative task, and teach a novice partner the same task. The youngest children had difficulty in performing the task, while the older children were progressively better at coordinating both roles. Moreover, only four-year-olds were able to teach the novice. However, the authors did not investigate how teaching could affect the children's ability to coordinate in the task.

Older children also benefit from collaboration with peers in different intellectual tasks developed in educational contexts (Gauvain, 2001), with some researchers developing methods to foster learning in schools by teaching collaborative techniques to children (Pepitone, 1985). Hence, there are many situations where children in pairs are able to solve new cognitive problems in better ways than children alone, whilst their individual performance also improves after the interaction (Pepitone, 1985; Rogoff, 1990; Tudge &

Rogoff, 1989). Nevertheless, research in collaborative learning involving children in preschool years is still rare (Milward & Sebanz, 2018; Ramani & Brownell, 2013).

The influence of social learning on children's collaboration has been also examined in research assessing the development of cooperation versus competitions among children (Cook & Stingle, 1974; Green & Rechis, 2006). The immense majority of this literature, however, looked into the effects of social cues and reward structure on the development of children's collaborative skills. Another segment focused on the effects of socialization by parents and school, and even led to the creation of educational programmes to improve children's social skills (Slavin et al., 1985). For example, Kagan & Madsen (1971) looked into the differences between cooperative and competitive behaviours of four- and five-year-olds in comparison to seven- and nine-year-olds, while under two different instructional sets: one of those sets emphasised individualism ("I" orientation), while the other emphasised collectivism ("we" orientation). The "I" orientation, consisted of the experimenter giving instructions in the singular form of the first person during the practice trials, while the "we" orientation had instructions in the plural form of the first person. Another two conditions had neutral instructions, without reference to "I" or "we", and instructions with a combination of both pronouns. Older children were more cooperative under the "we" orientation than the "I" orientation, but younger children were more cooperative in general. There remains to be tested whether, and if so, how collaborative versus competitive models would affect children's collaboration with peers.

Complementary to the literature on cognitive and social development described above, there is another field that investigated the development of collaborative behaviour in young children: social and pretence play or collaborative problem-solving (Brownell et al., 2006;

Cooper, 1980; Corsaro, 2009; Eckerman & Didow, 1996; Gräfenhain, Behne, Carpenter, & Tomasello, 2009; Hamann et al., 2012; Ross & Lollis, 1987; Warneken, Gräfenhain, & Tomasello, 2012; Warneken et al., 2011; Warneken, Steinwender, Hamann, & Tomasello, 2014). This field has addressed when children start to perform similar and complementary roles in coordinated activities, both with peers and adult partners. The development of reciprocal imitation and collaboration are linked, with imitation having an important role in generating coordination between young children and their social partners.

To summarise, the current evidence is that children start reciprocally imitating and coordinating around their first year and are able to establish and understand commitment to joint activities by their third year. Although in the beginning the amount of reciprocal imitation between children and their social partners was correlated with the emergence of coordinated activities, these interactions were not controlled to allow causal inferences; neither was there any focus on how previous experiences with adults and other children affected the learning of coordinative collaboration. One could ask whether children will be biased towards learning from peers in collaborative situations across different system of rewards. If children observe peers collaborating in a difficult task with uncertain rewards, would then copy those, or search for other strategies? And finally, the role that social learning biases (Laland, 2004), such as prestige, pay-off, conformity and so on, affect children's collaboration remains to be investigated including how these interact with characteristics of the immediate and extended social and cultural background of the children.

Social learning of collaborative behaviours may or may not operationally differ from the social learning of other types of behaviours. Consistent and knowledgeable models, combined with a supportive and structured environment that gives opportunities to children to

perform prosocial actions may contribute to the development of collaborative actions. Moreover, such an environment may have been important for the evolution of cooperation, providing a context that would foster and select, by means of the socializing strategies, specific generous behaviours towards others in a group (Castro, Castro-Nogueira, Castro-Nogueira, & Toro, 2010; O'Brien, 2014; Tomasello, 1999). Social learning processes are affected by the social behaviour of the models and the learners, and may be part of the social interaction, and a way of acquiring social behaviour towards others (Wood, Kendal, & Flynn, 2013a).

Therefore, collaboration can be investigated as both a product and a mechanism of social learning (Tomasello et al., 1993). Collaboration as a *mechanism* of social learning has been widely explored in educational settings, with strong experimental evidence that cooperative learning leads to the acquisition of new social and cognitive skills, compared to individual learning. Collaboration as a *product* of social learning, however, is scarcely studied in experimental settings. Although it is clear that at the age of five years children are able to coordinate with partners to achieve joint goals, how the influence of peers modulates the development of these skills remain relatively under-explored in experimental settings.

Three experimental paradigms to study the social learning of collaboration between children

In this section, I present and discuss how three different experimental approaches may bring new insights into the investigation of social learning of collaborative actions.

Collaboration in economic games

Economic games have been widely adopted to study cooperative behaviour, including in the field of child development (Gummerum et al., 2008). These games consist of a simulation of economic decisions involving some level of conflict of interest between the participants (also known as *social dilemmas;* Kollock, 1998). They allow researchers to investigate decision making in controlled settings and provide a standard model that can be applied to different populations (Henrich et al., 2005; House et al., 2013). Finally, economic games are particularly suitable to assess how people interpret and copy social information.

The literature on economic games with adults offer a variety of tools to be applied to the investigation of social learning among children. Lamba (2014) investigated the influence of social information (the past decision of both the player with the highest pay-off and the majority) on adults' decisions in a public goods game. The same paradigm could be applied to children in school age, since it is already established that they understand and even behave the same way to adults in similar games (Alencar, Siqueira, & Yamamoto, 2008; Harbaugh & Krause, 2000). For instance, preschoolers tend to donate less than older peers and adults in economic games (Benenson, Pascoe, & Radmore, 2007; Fan, 2000; Keil et al., 2017; Vogelsang, Jensen, Kirschner, Tennie, & Tomasello, 2014), as children's donations tend to increase with age, along with the influence of social norms of giving (Dutra et al., 2018; McAuliffe, Raihani, & Dunham, 2017). However, research on the effects of social learning mechanisms on children's decisions is rather incipient, with particular focus on past experience and norm psychology, that is how children follow social norms (Dutra et al., 2018; Fan, 2000; McAuliffe, Raihani, et al., 2017; Zarbatany, Hartmann, & Gelfand, 1985).

To conclude, it has been shown that a relevant feature of these experimental games is that the participants' decisions rely on social information, especially in repeated interactions. Combining social learning methods and economic games brings new insights into the investigation of the development of collaborative behaviour, which are relevant because they offer an opportunity to test the effects of social learning in the context of social interactions, when differing interests might be at odds with each other.

Cultural transmission of collaboration

The paradigm of cultural transmission has received much attention recently (Baum, Richerson, Efferson, & Paciotti, 2004; Caldwell & Eve, 2014; Caldwell & Millen, 2009, 2010; Mesoudi & Whiten, 2008). Cultural transmission experiments investigate the spread of behaviour between people in a variety of designs: model A demonstrates a sequence of actions to an observer B, who in turn will demonstrate the sequence to another observer C, and then from C to D, and so on. This transmission may happen from individual to individual (diffusion chains) or within a group (open diffusion), with or without substitution of participants, therefore simulating different situations of cultural transmission.

Cultural transmission studies have provided evidence for theories of cultural evolution (Mesoudi & Whiten, 2008), demonstrating the biases and social cues to which people respond when they copy other people's behaviour. Cultural transmission has been investigated between children, without direct instruction or scaffolding of adults (Flynn & Whiten, 2008, 2010; McGuigan & Graham, 2010). However, despite the claims that cultural evolution and the evolution of cooperation are closely linked, evidence on cultural transmission of cooperation is limited.

In terms of cultural transmission between children, it remains to be seen how children learn from, and transmit to, peers collaborative behaviours. In open diffusion experiments, Whiten & Flynn (2010) and Dean, Kendal, Schapiro, Thierry, & Laland (2012) observed instances of collaboration and prosocial behaviours in children attempting to open puzzle boxes. There is evidence on children's transmission of social norms as well: Göckeritz et al. (2014) showed that five-year-old children created norms regarding how to perform on a collaborative task, and transmitted those norms to new participants, consequently leading to the transmission of the collaboration established between the initial participants. Therefore, it seems that horizontal cultural transmission occurs early between children, and that reciprocal interactions may be relevant in the creation and transmission of social norms from an early age. Cultural transmission paradigms seem promising in the investigation of hypotheses concerning the relationship between the development of cooperative and cultural skills.

Cultural differences in collaboration

Children are usually involved in daily activities in their communities, often collaborative activities. However, the manner of the children's involvement and the kind of activities vary across societies (Rogoff, 1998). The manner in which children interact with peers is an important subject to investigate across cultures. Culture defines which characteristics are valued by a group and therefore affects the development of cooperative behaviours. For instance, a greater emphasis on the development of academic skills in schools and individualistic goals is generally correlated with greater autonomy and less cooperation towards the group, whilst societies with communal activities and greater emphasis on group dependency is generally correlated with the opposite (Chen & French, 2008). Consequently,

children from cultures where cooperation is valued in social relationships rather than individualism or competitiveness are predicted to be more cooperative.

As far as cross-cultural comparisons helped us to understand the dynamics of social learning and social interactions that underlie vertical (between generations) and horizontal (within the same generation) cultural transmission, there is still a need to develop and apply methods to investigate specific aspects of the cultural transmission process of collaborative behaviour between children; for example the manner in which peer culture among children is modulated by their social and cultural environments (Corsaro, 2009; Corsaro & Eder, 1990). The combination of economic games, cultural transmission experiments and cross-cultural comparisons will help to test hypotheses within this topic.

Conclusion

The creation and transmission of culture in humans is an interactive process, which requires collaborative skills. Nevertheless, much of what has been propounded and tested in the literature of culture and cooperation has addressed phenomena separately or focused on individual performance. In addition, traditional developmental and learning psychological theories have been studying the development of children's collaborative skills, without exploring further the influence of different social learning mechanisms, cultural transmission processes and the effects of social interaction itself. Therefore, I have shown that basic assumptions of the relationship between culture and cooperation in humans remain untested, including how this relationship manifests across child development.

Cultural learning differs from other types of social learning and at some point children must be able to imitate others and to create and transmit behaviours (Tomasello et al., 1993).

This seems to be particularly important in collaboration, where learning occurs with others. Cultural creation and transmission among children may take place early in humans, when peer pressure and conformity to norms appear (Haun, Rekers, & Tomasello, 2014; Haun & Tomasello, 2011). Cooperative strategies, thus, interact with social learning so that children are able to navigate their social world and make decisions regarding their participation in social interactions. Future studies can investigate how collaboration may spread, or not, among children by using one or more of the methods presented above. Furthermore, it can contribute to understand which roles the mechanisms of social learning play in the development of collaborative skills. With this, the role of collaboration on social development might be more directly tested. Even further, research on collaboration and cultural learning may even help us to understand just the opposite: how social inequality can emerge, spread and persist within cooperative groups, from childhood.

Chapter III

Is cooperation among children “infectious”?

This chapter is an empirical study investigating how four different types of collaborative tasks affect children’s imitation and transmission of actions between peers, by means of observation. This chapter will be submitted for publication.

The authorship will be as follows:

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Introduction

Humans show early collaborative skills, that later develop into increasing sophisticated forms of collective cooperation, such as the creation and enforcement of social norms, and moral institutions (Tomasello & Gonzalez-Cabrera, 2017; Tomasello et al., 2012). Thus, collaboration, or the ability to coordinate actions with others to achieve joint goals, underlie the human capacity for unique forms of social learning, communication, cooperation, and culture (Eckerman & Peterman, 2004; Tomasello et al., 2012; Warneken, 2018). In support to this hypothesis, coordination has been found to emerge quite early in human development, with the propensities to coordinate rhythmically with someone else emerging from birth (Eckerman & Peterman, 2004; Trevarthen, 2011), and being a distinguishable feature in humans compared to other primates (Tomasello et al., 2012, Warneken, 2018). These early cooperative skills help children to assimilate and transmit culture (Dean et al., 2012; Rogoff, 2003; Tomasello, 2016; Tomasello et al., 2005), while also having important implications for children's social relationships and cultural learning (Clegg & Legare, 2016; Nielsen & Blank, 2011; Over & Carpenter, 2013).

From two years of age, children accommodate their behaviour to coordinate actions with a peer or an adult partner to achieve a common goal, when it requires that they perform similar actions (e.g., pulling a lever simultaneously; Brownell et al., 2006; Warneken, Chen, & Tomasello, 2006) or simple complementary actions (e.g., manipulating a handle to provide access in another location to a toy; Brownell & Carriger, 1990; Warneken et al., 2006). For instance, in simple joint tasks young children are capable of planning joint actions (Warneken et al., 2014), taking other people's perspectives (Fletcher, Warneken, & Tomasello, 2012), reversing roles (Carpenter, Tomasello, & Striano, 2005), and even using cues to coordinate with others without using language (Grueneisen, Wyman, & Tomasello, 2015). However,

when children need to perform different actions at the same time or in sequence with peers on more complex tasks (e.g., one child pulling a lever while a peer lifts a handle), even older preschool children have problems adapting their actions to those of a partner, without an adult's assistance (three-year-olds: Ashley & Tomasello, 1998; Fletcher et al., 2012; five year-olds: Meyer, Wel, & Hunnius, 2016).

Cultural transmission relies on social learning mechanisms. Preschoolers tend to overimitate models, that is, to copy irrelevant actions in problem-solving tasks (Nielsen, Moore, & Mohamedally, 2012), especially when they are modelled intentionally (as opposed to accidentally, Gardiner, Greif, & Bjorklund, 2011), and they spontaneously tend to interpret social interactions as normative, even in the absence of cures of pedagogy or normative language (Rakoczy & Schmidt, 2013). However, when copying other peers, children imitate irrelevant actions with less fidelity (Wood et al., 2012), unless they are modelled in a playful manner (Nielsen, Cucchiaro, & Mohamedally, 2012), which supports the hypothesis that imitation serves a social function and underlie the process of collaborative cultural creation in humans.

Young children, therefore, are capable of learning how to cooperate with a partner on simple tasks from peers. However, regarding the development of cooperation between peers, there has been rare attempts to test the relation between cooperative skills and cultural transmission processes across development beyond the level of dyadic interactions. Moreover, most research on the relationship between social learning and peer cooperation addresses the *interaction* between models and observers (Ramani & Brownell, 2013; Rogoff, 1990; Tudge & Rogoff, 1989), by focusing on the cooperative relationship between the model and the observer (Ashley & Tomasello, 1998; Azmitia, 1988; Dean et al., 2012; Johnson-Pynn & Nisbet, 2002). Based on research that outlines young children’s propensity for cooperation

and social learning (Ashley & Tomasello, 1998; Azmitia, 1988; Eckerman & Peterman, 2004; Flynn, Turner, & Giraldeau, 2016; Johnson-Pynn & Nisbet, 2002), we hypothesise that, through *observing* peers as models in a cooperative task, young children (three- and four-year-olds) will be able to imitate the actions and establish coordination. Observation of peers in this context might enhance children's adaptation to other people's perspectives in social interactions with equally naïve partners, and improve their joint performance (Matheson, Moore, & Akhtar, 2013; Milward & Sebanz, 2018; Ramani & Brownell, 2013).

To accurately copy the actions of a model, the observer must interpret the model's actions and intentions from his or her own perspective, and re-enact the actions (Carpenter, 2006; Carpenter & Call, 2007). Young children attend to imitation tasks in flexible ways, choosing to copy the actions (means), the outcomes (ends), or both. One interpretation is that there is a hierarchy of goals to which an observer attends; for example, whether the goal is to achieve an outcome or to perform a sequence of actions in a specific order (Carpenter, Call, & Tomasello, 2005). In either case, children can copy other people's actions to establish social contact and form social bonds (a "social" goal; Over & Carpenter, 2013) or to learn something about an object or action (an "instrumental" goal; Carpenter, 2006).

Cooperative actions can provide different cues as they can have social and instrumental goals (Gräfenhain et al., 2009; Warneken et al., 2006). Cooperative games are an example of cooperation with social goals, where the children take turns, repeat sequences of actions, and act jointly for the enjoyment of the game. Though repetitive, games are also characterised by variations on a theme and creation of new actions (Eckerman & Peterman, 2004; Ross, 1982). Cooperative problem solving tasks involve cooperative actions with instrumental goals, where children must coordinate to reach a practical goal, such as retrieving a toy or solving a puzzle. These tasks may involve the creation of new actions or

not, depending on the demands of the task (Ramani & Brownell, 2013). This study investigated whether, and if so when, children choose to copy peers in cooperative tasks with instrumental and social goals, in the absence of direct instructions.

Additionally, this study aimed to investigate whether cooperative actions, if copied, would be faithfully transmitted between children, or whether they would eventually collapse, due to their higher complexity when compared to actions in simple individual imitation tasks. To do this, we adopted a cultural diffusion chain design, which is part of a relatively new set of experimental paradigms that have pioneered methods to assess the transmission of information along multiple individuals with experimental rigour and, at the same time, in more naturalistic settings (Caldwell & Millen, 2010; Flynn & Whiten, 2010). Diffusion studies with young children have investigated the cumulative effect of consecutive transmission of actions from child to child and within groups of children. More specifically, they have investigated the transmission of behaviour (or not) along a linear chain of children, from child A to child B, from B to C, from C to D, etc. These studies have found that children between two and five years can transmit actions with high fidelity from child to child, with fidelity in transmission increasing with age (Flynn & Whiten, 2008; Horner et al., 2006). But children also emulate the methods taught to them by parsing out irrelevant actions to solve a task along the chains (Flynn, 2008; McGuigan & Graham, 2010). Thus, we were interested in assessing whether children learn from each other with enough accuracy for cooperative behaviour to be consistently transmitted across pairs of children.

In addition, we were interested in exploring whether, and if so how, different types of cooperative tasks affect the imitation and transmission of cooperative actions between children. Drawing on Warneken et al. (2006), in this study three- and four-year-old children were tested across four tasks: two cooperative games and two cooperative problem-solving

tasks that could not be solved by one child alone. One of each of these task types could be played by partners in similar roles, that is, completing the same actions, and the other two required complementary roles, that is, complementary actions. These tasks were chosen because they provided a range of possible coordinated interactions, goals, and roles, giving us the opportunity to assess potential different patterns of imitation and transmission. Thus, we investigated whether there were differences in transmission of cooperative actions along diffusion chains according to the types of tasks with regards to their goals (social games *versu*s problem-solving tasks) and roles (similar *versu*s complementary).

It was predicted that children would copy and transmit actions across all tasks with high fidelity because coordination increase children's social affiliation, stimulate their perspective taking skills, and increase the tasks' conventional aspects. Although previous literature indicates that children will copy others faithfully in social games because they infer social conventions from simple joint activities (Rakoczy, Warneken, & Tomasello, 2008), there is also evidence that in social games children can spontaneously create other goals and actions (Ross, 1982). Hence, it was predicted that the social games could entail more variation in the transmission along chains. Moreover, it was predicted that the tasks with similar roles would be transmitted more faithfully (*i.e.*, children would demonstrate and imitate with more accuracy) than those with complementary roles, because they require less coordination and have partners using the same actions that one can observe as one attempts the task.

Thus, the present study focuses on the effect of different cooperative contexts (tasks with goals that are social versus instrumental) on children's copying of peers' coordinated actions through *observation* alone. Moreover, it addresses how these contexts affect the fidelity of imitation of cooperation in groups by examining its transmission over multiple pairs of children.

Method

Participants

Sixty-four children (M_{age} = 47.92 months, *SD* = 5.10; 36 girls) from four nurseries in the North of England were tested across four tasks. Fourteen mixed-sex and 18 same-sex pairs were recruited (11 pairs of girls). Forty-eight children were randomly allocated to the experimental condition and 16 children to the control condition. Most children were white (97%) and came from lower middle and working class families, according to the information provided by the schools. To form pairs, the experimenter asked the nursery staff to choose pairs of children who would work well together. Informed consent was provided by parents or guardians, and the nursery staff. Children also only participated after confirming verbally that they would “like to play a game”. This study was approved by the ethics committee from the University of Durham (project title: “Is cooperation among children ‘infectious’?”; reference number: 13/35).

Apparatus

Four tasks adapted from Warneken et al. (2006), which fitted our needs for specific action types and specific goal types, were used. Each task had a specific goal, and the rewards to be retrieved in the cooperative problem-solving tasks were familiar toys, such plastic miniature cars and animals, and wooden bells (see Figure 1).

Figure 1. Picture of toys (middle) and tasks used. Top left: double tube; top right: elevator; bottom left: trampoline; bottom right: tube with handles.

The *double tube* task (cooperative game with complementary roles) consisted of two tubes (75cm long, 10cm in diameter) mounted on a box in parallel, at a 20º inclination. The goal in this task was to catch in a tin can, a wooden block put into one of the tubes. For this, one child needed to put a wooden block into one tube from the upper end (role A), and another child needed to catch it with a tin can at the lower end (role B).

The *elevator* task (problem-solving task with complementary roles) consisted of a small table (45cmx65cmx45cm) with a cylinder attached to it (10cm in diameter). The goal in this task was to retrieve a toy from inside the cylinder. For this, one child needed to lift the cylinder and hold it in place, from one side of the table (role A), while another child had access to the object from a hole in the cylinder, on the other side of the table (role B). Transparent screens prevented a person from performing both roles by him- or herself.

The *tube-with-handles* task (problem-solving task with similar roles) consisted of a tube (110cm long, 10cm in diameter) with one handle on both ends. The goal in this task was

to retrieve a toy that was inside the tube. For this, two children needed to pull the ends simultaneously, as the tube was too long to be opened individually.

The *trampoline* task (cooperative game with similar roles) consisted of a ring (67cm diameter) made of two hoses connected by flexible joints and covered with cloth. The goal for this task was to make a wooden block bounce three times above the trampoline. For this, two children needed to hold the ring at opposite sides and make the block jump by shaking the trampoline up and down. The flexible joints prevented individual attempts to lift the trampoline as it collapsed in the middle.

Design

To investigate the *transmission* of actions between children, a diffusion chain design was adopted. A diffusion chain is similar to the game "Broken Telephone", in the sense that participants pass information along a chain of other participants. Hence, person A "seeds" the information within the chain, by starting the transmission and passing information to person B, who in turn passes the information to person C, and so on.

Procedure

Testing took place in a quiet room away from the other children in the nursery. Eight diffusion chains were run for each of the four tasks described above, yielding a total of 32 chains (with each pair taking part in four chains, one for each task). Diffusion chains were made up of three pairs in which consecutive pairs witnessed two attempts on a cooperative task by the previous pair in the chain (as in Flynn, 2008; see Figure 2). Pairs were allocated to a specific position in each chain before a testing session began, and each chain contained a

similar proportion of boys and girls. The pairs within the same chain were presented with the four tasks in succession, and the tasks were counterbalanced for order.

Pair	Chain			
P1	D			
P2	O	A	D	
P3			O	A

Figure 2. The first column represents the position of each pair of children in the diffusion chain. Pair 1 (P1) acted as models for pair 2 (P2), and P2 acted as models for pair 3 (P3). P2 and P3 observed the previous pair (O) and had two attempts at the task (A). P1 and P2 had two demonstrations to the next pair (D). P3 did not demonstrate to anybody, thus ending the chain.

Training of models. A pair of children (P1) were trained to act as models to a second pair of children (P2). The experimenter trained this "model" pair to perform the task, until they coordinated successfully. Training contained instructions, demonstrations and coordinated actions, as necessary, by the experimenter with each of the children. The pair were considered proficient in the task after five successful attempts at the task in sequence. On tasks that required similar actions (tube-with-handles and trampoline), both children were trained to use the same actions in coordination, whereas on tasks that required complementary actions (elevator and double tube) both children were trained to use both actions, irrespective of which child took which action position.

Experimental condition. Each session began with the experimenter inviting a second pair of children (P2) to play a game. Children in P2 were told to wait while children in P1 had two 'goes', after which it would be their turn. The experimenter did not tell children explicitly

to observe the models. The children in P1, who were previously trained, provided two demonstrations of the task in the presence of P2. After the second attempt of P1, the children on P1 returned to the nursery. Then, P2 were told that it was their turn, and had two attempts at the task. After the end of the second attempt, the experimenter invited a third pair of children (P3) to play the game. They were told to wait for their turn, whilst P2 had two demonstrations at the task. Then P3 had two attempts, thus finishing the chain. The same chain (the same pairs of children in the same positions) was repeated three more times, with the other tasks.

A demonstration or an attempt began with both children engaging in the task (e.g. one is looking at the apparatus, when the partner starts manipulating it) and ended when children reached the goal for the task or after 2 minutes manipulating the apparatus without success. If one child or both children did not engage in the task after the initial 60s, the experimenter used a prompt, saying for example: “you can touch it as much as you like, you can't break it”, and gave the pair one more minute. Regardless of children's engagement with the apparatus after the prompt, a second turn of 2 minutes would start after the first 2 minutes. If children did not engage with the apparatus at all, even after the prompt, or refused to participate, their turn would end after 4 minutes from the beginning of the session. If the pair achieved two successful attempts before the 4 minutes, then the turn was finished. The chain always continued irrespective of children's successful reproduction of the actions seeded within chains.

No model control condition. The no model control condition allowed us to assess if the transmission along the diffusion chains was due to individual learning only and assessed the degree of conformity to the methods seeded within the chains. In this condition, a pair of children were brought into the room and presented with one of the four tasks, being told: “lots

of boys and girls have had a go, and now it’s your turn”. Then, they had a maximum of two attempts at the task, each comprising of a maximum of 2 minutes, following the same criteria for completion as within the chains.

All children in both conditions, irrespective of success, received a sticker as a reward at the end of the testing sessions.

Coding

All the testing sessions were videotaped. Coding of the videotapes discriminated children's performance and communicative attempts at the tasks. Each child’s performance within pairs was scored according to three categories: coordination of actions, reproduction of the observed models' actions and outcomes, and the transmission of actions and outcomes seeded in the chains by the first pairs (see Table 1 for details).

Table 1

Discrimination of coding variables.

Variable	**Score**	**Description**
Coordination	1	No approach
	2	The child did not try to coordinate with the partner
	3	The child coordinated with the partner, but did not achieve the outcome
	4	The child coordinated with the partner and achieved the outcome
Reproduction of actions	1	No approach
	2	The child did not reproduce the models' actions
	3	The child partially reproduced the models' actions
	4	The child fully reproduced the models' actions
Reproduction of outcomes	0	The child did not reproduce the outcome (regardless of coordination or reproduction of actions)
	1	The child reproduced the outcome (regardless of coordination or reproduction of actions)
Production / transmission of actions or outcomes	0	The child did not produce/transmit the trained actions or outcomes
	1	The child produced/transmitted the trained actions or outcomes

The scores for *coordination* of actions addressed whether children attempted to coordinate with their partner and whether or not they were successful in the task. The scores for *reproduction* of actions addressed whether children copied the models' actions faithfully, that is, used similar gestures and manipulated the same parts of the apparatus. Hence, if

children manipulated parts of the task other than those manipulated by the models, and used other parts of the body than their hands to manipulate the task, their actions were not considered a faithful reproduction of the models' actions. Additionally, the scores for *reproduction* of outcomes were coded separately in case children found ways of achieving the outcomes without reproducing the models' actions.

In addition, the actions and outcomes demonstrated and reproduced by children could have been different from those initially trained in the first pairs by the experimenter (hereafter called "seeded" actions and outcomes). To account for the *transmission* of actions and the *transmission* of outcomes across the chains, a score of 1 was given for each seeded action and for each seeded result that was faithfully transmitted by the pairs, and 0 for each one that was different. The no-model control condition received scores regarding the *production* of actions and outcomes similar to those originally seeded within the diffusion chains, and this gave a measure of the level of individual learning children displayed at the tasks regarding the actions seeded within the chains.

Finally, five categories of communicative attempts were coded for each individual within pairs, to measure their level of engagement and coordination with their partners: engagement attempts (the child actively shows a partner how to do something, gives directives, tries to direct the partner's attention, e.g. "hold it"); responsiveness (the child responds to the partner's engagement attempts, e.g. "this one?"); experimenter (the child tries to communicate with the experimenter; e.g. "what's that?"); task (the child makes comments about the task, e.g. "this is heavy!"); and others (the child makes comments about something unrelated to the task, e.g. "I've got a new wristlet").

Data preparation and statistical analysis

The first author scored all data, and two independent raters scored a random sample of 25% of the data each, for each type of score. The raters had 73% of agreement or above between themselves and the first author, with most categories having an agreement above 80%. Eleven categories had an agreement of 100%, rendering any statistical comparison unnecessary. For the other categories, Cohen's kappa tests were performed, and they revealed a fair to strong agreement between the raters for each type of score and task ($p < .044$ or below; see Supplementary Table 4 for κ critical values).

This study used a within-group design to compare the transmission of collaborative (coordinated) actions in relation to the type of task. The tasks were compared individually, rather than by category (social versus problem-solving, and similar versus complementary actions), to include all the combinations and to assess whether children would rather copy the models in each particular task.

Preliminary analyses revealed that there was a high correlation between the reproductions of actions and outcomes ($\tau = 0.703$, $Z = 14.537$, $p < .001$), and the transmission of actions and outcomes ($\tau = 0.771$, $Z = 15.085$, $p < .001$). For this reason, we decided to combine each pair of actions scores and outcomes scores into a single score, representing whether children were successful in reproducing the models' solutions to the tasks or not (yes = 1, no = 0), and whether they transmitted (or spontaneously *produced*, in the no-model control condition) the seeded actions (yes = 1, no = 0). Given the high frequency of successes in coordination scores, we also converted them into a binomial response variable, meaning whether children successfully coordinated in the task or not (yes = 1, no = 0).

Only the individual scores for the pairs' attempts were considered as dependent variables for the analyses, with the scores for demonstrations being added as independent

variables. The total number of observed events was 384 (48 children, multiplied by two attempts for each task, and the four tasks). Logistic binomial mixed models were used for the analysis. We followed the "ten events for each predictor" rule (Vittinghoff & McCulloch, 2007). Given that our models have a range of two to six predictors, the number of events for each predictor fits the criteria (64-192 events for each predictor, depending on the model).

Results

All analyses were carried out with R software (version 3.4.0, R Development Core Team, 2017). The logistic binomial mixed models were fitted with *lme4* package *glmer* function (Bates, Mächler, Bolker, & Walker, 2015), and were compared using the likelihood ratio tests provided by the analysis of variance method (*stats* package *anova* function, R Development Core Team, 2017). When appropriate, post hoc analyses were performed with Tukey HSD multiple comparisons test (*multicomp* package *glht* function, Hothorn, Bretz, & Westfall, 2008).

Three statistical analyses were carried out, one for each category of action scores as response variables: coordination, reproduction, and transmission. A full model was initially fitted for each one of these categories, having the following variables added as fixed effects: task (double tube, elevator, handles, and trampoline), task order (1 to 4), trial (the order of attempts at each task: 1 or 2), model position (which model the pair witnessed: no model, pair in P1 or pair in P2), and the participants' age and gender. In addition, the pair and group affiliations were included as random effects to account for the influence of repeated measures (as all pairs had two attempts in each of the four tasks). The analyses for each category of actions' scores are described separately below.

Did children reproduce the specific actions they observed?

Initially, we tested whether the pairs were reproducing the actions demonstrated by the models. The full and the reduced models were fitted, with the reproduction of actions and outcomes (yes = 1, no = 0) as the response variable. The control condition was not included. The children's gender and age, the order of the children's attempts (trial), the demonstration witnessed by the children (model position), and the group did not contribute to explain the observed data in the full model; hence they were removed in the reduced model. This model, with the variables task, task order, and pair, had a slightly better fit to the data than the full model but the difference was not statistically significant (χ^2 = .223, *df* = 5; *p* = .999).

Thus, the children's overall reproduction of the models' actions and outcomes were significantly predicted by the intercept (the combination of the first categories of each covariate in the model), the task, and the order in which each task was presented while controlled for the effects of the pair (see Supplementary Table 1 for model estimates, and Figure 3 for predicted probabilities). Post hoc analyses were performed to assess these effects in detail, revealing that the trampoline task had significantly different reproduction scores from all the other tasks, and the handles task had significantly different scores from the elevator task (double tube vs. elevator: *Z* = 1.557, *p* = .397; double tube vs. handles: *Z* = -2.179, *p* = .126; double tube vs. trampoline: *Z* = -4.629, *p* = .001; elevator vs. handles: *Z* = -3.287, *p* = .005; elevator vs. trampoline: *Z* = -5.124, *p* = .001; handles vs. trampoline: *Z* = -3.019, *p* = .013). Additionally, it was revealed the tasks presented first had significantly different reproduction scores from the tasks presented in the subsequent orders (1 vs. 2: *Z* = 3.099, *p* = .010; 1 vs. 3: *Z* = 2.801, *p* = .023; 1 vs. 4: *Z* = 2.635, *p* = .041; 2 vs. 3: *Z* = -.184, *p* = .998; 2 vs. 4: *Z* = -.404, *p* = .978; 3 vs. 4: *Z* = -.187, *p* = .998).

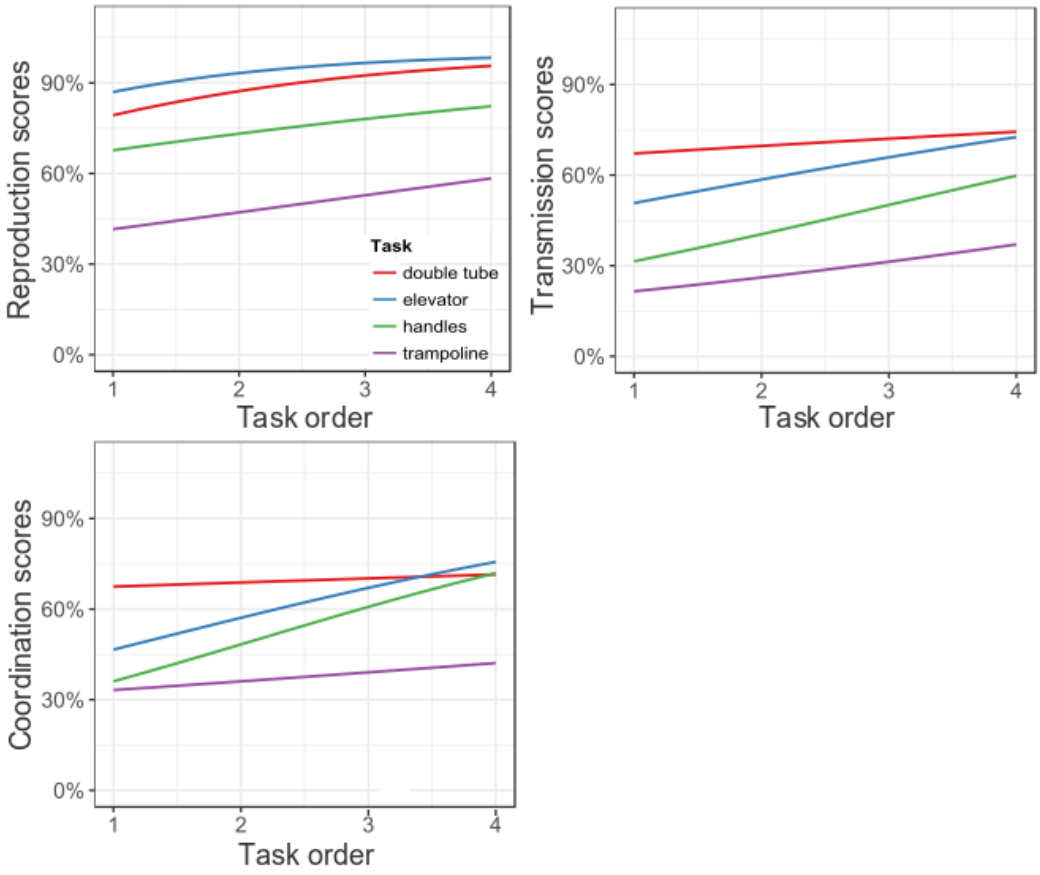

Figure 3. Predicted probabilities for the following children's actions: reproduction (copying), transmission and coordination, for each task and task order.

Did children transmit the actions and outcomes that were originally seeded in the chains? And were those different from pairs who have not seen demonstrations?

The actions and outcomes originally seeded within chains were faithfully transmitted through *at least one* of the attempts or demonstrations, for all the chains in the double tube and elevator tasks, six chains in the handles task, and five chains in the trampoline task (see Table 2). Faithful transmission in *all* demonstrations or attempts occurred in the double tube and elevator tasks, up until the second pair. Comparatively, children in the no-model control did not engage in the tasks on four occasions (two pairs in the double tube, and one pair in the handles and trampoline tasks), while they touched the apparatus but did not try to play a game

or retrieve the toy on 18 occasions (three pairs in the double tube, seven pairs in the elevator, and four pairs in the handles and trampoline each).

Table 2

Number of chains whose pairs reproduced the actions/outcomes seeded within chains in at least one of the attempts or demonstrations.

Pair	Double tube	Elevator	Handles	Trampoline
Pair 1 demo	8(8)	8(8)	8(5)	7(5)
Pair 2 demo	8(8)	8(8)	7(2)	5(2)
Pair 3 attempt	8(7)	8(5)	6(1)	5(1)

Note. Numbers in brackets represent the number of pairs who reproduced the trained (Pair 1) or observed (Pair 2 and Pair 3) actions/outcomes in all demonstration and attempts. Attempts of pairs in the second position were omitted because the actions/outcomes could only be transmitted if they reproduced the actions/outcomes during the demonstrations.

To test whether the children's actions were also faithful to the actions originally seeded in the chains, a full model was fitted with the same variables as fixed and random effects as before, but with the transmission of actions and outcomes (yes = 1, no = 0) as the response variable, and with the control condition included. Since the children's gender and age, and the order of the children's attempts (trial) did not contribute to explain the observed data, they were removed in the reduced model. This model, with the variables task, task order, model position, pair, and group, had a slightly better fit to the data than the full model but the difference was not statistically significant ($\chi^2 = .171$, $df = 3$; $p = .9821$).

Thus, children's overall transmission of the models' actions and outcomes were significantly predicted by the intercept, the task, the order in which each task was presented,

and the model's position, that is, the demonstration witnessed by the children (see Supplementary Table 2 for model estimates, and Figures 3 and 4 for predicted probabilities), while controlled for the effects of the pair and the group. Post hoc analyses were performed to assess these effects in detail, revealing that all the tasks had significantly different transmission scores from each other, except for the double tube and elevator tasks (double tube vs. elevator: Z = -1.847, p = .247; double tube vs. handles: Z = -4.934, p < .001; double tube vs. trampoline: Z = -6.111, p < .001; elevator vs. handles: Z = -3.483, p = .002; elevator vs. trampoline: Z = -5.451, p < .001; handles vs. trampoline: Z = -2.904, p = .019). Additionally, it was revealed the tasks presented first had significantly different transmission scores from the tasks presented in the third and fourth orders (1 vs. 2: Z = 1.818, p = .263; 1 vs. 3: Z = 3.636, p = .002; 1 vs. 4: Z = 3.886, p < .001; 2 vs. 3: Z = 1.899, p = .228; 2 vs. 4: Z = 2.476, p = .063; 3 vs. 4: Z = .529, p = .952). And finally, children who witnessed no demonstrations had significantly different scores from those who did (no model vs. P1: Z = 5.198, p < .001; no model vs. P2: Z = 4.602, p < .001; P1 vs. P2: Z = -1.322, p = .373).

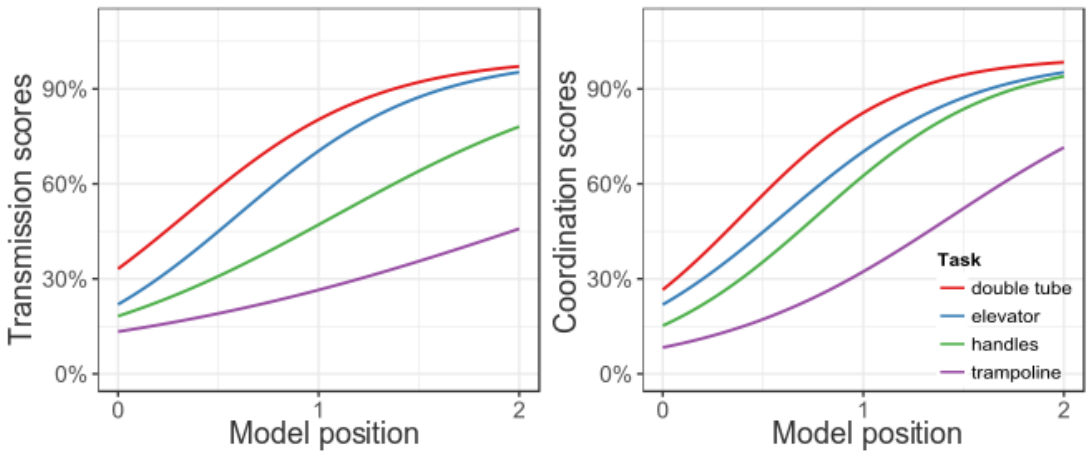

Figure 4. Predicted probabilities for the following children's actions scores: transmission (left) and coordination (right), by task and model position (0: no models, 1: pairs in P1 as models, 2: pairs in P2 as models).

Did children interpret the task as a cooperative engagement?

To test whether children coordinated their actions differently across tasks, and whether witnessing a pair as models influenced their level of coordination, a full model was fitted with the same variables as fixed and random effects as before, but with coordination (yes = 1, no = 0) as the response variable, and with the control condition included. Since the children's gender and age, the order of the children's attempts (trial) and their group affiliation did not contribute to explain the observed data, they were removed in the reduced model. This model, with the variables task, task order, model position, and pair had a slightly better fit to the data than the full model but the difference was not statistically significant (χ^2 = 1.174, *df* = 4; *p* = .882).

Thus, children's coordination scores were significantly predicted by the intercept of the model, the task, the order in which the task was presented, and the model's position, while controlled for the effect of the pair (see Supplementary Table 3 for model estimates, and Figures 3 and 4 for predicted probabilities). The Figures 3 and 4 present the predicted values for the coordination of actions by task and task order, and by task and demonstration. Post hoc analyses were performed to assess these effects in detail, revealing that the trampoline task had significantly different coordination scores from all the tasks, and that the handles task had significantly different scores from the double tube task (double tube vs. elevator: *Z* = -1.070, *p* = .704; double tube vs. handles: *Z* = -3.125, *p* = .009; double tube vs. trampoline: *Z* = -5.697, *p* < .001; elevator vs. handles: *Z* = -2.060, *p* = .163; elevator vs. trampoline: *Z* = -4.807, *p* < .001; handles vs. trampoline: *Z* = -3.667, *p* = .001). Additionally, it was revealed the tasks presented first had significantly different coordination scores from the tasks presented in the subsequent orders (1 vs. 2: *Z* = 3.479, *p* = .003; 1 vs. 3: *Z* = 3.906, *p* < .001; 1 vs. 4: *Z* = 4.422, *p* < .001; 2 vs. 3: *Z* = .369, *p* = .983; 2 vs. 4: *Z* = 1.556, *p* = .401; 3 vs. 4: *Z* =

1.137, p = .664). And finally, children who witnessed no demonstrations had significantly different scores from those who did (no model vs. P1: Z = 4.266, p < .001; no model vs. P2: Z = 4.662, p < .001; P1 vs. P2: Z = 1.093, p = .516).

In addition to these results, we recorded 483 utterances and gestures, a mean of 7.55 communicative attempts per child; 19 children performed the task silently, while the others made at least one comment (see Table 3). Sixty-six percent of all communicative attempts were made by children in the no-model control condition, with 88% of the children making at least one attempt at communication in the no-model control condition compared with 65% of the children within chains. Among those, around half (51%) of the communication between children within chains consisted of attempts to engage their partner (e.g. double tube task: a child pointed to the one of the tubes; "I do this and…let's do, let's do this one"), while 27% were comments about the task (e.g. handles task: "it's not opening"), compared to 34% and 32% respectively, in the no-model control conditions.

Table 3

Number of children who communicated and who did not communicate with partners or the experimenter (number of communicative attempts in brackets).

Pair	None	Engagement	Responsiveness	Experimenter	Task	Other
P1	8	6(16)	2(2)	1(1)	4(7)	2(3)
P2	6	9(31)	0(0)	0(0)	6(11)	1(6)
P3	3	11(36)	2(4)	7(10)	11(27)	4(10)
C	2	6(108)	0(0)	6(12)	12(102)	13(97)
Total	**19**	**32(191)**	**4(6)**	**14(23)**	**33(147)**	**20(116)**

Note. Pairs within chains: P1 (first position); P2 (second position); P3 (third position). Pairs in the no model control condition: C.

Discussion

Young children struggle to coordinate spontaneously with peers in more complex joint tasks (Ashley & Tomasello 1998; Fletcher et al., 2012; Meyer et al., 2016). Here we showed that third-party observation of peers (that is, in the absence of social interaction between the models and the observers) improve children's performance in collaborative tasks, regardless of its instrumental or social goals. In addition, it was predicted that children would have better performances in tasks with similar roles. However, children's scores across all categories of actions (reproduction, transmission, and coordination) were lower in tasks with similar roles than tasks with complementary roles. We explore the reasons for these findings below.

First, with regard to the coordination of actions, it is clear that witnessing coordinating models increased children's propensity to coordinate in the same task and at the same level as their models, while in contrast children without models or training only occasionally tried to coordinate by themselves. Social interaction affects social learning in a number of ways; it provides cues of social affiliation, and it indicates that people must follow certain norms, often established by convention. Children are sensitive to cues of affiliation (Over & Carpenter, 2013), and are capable of inferring social norms in the absence of explicit instructions from early on (Rakoczy et al., 2008). Hence, children's faithful imitation across tasks might reflect their early skills in interpreting observed collaborative interactions as the expected norm in a given situation. In addition, observation of social interactions between peers can improve children's global interpretation of the situation, providing a bird's-eye view of the roles in the task (see related evidence for this with adult models: Milward & Sebanz, 2018).

While previous research has found that children tend to imitate other peers less than adult models (Wood et al., 2012), our study found that young children copied same-aged peers with great fidelity across a variety of tasks, in the absence of direct instruction or teaching by either the experimenter or the models. Most of these previous studies have focused on individual actions or interactions between models and observers (e.g. teaching) without prior observation of similar interactions. The simple fact of witnessing peer collaboration can therefore increase coordination at a period where children have difficulty in achieving it spontaneously (at least in experimental settings and Western middle-class samples; see Nielsen, Mushin, Tomaselli, & Whiten, 2016 for a comparison between westernised and indigenous Australian children).

Regardless of the models' influence children were less able to coordinate their actions in the trampoline and handles tasks (which involved performing similar roles), compared to the double tube and elevator tasks (which involved performing complementary roles). A potential reason for these findings is that the children executed their actions simultaneously in the tasks with similar roles, as opposed to executing them in sequence in the tasks with complementary roles. Brownell et al. (2006) found that 2-year-olds had difficulty in coordinating pulling a handle simultaneously. Our findings show that 3- and 4- year old children may still have difficulty in coordinating simultaneously with peers to reproduce the actions observed, perhaps because they required a greater level of motor coordination than actions in the other two tasks. Hence, imitation could have been hindered by the children's motor skills.

Equally, children may not have been concerned by a lack of fidelity in copying tasks that had similar roles. In such a task, the trampoline task, the children kept laughing and playing, as opposed to the other tasks where they stopped playing or tried to adjust their

behaviours after failing to achieve the observed goal. For instance, two pairs who were able to shake the trampoline multiple times changed the goal of the game in the following attempts, and even expressed this by instructing their partners to do so. Therefore, both the trampoline and handles tasks induced more variation in children's actions compared to the other tasks, seemingly to make it more “fun”. This finding contradicts recent evidence on increased fidelity in imitation when tasks are modelled in a playful manner (Nielsen, Cucchiaro, et al., 2012), albeit with an adult model. Future studies can explore further the interaction between characteristics of the tasks and the models in collaborative settings.

An additional contribution of our study was the adoption of cultural diffusion chains to assess children’s skills to faithfully transmit collaborative behaviours among themselves. This is relevant because the transmission scores of pairs in the second position (who observed the first pair then demonstrated to the third pair) provides the evidence that children were able to repeat in their demonstrations the actions they observed, that is, beyond their own attempts at the tasks. Hence, their imitation of coordinated actions was likely not casual. We thus found that children transmitted the seeded actions with high fidelity across the tasks, though with more fidelity in the double tube and the elevator tasks than in the handles and the trampoline tasks.

The chains also provided a test of whether the children were in fact copying the actions demonstrated or only spontaneously reconstructing them. In the majority of cases, the demonstrated and reproduced actions matched those that were seeded in the chains. Alternatively, in the very few instances where the models had not performed the seeded actions, the observers could have transmitted the actions by means of spontaneous reconstruction; however, this was not observed. Finally, children's performance within chains was very different from children who did not witness models in most cases. The fact that three

pairs in the no-model control condition were able to reproduce similar behaviours in the double tube task may indicate that the design of the task could have induced a specific combination of actions. However, the other pairs who engaged with the tasks in the same condition were not successful.

An interesting additional finding was the effect of tasks' presentation order on children's performance. All the tasks had lower scores in all categories (reproduction, transmission, and coordination) when presented first to the pairs, but the scores increased when they were presented in the subsequent orders. Hence, children improved their performance over time across all tasks, regardless of which type of task. Hence, this "cumulative" effect of performing cooperative tasks in sequence provide indirect evidence that engaging children in previous potentially collaborative interactions, even without models and without instructing them to cooperate, can induce them to be more cooperative in subsequent interactions (Cortes Barragan & Dweck, 2014).

The majority of communicative attempts were made by children in the no-model control condition, which is interesting given the prominent role of communication in both human social learning and coordinated cooperation (Csibra & Gergely, 2009; Eckerman & Peterman, 2004). However, this might be explained by the fact that when children jointly observe a model, they may establish common ground in their understanding of the task, reducing the need for explanation (Bohn & Köymen, 2018). When there is no model, it requires greater communication between the children in the dyad to establish the goals and procedures of the task. Nevertheless, although children within chains communicated less than children who did not witness models, around half of the communicative attempts between the former involved engaging their partners.

There were only a few instances that indicated that some children did not understand or were not concerned with the role of their partners. In these situations, the children either failed to help their partners to complete the task or attempted to perform the task alone. Sometimes, after having one or two unsuccessful attempts at the task, a pair would stop performing or would change the game. In one pair, one child resumed or continued the activity in two of the games (double tube and handles task) without trying to re-engage the partner. The variations reported above may be an indication that these children were more interested in the outcomes of the task, rather than the actions, which may be related to children's perception of their partners' role and their coordination skills. Future studies could investigate this relationship further and its impact on children's cultural learning by adopting the experimental paradigm proposed in the present study.

This study has a few limitations. First, the sample size is small in terms of number of participants, and the sample is restricted to English children from one small region. However, the number of observations provided enough data for the analysis with regards to our sample, albeit providing limiting generalization to other groups of children. Second, the study lacks additional control conditions that could provide additional evidence for the claim that children are effectively imitating cooperative actions. For instance, a two-action design (McGuigan, Whiten, Flynn, and Horner, 2007) could have helped disentangle the influence of the models actions versus the tasks' outcomes on children's copying. We thus regards this evidence as preliminary and encourage other researchers to try to replicate it with bigger and more diverse samples, and including other experimental controls and treatments.

This study has relevant implications for the experimental study of the social learning of cooperation in humans. By comparing different types of tasks, we were able to investigate whether the tasks' goals or actions would affect children's reproduction of cooperative actions

with an equally naïve partner. By adopting diffusion chains of collaborative actions, we aimed to partially replicate how children learn in their natural social environment such as nurseries or schools. However, most of this research, this study included, has been done with children from Western middle-class families (Nielsen et al., 2017). Alternatively, research with children from rural and traditional populations have found that they engage more often in collaborative tasks with other children and adults (Clegg & Legare, 2016; Nielsen et al., 2016; Rogoff, 2003). Future studies can address whether children from other cultures and socio-economic groups will behave similar to the children tested in similar settings. Nevertheless, we speculate that children from other cultures might show an even higher level of fidelity in the imitation of collaborative tasks.

It has been argued that the ability to copy actions with a high level of fidelity and to keep them preserved across generations within groups is an essential component of human cultural evolution (Tomasello, 2014), together with the cumulative changes brought by innovations. Less has been said and tested about the spread of traditions within the same generation, especially regarding children's development and learning of essential cooperative skills to keep traditions in place, although conformity has recently received much attention in the study of children's imitation of peers and its relationship to cultural transmission (Claidière & Whiten, 2012; Coultas & van Leeuwen, 2015; Tomasello, 2016). To our knowledge this study is the first to combine different elements of cultural transmission-focused and cooperation-focused experimental paradigms, in an effort to understand how these processes are connected and their role in child development.

In conclusion, this study suggests that cooperation between young children may be "infectious", in the sense that it only requires a couple of observations for children to copy peers in several collaborative tasks, and in that this greatly increases children's success in

coordinating actions when compared to children who do not witness models. It thus provides experimental evidence that directly links children's early peer imitation and coordinating skills to the transmission of coordinated actions, through the process of observation. Moreover, it shows that faithful imitation is predominant regardless of whether these actions aim to solve joint problems or to play a social game, and whether children are performing similar or complementary actions.

Supplementary Information

Table 1

Model comparison for reproduction (imitation) scores

	Full model			Reduced model		
	Odds Ratio	*CI*	*p*	*Odds Ratio*	*CI*	*p*
Fixed Parts						
(Intercept)	4.40	0.70–27.86	.115	4.46	1.31–15.20	.017*
Task (elevator)	3.06	0.74–12.62	.122	3.08	0.75–12.68	.120
Task (handles)	0.28	0.09–0.88	.029*	0.28	0.09–0.88	.029*
Task (trampoline)	0.06	0.02–0.20	<.001*	0.06	0.02–0.20	<.001*
Task order (2)	6.33	1.97–20.33	.002*	6.29	1.97–20.11	.002*
Task order (3)	5.63	1.68–18.83	.005*	5.61	1.68–18.75	.005*
Task order (4)	5.06	1.52–16.80	.008*	5.00	1.51–16.57	.008*
Model position (2)	1.23	0.21–7.27	.820			
Trial (2)	0.87	0.41–1.82	.705			
Age (4 years-old)	1.04	0.17–6.54	.967			
Gender (female)	0.92	0.32–2.66	.882			
Random Parts						
τ00, Pair		2.370			2.423	
τ00, Group		0.000				
NPair		16			16	
NGroup		8				
ICCPair		0.419			0.424	
ICCGroup		0.000				
Observations		256			256	
AIC		227.625			217.848	

Note. Groups in the no model control condition were excluded from this analysis.

Table 2

Model comparison for transmission scores

	Full model			Reduced model		
	Odds Ratio	*CI*	*p*	*Odds Ratio*	*CI*	*p*
Fixed Parts						
(Intercept)	0.05	0.01–0.36	.003*	0.04	0.01–0.27	<.001*
Task (elevator)	0.38	0.14–1.06	.064	0.39	0.14–1.06	.065
Task (handles)	0.06	0.02–0.18	<.001*	0.06	0.02–0.18	<.001*
Task (trampoline)	0.01	0.00–0.05	<.001*	0.01	0.00–0.05	<.001*
Task order (2)	2.76	0.93–8.20	.068	2.75	0.92–8.18	.069
Task order (3)	7.71	2.56–23.23	<.001*	7.75	2.57–23.39	<.001*
Task order (4)	10.11	3.15–32.45	<.001*	10.14	3.15–32.61	<.001*
Model position (1)	491.84	47.04–5142.18	<.001*	518.81	49.12–5479.97	<.001*
Model position (2)	195.36	20.09–1899.93	<.001*	206.40	21.32–1998.11	<.001*
Trial (2)	0.95	0.49–1.81	.868			
Age (4 years old)	1.06	0.23–4.85	.938			
Gender (female)	0.84	0.35–2.07	.712			
Random Parts						
τ00, Pair		1.102			1.213	
τ00, Group		1.945			1.931	
NPair		24			24	
NGroup		16			16	
ICCPair		0.174			0.188	
ICCGroup		0.307			0.300	
Observations		384			384	
AIC		295.576			289.747	

Table 3

Model comparison for coordination scores

	Full model			Reduced model		
	Odds Ratio	*CI*	*p*	*Odds Ratio*	*CI*	*p*
Fixed Parts						
(Intercept)	0.01	0.00–0.14	<.001*	0.01	0.00–0.12	<.001*
Task (elevator)	0.54	0.18–1.60	.267	0.55	0.19–1.64	.285
Task (handles)	0.16	0.05–0.50	.002*	0.16	0.05–0.51	.002*
Task (trampoline)	0.02	0.00–0.07	<.001*	0.02	0.00–0.07	<.001*
Task order (2)	10.45	2.81–38.81	<.001*	10.31	2.77–38.39	<.001*
Task order (3)	12.55	3.52–44.76	<.001*	12.71	3.55–45.51	<.001*
Task order (4)	24.30	5.91–99.95	<.001*	24.61	5.95–101.80	<.001*
Model position (1)	498.18	29.62–8379.86	<.001*	602.75	31.83–11413.93	<.001*
Model position (2)	2098.64	86.10–51152.13	<.001*	2576.87	94.85–70007.37	<.001*
Action order (2)	1.22	0.60–2.47	.588			
Age (4 years-old)	1.54	0.28–8.64	.621			
Gender (female)	0.67	0.25–1.81	.430			
Random Parts						
τ00, Pair		4.691			5.293	
τ00, Group		0.000				
NPair		24			24	
NGroup		16				
ICCPair		0.588			0.617	
ICCGroup		0.000				
Observations		384			384	
AIC		265.888			259.062	

Table 4

Cohen's kappa test results for inter-rater agreement

Type of scores/Task	Rater 1 – Rater 2			Rater 1 – Rater 3		
	κ	*p*	% of ag.	κ	*p*	% of ag.
Coordination scores						
Double tube	.731	.000*	94%	.669	.000*	93%
Elevator	.864	.000*	97%	.448	.000*	73%
Handles	.597	.000*	92%%	.474	.000*	80%
Trampoline	.[b]	.[b]	100%	.924	.000*	95%
Reproduction of actions						
Double tube	.[b]	.[b]	100%	.[a]	.[a]	92%
Elevator	.[a]	.[a]	96%	-.034	000*	79%
Handles	.[a]	.[a]	89%	.[a]	.[a]	79%
Trampoline	.571	.002*	79%	.750	.001*	92%
Reproduction of outcomes						
Double tube	.[b]	.[b]	100%	.[a]	.[a]	94%
Elevator	.[b]	.[b]	100%	.[a]	.[a]	94%
Handles	.[b]	.[b]	100%	.[a]	.[a]	97%
Trampoline	.[b]	.[b]	100%	.613	.001*	81%
Transmission of actions						
Double tube	.636	.014*	94%	.630	.002*	93%
Elevator	.[b]	.[b]	100%	.754	.000*	93%
Handles	.341	.044*	83%	.545	.000*	80%
Trampoline	.620	.000*	83%	.900	.000*	95%
Transmission of outcomes						
Double tube	.[b]	.[b]	100%	.625	.004*	93%
Elevator	.[b]	.[b]	100%	.692	.000*	90%
Handles	.[b]	.[b]	100%	.925	.000*	98%
Trampoline	.[b]	.[b]	100%	.700	.000*	85%

Note. Exact *p*-values. % of ag.: Percentage of agreement between raters.

[a]No statistics were computed because one or both variables were constant.

[b]No statistics were computed because there was 100% agreement between the raters.

Chapter IV

Do children copy others in a collective social dilemma?

This chapter is an empirical study investigating whether children copy social information from peers in a collective social dilemma, and whether they prefer payoff- or majority-biased information. This chapter will be submitted for publication.

The authorship will be as follows:

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Introduction

Cultural transmission and cooperation are considered to be two of the most relevant factors influencing human's successful adaptation to a wide range of environments (Richerson et al., 2003). Cultural group selection theory has proposed that similar levels of cooperation within groups are supposed to be maintained by the cultural transmission of social norms (Guzmán et al., 2007; Henrich, 2004). Therefore, while human groups remain genetically similar, they exhibit remarkable cultural and social differences across the world, even when inhabiting the same territory (Richerson & Boyd, 2008). Moreover, groups with more cooperative members will tend to outcompete other groups, with less cooperative members.

The cultural transmission of norms is mediated by selective social learning (Boyd & Richerson, 1988; Henrich & McElreath, 2003; Laland, 2004). For social learning to be effective, people need to know whom they should copy to be successful (Wood, Kendal, & Flynn, 2013b; also when to copy: see Laland, 2004). *Conformity bias* is one of the proposed social learning biases that may have stabilised cooperation within human groups while keeping differences between groups (Henrich & Boyd, 2001). It is defined as a disproportionate individual propensity to acquire the most frequent behaviour in a group (Coultas & van Leeuwen, 2015). By copying the majority, the individual has greater chance of indirectly adopting a successful behaviour, especially in the absence of any other reliable information about the environment.

The evidence for conformity bias has been observed in children as young as two years (Haun & Tomasello, 2011). From three years, children conform to peers and adults in a variety of situations; for example, children tend to follow the majority's judgement against a dissenter when labelling unfamiliar objects (Corriveau, Fusaro, & Harris, 2009; Fusaro & Harris, 2008). They also follow the majority when copying instrumental and conventional

actions (Burdett et al., 2016; DiYanni, Corriveau, Kurkul, Nasrini, & Nini, 2015; Flynn & Whiten, 2012; Haun et al., 2014; Herrmann, Legare, Harris, & Whitehouse, 2013; McGuigan & Burgess, 2017; McGuigan & Robertson, 2015; Turner, Nielsen, & Collier-Baker, 2014; Whiten & Flynn, 2010; Wilks, Collier-Baker, & Nielsen, 2015). Even in the presence of unambiguous stimuli (e.g. lines of different sizes), roughly a third to a half of children will tend to eschew their own judgement and follow the majority's statements (Bond & Smith, 1996; Corriveau & Harris, 2010; Haun et al., 2014; Haun & Tomasello, 2011; Walker & Andrade, 1996).

Children can conform to the majority as a form of social coordination or shared experience (Grueneisen et al., 2015; Nielsen & Blank, 2011), and due to social pressure (Haun & Tomasello, 2011; Haun et al., 2014). For instance, McGuigan and collaborators (McGuigan & Burgess, 2017; McGuigan & Robertson, 2015) asked children to witness a model performing an efficient method to open a puzzle box and a majority of four models performing unnecessary (thus, inefficient) actions to achieve the same goal. Children copied the inefficient actions displayed by the majority even when they had performed the efficient actions previously. However, children stopped copying the unnecessary actions once the models were absent, indicating that there is a social motivation behind children's conformist strategies (Over & Carpenter, 2013; Uzgiris, 1981).

Another type of bias that affects children’s social learning is the *payoff bias*, that is, a tendency to copy successful individuals. Children prefer to copy more competent, reliable or proficient models, which are all indications of success (Brody & Stoneman, 1985; Burdett et al., 2016; Koenig & Harris, 2005; McGuigan & Robertson, 2015; Wood et al., 2013b; Zmyj, Buttelmann, Carpenter, & Daum, 2010). Successful, prestigious or high-status individuals provide indirect information regarding which strategies are more effective (McGuigan, 2013;

Mesoudi, 2011; Wood et al., 2013b). Biases towards copying these individuals also could have facilitated the evolution of cooperation in certain circumstances, when combined with altruistic punishment and conformist learning (Guzmán et al., 2007; Henrich & Boyd, 2001).

Burdett et al. (2016) and Wilks et al. (2015) compared children's performance in different tasks after witnessing successful individual models versus a majority. Burdett et al. (2016) tested whether 4- to 7-year-old would copy an expert or a consensual majority in tasks across instrumental and normative contexts. Instrumental contexts provide information about what works best in a situation; for example, what is the best tool to solve a problem. While normative contexts provide information that facilitate social relationships; for example, what rituals are followed in a specific group. Children trusted *either* a more competent model or a majority consistently across both contexts. However, they did not explicitly compare a successful model to an unsuccessful majority. In Wilks et al. (2015), 4- and 5-year-olds watched a model or a group demonstrate how to open novel puzzle boxes, and found that the children copied both the majority and a successful individual in opening the boxes, but they preferred to copy the successful individual over a clearly unsuccessful majority.

The early emergence of both payoff and conformity biases show that children are very sensitive to social influences that affect the transmission of culture (Chudek, Brosseau-Liard, Birch, & Henrich, 2013). In this study we compared the influence of both biases on children’s cooperative behaviour in an experimental economic game, the public goods game. Our study contributes to a growing literature about children’s early cooperative tendencies (see Tomasello, 2014, for an overview), with a focus on sharing behaviour and the development of a sense of fairness (McAuliffe, Blake, et al., 2017). Understanding how these cooperative tendencies are mediated by social learning mechanisms can help us decipher how children’s actions vary in cooperative contexts.

The public goods game is a simulation of a social dilemma in which people are asked to decide whether and how much they would like to invest in a common-pool resource, with the prospect of increasing their rewards if everyone collaborates (Kollock, 1998). The players commonly have access to some information about the other players' strategies, but not necessarily their identities. In fact, a relevant aspect of these experiments, either with adults or children, is that the decisions are anonymous. Moreover, it is often not possible to exclude or punish those who do not contribute to the pool and end up with more rewards than the others, hence the dilemma. Thus, relevant variables that affect public behaviour are completely or partially removed in these experiments, such as reputation concern, reciprocity, social pressure and other potential sources of model bias (e.g. familiarity, dominance, popularity, and age).

When people play this game multiple times, the donations tend to decline over time. The initial cooperation of some of the players was explained as a cooperative strategy: when faced with other players' defection, the cooperators withdraw their donations to punish the other and keep their rewards. Recently, Burton-Chellew, Nax, & West (2015) argued that this typical trend of decline is due to learning factors and payoff biased learning rather than any cooperative preferences. Thus, people generally start by making greater donations at the beginning as a strategy to obtain more rewards, and reduce them gradually as it becomes clear that successful individuals cooperate less (Burton-Chellew, El Mouden, & West, 2017).

Lamba (2014) proposed a way to test whether the players in a public goods game are using the information from other players to adjust their cooperative strategies or to increase their payoffs. Based on the assumption that people acquire cooperative strategies through social learning, Lamba (2014) tested whether adults from a forager-horticulturist society, the Pahari Korwa of India, would adopt different types of social information to make decisions in

a public goods game. She predicted that, if models of cultural group selection were correct, the participants from the same village would employ similar cooperative strategies. By adopting social learning strategies, anonymous individuals would be able to adopt similar norms of cooperation. She tested groups of 14 villages from the same ethnic group but subjected to different demographic conditions. The behaviour of the participants in the game was determined mostly by the circumstances in which they lived and she did not find any significant tendency to copy the behaviour of the majority or towards copying the most successful players.

Experimental economic games have been successfully adopted with children (Gummerum et al., 2008), but there are only a few studies that focused on children playing public goods games (Alencar et al., 2008; Blázquez & Chaverri, 2014b, 2014a; Dutra et al., 2018; Harbaugh & Krause, 2000; Silva et al., 2016; Vogelsang et al., 2014). Moreover, only one study addressed social learning indirectly in a public goods game, with negative results. Cipriani, Giuliano, and Jeanne (2013) tested whether African and Hispanic American parents transmitted prosocial actions to their children, by assessing whether the parents' and the children's separate decisions in the game were correlated. The children, however, had no access to the parents' decisions. To our knowledge, no study explored the social learning of cooperation in public goods games between children.

In our study, we aimed to investigate the adoption of different types of social information by children in a public goods game. Six- and 7-year-olds were tested because this is the earliest age at which children clearly understand the rules and structure of a public goods game (Dutra et al., 2018; although see Vogelsang et al., 2014 for a variation with 4-year-olds). Around this period, children had already developed a reputation concern and group affiliations, but they will progress to more sophisticated social strategies only after 8 years

(Engelmann & Rapp, 2018; Sparks, Schinkel, & Moore, 2017). Hence, at the age of 6 and 7 years children might behave differently from older children and adults in a similar experimental setting.

We were also interested in comparing the decisions of children from different social backgrounds. Socio-economic status (SES) affects humans' social and cognitive development across a variety of domains. People of lower SES seem to be "more impulsive, less future-oriented, and more pessimistic about their futures" than people of higher SES (Pepper & Nettle, 2017, p. 3). However, while children from lower SES backgrounds recently have been shown to donate less than children from higher SES backgrounds across experimental social dilemmas or windfall sharing tasks (Benenson et al., 2007; Rochat et al., 2009), earlier studies found no consistent influence of SES (Eisenberg & Mussen, 1989).

In our study, the children had to decide how much to donate to their group as an investment, risking losing their rewards in the short term. Children received the information about others' performance from a third party (an experimenter) and were required to make their decisions anonymously. If the evolutionary theories of social conformism are correct (e.g. Coultas & van Leeuwen, 2015), we would predict that children would show greater conformism, given it would provide social information about the behaviour of the group, and children could use it to collaborate with their peers in the game. Conversely, if alternative theories of self-interest and payoff learning are true (e.g. Burton-Chellew et al., 2017), then children would prefer to copy the information of the most successful players. We had no specific predictions regarding the effects of SES on children's copying of the social information. However, we predicted that children of lower SES would choose to donate lower initial amounts than children from higher SES.

Method

Participants

Participants were 53 Brazilian children between six and seven years (M = 6.71±SD = 0.65; 27 girls), recruited in two primary schools, in the city of Natal. The parents were provided with information about the study and asked to sign an informed consent form if they agreed to participate, and their children were verbally asked whether they would like to play a game. The children were also told they could stop participating at any time. This study was approved by the ethics committee from the Federal University of Rio Grande do Norte (project title in Portuguese: “Aprendizagem social entre crianças em um jogo de tomada de decisão”; CAAE: 51046015.7.0000.5537).

Children came from families of lower to upper-middle socio-economic status. We recruited samples from one public and one private school. In Brazil, private schools enrol 39.2% of children from families of the top 20% of the income distribution, while the public schools enrol 39.5% of the bottom 20% of the same distribution (Instituto Brasileiro de Geografia e Estatística, 2014). The schools were therefore used as an indirect measure for socio-economic status.

The Public Goods Game (PGG)

Each child received five paper pretend notes of five *Reais* (the Brazilian currency) and s/he was asked to decide anonymously how many notes s/he would donate to a group of which s/he was a member. The amount donated by the children in the same group was then multiplied by two and distributed equally among the group members, regardless of the amount donated individually. These values were decided based on previous studies of public

goods games with children and adults (e.g. Harbaugh & Krause, 2000; Lamba, 2014). The game is designed to make cooperation profitable if everyone contributes, but there is also the temptation to cheat (i.e. invest less than others) and increase one's individual payoff. Conversely, if everyone decides to donate nothing, all the players are worse off.

Experimental Procedure

The experimenter initially addressed the children collectively and invited them to play a game. Once the children accepted, they received instructions about the game. The children were told that they would play a game with other five children, in which they could win points. Then, the children were told that they would receive two envelopes, one white and another orange, and five pretend notes. They were instructed to choose how many of their notes (zero to five) they would like to donate to their group of six players, then to put the chosen amount inside the white envelope (or leave it empty), to close the envelope, and to deposit it inside a sealed plastic box with an opening on the top of it. The children were also told that the box was "magic", and that they could win more or less notes back, depending on how much they and their group donated. They were told that the box would be opened after the game, and that for each note they gave to their group, the group would get one additional note. Then, they were told that the notes would be counted and distributed evenly among the group members. Finally, they were instructed to put the notes they kept for themselves in the orange envelope, and to keep their donation a secret from other children, otherwise the game would not work. Children were repeatedly told their decisions were anonymous to everyone, including the experimenters.

Then, each child was called separately to another room, where another experimenter instructed the children again, this time individually, and asked them to explain the rules to the

experimenter as a measure of understanding. If the child had not understood the rules, the experimenter repeated the instructions and asked the child to explain them again. A child was only allowed to participate if s/he understood the rules; one participant was excluded because he failed to explain the instructions back to the experimenter. The helper then gave the notes and envelopes to the child, and asked the child to go behind a cardboard panel and make a decision (see Figure 1).

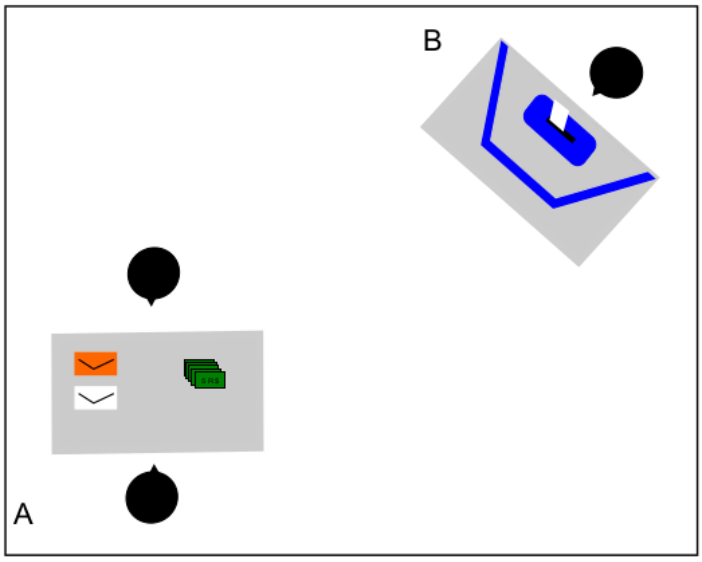

Figure 1. Diagram depicting: the experimenter providing the instructions and materials to the child (A); and the child inserting her donation in a blue box behind a blue panel (B).

In the second round (PGG2), the instructions were repeated, both collectively and individually. The groups in PGG2 were reconstituted, so children were told that they would play the game with a different group (this was done to prevent any effects from reciprocity). Additionally, they were informed individually that they would have access to two types of information from PGG1, before making their decision: the contribution of the majority of the group (modal contribution, MC), and the contribution of the players with the best payoffs (highest earner's contribution, HEC). The experimenter also showed the number of notes

corresponding to each contribution (MC and HEC), and provided the information regarding the MC and HEC in counterbalanced order across participants.

For each group within both rounds, the children's donations were counted, multiplied by two, and divided among the participants. The children only received their rewards from both rounds after the experimental session was finished, to avoid children's inference about the other player's strategies (other than the MC and HEC) by, for example, comparing their rewards at the interval between the sessions.

Due to the number of children recruited, they could not always be split in groups of six. Thus, children were split in anonymous groups of three to six, although they were led to believe they would always play with other five players. Because the decisions were individual and separated, they could not possibly know how many children were in their group. If the individual amount donated by the majority, the MC, was equivalent to the amount donated by the player with the highest payoff, the HEC, then the MC was replaced by the most frequent amount donated among the groups tested. And finally, when there was more than one MC, the highest amount was chosen as information.

Coding, data preparation and analysis

The coding and analysis were adapted from Alencar et al. (2008) and Lamba (2014). Individual donations were counted for both rounds. Donations were purportedly anonymous to the participants, but the experimenters put a discreet code inside each envelope to identify individual donations, after removing the envelopes from the box (as in Alencar et al., 2008). The envelopes were open, and each amount donated was assigned to the identified code of each player in a spreadsheet. After counting the donations for each group, the experimenters

separated the amount donated by the majority (MC) and by the most successful player (HEC), providing this information to the players in the second round.

For each group, the HEC and the MC were calculated (and the MC value was adjusted whenever applicable, as explained above). To investigate whether children chose to copy the HEC or the MC, the players were grouped in three sets, according to whether they donated the same amount as the MC, the same as the HEC, or a different amount from both the MC and the HEC, in PGG1. Then, for each set of players, children's decisions were further categorized regarding: a) whether they changed their donations from the first to the second round (PGG2), and b) whether they were biased towards the HEC (payoff biased), the MC (conformist) or none of them (see Table 1).

Table 1

Groups of players for analyses.

Round	Criteria for selection	Group
PGG 1	Donated the smallest amount (Highest Earner Contribution, HEC)	Coordination with HEC
	Donated the same as the majority's (Modal Contribution, MC)	Coordination with MC
	Donated differently from HEC and MC	Coordination with neither HEC or MC
PGG 2	Changed donations in direction to HEC	Payoff biased
	Changed donations in direction to MC	Conformist
	No trend in donations towards either HEC or MC	None (no bias)

To establish whether children were biased towards either social information (HEC or MC) or neither, we calculated the absolute difference between the children's donations in each round and the HEC, and subsequently calculated the difference in these values between both rounds (|PGG1 – HEC| - |PGG2 – HEC|). The same was done to calculate the bias towards the MC (|PGG1 – MC| - |PGG2 – MC|), and each group of scores were calculated for each set of players as specified in the previous paragraph. This equation provided the number of players who were biased or not towards the HEC or the MC (adapted from Lamba, 2014). Positive numbers indicated children's bias towards the HEC or the MC, and negative numbers indicated no particular bias towards the HEC or the MC. The number zero in the calculations indicated no change in children's decisions across both rounds. When there was no change in children's decisions, but they donated the same as the HEC or the MC in both rounds, they were considered biased towards the HEC or the MC in the PGG2, respectively. When there was no change in children's decisions, but they donated differently from the HEC and MC in both rounds, they were considered without any particular bias.

Results

Did the social information provided affect children's contributions in PGG2?

The variances of children's contributions in both rounds were similar, although the donations decreased over time (from M = 9.34, SD = ±6.65 in PGG1 to M = 8.49, SD = ±6.76 in PGG2). The children's contributions did not differ significantly between rounds (Z = -.559, p = .576, r = -.077).

Given that the HEC and the MC were presented simultaneously, stepwise backwards multinomial logistic regression models were fitted to assess whether either information

provided affected children's decisions from one round to the other. The full model was fitted with the following variables: MC, HEC, whether children donated the same as the HEC or MC (i.e. coordination with HEC or MC), and the children's sex. The response variable was the difference between the donations in both rounds, categorised by whether children decreased, increased or did not change their donations. For this model (the full model), the variables sex and children's coordination with HEC or MC significantly predicted the children's decisions.

A second model was fitted with both variables (sex and coordination), and only the coordination with HEC or MC remained significant. A third model was then fitted, only with the coordination variable, which also showed that this variable significantly predict children's decisions (coordination: $\chi^2(4) = 15.475$, $p = .004$; sex: $\chi^2(2) = 5.790$, $p = .055$). The full model and the second reduced model were not significantly different from each other ($\chi^2(10) = 12.844$, $p = .233$), as well as the second and the third ($\chi^2(2) = 5.7890$, $p = .055$). However, the AIC was smaller for the second reduced model, compared to the others and, therefore, it was chosen as the best model to predict the response variable (full mode AIC: 117.1304; second model AIC: 109.9744; third model AIC: 111.7639).

Least-squares means (Lenth, 2016) were calculated to assess the influence of the coordination with the HEC, MC or none of them, on the children's change in their decisions in PGG2. For children who were coordinated with HEC, there was a significant difference between children who decreased their donations and children who increased their donations ($t(8) = -3.984$, $p = .011$), and children who did not change their donations ($t(8) = 3.527$, $p = .019$; see Figure 3). That is, children were either likely to stay with their original choice or increase their donations in PGG2 if they had donated in line with the HEC in PGG1. The modal response of children in other categories in PGG1 was to reduce donations in PGG2.

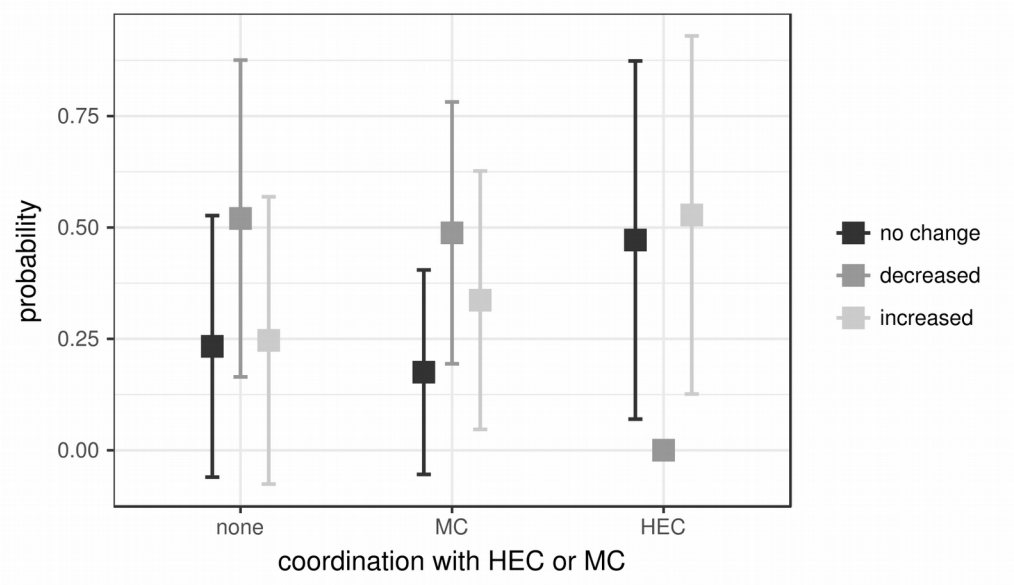

Figure 3. Probability of change in children's decisions regarding how much to donate in PGG2 (whether they decreased, increased or did not change their decisions), grouped by their coordination with the social information in PGG1 (whether they donated the same as the HEC, the same as the MC, or different from either of them).

Were children biased towards the payoff or the majority in PGG2?

A full multinomial logistic regression model was fitted with the same predictors as above (HEC, MC, coordination with HEC or MC, sex, and school), but with a different response variable: whether children were biased towards the HEC or the MC, or showed no bias. Coordination with either HEC or MC and the MC of the groups significantly predicted the response variable. A second model (reduced model) was fitted, with both coordination and the MC, but only coordination had a significant effect. Then a third model, only with coordination as the predictor variable was fitted, and again it had a significant effect ($\chi^2(4) = 11.367$, $p = .023$). All models were not significantly different from each other (full model versus second model: $\chi^2(6) = 6.322$, $p = .388$; second model versus third model: $\chi^2(6) = 10.747$, $p = .097$). Therefore, the third and simplest model was chosen, which also had the

smallest AIC (full model AIC: 120.457; second model AIC: 114.7791; third model AIC: 113.5257).

Least-squares means were calculated to assess the influence of the coordination with the HEC, MC or none of them, on the children's bias in PGG2. For children who were coordinated with the HEC, there was a significant difference between children who showed no bias and children who were payoff biased ($t(6) = -3.337$, $p = .036$) and children who were conformists ($t(6) = 3.893$, $p = .019$, see Figure 4). That is, children who had the greatest payoff in PGG1 were inclined to be biased towards either the majority (MC) or the HEC, in comparison to the other categories that showed no significant bias.

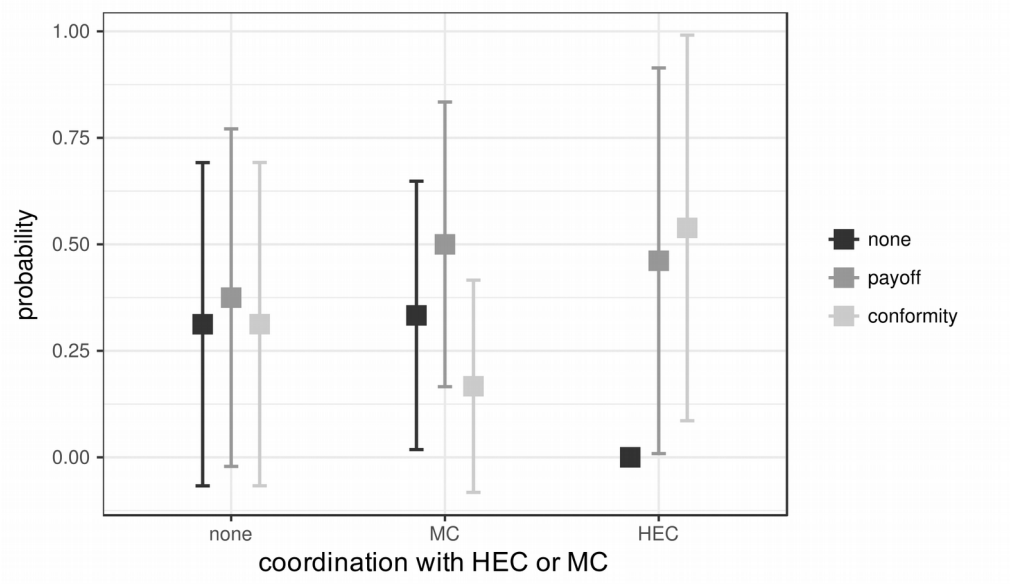

Figure 4. Probability of bias towards the payoff, the majority (conformity) or no particular bias (none) in PGG2, grouped by their coordination with the social information in PGG1 (whether they donated the same as the HEC, the same as the MC, or different from either of them).

Discussion

This study provided no evidence of either an effect of conformity in promoting co-operation or an effect of payoff bias in a public goods game (PGG) with children, nor any effects of socio-economic status on children's decisions. Although children made smaller contributions over time, the variances of the contributions were very similar between both rounds. Furthermore, although some children decreased their donations, there seems to be no particular trend towards copying the highest earner's payoff.

To assess whether children were effectively copying the information provided, we looked into whether there were any differences between children who were the highest earners or part of the majority in the first round (as in Lamba, 2014). A greater number of children who donated the same as the majority decreased their donations and showed a greater payoff bias. However, they did not differ significantly from the children who donated the same as the majority but subsequently increased or did not change their donations in PGG2. Interestingly, almost half of the children who were the highest earners in the first round increased their donations in the second. Thus, they showed some bias towards either the payoff or the majority, while none of the other categories (those who donated the same as the majority, and those who donated different amounts from the highest earners and the majority) did.

Previous studies have shown that children's imitation of others can have social motivation (Uzgiris, 1981; Over & Carpenter, 2013). Children's responses in public are more likely to match those of the majority than their private responses, or when the majority is absent (Corriveau & Harris, 2010; Haun & Tomasello, 2011; McGuigan & Burgess, 2017; McGuigan & Roberston, 2015; Nielsen & Blank, 2011). Other model biases can affect the children's behaviour when the models are present, such as the model's social status in the group and the relationship between the models and the observers (Haun et al., 2012; Wood et

al. 2013b). Children can also choose to follow others to maintain or improve their reputation in their groups (Engelmann, Over, Herrmann, & Tomasello, 2013). Hence, since the presence and identity of the models could affect children's decisions in such ways, we attempted to avoid these biases in this study by ensuring anonymity of the participants' and models' decisions. Thus, our findings show that children in these circumstances are not inclined, at least at first, to copy the majority.

Additionally, recently it has been argued that the typical trend of decline in donations in public goods games is due to learning factors and payoff biased learning rather than co-operative preferences (Burton-Chellew et. al, 2015). Thus, people start by making greater donations at the beginning as a strategy to obtain more rewards, and reduce them gradually as it becomes clear that they are better off by donating small or no amounts. Burton-Chellew et al. (2015) argued that people will vary their decisions in a public goods game until choosing what they considered as the best strategy. Future work could ask children for their reasoning supporting their decisions.

We predicted that the children could attempt to use the majority's information to co-ordinate with their partners, since communication between them was impossible. It seems likely, however, that children focused on individual strategies in the game, even though they were told that the outcomes would depend on the groups' performance. Anonymity, as well as the group's reconstitution between rounds and the short number of rounds, might have prevented any sort of group identification among the players.

It must be born in mind that studies with the public goods games usually have a greater number of rounds (ten on average). However, increasing the number of rounds could have led to confounding effects of children's daily contact with their peers (Dutra et al., 2018); that is, children would be able to exchange information about the games between

experimental sessions, and this factor would have made any conclusions regarding the lack of social information difficult to interpret. Moreover, Lamba (2014) used the same approach, with adult participants, to avoid the same potential problem: communication between rounds.

An important concern regarding decision-making studies with children is whether they are able to understand and remember the information provided to them. As explained in the Method section, we had manipulation checks in place for the public goods game, by asking the children questions about the rules of the game, and we followed Lamba (2014)'s protocol in presenting the amount donated by both the majority and the highest earner at the same time, while also illustrating the amounts with the fantasy notes. However, we could have added a memory check with regards to the social information (that is, the amount donated by the majority and the highest earner) presented. Thus, we cannot be entirely sure whether children were able to understand or accurately remember both options, and make their decisions in the second round based on that.

It would have been interesting to test whether the access to the social information available would affect the participants' behaviour differently over time. Also, evolutionary models of conformity, payoff bias, and cooperation in humans have proposed that conformity is effective when altruistic punishment is present (Guzmán et al., 2007; Henrich & Boyd, 2001). Conformist learning and punishment stabilize cooperation within groups, and conformists tend to be more successful in these groups than payoff biased imitators. Anonymity, while critical to avoid the effects of social pressure, reputation, and reciprocity in our study, obviously hinder the potential effects and consequences of conformity that are present in natural environments. An alternative approach could focus on manipulating different levels of information about other participants' identity and also giving the participants the option to punish other players (Fehr & Fischbacher, 2004).

An important contribution of this study is the recruitment of a diverse sample, Brazilian children from different social classes. There has been a great deal of criticism on sample bias in the study of human behaviour (Henrich, Heine, & Norenzayan, 2010; Nielsen et al., 2017). Similarities across cultures and social groups should be tested rather than assumed; however, we have not found any differences between children from different social classes (having school as an indirect measure). Future studies could explore these questions even further. For instance, by comparing groups from different social groups within the same country, and controlling for the effect of scarcity of resources, specially in early development (Pepper & Nettle, 2017).

To our knowledge, this study is the first to control for the effects of two types of social information on children's performance in a collective social dilemma. Moreover, our study provides additional evidence that children and adults behave similarly in public goods games, by focusing on individual strategies rather than conditional cooperation. It has shown that, in a public goods game, children do not increase their cooperation by conforming to their peers, and do not show any particular trend towards copying the social information available. Conformity may have a relevant role in the development of human cooperation and the evolution of cultural differences, but it does not seem enough to enforce cooperation in an anonymous social dilemma among children.

Chapter V

The antecedents of sharing: context, individual characteristics, and sociocultural environment

This chapter focuses on reviewing the literature on collaboration between children and discussing the variables that moderate children's sharing decision in collaborative contexts. This chapter will not be submitted for publication.

Introduction

Cooperation is often addressed as a general skill, across a variety of settings and techniques (Warneken, 2018). However, if cooperation is a strategy to obtain resources, it must be flexible and moderated by environmental cues. Here we discuss the recent literature about sharing between children in the light of Tomasello and collaborators' interdependency hypothesis (Tomasello et al., 2012). We put it in context within the traditional developmental psychology literature, and discuss the influence of potential moderating variables sharing after collaboration. Hence, in this review, we set out to look for the variables that moderate children's sharing decision in collaborative contexts. We argue that experiments with children must make sense of the context in which children's actions take place. Furthermore, we make a case for including more of these variables when looking into the development of sharing after collaboration.

Sharing, donation and allocation studies are numerous in developmental psychology and involve a variety of experimental methods and theories (Damon, 1977; Eisenberg et al., 2006; Gummerum et al., 2008). We define sharing as any decisions made by one or more individuals concerning the distribution of any items among themselves and others. That is, by this definition we exclude any studies involving children's decisions regarding the division of resources between others, in which the child acts as a third party judge. Therefore, we only consider sharing decisions where children might benefit directly from it. And finally, sharing might refer to common use (e.g. sharing a toy) or a clear division (e.g. allocation or donation of stickers).

The Interdependency Hypothesis

Humans communicate and coordinate to achieve joint goals, often by means of mutual agreements about how people should collaborate and ultimately share resources (Tomasello et al., 2005). The interdependency hypothesis states that human sharing skills have evolved in the context of obligate collaboration in foraging activities (Tomasello et al., 2012). Hence, collaboration was necessary for the acquisition of resources, which leads to the problem of how these resources would be shared between partners. This hypothesis argues that among early hominids, those who were better than other primates at collaborating with others and tolerated others proximity near food, fared better in specific environmental challenges that took place about 2 million years ago (Tomasello & Gonzalez-Cabrera, 2017). Tolerance of others acquiring a share of relevant resources may have helped to develop social norms to regulate the acquisition of resources in the group. In this context, it is predicted that humans should be more sensitive to rules of fairness when the resources are acquired in collaboration rather than independently. Also, they may show earlier dispositions to share resources according to these rules. Three-year-old children are able to share resources equally even when they have the opportunity to accumulate them, but only when they work together to get the rewards (Hamann et al., 2011; Warneken et al., 2011). Therefore, humans seem to develop a sense of fairness in tandem with their collaborative skills (Warneken, 2018).

We argue that, given the context in which collaborative skills likely evolved, young children will be sensitive to other environmental demands, complementary to social interactions, such as the resources available, the costs to obtain those resources, the social and cultural environment. Additionally, individual differences might also account for children's performance in collaborative interactions, determining who will get more resources, and how those will be distributed. We present in the following an overview of the evidence on the

influence of moderating variables on children's sharing decisions, and discuss the contribution of this evidence to an evolutionary developmental theory of human cooperation.

Children's sharing after collaboration

Young children take context into account when making decisions regarding the distribution of resources between two characters in a story who have worked together (Baumard, Mascaro, & Chevallier, 2012; Chai & He, 2017; Schäfer, Haun, & Tomasello, 2015). Three-year-olds are able to restore equity between partners and take effort into account, by giving more resources to the child who have worked more than the other, compared to controls in which children did an equal amount of work or no previous work (Baumard et al., 2012; Schäfer et al., 2015). This behaviour, however, seems to be sensitive to the wealth of the recipients and influenced by cultural norms. Three- and five-year-old Chinese children give equal resources to poor and rich children in collaborative tasks, while only three-year-olds give more to the poor children in non-collaborative contexts. The fact that older children took fairness in to account regardless of prior collaboration or not is at odds with previous findings with German children by (Paulus, 2014), in which five-year-old children in a similar experimental setting give more resources to the poor children, even in collaborative tasks. The authors interpret their findings through the cultural difference between China, a collectivistic society, and Germany, an individualistic society. In the latter, children might seek to compensate the inequality, while Chinese children understand that everyone must receive the same amount according to their contribution, regardless of wealth, therefore accepting inequality more often than German and other Western samples.

Three-year-olds share equally about 75% of the time, after pulling a board together to obtain the resources. This has been observed when resources were clumped together, and

when one child ended up with more resources than the other (Hamann et al., 2011; Melis, Altrichter, & Tomasello, 2013; Ulber, Hamann, & Tomasello, 2015; Warneken et al., 2011). It happens more often than after parallel work or no work at all. However, there is a remarkable lack of studies on sharing after actual collaboration investigating variations in the setup (e.g. number of and access to resources available, types of roles) or in children's characteristics (e.g. wealth, social class, culture).

Evidence about sharing behaviour in children usually comes from two groups of studies: the first involves third party decisions regarding hypothetical scenarios, in which the children act as judges. The second involves first party decisions regarding donation or distribution of resources, between the child and others (Eisenberg & Mussen, 1989). When it comes to the role of collaboration prior to sharing, researchers are interested in whether, and if so, how children will judge merit or effort (Damon, 1977). That is, do children monopolise resources, share equally, share according to each one's contribution, or share according to something else?

Damon and Killen (1982) investigated whether group discussion lead to children's moral reasoning improvement. Children were told stories in which a group of peers worked in parallel on a task (e.g. making beads or paintings) and received a quantity of rewards afterwards. Then children were asked a number of questions regarding the distribution of these rewards. Children were influenced by the interaction with their peers, but only those who engaged with others, accepting others' opinions or collaborating in the discussion. Children who disagreed or refused to engage with others' opinions had lower rates of changing their opinions.

Children's decisions and interaction with others might differ when they face a real situation. Children behave strategically from an early age, in relation to children's choice of

cooperative versus competitive strategies in games, when making decisions regarding limited resources (Charlesworth, 1996; Charlesworth & La Freniere, 1983; Kagan & Madsen, 1971, 1972; Madsen, 1967, 1971; Madsen & Yi, 1975). Charlesworth and LaFreniere (1983) presented four-year-old children with a toy called Movie-Viewer, which was basically a hand operated camera that allowed children to watch a short movie when looking through an entrance at one end of it. They adapted this toy to make it a cooperative game, in which the children needed to recruit partners to perform two roles (operate a light switch and crank the gears) while one watched the movie. The task also required that one of the children stayed as a bystander, waiting for his or her turn; hence the cooperative task was also a competitive one. They found that some children had more viewing time than others, and the children with the most viewing time were more dominant and active in the task, coordinating with the others and giving commands. Thus, cooperation may be a strategy to compete for resources, and young children have the skills necessary to coordinate their interests and those of the group, but with some children dominating their groups.

Children in of preschool and school age will sometimes compete in cooperative tasks when facing a potential conflict of interest, even if competing leads to failure (Kagan & Madsen, 1972; Madsen, 1967, 1971; Madsen & Yi, 1975). Consider for example, a task in which children are at the opposite sides of a board, and they have to coordinate their moves to get a marble inside an entrance (Madsen, 1971). However, they both have an entrance close to their side, and they have to decide to which entrance they will move the marble. If both pull the rope, the marble holder will collapse and the marbles will be lost. In general, North American children were observed to be more competitive and enjoy conflict more than Mexican children, with American-Mexican children showing an intermediate behaviour between cooperation and competition. Moreover, this difference increased with age. However,

there was also evidence from other cultures; children from South Korean, South Africa, India, and Malaysia, behaved similarly regarding competition.

Which variables moderate sharing in collaborative settings?

Moderating variables, such as individual differences, socio-economic status and culture, are often deemed secondary in evolutionary explanations of behaviour (Kline et al., 2018). While the search for general mechanisms and explanations to the evolution and development of behaviour is relevant to a general theory of human behaviour, it seems problematic to ignore the influence of these other variables, especially when the majority of developmental research published in top journals may be biased towards samples from North America and Western Europe (Nielsen et al., 2017). I present and discuss evidence regarding variables that moderate the development of sharing decisions in collaborative situations, some of which have been carefully investigated by developmental psychologists, but whose evidence are often overlooked or ignored in evolutionary accounts of cooperation between children. As it has been said, this choice does not constitute a problem in itself. However, as other authors are warning, the influence of these variables must be tested, rather than dismissed or assumed (Nielsen et al., 2017).

Children's prosocial behaviours can be affected by moderating variables in a variety of ways (Eisenberg & Mussen, 1989); here we are concerned here with two categories: the characteristics of the task, the individual differences and the influence of social and cultural environments. We argue that these characteristics must be confounding variables in the explanation of children’s behaviour in collaborative settings, and this brings implications to a general theory of evolution and ontogeny of human sharing.

The characteristics of the task: resources and effort

The evidence described above on children's sharing behaviour after collaboration has been promoted as a strong evidence of human's general tendency towards fairness and equity. However, it becomes necessary to test this hypothesis across a range of situations, to detail how humans are sensitive to environment demands regarding the distribution of resources. This is particularly relevant for an evolutionary perspective because modern humans and our close ancestors most likely evolved in changing environments. Hence, children should be attuned to physical and social cues from early on.

The first of these cues we would like to discuss is the type of resources involved in collaborative interactions. Recent experiments showing children's remarkable sharing skills in collaborative contexts usually adopt an even number of resources (e.g. 4), and given a random imbalance in the resources distribution (e.g. 3 to one child and 1 to another), they test whether children will restore equity or not. Other studies involving children's third party distribution of the products of collaboration or effort also adopt even numbers. However, despite children's ability to distribute rewards is clearly superior to other apes, there are many other situations in which the resources cannot be shared in equal parts by definition. One obvious case is when a child has an odd number of resources. A number of studies explored whether children choose to drop the "extra" rewards when they have this option. However, it is less common to assess what children do when this option is not available to them. Moreover, people would hardly drop extra resources in a real environment just for the sake of equality. Another case is when the resource is not something that can be easily divided, such as time. As explained above, Charlesworth and La Freniere (1983) found that young children will not share time in a task equally. However, one can argue that, regardless of time, children could have shown similar rates of enjoyment in the task. Another resource that can be shared with

relative low costs is knowledge or information. In collaborative settings, children are not only good at coordinating, but also share information with their partners (Dean et al., 2012). Therefore, it is relevant to test children for their preferences regarding the resources available, and also reflect upon different types of resources.

The second type of cues is the children's level of effort in a task. Warneken (2018) argues that mutualistic collaboration is likely a factor in originating children's sharing based on a sense of fairness. He bases his argument on the evidence that children are assessing the level of effort in a task, and judging merit based on that. Hence, when children restore equity in a collaborative task, they do so because they pay attention to the amount of work each person did. However, as we showed above, this does not necessarily happen. Thus, it seems necessary to consider the role that limited resources have on children's perception and management of effort in joint tasks.

Individual characteristics

In experiments of prosocial behaviour, individual differences are often downplayed in favour of explanation of general propensities across individuals and for particular settings. Conversely, the investigation of dispositional variables, related to individual characteristics, aim to explain general dispositions that emerge across a variety of circumstances (Eisenberg et al., 1996). It has been shown that prosocial behaviour is linked to certain personality and social traits. However, the relationship between these general dispositions, development, and children's behaviour in particular circumstances needs to be further explored.

Personality is considered the joint product of temperament traits and a person's experiences, while temperament is defined as the set of biologically based "individual differences in emotional, motor, and attentional reactivity measured by latency, intensity, and

recovery of response, and self-regulation processes such as effortful control that modulate reactivity" (Rothbart, 2007, p. 207). There are three main high-order dimensions of temperament: surgency or extraversion, effortful control , and negative affect. Surgency refers to the level of activity and affect. Effortful control refers to the level of self-control and attention skills. Negative affect refers to the level of negative feelings. Children with higher levels of surgency and effortful control, and lower levels of effortful control are predicted to show better prosocial skills.

Another measure of prosociality is social competence, which can be defined as the ability to establish successful social relationships (Chen & French, 2008). Contrary to temperament, social skills are expected to be influenced by social and cultural demands. Therefore, although it is predicted that children with higher scores in social competence tend to be more cooperative, this relationship will likely vary across different cultures and social contexts (Chen & French, 2008).

However, little research has investigated the effects of individual differences in temperament and social competence on children's prosocial behaviour in collaborative settings, where children must negotiate different perspectives (Endedijk et al., 2015). Although theories of the influence of dispositional variables on children's prosocial behaviour have generated hypotheses from a variety of measures, it is unclear how children with different characteristics will interact to achieve prosocial or collaborative goals together in controlled environments.

Socialization and family

Evidence on the influence of social preferences of parents on their children's prosocial behaviour is mixed (Bauer et al., 2013; Bryant & Crockenberg, 1980; Eisenberg et al., 2006;

Turner & Harris, 1984). Children with parents who practice altruistic acts usually are more prosocial, while children whose parents are inconsistent models (by preaching but not practising prosocial acts, for instance) tend to be less prosocial (Eisenberg & Fabes, 1998; Eisenberg et al., 2006). However, parents' influence might be confounded with other demographic variables, which makes it difficult to isolate this variable. For instance, children and adolescents with low-education parents tend to be more selfish (Bandy & Ottoni-Wilhelm, 2012; Bauer et al., 2013). This effect held even when age, gender, health, cognitive skills, and siblings composition were taken into account. The authors argue that their findings represent an evidence of socialization effects, but a more likely explanation is that those children are more selfish because they have fewer resources; hence, the resources' marginal utility are higher for them. Nevertheless, Bauer et al. (2013) also found that children with low-education parents were also weakly spiteful (that is, these children chose to minimise their partner's payoff in a dictator game, but only if they did not lose resources by doing it), which is harder to be explained by scarcity, albeit it does not contradict this explanation.

In the same fashion as research on temperament and social skills, research on parents' influence relies on reported measures, and observational studies. Evidence from controlled studies comparing parents and their children's behaviour in collaborative tasks is rare (e.g. Cipriani et al., 2013). Therefore, there is a need to investigate experimental hypotheses concerning children's collaborative skills and the influence of their parents on the former.

Social class

Socio-economic status or social class refers to the economic conditions in which people live, and their social status compared to others within their society. Socio-economic status is measured in a variety of ways; many developmental studies consider the family

income and parents' education, whilst others consider demographic indicators specific to each country, and others also infer it indirectly from people's locations and ways of living. Social class is predicted to affect children's prosocial behaviour. However, the majority of developmental research focus on children who are middle class. Children from lower classes are expected to accumulate or retain resources due to the context of scarcity in which they live; conversely, they can be more cooperative because they are expected to participate in domestic chores (Whiting & Whiting, 1975). However, children from upper classes were shown to be more prosocial in sharing windfall resources (Benenson et al., 2007; Rochat et al., 2009). Nevertheless, social class does not seem to be considered often, and even studies that have included social class as a variable describe their sample's characteristics superficially.

Culture

Childhood is a relevant phase in learning cultural norms, which involves much of learning how to behave towards other people. Culture also potentially interacts with all the factors described above (Eisenberg et al., 2006; Whiting & Whiting, 1975). However, as we argued before, much of the research on the development of cooperation between children assumed a universal pathway, common to all humans, and downplayed the effects of other variables such as culture and the social environment on the evolution and development of cooperative behaviours (Nielsen & Haun, 2016; Kline et al., 2018; Warneken, 2018).

Culture is the set of beliefs and practices shared by a group (Hofstede et al., 2010), and it can mediate the effect of social interaction on human development (Chen & French, 2008). For instance, families from individualist cultures emphasise the development of social initiative (that is, the ability to start relationships) and greater self-expression. People are also

stimulated to pursue personal goals and be more competitive (Knight & Kagan, 1981). Conversely, families from collectivistic cultures emphasise the development of self-restraint, instead of social initiative, and less self-expression. In this context, conformity to the group is highly valued. Nevertheless, cross-cultural comparisons of children's sharing in collaborative contexts are still incipient (Cipriani et al. 2013; Chai & He, 2017).

How to make sense of the effect and inter-relations of these variables?

Recent research on children's sharing in collaborative contexts laid the groundwork to a general theory of the evolution of human cooperation and culture, along with other studies on children's cooperative behaviours (McAuliffe, Blake, et al., 2017; Tomasello, 2018; Warneken, 2018). However, there are other potential explanations, and specifics of the theory that must be investigated, by considering the complexity of human variation (Kline et al., 2018). To make sense of other variables of interest, as the ones described in the previous sections, in an evolutionary developmental approach to human cooperation, a combination of different approaches is necessary (Carlo et al., 2001; Nielsen & Haun, 2016). Experimental studies could be performed in tandem with the assessment of other measures by naturalistic observations or reported measures from questionnaires. Cross-cultural comparisons could include a more thorough assessment of the sample's characteristics, including demographics and other potential confounding variables (see, for example, the samples' description in House et al., 2013's Supplementary Information).

Finally, limitations should be addressed regarding other potential explanations that could undermine or change specifics of the underlying theory that is being forwarded. For example, Lamba and Mace (2013) argued that cultural variation in norms of fairness may not necessarily reflect differences in transmission of cultural norms, but rather variations in local

demographics. Rochat et al. (2009) compared 3- and 5-year-old's decisions in donations across different social and cultural groups: three groups of Brazilian children (from middle-class, lower-class and very lower-class) were compared with each other and with children across other four countries with different levels of socio-economic status and environment. The Brazilian cohort provided a control for these cross-national comparisons. The authors found that children from traditional and small-scale rural societies were more inclined to share resources more equally, while Brazilian children from very lower-classes (children living in the streets) hoarded the resources at a similar rate than American middle-class children, and at higher rates than Brazilian children from the other two groups. Nevertheless, children across all the cultures tested showed a trend towards more fairness by 5 years of age, while showing differences regarding the magnitude of self-interest. Therefore, a comprehensive theory of human cooperation can only be build by recognizing the role of moderating variables and variation across human groups.

Conclusion

The distribution of resources is a puzzling subject because humans engage in this behaviour often, across different aspects of their lives even when it is costly for the individual who performs it. Moreover, human children show remarkable sharing skills from an early age. Nevertheless, humans are also strategic when making sharing decisions. Hence, to understand the development of the sharing behaviours and social norms that regulate those behaviours in more detail, it is important to understand how people come to equilibrate cooperative versus competitive strategies with peers and how the cultural and social milieu can affect these interactions across development.

We have argued here that recent studies that include collaborative tasks ignore or downplay other relevant variables such as cultural background, social class, social relationships, socialization practices, and even situational variables such as temperament and social skills. Recently, Kline et al. (2018) made a similar argument, regarding the use of culture as an explanatory variable in developmental theories. Quite often, culture and other moderating variables are seen as secondary in the explanation of human behaviour. This is problematic because the theory that underlies these studies seek to propose a general theory of human behaviour. Without testing alternative hypotheses regarding variation across different contexts, it is difficult to generalise.

To conclude, cooperative behaviours are a complex product of interactions between individual predispositions and life history, social influences, and the cultural background. It seems important to distinguish the investigation of general abilities, with potential to be universal across different environments, and the investigation of flexible strategies, that may also be universal or specific, depending on the variables involved.

This review focused on the discussion of the role of moderating variables on the development of cooperative behaviour. It attempted to propose a more integrated approach to the experimental investigation of the development of cooperative behaviour and the influence of these variables on this type of behaviour. On the one hand, experimental studies and the use of indirect measures, such as questionnaires, might be criticised for their limited external validity. On the other hand, the combination of different methods might bring new insights into the study of the development of human cooperation from an evolutionary perspective.

Chapter VI

The effect of unequal outcomes on sharing after collaboration between children: a cross-cultural comparison

This chapter is an empirical study investigating the effects of age, gender, socio-economic status, and culture on children's collaboration and sharing in a task with unequal outcomes. This chapter will be submitted for publication.

The authorship will be as follows:

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Introduction

Cooperation can be defined as a strategy for acquisition of resources (Green & Rechis, 2006) that, once acquired, must be shared according to specific norms (Damon, 1977). Sharing behaviour in humans probably evolved as a consequence of collaborative foraging and increased tolerance of others proximity and sharing of food (Tomasello et al., 2012). Hence, to ensure participation in collective actions, social norms were developed to enforce a fairly equitable sharing of resources among the group members. When the partners' interests are perfectly aligned and the resources can be shared equally, cooperation is easily promoted. However, this is often not the case; collaboration between humans can involve a variety of conflicts, especially when resources are scarce or when equal division is difficult.

Three-year-old children show a propensity to cooperate with others and share equally after collaborating with each other (Corbit, McAuliffe, Callaghan, Blake, & Warneken, 2017; Hamann et al., 2011; Warneken et al., 2011). Moreover, meritocratic sharing (that is, giving to each partner their share in proportion to their contribution to the work) after collaboration had been shown to occur in children as young as three and a half years old (Hamann, Bender, & Tomasello, 2014), and earlier than previously thought (Damon, 1977; Hook & Cook, 1979; Lerner, 1974). Hence, the equal sharing of items after collaboration may be the first expression of distributive justice among young children (Hamann et al., 2011).

Recent studies of sharing after collaboration between children consist of a task with unequal rewards (Hamann et al., 2011; Warneken et al., 2011). To restore equity, a child who ends up with most rewards may share one with his/her partner, a peer of similar age, after finishing the task. In these experiments rewards are placed at the middle of the apparatus, clumped or split in equal parts, with children at a similar initial distance from the rewards and having to perform similar, mirrored actions. Then, after both children coordinate to retrieve

the rewards, one reward slips accidentally towards one of the children, resulting in unequal share, that is one unit for a child and three units for the other. In these studies, children shared more often with a peer in the collaboration condition than in parallel work and in no-work conditions. We hypothesise that such conditions might have made it easier for children to restore equity, regardless of actively handing the rewards to the partner or taking it from the partner's dispenser, because the way the marbles are dispensed make it look like there is a malfunction in the apparatus.

The use of the distribution of unequal outcomes in sharing experiments is useful for two reasons: it induces a potential conflict of interest and it increases the costs of being cooperative. Experiments with unequal outcomes usually split an even amount of resources into unequal shares, as explained above. Another option is to provide an odd number of resources; when this happens, younger (three-year-old) children tend to keep a greater share to themselves, while older (five-year-old) children share the resources equally or keep a lesser share, regardless of whether children collaborated before to obtain these rewards (Handlon & Gross, 1959; Melis, Floedl, & Tomasello, 2015) or not (Rochat et al., 2009; Ugurel-Semin, 1952). To increase the potential conflict of interest in the experiment, we decided to investigate children's sharing behaviour in a collaborative task with unequal distribution of an odd number of rewards.

We wanted to test how children would solve cooperation problems when the factors described above are altered. Thus, we adopted the "marble run" task (adapted from Göckeritz et al., 2014, see description in the Methods section), in which children were asked to perform different but complementary roles in a collaborative task to win rewards (in this case, wooden marbles that could be exchanged for stickers). As in previous studies in the literature, we adopted a task in which collaboration was necessary to obtain any rewards, but one child

would be in the position of monopolising these rewards by reaching out to them first after both children had worked together. Moreover, given that the rewards were released further from both children, and by the experimenter, there was no possible indication of ownership or property prior to the release of them. Finally, this task provided an additional feature: children could lose the rewards while performing the task. Therefore, in addition to an odd amount of rewards, children could win different amounts based on their joint performance in the task.

Children's cooperative behaviours may be constrained by the availability of resources (i.e. rewards in a task), as well as by norms of their cultural and social group. Disadvantageous inequity aversion, that is the aversion to unequal distributions of resources among individuals in which the person receives less than the other, develops early in children, around five or six years of age (Corbit et al., 2017; Paulus & Moore, 2014). Aversion to advantageous inequality, in which the person receives more than the other, develops later, from eight years of age (Blake & McAuliffe, 2011). This sensitivity, however, seems to be moderated by culture (Blake et al., 2015; Corbit et al., 2017; House et al., 2013), particularly when the sharing is costly. Moreover, the emergence of these differences coincides with the increase in equal sharing among children, during middle childhood (Smith, Blake, & Harris, 2013). Hence we chose to investigate two different age groups to assess both the developmental path of sharing and the evidence of cultural differences, based on the assumption that older children (eight to nine years old) will behave according to the norms of their social and cultural groups more than younger children (four to five years old).

Culture is the set of thoughts and collective practices that differentiate one group from the other and affect the meaning people attach to different aspects of their lives and that are reflected in the institutions of society (Hofstede et al., 2010). Cultural differences have been traditionally explored in the study of the development of cooperative behaviour (Chen &

French, 2008; Tomasello & Vaish, 2013). But cultures differ as a consequence of many factors, such as their economy, history and social structure. In fact, the comparison between very different cultures has been criticised for including many potential factors together as cultural effects, such as demographic factors (Keller et al., 2006; Lamba & Mace, 2011; Lamba & Mace, 2013). Therefore, though evolutionary research is increasingly focusing on cross-cultural comparisons, these tend to group socio-economic, demographic and social differences in one category, which makes it difficult to determine the effects of different elements on cooperative behaviour.

We chose to compare Brazil and England because these countries have relevant differences regarding the socio-economic status of their inhabitants, and different social and historic backgrounds, even though they do not differ in terms of market integration. Brazil and England differ in relevant cultural dimensions (Hofstede et al., 2010); Brazilians tend to respect social hierarchies, to accept social inequality and to value signals of status and power. People are integrated early to strongly cohesive groups, whether in family or in the workplace, and they tend to build strong bonds of loyalty and exchange of favours. England has a more individualistic society with effective laws, which focuses on individual independence and the pursuit of personal goals. Such dimensions may significantly affect how people cooperate and follow rules in these societies (see Gächter & Herrmann, 2009, for a similar comparison between different countries).

Previous experimental research within and across cultures have found greater sharing among children from higher socio-economic status and more affluent environments (Benenson et al., 2007; Rochat et al., 2009). To investigate cultural and socio-economic differences, we recruited children from two sets of schools, in both countries. We called ‘public’ schools those schools that are mainly funded by taxes, the state, or charities (e.g.

churches). These schools take in children from a variety of social classes. We compared these to ‘private’ schools, which are mainly funded by parents or at least charge term fees to accept pupils (e.g. independent schools in England). These schools usually have a greater share of children from more affluent classes. These cohorts allowed a comparison of children from differing social classes within both countries.

In addition, we tested whether boys and girls would differ in their sharing behaviour after collaborating with peers of the same gender. Girls are generally seen as more prosocial than boys, and this is supported by many studies (Eisenberg et al., 2006, 2016). However, when other variables are controlled, such as the type of prosocial behaviour, the recipient of children's actions, and the research method these differences vary in effect or even disappear. For instance, the effects are smaller in sharing and experimental studies. Regarding sharing after collaboration, the effect of gender was either not tested (Hamann et al., 2011; Warneken et al., 2011) or no differences were found (Handlon & Gross, 1959).

In summary, we aimed to investigate developmental changes and sociocultural differences in the effects of unequal outcomes on collaboration and sharing with peers. Therefore we compared different age groups and types of schools in an attempt to address the influence of culture and social class, if any, on children’s behaviour, while also controlling for the influence of sex. We predicted that Brazilian children would share more than English children, given that Brazilians seem to be more reliant on social bonds and hierarchies than institutions to solve collective problems. Conversely, given that Brazilians seem to tolerate more rigid social hierarchies and inequalities than the English, Brazilian children might share less than the English children. To test the effect of culture on development, we predicted that eight- and nine-year-old children would show a stronger cultural difference than four- and five-year-old children, and that there would be no sex differences. Finally based on the

findings described above (albeit with windfall resources; Benenson et al., 2007, Rochat et al., 2009), we predicted that children from public schools (lower SES) would share less than children from private schools (higher SES).

Method

Participants

Participants were 136 4- and 5-year-olds (M = 4.99, SD = .50, 86 from Brazil and 50 from England), and 148 8- and 9-year-olds (M = 8.71, SD = .72, 88 from Brazil and 60 from England) children. One additional pair was removed due to a mistake by the experimenter, and four additional pairs were removed because a data check revealed that one child or both children in the pairs had ages outside the age group of interest. The children's parents signed an informed consent form, and all children were informally asked whether they would like to play a game. In addition, Brazilian older children were asked to sign an informed consent adapted to their age, according with the country's ethics regulations. The children were tested in public and private nurseries and primary schools from Natal, RN (Brazil), and County Durham (England). The majority of English children were white, and the majority of Brazilian children were of mixed ethnicity.

This study was approved by the ethics committees from the University of Durham, England (project title: "Investigating the effects of unequal outcomes on collaboration and sharing with peers in different cultures, social classes and generations"; reference number: 13/57), and the Federal University of Rio Grande do Norte, Brazil (project title: "Uma investigação sobre a aprendizagem social da cooperação em crianças: diferenças individuais, sociais e culturais"; CAAE: 46203715.5.0000.5537).

Table 1.

Sample details by age group, sex, school type and country.

		Brazil		England		Total
		Public	**Private**	**Public**	**Private**	
4- to 5-year-olds	**Girls**	23	22	17	8	70
	Boys	23	18	15	10	66
8- to 9-year-olds	**Girls**	30	21	22	9	82
	Boys	20	17	24	5	66
Total		96	78	78	32	284

Task

The task was a “marble run” (adapted from Göckeritz et al., 2014, see Figure 1), and consisted of interconnected PVC tubes, in which marbles could travel from an entrance hole to an exit hole. There were two significant task locations: a hole in the middle and a hole in the end of the tube, in which a child could insert their fingers to prevent the marbles from falling into inaccessible containers. Thus, children had to perform complementary roles and could win a number of marbles out of a total of three in each trial.

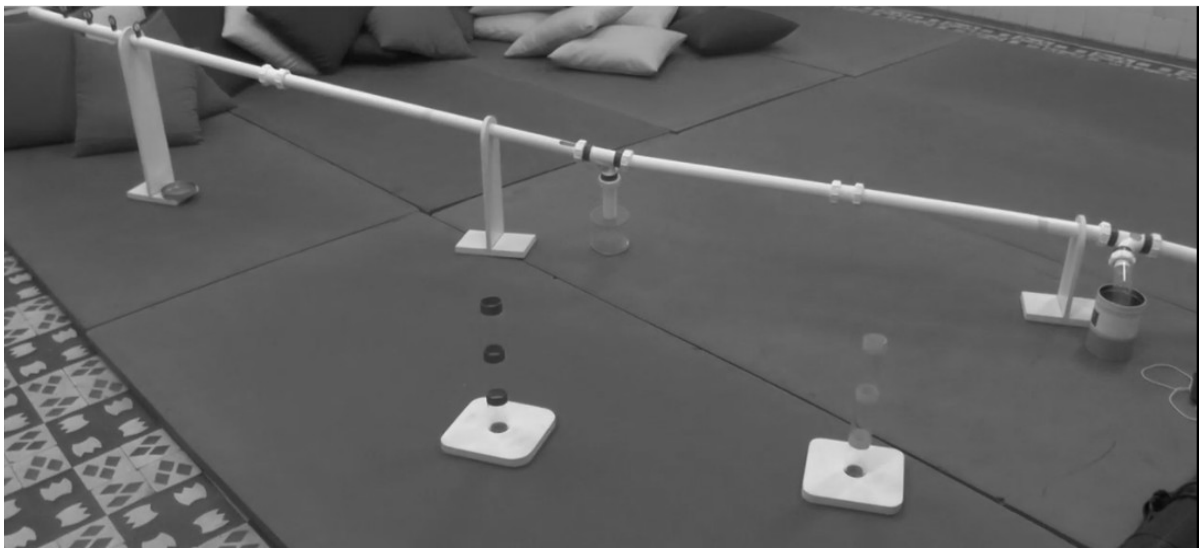

Figure 1. The “marble run”, a tube with an entrance on the left, where the marbles were inserted by the experimenter and released, two holes attached to inaccessible containers (one in the middle and one on the right end), and an exit, where marbles could be released into a can. Beside the tube, there were two tubes (“marble towers”), where children could put their marbles and use the marks to measure their gains.

Experimental procedure

Children were tested in pairs in a separate room or hall within the nurseries/schools premises. The pairs were randomly selected, but teachers were asked to match the pairs based on whether children would work well together, but were not best friends, since that would increase the chances of children sharing equally based on their friendship and not on their collaboration in the task (Paulus & Moore, 2014). The majority of children were divided in same gender pairs (6 pairs were mixed gender, due to children’s availability).

Each pair of children was introduced to the marble run. The experimenter showed the task to the children, explaining how it worked and how many trials they would have. They were told that they could win marbles by manipulating the apparatus, but were not instructed

to assume specific roles or told to work together. Each task location was shown to them, and children were encouraged to insert their hands and fingers inside the holes; then the tube was filled with marbles. Children needed to coordinate actions/roles to win marbles in the task; otherwise the marbles would drop into the inaccessible containers.

Practice trials. Before the testing began, the experimenter gave the children the opportunity to practice with the task. They had a minimum of three practice attempts, in which if they retrieved all the three marbles in a row, they moved on to the testing trials; otherwise, they had two additional practice trials until completing the requirement of three successful practice trials. During these trials the three marbles were not shared between them, being left inside the can. All children completed the practice trials and were included in testing trials.

Testing trials. Children were told that they would have four more trials and that they could exchange the marbles in the end for stickers (four marbles for one sticker). They each received a vertical tube, called a “marble tower”, and were instructed to collect marbles and put them inside their towers after each trial; children were not instructed to share the marbles. The towers had marks with tape, so that children could win a sticker for each height reached by the piled marbles (one sticker for the first mark, two stickers for the second, and three stickers for the third).

The experimenter released the marbles in each trial. This was done to prevent children from releasing more than three marbles. The experimenter tried to intervene in the task as little as possible. When children asked about how they should play the game or share the marbles, the experimenter asked them to decide by themselves. Once children finished the session, the experimenter counted the number of marbles inside each tower and gave the appropriate number of stickers to the children.

Prompts during testing. If children lost marbles within containers, the experimenter prompted the children to keep playing and to ignore the lost marbles. If the children waited for the release of more marbles before putting them inside the marble towers, the experimenter reminded children that they should play with only three marbles at a time and that the can should be emptied after each trial.

Conflicts. The experimenter was prepared to intervene in situations of conflict, by calming children down or interrupting the session, to prevent any further distress. There was just one potential conflict that was resolved after the experimenter told the children to calm down, and no session was interrupted.

Coding and analysis

Data was coded by the first author. Children could win zero to three marbles within each trial and zero to 12 marbles across all four trials. To account for sharing within trials, the following variables were coded for each child and trial: the number of marbles they won, their position in the task (middle or end of the tube), whether they shared the marbles with the partner or not (only one child in each pair made the sharing decision, the ones who were at the end of the tube), and the type of sharing (also with regards to the children who made the sharing decision). There were three types of sharing: *active*, in which the child actively shared the marbles with their partner (e.g. by handing a partner the marbles or the can); *passive*, in which the partner asked for the marbles or took them from the child (e.g. by taking the marbles out of the child's hand or the can); and *none*, when there was no sharing. Additionally, to account for sharing across trials, the total number of marbles the pair won and the number of times the child chose the end position in the tube (thus closer and with access to the rewards) across trials were also scored.

All analyses were performed with R software (version 3.4.0, R Development Core Team 2017). The logistic binomial mixed models were fitted with *lme4* package *glmer* function (Bates et al., 2015). Comparison between models were performed with the likelihood ratio tests provided by the analysis of variance method (*stats* package *anova* function, R Development Core Team, 2017). Post hoc analysis were performed with Tukey HSD multiple comparisons test (*multicomp* package *glht* function, (Hothorn et al., 2008).

Results

Sharing within trials

To assess which variables affected children's sharing behaviour within trials, a binomial model was fitted with the following independent variables as fixed effects: sex, age group, school type, number of marbles won by the pair, position in the task (middle or end of the tube), and trial. Children's individual, pair, and school identifications were added as random effects. The dependent variable was a binary variable representing whether children shared marbles or not with the partner, which varied within trials depending on whether the children were at the end of the tube or not in each trial. All the independent variables were added at once as main effects (full model), and removed individually. Also, second order interactions between the following variables were assessed: age, gender, country, and school type. The model that fitted the data best, according to the AIC (full model: 731.089 ; reduced model: 719.733), was the reduced model that included the number of marbles won by the pair, the age group, the trial, and the pair identification (see Figure 1 and Supplementary Table 1).

Tukey contrasts revealed that there was a significant difference between all the three categories representing the number of marbles the pair won (1 marble vs. 2 marbles: Z = 6.741, p < .001; 1 marble vs. 3 marbles: Z = 8.702, p < .001; 2 vs. 3 marbles: Z = 5.699, p < .001). Moreover, only the first trial was significantly different from the others (1 vs 2: Z = 4.013, p < .001; 1 vs 3: Z = 3.082, p = .011; 1 vs 4: Z = 3.788, p < .001; 2 vs 3: Z = -.876, p = .817; 2 vs 4: Z = -.114, p = .999; 3 vs 4: Z = .782, p = .862). Thus, eight- and nine-year-old children shared more often than four- and five-year-old children, but for both age groups children shared significantly more often as the number of retrieved marbles increased, and in all subsequent trials compared to the first one.

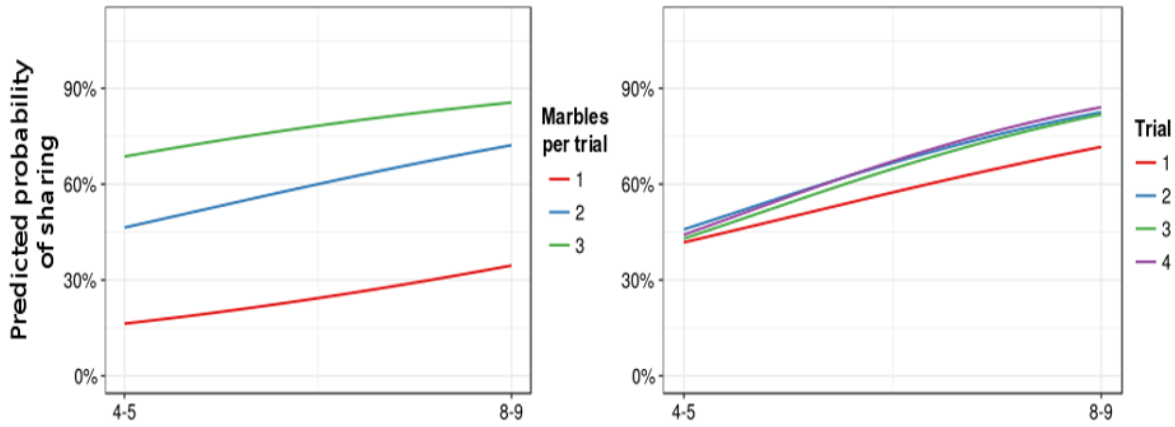

Figure 1. Predicted probability of sharing marbles for each age group, the number of marbles the pair won, and the trial.

Type of sharing

To assess the type of sharing in which children were engaging, a binomial model was fitted with the following independent variables as fixed effects: sex, age, school type, number of marbles won by the pair, and trial. Children's individual, pair, and school identifications were added as random effects. The dependent variable was a binary variable representing whether children shared marbles *actively* or not with the partner, which varied within trials

depending on whether the children were at the end of the tube or not in each trial. All the independent variables were added at once as main effects (full model), and removed individually. Also, second order interactions between the following variables: age, gender, country, and school type were assessed. The model that fitted the data better, according to the AIC (full model: 550.212; reduced model: 539.031), was the reduced model that included the number of marbles won by the pair, the country, and the children's individual and pair identifications (see Figure 2 and Supplementary Table 2).

Tukey contrasts revealed that there was a significant difference between pairs who won 1 marble, and the pairs who won 2 or 3 marbles within trials (1 marble vs. 2 marbles: Z = 3.409, p = .002; 1 marble vs. 3 marbles: Z = 4.435, p < .001 ; 2 vs. 3 marbles: Z = 1.597, p = . 242). Thus, English children actively shared the marbles more often than Brazilian children, and regardless of nationality children shared more actively as the number of retrieved marbles increased.

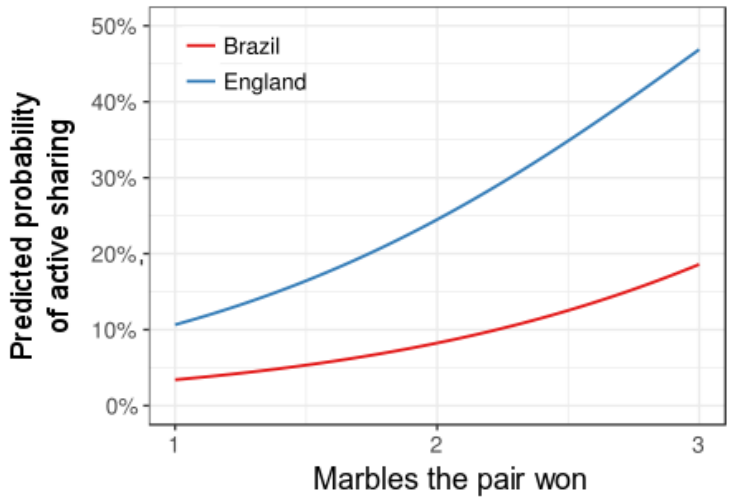

Figure 2. Predicted probabilities of active sharing for each country and the number of marbles the pair won.

Sharing across trials

The previous analyses assessed sharing within trials. To investigate whether children shared equally *across* trials, a binomial logistic regression model was fitted. The following independent variables were added as fixed effects: sex, age, school type, position in the task, and trial. The dependent variable was the proportion of marbles won by each child divided by the total of marbles won by the pair. Also, second order interactions between all the variables were assessed. The model that fitted the data better, according to the AIC (full model: 959.845; reduced model: 935.018), was the reduced model that included the children's age group, their position in the task, and the interaction between both variables (see Figure 3 and Supplementary Table 3). Hence, the number of marbles four- and five-year-old children won, in relation to the number won by their partners, increased with the number of times they had easier access to the marbles (by being close to the exit, at the end of the tube).

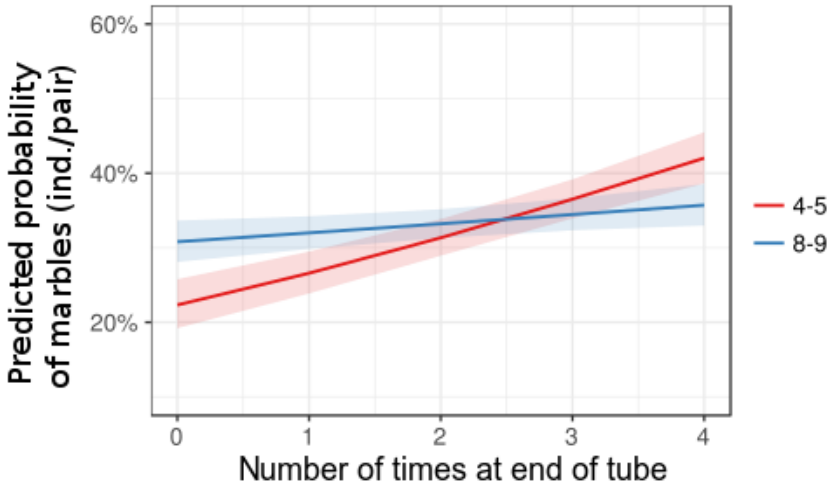

Figure 3. Predicted probabilities of the proportion of marbles each child won over the total won by the pair, grouped by age group and the number of times the child stayed at the end of the tube (hence closer to the marble's exit).

Distribution of marbles and sharing of stickers

In addition to the analyses, the histograms below show the density of the distribution of the proportion of sharing for each age group (amount of marbles the child won over the amount of marbles the pair won, see Figure 4). In both histograms, extreme values such as 0 and 1 represent complete monopoly of the marbles by one of the children within pairs; that is, where children either won zero or all the marbles across trials. Values around 0.4 and 0.6 represent equal or almost equal sharing; that is, where children within pairs shared about half of their marbles between themselves. While the younger children had great variation in the proportion of sharing across pairs, with higher density in the extremes and in the middle, the older children clearly had the majority of sharing decisions concentrated in the middle. The histograms thus show that 4- and 5-year-old and 8- and 9-year-old children had clearly different patterns, with older children sharing more equally between themselves more often than younger children.

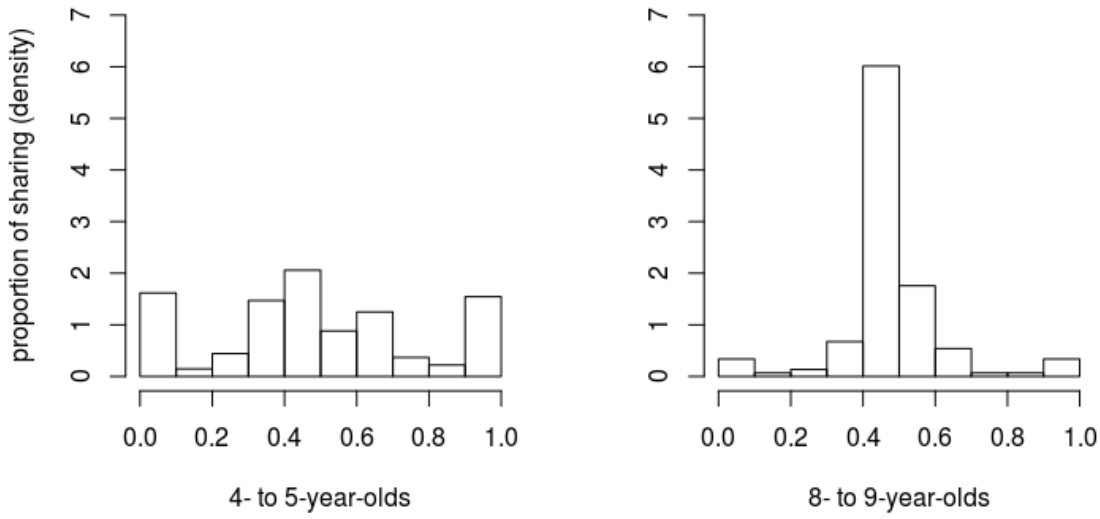

Figure 4. Density histogram of children's proportion of sharing (amount won by the individual over the amount won by the pair).

On two occasions (one from each age group), children asked the experimenter if they could remove the marbles that were already in the towers, to redistribute them equally between themselves and their partners. We did not account for those redistributions in the analyses because they were extremely rare, and concentrated on sharing decisions.

We also recorded the moment when children exchanged their marbles for stickers, to assess whether they would share the stickers with the partner, even if one of them monopolised the marbles during the game. This happened twice with eight- and nine-year-old children, who negotiated beforehand, so they could maximise the rewards (by accumulating all the marbles in one tower, instead of splitting them up in two). Nevertheless, one child always ended up with an additional sticker.

Discussion

This study contributes to the growing literature on children's sharing after collaboration by showing that four- and five-year-old children's sharing is constrained by children's access to the rewards, as opposed to more equal sharing among eight- and nine-year-old children. Though culture, social class and gender have not affected children's amount of sharing, this study also provides evidence that children from different, but economically similar, cultures may differ in the way they share the resources.

Across the two cultures, eight- and nine-year-old children consistently shared more than four- and five-year-old children across trials, and regardless of the number of marbles won by the pairs. We have shown that, even though humans have prosocial tendencies from an early age, young children struggle to understand a collaborative task as a reason for sharing equally if the rewards are in an unequal number, and children are not, ostensibly or implicitly, prompted to cooperate or be generous. Hence, for the two cultures investigated, older children engaged in more spontaneous sharing than younger ones. One possible explanation for the lower levels of sharing among younger children is that, to display cooperative behaviour, the conditions must be structured to make them more sensitive to other people's needs as well as to make them more aware of proportional reasoning (Ng, Heyman, & Barner, 2011).

It seems that, when the situation facilitates unequal sharing, young children will tend to focus on their own gains and not perceive a collaborative task as a reason for sharing with a partner. Moreover, in our study, the children who had the opportunity to monopolise the rewards were the ones at the end of the tube and who worked less in the game, since the entrance in the middle section was the most difficult to handle – i.e. distribution was anti-meritocratic. Older children, however, had no problems in sharing their rewards equally

across the trials, and also did not differ according to their position in the tube, therefore seemingly not caring for merit in this particular task.

Another explanation for the differences observed between the two age groups is that four- and five-year-old children have less emotional regulation and less communication and conflict resolution skills than eight- and nine-year-old children, which makes it difficult for the former to negotiate and reach a solution in this type of game (see Ramani & Brownell, 2013, for a review). Older children are more likely engaged in domestic chores and sharing with siblings, and they also have better understanding of social rules (Bauer et al., 2013; Whiting & Whiting, 1975). Young children may not have the necessary skills to understand and navigate the reward distribution of the task and potentially similar situations (Ng et al., 2011). Hence, human's early prosocial tendencies may develop earlier in contexts where the advantages of cooperation are clear and the costs and conflicts are downplayed, and later in costly interactions, in which more refined socio-cognitive skills are necessary as well (Warneken, 2018).

Our task is different from a number of others in the recent literature on collaboration because children had an odd number of resources to share in each trial, and these could be monopolised by one child in the pair. Moreover, children faced the risk of losing marbles before sharing them. We believe that the variation in the number of marbles that children could win in each trial, and the possibility of exchanging the marbles for a reward increased their value, thus also adding an element of individual competition in a collaborative setting, which is often not assessed (but see Charlesworth, 1996, for a similar approach). A potential limitation of this design is that it is not entirely possible to disentangle the effects of inequality and uncertainty on children's sharing decisions in this task. Moreover, the task seemed to be more difficult for younger children, with 62% of them obtaining 2 or 3 marbles,

in comparison to 92% percent of the older children. Nevertheless, our model shows that younger children shared less irregardless of the number of marbles the pair won. However, it might be that they were compelled to share less because of the higher difficulty in performing the task. Future studies may explore the relationship between collaboration, sharing and costly decisions in terms of uncertainty and performance in similar tasks with children.

We also attempted to avoid priming children into collaborating with the partner by not using any terms during the practice trials that should indicate that they had to work together to get the marbles (though this was the only possible way of being successful in the task). A potential limitation to this study was that the experimenter had to be present at all times during the task, and release the marbles for the children. Although the experimenter tried not to influence the children's collaboration, children might have shared *more* due to her presence (Dutra et al., 2018; Engelmann, Herrmann, & Tomasello, 2016). While this might have been true for the eight- and nine-year-old children, four- and five-year-old children seemed less affected.

For this study, schools were used as indirect measures of social class. But there was no difference between children regardless of attending a public or private school. This was done because cultural differences can be confounded with the influence of other demographic and economic variables (Carlo et al., 2001; Lamba & Mace, 2011, 2013). Nevertheless, children did not show any differences regarding sharing across the types of schools or both cultures. To our knowledge this is the first study to compare collaborative behaviours between Brazilian and English children.

The absence of cultural differences between Brazilian and English children regarding whether they shared and the amount shared may indicate that children from these cultures are similar regarding sharing behaviour in a collaborative context with unequal outcomes.

However, the study took place within two urban samples, although from two cultures with striking historical and socio-economic differences. Perhaps children from other regions and rural areas from these countries would behave differently. Additionally, cultural norms and practices do not necessarily overlap with nationality. Nevertheless, the sample size might also be insufficient to detect any differences, should they exist.

Regarding the type of sharing decisions (active versus passive), English children shared more actively than Brazilian children, regardless of age. This might indicate that children from these cultures differ in how they make decisions on sharing in a social interaction, even though they achieved similar outcomes in this task. Perhaps Brazilian children are more inclined to enforce equality in direct social interactions than English children, who would expect the partner with the resources to make the decision. This would be in tandem with the evidence that Brazilians rely on close relationships to achieve collaboration, rather than authorities or institutions. However, it seems surprising that such difference would emerge as early as ages four and five years, given that the literature points towards a stronger cultural influence from six or seven years (House et al., 2013; Warneken, 2018).

Our study shows that, although young children are willing to collaborate and share resources, their actions are constrained by the situation, and their access to and manipulation of the rewards. Experiments that take this into account may contribute to a more realistic approach to human cooperation. Furthermore, cooperation is influenced by social and cultural group factors, while also stemming from universal patterns in human behaviour. We hope that these findings will lead to further explorations of the development of cooperation in more diverse contexts.

Supplementary Information

Table 1

Model estimates for children' sharing behaviour within trials (whether they shared or not)

	Full model			Reduced model		
	OR	*CI*	*p*	*OR*	*CI*	*p*
Fixed Parts						
(Intercept)	0.00	0.00 – 0.03	<.001	0.00	0.00 – 0.02	<.001
Trial (2)	4.65	2.19 – 9.87	<.001	4.67	2.20 – 9.90	<.001
Trial (3)	3.29	1.54 – 7.04	.002	3.30	1.54 – 7.05	.002
Trial (4)	4.47	2.06 – 9.70	<.001	4.46	2.06 – 9.68	<.001
Pair won (2)	52.73	16.65 – 167.02	<.001	52.38	16.57 – 165.59	<.001
Pair won (3)	1165.23	236.62 – 5738.14	<.001	1160.92	236.85 – 5690.16	<.001
Position (M)	1.03	0.64 – 1.65	.901			
Age group (8-9)	68.40	5.89 – 794.48	<.001	71.54	6.19 – 827.38	<.001
Gender (M)	0.69	0.11 – 4.21	.690			
Country (England)	0.61	0.08 – 4.70	.632			
School type (public)	1.81	0.24 – 13.90	.567			
Random Parts						
τ00, child id		0.000				
τ00, pair		27.571			27.821	
τ00, school		0.000				
Nchild id		284				
Npair		142			142	
Nschool		18				
ICCchild id		0.000				
ICCpair		0.893			0.894	
ICCschool		0.000				
Observations		1082			1082	
AIC		731.089			719.733	

Table 2

Model estimates of the type of sharing within trials (active or passive)

	Full model			Reduced model		
	OR	*CI*	*p*	*OR*	*CI*	*p*
Fixed Parts						
(Intercept)	0.01	0.00 – 0.06	<.001	0.02	0.00 – 0.07	<.001
Trial (2)	1.20	0.56 – 2.57	.643			
Trial (3)	1.34	0.63 – 2.85	.447			
Trial (4)	1.22	0.56 – 2.64	.612			
Pair won (2)	6.50	2.12 – 19.94	.001	6.86	2.27 – 20.77	<.001
Pair won (3)	11.04	3.48 – 35.03	<.001	12.71	4.13 – 39.10	<.001
Age group (8-9)	1.89	0.58 – 6.11	.291			
Gender (M)	0.82	0.27 – 2.54	.733			
Country (England)	3.38	1.03 – 11.07	.044	3.78	1.16 – 12.31	.027
School type (public)	1.70	0.53 – 5.44	.369			
Random Parts						
τ00, child id		1.919			2.108	
τ00, pair		5.460			5.370	
τ00, school		0.000				
Nchild id		159			159	
Npair		142			142	
Nschool		18				
ICCchild id		0.180			0.196	
ICCpair		0.512			0.499	
ICCschool		0.000				
Observations		540			540	
AIC		550.212			539.031	

Table 3

Model estimates for the proportion of the total of marbles children won over the total of marbles the pair won

	Full model			Reduced model		
	OR	*CI*	*p*	*OR*	*CI*	*p*
Fixed Parts						
(Intercept)	0.38	0.32 – 0.45	<.001	0.29	0.24 – 0.35	<.001
Age group (8-9)	1.02	0.89 – 1.18	.749	1.55	1.23 – 1.95	<.001
Country (England)	1.00	0.87 – 1.15	.989			
Gender (M)	1.00	0.87 – 1.15	.996			
School type (public)	1.00	0.87 – 1.15	.968			
Position (End)	1.13	1.09 – 1.17	<.001	1.26	1.19 – 1.34	<.001
Age group (8-9) * Position (End)				0.84	0.78 – 0.90	<.001
Random Parts						
τ00, pair		0.000			0.000	
Npair		142			142	
ICCpair		0.000			0.000	
Observations		284			284	
AIC		959.845			935.018	

Chapter VII

Dispositional and family variables do not influence children's sharing after collaboration

This chapter is an empirical study investigating the effects of moderating variables on children's sharing after collaboration. This chapter will be submitted for publication.

The authorship will be as follows:

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Roles: conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, validation, visualization, writing – original draft, writing – review and editing

Lynda Boothroyd[1,]

Roles: supervision, writing – review and editing

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Roles: conceptualization, funding acquisition, supervision, writing – review and editing

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Introduction

Sharing refers to any decisions regarding the division of resources between two or more individuals. Humans are considered to be highly cooperative, when compared to other species (Melis & Semmann, 2010), and have evolved a number of strategies to enforce collaboration and sharing, whose underlying psychological mechanisms develop early in life (Warneken, 2018). However, sharing decisions commonly involve the negotiation of different interests among partners, and the knowledge of rules of fairness and proportional distribution (Ng et al., 2011). The early development of such skills have only been unravelled in detail recently (McAuliffe, Blake, et al., 2017; Warneken, 2018), and questions regarding the effect of context and individual differences on sharing decisions in interactive situations remain relatively unexplored.

Interactions with peers are relevant to the development of children's cooperative skills, other-regarding preferences, and moral values related to justice, fairness, and equality (Eckerman & Peterman, 2004; Piaget, 1932). These interactions occur within structured contexts established by their caregivers, and these contexts and interactions are embedded in sociocultural groups (Rogoff, 1990). Moreover, culture interacts with social factors, such as family structure, socialization processes, and social relationships, as well as with individual characteristics, such as social skills and temperament traits (Eisenberg et al., 2006). Therefore, cooperative behaviours, sharing included, are a complex product of interactions between individual predispositions and life history, social influences, and their cultural background.

In a previous study (thesis chapter VI), we investigated the effects of age, sex, social class (measured indirectly by type of school), and culture (measured indirectly by country) on children’s sharing behaviour after collaboration in a task with unequal outcomes. In this task (adapted from Göckeritz et al., 2014), children had to collaborate to retrieve a number of

rewards, which could also be lost in the process. Hence, children could win zero to three marbles, in each of a total of four trials. We found that older children (8- to 9-year-olds) shared more equally between themselves than younger children (4- to 5-year-olds), and that there was no effects of the other variables on the amount shared. Additionally, we found that English children shared their rewards more actively than Brazilian children. For the present study, we assessed the effects of children's individual, dispositional characteristics (temperament and social skills), their mothers' prosocial preferences, and the children's socio-economic status on children's sharing behaviour in the same task. Each of these variables will be discussed in the following sections.

Children's dispositional characteristics: temperament and social skills

Children who are more sociable, who approach people, things, and new activities, and who have low scores of shyness and social anxiety display more prosocial behaviour, especially when it involves social interaction (Diener & Kim, 2004; Eisenberg et al., 1996; Hart, Newell, & Olsen, 2003). Therefore, greater sociability predicts more prosocial behaviour involving social interactions. Moreover, research on the influence of the three dimensions of temperament (surgency, negative affect and effortful control) on prosocial behaviour showed that children with low scores of surgency and negative affect, and high scores of effortful control are more collaborative (Endedijk et al., 2015; Eisenberg et al., 2006). However, research on this topic has rarely addressed the influence of such dispositional variables on children's behaviour in social interactions beyond naturalistic observations of children with their parents and siblings, and even less in coordinated tasks (Eidendjik et al., 2015). We tested whether theses variables would predict greater prosociality

in children in a collaborative task with potential conflicts of interests, and with variable outcomes.

Mothers' prosocial preferences and socio-economic status (SES)

The family income is a predictor of social development; for instance, families with higher incomes and better education tend to have children with better social development (Bauer et al., 2014; NICHD Early Child Care Research Network, 2003). Children from lower SES groups are expected to retain resources due to the scarce environment in which they live; conversely, they can be more cooperative because are expected to participate in domestic shores (Whiting & Whiting, 1975). However, research on this subject provided inconsistent evidence (Eisenberg et al., 2006), and much of the evidence supporting the arguments regarding the evolution of cooperation still "comes from individuals living in pacific and often affluent environments" (Li, Li, Decety, & Lee, 2013, p. 1686).

Differences in SES are also linked to different socialization practices and it is an indirect measure of the influence of parents' behaviour (Carlo et al., 2007; Evans, 2004). Parents influence their children's behaviour in complex ways, through socialization practices and by sharing similar genetic predispositions (Bugental & Grusec, 2007; Eisenberg et al., 2006). It can also either reinforce or reduce culture's influence (Bugental & Grusec, 2007). Because of this, parents' prosocial values can correlate with their children's values (Hoffman, 1975), but some studies, however, do not find any relationships or even found negative correlations (Bryant & Crockenberg, 1980). Therefore, evidence regarding the influence of the social values of parents on their children's behaviour is mixed (Bryan & London, 1970).

Considering the variables discussed above, our hypotheses and predictions are summarised in the following. We measured: a) the children's temperament, and social skills;

b) family socio-economic status (SES), and c) the prosocial preferences of the children's mothers in hypothetical cooperative dilemmas. The children's age, gender, and the culture were added as control variables. The main goal of this study was to investigate whether and how these factors affect children's sharing behaviour in a collaborative task with unequal outcomes. By comparing different social and cultural groups across two different age groups we were able to assess the relations, if any, between children's personality traits and their sociocultural environment.

Regarding each variable, our hypotheses and predictions were:

- Temperament: spontaneous sharing is influenced by high effortful control and low surgency and negative affect, but effortful control seems to be determinant (Endedijk et al., 2015). Thus, children with higher scores in effortful control will share more equally or will give more, while the other dimensions may not be particularly relevant in determining children's decisions.
- Social skills: Children with good social skills are considered more prosocial than children with poor social skills. Therefore, children with higher scores in social skills will share more equally in the task.
- Mothers' social preferences: mothers' prosocial values may influence their children's behaviour towards being more prosocial, and this influence might be stronger as children get older. Thus, mothers with higher scores in social preferences will have children who will share more equally or a greater share of their rewards, and this effect may be only present for older children.
- Socio-economic status (mutually exclusive hypotheses): on one hand, family income and better education are predictors of prosocial behaviour. Children from lower classes need more resources, so sharing is harder. Children from higher classes will share

more equally. Their mothers will have higher scores of social preferences. On the other hand, children from lower classes are recruited in domestic shores and there is evidence that they are more prosocial. Children from lower classes will share more equally. Their mothers will have higher scores of social preferences.

Method

Participants

Participants were 88 4- and 5-year-olds (M = 4.98, SD = .51; 59 from Brazil; 29 from England) and 89 8- to 9-year-olds (M = 8.71, SD = .68; 54 from Brazil, 35 from England), and their respective mothers, from two countries (see Table 1 for sample details). Children came from different social backgrounds (lower, middle, and upper middle classes). English children were mostly white, and Brazilian children had mixed ethnicity. The data was collected through questionnaires, which were sent to parents via the children's school, across the period of the experimental sharing data collection. The parents were asked to sign an informed consent form. All English children and the Brazilian younger children were asked informally about whether they would like to play a game, while the Brazilian older children were asked to sign a document where the research was explained to them in accessible language (in accordance with the ethics regulations from this country). The participants were selected from the same sample recruited in chapter VI of this thesis (another 107 participants were excluded because their mothers did not return the questionnaires).

This study was approved by the ethics committees from the University of Durham, England (project title: "Investigating the effects of unequal outcomes on collaboration and sharing with peers in different cultures, social classes and generations"; reference number: 13/57), and the Federal University of Rio Grande do Norte, Brazil (project title: "Uma

investigação sobre a aprendizagem social da cooperação em crianças: diferenças individuais, sociais e culturais"; CAAE: 46203715.5.0000.5537).

Table 1

Sample distribution across age group, sex, and country

		Brazil	England	Total
4- to 5-year-olds	**Girls**	30	13	43
	Boys	29	16	45
8- to 9-year-olds	**Girls**	33	16	49
	Boys	21	19	40
Total		113	64	177

Procedure

Experimental procedure with the children

The experimental procedure was described in detail in chapter VI. The children were paired with same gender partners, with the exception of six pairs, who were mixed due to children's availability. The pairs were randomly selected, but the teachers were consulted about whether these children would work well together and whether they were best friends. This was required to avoid increasing the chances of children making decisions based on their friendship and not on their collaboration in the task (Paulus & Moore, 2014). The sessions happened in a separate room or hall within the nurseries/schools premises.

Task. The task was a "marble run" (adapted from Göckeritz et al., 2014), and consisted of interconnected PVC tubes, in which marbles could travel from an entrance hole to an exit hole. There were two significant task locations: a hole in the middle and a hole in the end of the tube, in which a child could insert the fingers. After the experimenter released the marbles, children should insert their fingers in the holes to prevent the marbles from

falling into inaccessible containers. Thus, children should perform complementary roles and could win a number of marbles out of a total of three in each trial.

Experimental procedure. The experimenter introduced the task to the children, by showing the relevant parts of the tube and explaining the goal of the task. The children were told that the goal was to release up to three marbles each trial, and that these marbles would be exchanged at the end by stickers. The experimenter was in charge of releasing the marbles for each trial, to prevent children from releasing more than three marbles each time. The experimenter tried to intervene in the task as less as possible, giving only the instructions about the manipulation of the task, and asking the children to resolve any conflicts by themselves.

Practice trials. The pairs had three to five practice trials, with the minimum requirement of retrieving three marbles in a row, or in total, successfully across the trials. In these practice trials they had the opportunity to learn their roles in the task and to attempt to retrieved all the marbles, but were not encouraged to collaborate or to share the rewards, which were left inside the can at the exit of the tube. They were told that the practice trials did not count to get the stickers at the end. All the tested pairs were able to perform at least three correct attempts and moved on to the test trials.

Test trials. The pairs were tested in four trials, in which they were instructed to attempt to retrieve the marbles, which could be exchanged by stickers at the end of the session. After each test trial, they were instructed to put their rewards in separate vertical tubes, called marble towers. In all trials, they could retrieve up to three marbles for each trial, if they worked together in the task.

If children committed any mistakes leading to the loss of marbles within containers, the experimenter just prompted children to keep playing the game and to ignore the lost

marbles. If the children waited for the release of more marbles before putting the ones they have won inside the marble towers, the experimenter reminded children that they should play with only three marbles at a time and that the tin can should be emptied after each trial. Children could exchange four marbles for one sticker at the end of the experimental session.

Questionnaires

After receiving the mothers' written consent, a letter was sent with questionnaires attached, explaining the study and presenting the questionnaires and instructions for completing them. Mothers were asked to complete a questionnaire about their prosocial preferences (adapted from Peysakhovich, Nowak, & Rand, 2014, see Supplementary Information and below) and the following questionnaires about their children's temperament and social behaviour: a) the Social Skills Improvement System – Rating Scales (SRSS-RS, Gresham, Elliott, Cook, Vance, & Kettler, 2010); and b) the Children's Behaviour Questionnaire (CBQ; Putnam & Rothbart, 2006), for children aged three to five years, or the Temperament in Middle Childhood Questionnaire (TMCQ; Simonds & Rothbart, 2004), for children aged seven to ten years. Mothers were also asked to answer a socio-economic status questionnaire, as described below. We measured the mothers' answers and compared them to their children's behaviour in the collaborative task. Translated versions of all measures were applied to Brazilian mothers.

Prosocial preferences in hypothetical social dilemmas. Mothers had to answer questions concerning three hypothetical social dilemmas: the dictator game, the ultimatum game, and the trust game. Each game required the participants to imagine an interaction with strangers, in which they would assume each of two roles, person A and person B. As person A, they had to decide how much money they would share with strangers; as person B, they

had to decide how much money they would accept from or return to strangers (see Table 2 for each person's role and the games' description; see the questionnaire in the Supplementary Information). Each game also had a check question, to assess whether the mothers understood the rules of the game.

Table 2

Description of each game (social dilemma) and the roles played by the participants

Social dilemma	**Description**	**Person A (actor)**	**Person B (recipient)**
Dictator game	1) Person A will choose how much of the £100 to transfer to person B. 2) Person B will get the money A transfers and A will get to keep the rest.	How much will you transfer to person B?	-
Ultimatum game	1) Person A will make an offer on how to split the £100 with person B. 2) Person B will either accept or reject this offer. If person B accepts, then B will get the offered amount and A will keep the rest. If B rejects the offer then both individuals will get £0.	What amount will you offer to person B?	Please indicate your minimum acceptable offer (from person A).
Trust game	1) Person A can choose to transfer their £50 or not. If person A transfers £50 then it is TRIPLED and given to person B (so person B now has £200). 2) Person B can then choose how much of the	Do you want to transfer your £50 to B?	How much money do you want to transfer back to A?

	money they want to transfer back to person A (between £0 and £150).

Social skills and problem behaviours. The Social Skills Improvement System – Rating Scales (SSIS-RS, Gresham et al., 2010), version for parents, was used to measure the domains of social skills and problem behaviours. The scale measures the social skills dimension across seven subdomains and 46 items: communication, cooperation, assertion, responsibility, empathy, engagement, and self control; and the problem behaviour dimension across five dimensions and 33 items: externalizing, bullying, hyperactivity/inattention, internalizing, and autism spectrum. Each item is rated on a 4-point frequency scale (0 = Never, 1 = Seldom, 2 = Often, and 3 = Almost Always), based on the parents' perception of the frequency of behaviour in their children.

Temperament dimensions. Two questionnaires were used to measure the three temperament dimensions: the very short version of the Children's Behaviour Questionnaire (CBQ; Putnam & Rothbart, 2006), for children aged three to five years, and the Temperament in Middle Childhood Questionnaire (TMCQ; Simonds & Rothbart, 2004), for children aged seven to ten years. The very short version of CBQ has 36 items, across three factors: surgency, effortful control, and negative affect. Each item is rated in a 7-point scale (1 = extremely untrue of your child, 7 = extremely true of your child). The TMCQ has 157 items across the same three factors, and each item is rated in a 5-point scale (1 = Not, 5 = A lot).

Measures of social economic status (SES). We compared measures of SES in both countries, England and Brazil, by using social indicators provided by the Acorn score (CACI, 2014) and the Brazilian Association of Research Companies (Associação Brasileira de Empresas de Pesquisa [ABEP], 2014). Both systems provide reliable information regarding

families' social status within each country. Based on this information, we drew comparisons between people from similar levels of social class between countries. Therefore, although the English middle class is not necessarily similar to the Brazilian middle class in absolute terms, they can, nonetheless, be compared in terms of their relative social status within each country. The final categories were decided based on the comparison between the information obtained from the families' household items, educational level, occupation, and postal code. Hence, we divided the families in lower class, middle class, and upper middle class within each country (see Supplementary Information for details).

Coding scheme and data preparation

Children's performances were video recorded, and data was coded by the first author. The following information was coded from the footage, collapsed across the trials: the total of marbles each child won, the total of marbles each pair won, the number of times the child was at the end of the tube (as opposed to the middle), the number of times the child shared the marbles, and the number of times the child shared the marbles actively (as opposed to passively).

Each set of questionnaires for social skills and temperament was coded as instructed by their authors. For the analyses of social skills scores, which are divided in social skills and problem behaviours , we calculated and adopted the standard scores for each characteristic separately. For the analyses of temperament scores, which are divided into three dimensions (surgency, effortful control, and negative affect), we calculated the score for each one of them. However, although the temperament questionnaires were similar, they had different scales of measurement for each age group. Thus, the temperament scores were transformed to *z* scores, for each dimension, so both age groups could be compared in the same analysis.

For the mothers' prosocial preferences questionnaires, there were five roles in which the mothers had to make decisions (one in the dictator game, two in the ultimatum game, and two in the trust game). The scores for all decisions were added up, and this sum was used as a measure of prosocial preference.

Analysis

The analyses were performed with R software (version 3.4.0, R Development Core Team 2017), and the logistic binomial mixed models were fitted with *lme4* package *glmer* function (Bates et al., 2015). Likelihood ratio tests provided by the analysis of variance method (*stats* package *anova* function, R Development Core Team, 2017) were used to compare models. Finally, Tukey HSD multiple comparisons test (*multicomp* package *glht* function, Hothorn et al., 2008) were used in post hoc analyses.

Children whose mothers did not return the questionnaires were excluded from the analysis. When both children within pairs had returned their mothers' questionnaires, one child for each pair was randomly selected for inclusion in the analyses. This was done to avoid redundancy in the data, given that the dependent variables represent children's sharing outcomes. Thus, we had a final dataset with 118 observations, with information about only one child for each pair. However, complementary analyses of children's and their mothers' scores as dependent variables included all participants, as in this case children's scores were independent of their partners (n = 177).

Since we used school type as a proxy for socio-economic status in our previous study, we compared school type and social class to test this relationship. A chi-square test revealed that there was a significant relationship between social class and school type ($\chi^2 = 24.713$, $df = 2$, $p < .001$), indicating that children from middle and upper classes ($p = 1$, Bonferroni

correction) attended private schools more often than children from lower classes (upper middle class versus lower class: $p < 000$, middle class versus lower class: $p < .001$, Bonferroni correction). Therefore, school type and social class seem to overlap as measures of social class for both cities where the study took place.

Results

Binomial logistic regression models were fitted with the forward stepwise method. Hence, every variable or interaction was kept or removed based on their effect on the outcome variable. The number of observations (i.e. sample size) varied across the analyses because of missing data across the prepared data (for example, children who had temperament scores, but not social skills scores and so on).

The first model was fitted with the following independent variables as main effects and second order interactions: the number of times the child was in the end of the tube, the proportion of sharing within the pair, country, age group, gender, SES, type of school, the mothers' social preferences, and the children's social skills, problem behaviours, and temperament scores. The dependent variable was the proportion of marbles the child won over the proportion of marbles the pair won. The final model only included the proportion of sharing within the pair ($Z = 5.598$, $p < .001$, $OR = 4.57$, 95% CI [2.72, 7.89]), the number of times the child was at the end of the tube (E position; $Z = 7.424$, $p < .001$, $OR = 1.73$, 95% CI [1.50 – 2.00]), and the interaction between both ($Z = -6.327$, $p < .001$, $OR = 0.57$, 95% CI [0.47, 0.67]).

The second model was fitted with the following independent variables as main effects and second order interactions: country, age group, gender, SES, type of school, the mothers' social preferences, and the children's social skills, problem behaviours, and temperament

scores. The dependent variable was the proportion of sharing the children performed over the number of times they were at the end of the tube. Only age had a significant effect in the final model ($Z = 2.837$, $p = .005$, $OR = 1.94$, 95% CI [1.23, 3.09]).

Finally, the third model was fitted with the same independent variables as the previous model. The only difference was that the dependent variable was the proportion of active sharing the children performed over the number of times they had the opportunity to share. Only country had a significant effect in the final model ($Z = 2.241$, $p = .025$, $OR = 2.15$, 95% CI [1.10, 4.22]). Together, the three models specified above show that there were no effects of family (i.e. the mothers' social preferences scores) or dispositional variables on children's sharing behaviour in the task (see Figure 1 and Supplementary Figures 1 and 2).

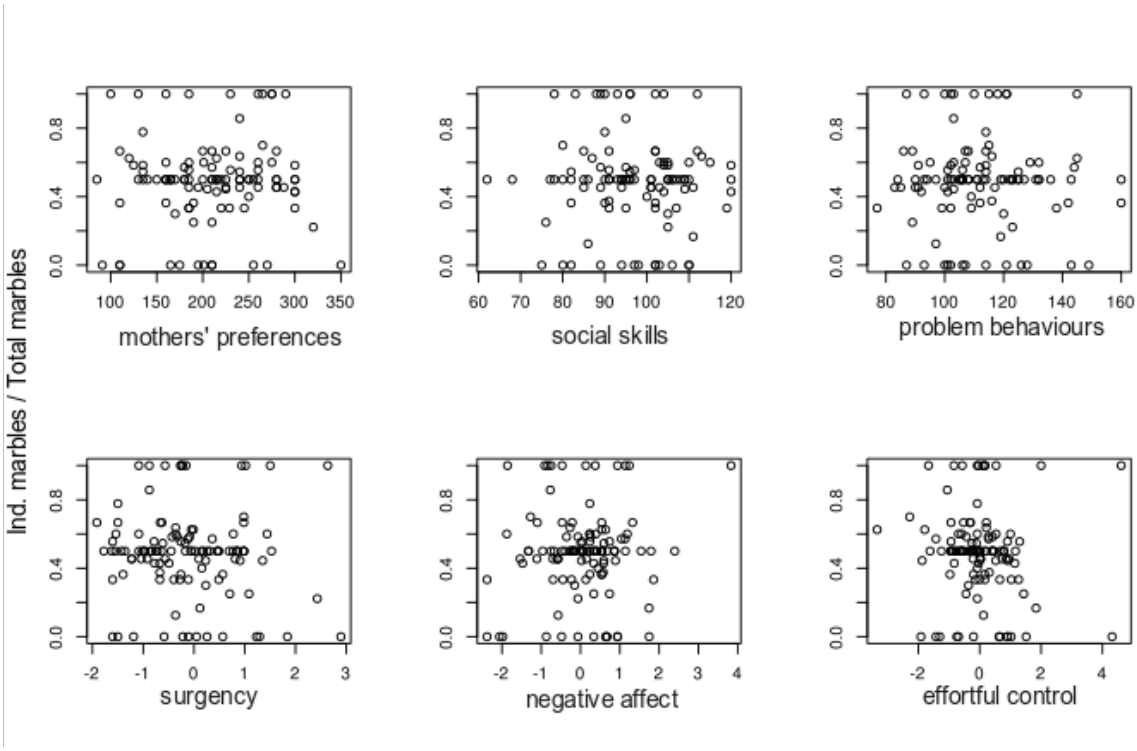


Figure 1. Scatter plots of the relationship between the proportion of marbles won by the children (over the total won by the pair) and the family and dispositional variables. The dots cluster around the middle area (representing equal sharing), and show no particular trend regarding the distribution of scores for each variable.

Additionally, we tested the effects of the demographic variables on the mothers' social preferences and the children's dispositional variables. An ANOVA was fitted to test the effect of country and social class on the mothers' social preferences. Only country had a significant effect on the mothers' social preferences ($F = 5.611$, $p = .019$, $d = -.39$ see Figure 1), with English mothers having a significantly greater score than Brazilian mothers.

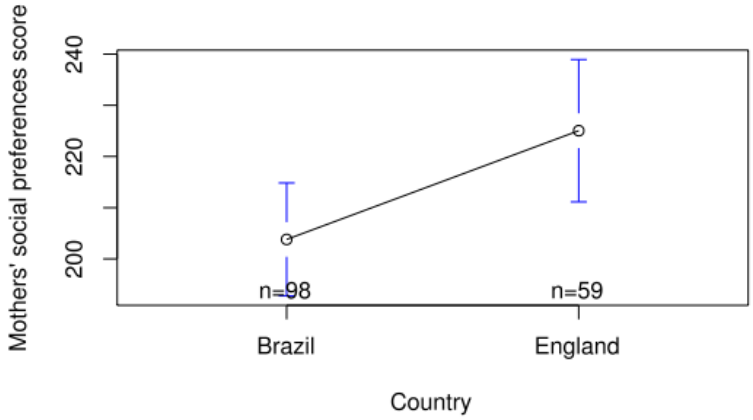


Figure 2. Scores of mothers' prosocial preferences grouped by country.

Non-parametric tests were performed to assess the effects of age group, gender, country, and social class on the children's dispositional scores (see Figure 3). Age had no effects on children's scores. Country had a significant effect on problem behaviour scores ($W = 4482.5$, $p < .001$, *Median of the differences* = 14.000, 95% CI [9.000, 19.000]) and negative affect ($W = 4849.5$, $p < .001$, *Median of the differences* = .735, 95% CI [.489, 1.006]), while gender had a significant effect on social skills scores ($W = 4066$, $p = .002$, *Median of the differences* = 5.000, 95% CI [2.000, 9.000]) and effortful control ($W = 4802.5$, $p < .001$, *Median of the differences* = .490, 95% CI [.245, .739]). Social class had a significant effect on children's negative affect ($\chi^2 = 20.459$, $p < .001$). Post-hoc tests revealed that children from

upper middle class families had significantly less negative affect than children from both the middle ($p < .001$) and lower classes ($p < .001$).

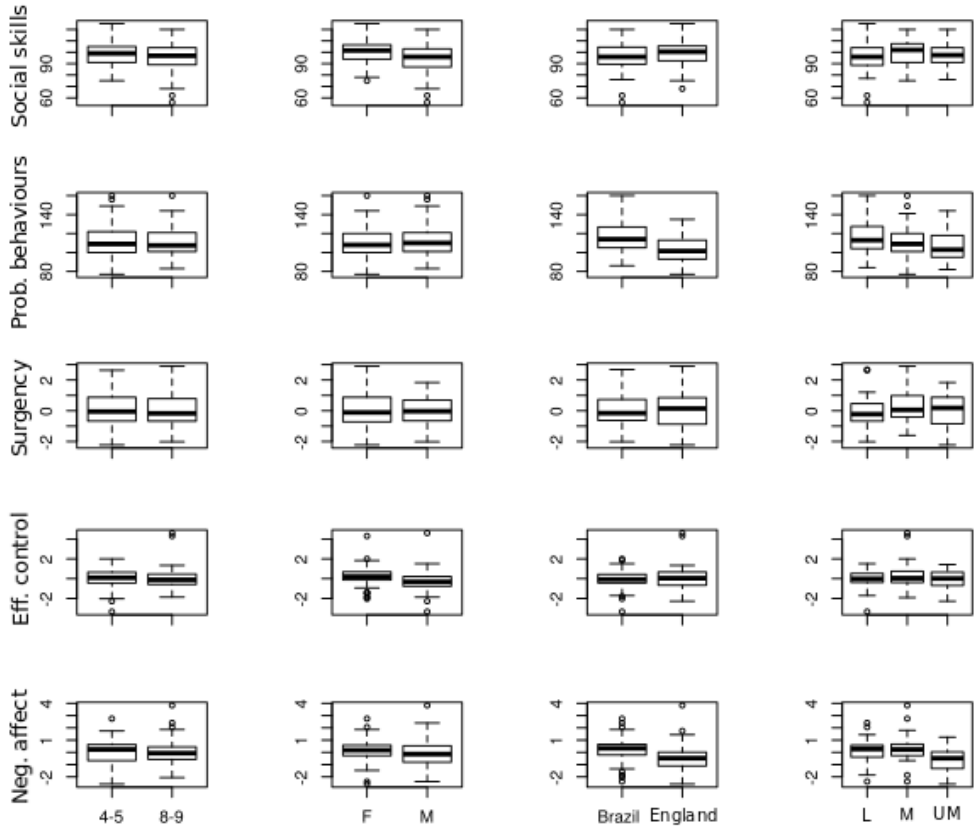


Figure 3. Box plot of children's characteristics grouped by age, sex, culture, and social class. Scores for temperament dimensions are standardised to allow comparisons across age groups. Raw scores were used for social skills and problem behaviours. L: lower class; M: middle class; UP: upper middle class.

Correlation tests were performed to compare the dimensions of temperament, the social skills and the problem behaviour scores, and to compare these scores to the mothers' social preferences scores (see Table 3). There was no correlation between the three dimensions of temperament (surgency versus effortful control: $p = .426$; effortful control versus negative affect: $p = .363$; negative affect versus surgency: $p = .075$), while the social

skills and problem behaviour scores were negatively correlated ($p < .001$). The social skills scores had a significant positive correlation with surgency ($p = .034$) and effortful control ($p < .001$), and a negative correlation with negative affect ($p = .026$). While the problem behaviour scores had a significant negative correlation with effortful control ($p < .001$) and a positive correlation with negative affect ($p < .001$), but no correlation with surgency ($p = .526$). Finally, there were no correlations between mothers' social preferences and their children's social skills ($p = .738$), problem behaviours ($p = .058$), and temperament scores (surgency: $p = .882$, effortful control: $p = .084$, negative affect: $p = .593$).

Table 3

Correlation coefficients for comparisons between temperament dimensions, social skills, and problem behaviours scores

	1	2	3	4	5
1. Social Skills	-	-	-	-	-
2. Problem Behaviours	**-.299** (159)	-	-	-	-
3. Surgency	**.169** (158)	.051 (158)	-	-	-
4. Effortful Control	**.377** (158)	**-.291** (158)	.062 (170)	-	-
5. Negative Affect	**-.177** (158)	**.449** (158)	.137 (170)	.070 (170)	-
6. Mothers' preferences	.029 (140)	-.160 (140)	-.012 (151)	.141 (151)	-.044 (151)

Note. Numbers in bold represent significant correlation ($\alpha < .05$), and numbers in brackets refer to the sample sizes tested, which differ across measures due to non-responses.

Discussion

This study found no evidence of the influence of children's characteristics, their mothers' prosocial preferences, or socio-economic status, on children's sharing behaviour after a collaborative task with unequal outcomes. Additionally, we found that culture, gender, age group, and social class may affect different aspects of children's and their mothers' traits, albeit with generally small effect sizes or low correlation coefficients. We discuss the potential reasons for these findings below.

First of all, with this smaller sample, we find the same effects as in Chapter VI: age was the strongest predictor of children's decisions in this particular game; and children's position in the task (at the middle or the end of the tube) and the number of marbles the pair won also predicted children's sharing decisions. Children's position was related to age, so that younger children that were at the end of the tube won more marbles than those who were in the middle, while older children won similar amounts regardless of their position. Hence, children at any age were better at sharing when they have more resources, but older children shared more equally regardless of their opportunity to monopolise the rewards.

Regarding the effect of temperament and social skills, it was predicted that children with higher effortful control, lower scores of surgency and negative affect, and better social skills would share more equally or generously, since they tend to be more prosocial (Eisenberg et al., 2006). However, no effects whatsoever were found, for any dimension of temperament or the children's social skills, on their sharing decisions for this task. A possible explanation for the absence of any influence of children's temperament or social skills on their sharing decisions is that the children's performance in the task has more to do with children's understanding of social norms and skills in the game, than particular individual social traits. Another explanation is that the interactive context in this task provided other

challenges than the usual prosocial tasks adopted in research that combine observational and reported measures. Thus, to assess the effects of individual characteristics in an interactive task, it is necessary to account for the behaviour of both children, and individual characteristics might have a weaker influence because of that. Other variables might be of more influence, such as children's dominance and popularity with their peers. For instance, there is evidence that more prosocial children influence peers positively (Eisenberg et al., 2006); therefore, the more prosocial children in the task could have influenced the partner in sharing more equally, even though this child would not be inclined to do so in the first place.

The evidence in the literature for the relationship between children's dispositional characteristics and prosocial behaviour primarily comes from observational studies of interactions between children and their mothers. In addition, experimental approaches that combine the investigation of individual differences and prosocial actions among peers are rare (Eisenberg et al, 2016). The present study does not offer support to the predictions that children with better social skills and effortful control will share more equally after a collaborative task, and it opens interesting avenues for further research. For instance, future studies can manipulate the composition of dyads regarding children's individual characteristics and test their interaction in similar collaborative tasks, which can help test further whether and how these characteristics can affect children's actions in interactive tasks.

Regarding the mothers' social preferences, it was predicted that mothers with higher scores in social preferences would have children who shared more equally or more generously. Moreover, given that older children have had more opportunities to interact with and learn from their parents, it was predicted that there would be a stronger relation between children's sharing behaviour and their mothers' social preferences; thus children who shared more equally or more generously would have mothers' with greater scores in social

preferences. These predictions were not confirmed; no relationship was found between children actions and their mothers' answers, nor interaction of those and the children's individual characteristics. Establishing a relationship between the parents' social values and the children's behaviour is particularly difficult. A limitation of our study was that the mothers were asked to answer hypothetical questions, instead of performing in an experiment, due to time constraints on the project. Future studies might investigate this influence experimentally with one or both parents and their children, or in combination with different measurements.

There was two mutually exclusive hypotheses regarding the effect of socio-economic status on children's sharing decisions. On one hand, it was predicted that children from lower classes would share less than children from higher classes, and the mothers from lower classes would have lower scores of social preferences, given previous evidence that children from low socio-economic status tend to share less resources (Rochat et al., 2009). On the other hand, it was predicted that children from lower classes would share more equally instead, given the evidence that they most likely are recruited to help their parents at home (Bauer et al., 2014), and the recent evidence that people with less resources cooperate more with each together (Pepper & Nettle, 2018). However, no influence of socio-economic status on children's sharing decisions was found.

Finally, culture, but not social class, had an influence on the mothers' social preferences: English mothers had greater scores than Brazilian mothers. There are at least three possible explanations. First, culture might affect specific prosocial decisions at a later age, and this would explain the absence of cultural differences for children in this task, but not their mothers' answers to social dilemmas. This is partially supported by the modest effect of culture on the type of sharing between children, with English children sharing more actively than Brazilian ones. Thus, English people might enforce sharing by actively giving to others,

while Brazilian people might enforce sharing by asking for or taking their share. Second, this difference between mothers from both cultures might be specific to hypothetical decisions, rather than actual ones. Hence, the mothers could have shown no differences in a similar task as the marble run.

A caveat of this study is that, despite our efforts to diversify the sample according to their socio-economic status, the English sample was clustered around the upper-middle class bracket. Perhaps the differences between children's active sharing decisions, and the mothers' social preferences scores (albeit without a direct relationship between the former and the latter) might only reflect differences between the English upper class and other social classes. Nevertheless, the influence of culture on children's active sharing, and the mothers' prosocial scores had relatively small effect sizes, which might indicate that there are no influence of these cultures or social classes whatsoever.

The results discussed in the following provide a few interesting insights, although they were not the main focus of the study. First, we found a number of relations between the mother-reported measures, that were in agreement with previous literature (Eisenberg et al., 1996, 2001, 2006). Children's social skills scores were negatively correlated with problem behaviours scores. Social skills were positively correlated with surgency and effortful control, and negatively correlated with negative affect, while problem behaviours were negatively correlated with effortful control, and positively correlated with negative affect. Therefore, the mothers' reports were consistent across and within measures, which gives validity to the data.

We found an influence of gender on children's social skills and effortful control: girls had greater scores than boys in both characteristics. However, there was no effect of gender, neither there was any interaction between gender and temperament whatsoever on children's sharing decisions in the task. A possible explanation is that parents tend to attribute different

characteristics to boy and girls, which might not reflect their children's actual behaviour, given that girls and boys behaved roughly similarly in the task, even in the presence of the experimenter. This is at odds with previous research that have shown that girls have greater sensitivity to social evaluation, and that they tend to behave similarly to boys in anonymous, but not public, settings. Future studies could further explore the relationship between parents' ratings, gender socialization and children's prosocial behaviour in interactive contexts.

Both social class and culture had an influence on children's negative affect scores, with children from upper middle classes and English children having lower scores for this dimension. In addition, English children also had lower scores for problem behaviours. The fact that the English sample had more participants from the upper-middle class, as explained above, might explain this difference between Brazilian and English children concerning their negative affect scores. Nevertheless, there was no effect of both temperament and culture on children's sharing decisions.

Taken together, our findings point towards possible separate influences of culture, social class, and gender on children's characteristics and their mothers' prosocial behaviour that, for a number of reasons, were not correlated with children's sharing behaviour for one particular task. However, our reported measures should be taken with caution, for two reasons. First, there is a chance that reported measures, such as parents' ratings, are not completely accurate regarding the children's actual behaviour in prosocial contexts, and that any relationship between the variables are an artefact of the questionnaires. Second, the relatively small sample size of the study, due to the number of questionnaires not returned. Nevertheless, our findings raise potential avenues for research regarding the influence of moderating variables on children's sharing decisions in interactive contexts.

This study aimed to fill a gap in the experimental studies of collaboration between children, regarding the influence of dispositional and sociocultural variables, which are often not investigated together. The interaction between children must bring different prosocial outcomes than when these children have to make social decisions alone. Hence, any study that focus on the investigation of children's individual behaviour must be careful when extrapolating to interactive decisions. More data is necessary to assess the interplay between individual, social and cultural variables on the development of collaborative behaviour and sharing.

Supplementary Information

Additional demographic information

Cultural and demographic factors are often confounded in studies of human behaviour (Pollet, Tybur, Frankenhuis, & Rickard, 2014), and particularly in studies of human cooperation (Lamba & Mace, 2011, 2013). In an attempt to disentangle those effects on the children's sharing decisions after collaboration, we measured socio-economic status across a number of factors, and compared two economically similar cultures, but with different historical backgrounds.

Children, and their respective mothers, from two different Western cultures were compared across three categories of socio-economic status. The characteristics of both countries were described in chapter VI.

Measures of socio-economic status

Socio-economic status (SES) or social class is a relevant variable on psychological literature and it affects human development (Amir, Jordan, & Rand, 2017; Pepper & Nettle, 2017). SES can be defined as "a complex construct that aims to define a person's ranking in a social and economic hierarchy. It is generally measured by such factors as education, occupation, income, or wealth." (Pepper & Nettle, 2017, p. 2).

We attempted to measure it by a number of factors, to be able to establish with more accuracy the social class of the participants. This was done mainly to allow a comparison between both countries and reduce the influence of confounding variables. We chose to collect data in different ways in an attempt to establish a more accurate categorisation of the participants' social class. It is rather difficult to establish a level of comparison between

different societies. In experimental studies of cooperation, the socio-economic status of participants is either omitted or vaguely stated. Additionally, studies who have been recently compared samples from different societies or cultures rely on demographic variables of the population, but rarely report on the social class of the sample within their populations. This sort of information can be assessed by asking the participants directly through questionnaires or interviews; assessing their location; or through some proxy information such as the type of society or social group they come from, or whether and where their children attend school.

We collected the same demographic data for both samples, to allow comparison between groups. The social class of the participants were determined by: the type of school the children attended; a British index (ACORN), created by CACI Limited (CACI, 2014), and a Brazilian index created by the Brazilian Association of Research Companies (Associação Brasileira de Empresas de Pesquisa, 2014). Both scores provided indicators based on official government records to assess background family incomes relative to each population. Then, we grouped the participants in three groups: higher, middle, and low socio-economic status, based on the usual interpretation of these indexes for each country. In the following sections we detail the measures we have used to determine and compare SES of Brazilian and English children.

Type of school. To achieve more variety in our sample, we sought to collect data from children in different types of schools. Public schools bring in children from a variety of social classes, while private schools bring in mostly children from upper classes. Hence, we collected data from children in "public" schools (mainly funded by taxes, the state, or charities), and "private" schools (mainly funded by the parents or at least charge term fees to accept pupils), for both countries.

ACORN score (CACI). ACORN is "a segmentation tool which categorises the UK's population into demographic types" (CACI, 2014, p. 2). There are 6 categories, 18 groups, and 62 types. It is measured by asking the family's postal code. We divided the categories in three types: upper middle class (categories A to E), middle class (F to J), and lower class (K to R), as shown in Table 1.

Table 1

English children's distribution by ACORN score

Social class (ACORN score)	**N**
Upper middle-class (A-E)	36
Middle-class (G-J)	9
Lower-class (L-Q)	11
No answer	8
Total	**64**

CCEB score (ABEP). The CCEB is a Brazilian standard questionnaire (Associação Brasileira de Empresas de Pesquisa, 2014) with items that can be summed up and will give a score that represents the family's socio-economic status in Brazil, according to a formula. families are grouped in seven categories, from the wealthiest to the poorest: A1, A2, B1, B2, C1, C2, and D-E, according: a) the number of items; b) the number of domestic workers; c) whether there is piped water, well or other source of water; d) whether the street is paved or not; and e) the highest educational level in the family. We divided these categories in upper class (A1, A2), middle-class (B1, B2), and lower class (C1, C2, D-E), as shown in Table 2. This questionnaire was translated to English and applied to the English mothers as well to provide an additional level of comparison between the two samples (see Table 3 for comparisons regarding educational level, and Table 4 for comparison between CCEB scores).

Table 2

Brazilian children's distribution by social class according to CCEB scores

Social class (CCEB score)	**N**
Upper middle-class (A1, A2)	18
Middle-class (B1, B2)	35
Lower-class (C, D-E)	47
No answer	13
Total	**113**

Table 3

Comparison between English and Brazilian children's by highest educational level within the families

Highest level of education	**Brazil**	**England**
Higher Education (University/HEI)	42	49
Secondary Education / Incomplete Higher Education	26	12
Primary Education/Incomplete Secondary Education (until Year 11)	11	1
Primary Education/Incomplete Secondary Education (until Year 9)	8	0
Incomplete Primary Education	17	0
No answer	9	2
Total	**113**	**64**

Table 4

Comparison between English and Brazilian samples regarding social class according to CCEB scores

CCEB class	**Brazil**	**England**
A1	20	39
A2	16	15
B1	15	5
B2	19	4
C1	20	-
C2	7	-
D-E	10	-
No answer	6	1
Total	**113**	**64**

We also collected information regarding the parents' occupation, but this information was not assessed, due to wide variation in the responses, and a large number of non-responses.

Supplementary Figures

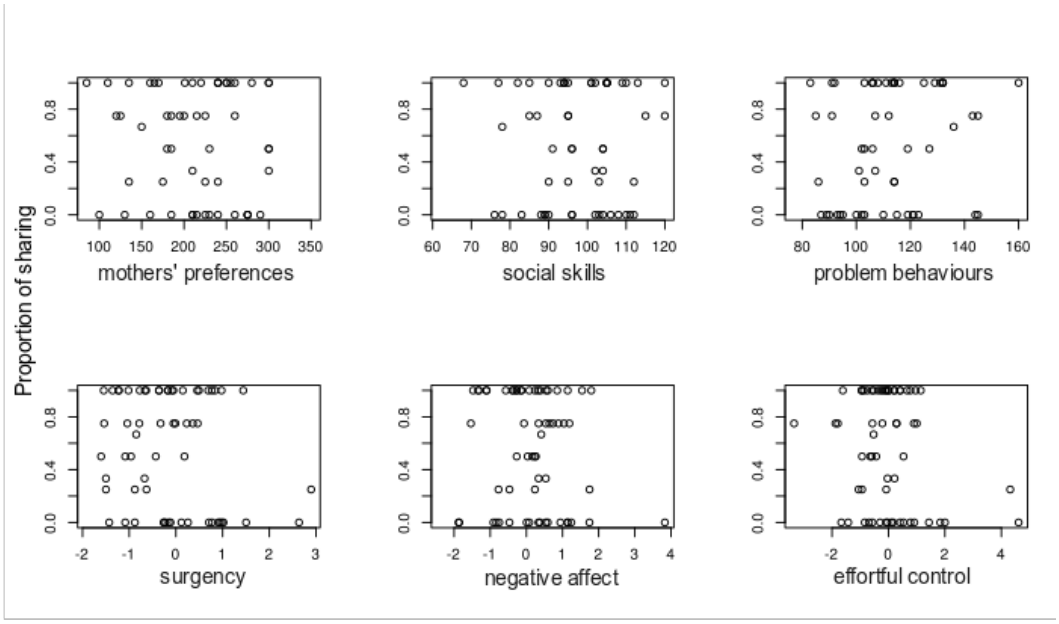


Figure 1. Scatter plots of the relationship between the proportion of children's sharing over the number of times they were at the end of the tube. and the family and dispositional variables.

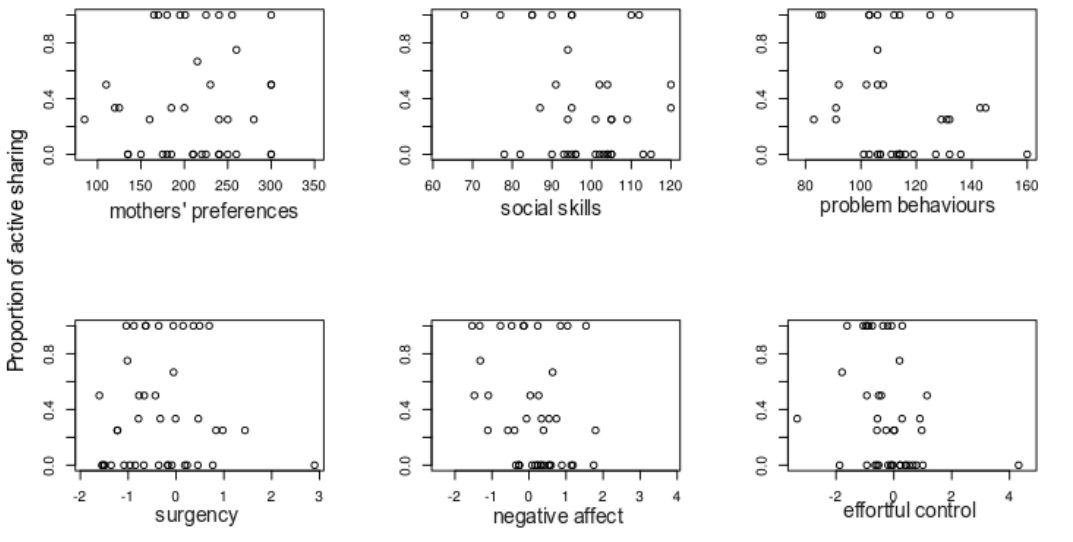


Figure 2. Scatter plots of the relationship between the proportion of children's active sharing over the number of times they had the opportunity to share, and the family and dispositional variables.

Economic games

The children's mothers were asked to answer to three social dilemmas. These dilemmas were all hypothetical, and were similar to the dictator game, the ultimatum game and the trust game, respectively. The mothers' should answer by writing down their decisions. A template of the form delivered to the mothers is shown below.

Social Preferences Questionnaire

Your name

_____

Sex: ( ) Female ( ) Male

Relationship to Child: ( ) Mother ( ) Father ( ) Guardian

( ) Other _____

General Instructions

PLEASE READ THESE INSTRUCTIONS CAREFULLY.

Thank you for participating in our study.

We are interested in how the decisions people make affect how much they win. You will be asked to imagine a series of interactions, each one matched with a different person. Answer as if you were in a real interaction involving these decisions.

The rules for each interaction will be different, so please read the instructions carefully.

Some interactions will have different "roles" for different participants. We will ask you what you would like to do in each possible role. We're interested in your choices, and we're not interested in "tricking" you in any way.

If you have any questions, please contact me at the number [phone number] (Natalia) or send me an email: nbdutra@gmail.com.

The example below show how you should answer to the questions:

Example of question 1 – Tick box

Which colour did person A prefer? Please choose the correct answer below:

■ Blue

□ Yellow

Example of question 2 – Write down the answer

If you are person A, which colour will you prefer? [Please write down your answer: blue or yellow]

Answer: Blue

Situation 1

In this interaction you are matched with one other person. One of you will be person A, one of you will be person B. Person A starts with £100 and person B starts with £0.

This interaction has one single decision:

1) Person A will choose how much of the £100 to transfer to person B.

2) Person B will get the money A transfers and A will get to keep the rest.

The graphic below shows a summary of the interaction:

A transfers to B

Question 1

What happens if person A transfers £20? Please choose the correct answer below:

□ A keeps £80 and B gets £20

□ Both get £20

Question 2

If you are person A in the interaction, how much will you transfer to person B? [Please write down your answer from £0 to £50]

Answer: _____

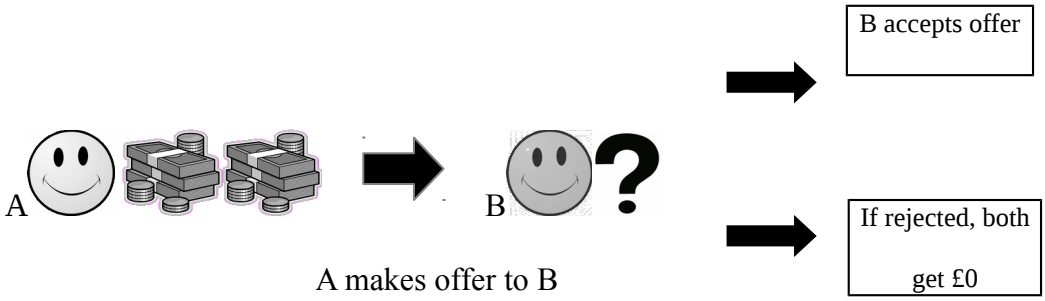
Situation 2

In this interaction you are matched with one other brand new person. One of you will be person A, one of you will be person B. Person A starts with £100 and person B starts with £0. First person A makes a choice, then person B responds.

1) Person A will make an offer on how to split the £100 with person B.

2) Person B will either accept or reject this offer. If person B accepts, then B will get the offered amount and A will keep the rest. If B rejects the offer then both individuals will get £0.

The graphic below shows a summary of the interaction:



Question 1

What happens if person B accepts an offer of £20? What happens if person B rejects this offer? Please choose the correct answer below:

□ If B accepts this offer then A gets £80 and B gets £20, if B rejects then A gets £80 and B gets £0

□ If B accepts this offer than A gets £0 and B gets £0, if B rejects then A gets £0 and B gets £0

□ If B accepts this offer then A gets £80 and B gets £20, if B rejects then both get £0

Question 2

If you are person A, what amount will you offer to person B? [Please write down your answer from £0 to £50]

Answer: _____

Question 3

If you are person B, please indicate your minimum acceptable offer. That is, if the offer that A gives you is **below this, you would reject** and if the offer A gives you is **above or equal to this, you would accept**. [Please write down your answer from £0 to £50]

Answer: _____

Situation 3

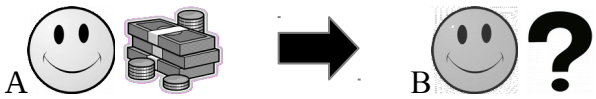
In this interaction you are matched with one other brand new person. One of you will be person A, one of you will be person B. Both of you start with £50. First person A makes a choice, then person B responds.

1) Person A can choose to transfer their £50 or not. If person A transfers £50 then it is TRIPLED and given to person B (so person B now has £200).

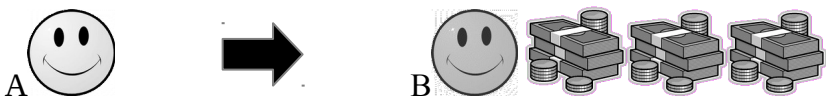
2) Person B can then choose how much of the money they want to transfer back to person A (between £0 and £150).

The graphic below shows a summary of the interaction:

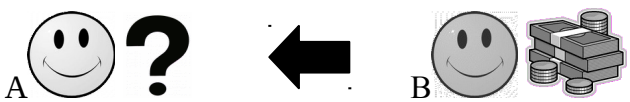
A makes a choice



If A transfers the money, the amount is tripled



B makes a choice



Person B can transfer money back

Question 1

What happens if Person A transfers £50 and Person B transfers back £25? Please choose the correct answer below:

□ Person A earns £25, person B earns £175

□ Person A earns £50, person B earns £50

□ Person A earns £100, person B earns £100

Question 2

If you are person A, do you want to transfer your £50 to B? Please choose the correct answer below:

□ No Transfer

□ Transfer £50

If you are person B and person A transfers you £50 (which is multiplied to £150), how much money do you want to transfer back to A? [Please write down your answer from £0 to £150]

Answer: _____

Chapter VIII

General Discussion

The main goals of the work in this thesis were to investigate whether, and if so how, children learn from others to collaborate and make sharing decisions in interactive settings, and how contextual variables affect their behaviour. A secondary goal was to attempt to integrate theoretical approaches to the development of human cooperation and culture into the explanation of children's collaborative decisions. To achieve those goals, three different experimental approaches were adopted to investigate children across different age groups in early and middle childhood.

In the previous chapters (chapter II to VII), this thesis addressed a number of questions: how do children copy collaborative decisions? What roles do individual, social, and cultural factors play on children's development of collaborative skills? What methods are best suited to investigate the influence of these multiple factors on children's collaborative decisions? And, how does the evidence on children's sensitivity to context in collaborative settings add to an evolutionary approach to the development of human cooperation? The following sections address each question separately, while discussing how the studies that comprise this thesis contributed to the understanding of the effects of contextual variables and individual differences on children's social learning of cooperation.

How do children copy collaborative decisions from peers?

Chapter II reviewed the evidence on children's social learning and cultural transmission of collaborative actions. Children participate in turn taking activities with their caretakers from their early months of life (Trevarthen, 2011). Toddlers spontaneously help and collaborate with adults in experimental tasks (Warneken et al., 2006; Warneken & Tomasello, 2007), and their early engagement in reciprocal interactions seem to influence their willingness to help adults in these

situations (Cortes Barragan & Dweck, 2014). Naturalistic observations of children and their families provided evidence that children are engaged in domestic chores from early in life (Pettygrove, Hammond, Karahuta, Waugh, & Brownell, 2013; Whiting & Whiting, 1975); and specifically in more collectivistic cultures, children learn by observing adults and pitching in with activities (Rogoff, 1990, 2003). Among peers, children express social roles, coordination and communication between themselves in social play (Corsaro, 2009; Corsaro & Eder, 1990). However, children struggle to coordinate with peers in complex tasks up until the age of five years (Ashley & Tomasello, 1998; Meyer et al., 2016), and it is not entirely clear how they learn from observing and copying joint actions from each other (Fawcett & Gredebäck, 2013; Fawcett & Liszkowski, 2012).

Chapter III described a study that investigated whether different types of roles and tasks would influence young children's reproduction of collaborative actions across three "generations" of peers. This study addressed a simple question: what children would do in a standard imitation test involving the observation of two other children interacting in a collaborative task? This question addressed two aspects of imitation research: the first one was that most imitation tasks require individual work, with the interaction limited to the observer and the model (who usually are the experimenters themselves; see for example (Haun & Tomasello, 2011; van Leeuwen et al., 2018; Want & Harris, 2002; Whiten, McGuigan, Marshall-Pescini, & Hopper, 2009); the second one was that previous attempts at testing imitation of collaboration relied on interactional settings rather than observational settings (Ashley & Tomasello, 1998; Dean et al., 2012; Göckeritz et al., 2014; Slavin et al., 1985; Tudge & Rogoff, 1989). That is, there was no experimental testing of the effects of observing other peers interacting with each other on children's subsequent social interaction (although, for children's observation of collaborative adult models, see: Matheson et al., 2013; Milward & Sebanz, 2018).

In the study described in chapter III, three- and four-year-old English children were tested in four collaborative tasks, based only on third-party observation, that it, without interaction with the models. I investigated whether the observers would show different levels of fidelity in copying instrumental or social tasks, to test to which aspects of the task children would spontaneously attend. It was hypothesised that children would copy more faithfully the instrumental aspects, given that social games could provide more room for deviation from what had been observed for children interacting with their partners (Ross, 1982). However, part of the literature on social games point to children being highly conventional in their following of games rules (Rakoczy & Schmidt, 2013). Therefore, it was also predicted that children could copy more or less faithfully in social games, depending on how they perceived the tasks' demands. Regarding the fidelity of copying of tasks with similar versus complementary roles, it was hypothesised that it was more challenging to reproduce complementary, rather than similar, actions. It was assumed that the complementary actions required more sophisticated perspective taking skills, given that children had to interpret two different sequences of actions, and their own actions in relation to their partners. Conversely, similar actions were assumed to require less effort to interpret them, and therefore to be easier to copy.

Cooperation was found to be "infectious" between those children; that is, they copied all the actions demonstrated across the four tasks, with high fidelity most of the time. The collaborative actions demonstrated by peers were faithfully copied and transmitted to other peers, across tasks with different roles (similar versus complementary), and outcomes (problem-solving tasks versus social games). Although children copied the actions with similar fidelity across the four tasks, they did so with lesser fidelity in tasks with similar roles, which was contrary to my predictions. This could have happened because both tasks required simultaneous actions, which might have been harder to achieve than in tasks with complementary roles, where the actions occurred in sequence. While children were able to understand their roles in the tasks, they had some difficulty with

performing them, probably due to their motor skills. An interesting related exploratory finding, however, was that children in those tasks exhibited more variation, even when capable of reproducing the models' actions. Moreover, they seemed to be having more fun, by laughing and interacting with each other, than in other tasks. It might be worth pursuing hypotheses regarding the copying of collaborative tasks with different levels of difficulty, and framed as fun or play tasks in the future (Nielsen, Cucchiaro, et al., 2012; Ramani & Brownell, 2013).

Children, in presence of models, did not need extensive communication to coordinate their actions. Children in control conditions, without demonstrations from peers, had trouble identifying the goals of the task, and which roles they could perform. Thus, they had difficulty in coordinating in the tasks, which has two implications. The first is that children are better at coordinating in the presence of models, and that third-party observation might play a relevant role in promoting collaboration (Milward & Sebanz, 2018). The second is that children most likely need a structured environment (usually set up by adults) to be able to perform tasks (Rogoff, 2003). Children are very attentive to cues of normativity (Rakoczy & Schmidt, 2013). In the study, the experimenter attempted to reduce the influence of such cues on children's collaborative behaviour by giving them general instructions and avoiding coaxing children to collaborate. However, children's imitative behaviour might have been reinforced by the experimenter's presence and directions. Furthermore, the setting and the peers acting as models established the requirements for the children's performance. Therefore, these act as social cues that preschool children are able to pick up and use to perform roles that they think are expected from them, even in tasks that require mutual coordination, and in which children usually struggle to perform by themselves. Future studies might investigate further the role of such cues in the development of collaborative interactions.

Chapter IV describes a second study designed to further investigate the effects of contextual cues on children's collaborative decisions, and the relationship between these cues and social learning mechanisms. It investigated children's use of social information when there is potential

conflict of interest, and children cannot communicate between themselves or assess cues of reputation and reciprocity from their partners. The public goods game, which is a collective social dilemma, seemed a suitable paradigm to investigate the effects of social learning and contextual cues, allowing the control of different access to the information. It is also a paradigm that has been rarely, but successfully, adopted with children (Alencar et al., 2008; Dutra et al., 2018; Harbaugh & Krause, 2000; Silva et al., 2016; Vogelsang et al., 2014). Thus, six- and seven-year-old children had to play two rounds of a public goods game, in which they were given information regarding the decisions of both the highest earner and the majority (modal contribution) in the game between rounds. It was assessed whether the information affected children's subsequent decisions in the game, and whether the results indicated pay-off, conformity or no bias towards copying the other players' decisions. In addition to this, children were told their decisions were anonymous, and that they would play with different groups of children each time. Therefore, there was no opportunity for them to communicate with the other players or use their decision as a cue for reputation.

Two types of conformity have been identified: informational and normative (Deutsch & Gerard, 1955). Informational conformity is related to an individual's attempt to obtain accurate information about their environment. Normative conformity is related to social interactions, peer pressure and group identity. In the absence of social control, Claidière & Whiten (2012) predict that people will tend to show a form of linear or weak conformity, in which the probability that they will reproduce the most common trait in the population is equal to the frequency of this trait. Therefore, the study described in chapter IV attempted to remove any cues of normative conformity, while leaving information that could lead to informational conformity, that is, the decisions of the majority. In addition, children had access to a second type of information, which indicated the behaviour of those who achieved the greatest pay-off. One might argue that this information should be enough to drive children towards copying it and ignore the behaviour of the majority. In support to this hypothesis, previous research comparing conformity and pay-off biases among children

found that they prefer to copy those with the highest pay-offs, but only when the majority is clearly unsuccessful (Burdett et al., 2016).

When children had donated in line with the highest earners in the first round of the game, they were similarly inclined to copy either types of social information. This is interesting because one would expect that they would keep to their original decision; that is, they would continue to donate the same amount that gave them the highest return in the group. However, some of these children decided to increase their donation towards similar amounts to those donated by the majority. Children who donated in line with the majority, however, were equally likely to copy either social information or none of them. Moreover, children who had not shown any particular tendency in the first round, were not inclined to be biased towards any information. It seemed that some sort of social comparison might have influenced children's decisions. Only children who were aligned with one or other social information showed some inclination towards copying either one or another, as discussed previously. Hence, children used the information as a cue to vary their behaviour, but were not particularly inclined to one of them.

This finding is even more interesting when it is considered that, in contrast to the study described in chapter III, the children tested in chapter IV were Brazilian. According to Hofstede et al.'s (2010) theory of cultural dimensions, Brazil has characteristics that put it in the middle between collectivism and individualism, being more collectivistic than England. Thus, Brazilian children could have been expected to have a strong propensity to conform to their peers' behaviours (Bond & Smith, 1996; van Leuween et al., 2018); however, this was not observed. No differences were observed across the groups' studied as well; if differences had been found it could have indicated potential differences across social classes (children came from one private and one public school). Finally, this period, between six and seven years of age, is marked by an increased egocentrism, which can also explain the non-significant rates of conformity (Morgan, Laland, & Harris, 2015). More recently, a reduction in conformity and prosocial behaviour around the same

period has been observed across different cultures (van Leuween et al., 2018). However, it does not explain why some children chose to increase their donations instead. Thus, more studies are necessary to explore further the roles of social cues on children's conformity, across different types of social interactions, and different sociocultural groups.

What roles do individual, social, and cultural factors play on children's development of collaborative skills?

Chapters V to VII reviewed and investigated the role of individual, social, and cultural variables on children's sharing decisions after collaborating with each other. The original aim was to also test whether there were any differences in children's collaboration prior to sharing decisions. However, all children, except for one pair, chose to collaborate in the task up until the end, and sharing decisions did not seem to affect their compliance. This supports previous evidence that children show great coordination skills and commitment to partners from early on, but decisions regarding sharing of resources are a more nuanced skill (Warneken, 2018). Hence, I tested whether children would share more equally after collaborating with a partner, but in a task with unequal outcomes, alongside the influence of individual, social, and cultural variables on their behaviour (chapters VI and VII).

Two samples from "Western" countries were compared: Brazil and England (geographically speaking, both countries are Western; culturally speaking, however, Brazil is seen as part of Latin America culture, while England is part of the Anglophone Western culture; see Henrich et al., 2010). These countries are considered similar in economic terms, but different in social and historical terms (Hofstede et al., 2010). Cultural comparisons have been criticised for making assumptions and reaching conclusions without considering alternative hypothesis concerning the samples' demography (Lamba & Mace, 2011) or the influence of other variables, such as individual differences (Pollet et al., 2014). Hence, though both studies had a limitation of using nationality as a

cross-cultural measure (Pollet et al., 2014), they attempted to assess the influence of other potential confounding variables before making any conclusions regarding cultural similarities or differences.

In Chapter VI, Brazilian and English four- and five-year-old and eight- and nine-year-old children were asked to play four trials of a collaborative game, called the “marble run”, in which they should insert their fingers in separate entrances to make marbles run through a long tube and be released at the end of it. Older children were consistently better at sharing rewards more equally after collaborating, and that English children shared the rewards more actively than the Brazilian children. Older children have better socio-cognitive skills regarding self control, perspective taking, communication, and understanding of social norms; therefore it was expected that they would perform better at the task. However, the interesting aspect of these findings is that young children tended to share much less than older ones, and only a small percentage of than shared equally. Moreover, their donations towards more or less marbles did not cluster around the equal share (meaning they were sharing only slightly unequal amounts); the children who won more marbles tended to keep all or almost all of them to themselves.

The findings described seem at odds with previous literature regarding increased sharing in young children after collaboration (Hamann et al., 2014; Hamann et al., 2011; Warneken et al., 2011). It has been argued that collaboration stimulates young children perspective taking skills, and that they show early skills to share amounts equivalent to the input of each partner (Ng et al., 2011). However, for this to happen, the situation must clearly signal the collaborative nature of the task, and it is possible that the experimental setup might induce children to share more equally. It is important to stress that, even if this is the case, it is still remarkable that young children are able to pick up on cues of collaboration and respond in kind. However, it is misleading to affirm that children show propensity to share in collaborative situations without addressing the role of the adult influence and the task scaffolding in this.

For all the experiments that comprise this thesis, but specially for this study, warm up sessions and language that could induce children to collaborate with each other were avoided. As it has been argued in the previous section, children are very sensitive to contextual cues. They learn from an early age to identify cues from adults regarding what actions are considered appropriate for a particular situation. Thus, it is likely that they are able to detect even subtle cues in an experiment regarding what is expected from them. Moreover, children are already instructed in their natural environments to follow certain rules of fairness. Thus, any cues that could indicate that children were expected to share the rewards equally were reduced. Moreover, the chosen task allowed children to have access to a variable number of rewards depending on their performance, and the maximum number of rewards they could win per trial was an odd number. This was done to make it difficult for children to infer from the task and the instructions what they thought it was expected from them, and test whether they would spontaneously collaborate and share with each other.

Finally, this study demonstrates that the manner in which social interactions are framed matters. Most collaborative tasks with young children involve the performance of similar roles, sometimes in simultaneous coordination (e.g., two children pull a rope; Warneken et al., 2001) or in parallel (e.g., a child and a puppet "fish" buckets individually; Kanngiesser & Warneken, 2012). The children sit beside each other or beside the experimenter. The outcomes are generally speaking, easy to share. And finally, most children come from middle class families, in which the "loss" of such resources would not mean a great deal for them. More studies are necessary to disentangle what is involved in experiments that look into collaborative problem-solving tasks across development. A more nuanced approach, from this thesis' perspective, involve the consideration of how children's actions change or not across situations. It would be interesting to manipulate different degrees of access to rewards, social interactions, and levels of difficulty in collaborative tasks to better understand which process determine children's decisions. In chapter V, a couple of

examples of studies that approached this problem were offered, in other fields of psychology. An evolutionary developmental approach might benefit of drawing from this literature.

In a complementary study to Chapter VI, the study in Chapter VII looked into the influence of other variables on children's collaborative decisions in the same sample. The children's mothers were asked to answer to a number of questionnaires regarding children's individual characteristics (temperament and social skills), the mothers' social preferences, and the families' socio-economic status. The findings of chapter VI held for the analyses in chapter VII, in which about half of the sample was used, corresponding to the children whose mothers returned the questionnaires. For both age groups, there was no effect of individual characteristics on children's decisions in the interactive task. One possible interpretation is that social interaction itself might be a relevant factor in promoting more egalitarian sharing for older children in face-to-face interactions, while young children still need more scaffolding from adults to act on problem-solving that involve negotiation, regardless of particular individual traits. Moreover, the mothers' social preferences, which were measured across three different social dilemmas, had also no statistical significant relationship to the children's decisions. An interesting parallel, however, was found for the influence of culture on both mothers' social preferences and children's active donations. The English mothers had higher scores, meaning they had more generous choices across the games, than Brazilian mothers. The way children negotiate or dispute rewards in a collaborative situation may be a product of cultural differences: English people might actively share resources in prosocial tasks, while Brazilian people might share more only in situations where sharing is enforced by others of similar status. This is in line with the differences between both countries across cultural dimensions individualism versus collectivism (Hofstede et al., 2010) and recent evidence on less prosociality among Chinese children (China is a country with even higher levels of collectivism than Brazil; Chai & He, 2017).

Across the two studies (chapters VI and VII), and the study discussed in chapter IV, socio-economic status did not affect children's performance. Socio-economic status was measured in two

ways: by using school type as a proxy to social class (with children from upper classes being more common in private schools, and children from lower classes being more common in public schools); and by using individual reports based on standard measures of socio-economic status from both countries. Once again, this might indicate that this particular task tapped into a general path of development towards better negotiation and perspective taking skills, as well as the ability to understand and enforce norms of fairness. The fact that both samples were from "Western" and urban samples might also point to more similarity among children that come from these environments. Moreover, given that children across all classes were recruited in schools might also explain these similarities; children that are not schooled might have behaved differently (López, Correa-Chávez, Rogoff, & Gutiérrez, 2010).

Evidence on the influence of dispositional variables, such as temperament and social skills, on prosocial behaviour rely greatly on self-reports or report from others, and observational studies. However, no relationship was found between the parents' reports of children's dispositional variables in five dimensions (three of temperament and two of social skills), and the children's actual performance in sharing decisions after collaboration. In addition, no interactions were found between those dimensions and the other variables: the mothers' social preferences, and the children's socio-economic status and country. However, a number of relations were found between the reported measures for children's dispositional characteristics (social skills and temperament), that were in agreement with previous literature. Therefore, the mothers seemed to be consistent across their reports of the children's dispositional characteristics. Additionally, there was also indication of the separate influence of culture, social class, and gender on children's characteristics and their mothers' social preferences, as discussed in chapter VI.

The absence of effects of the variables reported above on children's behaviour in the sharing task might indicate that, in interactive contexts, such variables might not have the same strength as when one is making individual decisions. Even though one child could decide how to share the

rewards, the outcome was always the result of children's interactions and discussions during the task. An implication is that perhaps children's skills in this kind of task develop similarly across individual, social, and cultural characteristics (Warneken, 2018). In other words, the developmental path of collaborative and sharing skills and norm enforcement follows an ordered sequence that is common across children from urban settings and Western societies (although with variations across more diverse cultures; House et al., 2013). Nevertheless, more information from well powered studies is needed to achieve a more definite conclusion.

To conclude, psychology has been criticised recently for not reporting null findings and prioritising "positive" results, that is, results with a significant effect or difference given a threshold level of significance (usually $\alpha < .05$). This has led to a false positive publication bias, given that statistics relies on the assumption that a percentage of studies on the same subject will reject true hypotheses when those are false, and accept false hypotheses when those are true. On top of the contributions already described in the previous chapters and in this discussion, it is important to emphasise the relevance of making null results public, which can inform decisions of whether to pursue or not a line of thought based on those findings.

Which methods are best suited to investigate the influence of individual, social, and cultural factors on children's collaborative decisions?

Three experimental approaches were adopted to investigate the social learning of cooperation between children. The first one consisted of a combination of a diffusion chain experiment and collaborative tasks. The second one consisted of the application of a collective social dilemma to the investigation of the use of social information by children. The third approach consisted of a cross-cultural comparison of children's performance in a collaborative task with unequal outcomes, and use of questionnaires to assess individual, family, and social variables.

A caveat of the studies described in this thesis was that some decisions had to be made concerning the time available to perform the experiments. Social learning experiments are more complex than individual experiments or experiments that look into behaviours at a particular point in time (e.g. pairs of children performing a joint task), due to the logistics of coordinating the pairs and timings in the tasks. Because of this, only one of the experiments was performed with multiple generations (the cultural transmission chain study, in chapter III), one with a closed group transmission paradigm (the public goods game study with two rounds and the same participants, in chapter IV), and the other remaining two studies focused on the indirect influence of the social or cultural group on children's decisions (chapters VI and VII). Nevertheless, this limitation allowed us to test a variety of methods in the assessment of children's collaboration and sharing. Each approach aimed to investigate a particular aspect of children's social learning of collaboration and sharing with peers, and the influence of contextual variables on children's decisions. I will discuss below in which ways each approach contributes to a better understanding of these phenomena.

Cultural transmission of collaboration between pairs

The majority of studies on children's social learning focus on children's individual decisions and performance. This is understandable because it increases experimental control and facilitates the data analysis and interpretation. Moreover, many psychologists are concerned with the underlying psychological mechanisms of social learning, which are often assessed by isolating specific aspects of the child's behaviour. Conversely, the studies in this thesis are concerned with how children behave in collaborative interactions, and how context influences children's learning of collaborative skills.

Evolutionary theories of human cooperation have argued that cooperation and culture are intertwined phenomena (Boyd & Richerson, 2009; Burkart et al., 2014; Tomasello & Gonzalez-Cabrera, 2017). Nevertheless, the literature applied to child development that draw from these

theories usually investigate only one of these two phenomena, and draw inferences about the other. For instance, there seems to be no studies adopting the cultural transmission paradigm to the investigation of collaborative interactions between children, as proposed in this thesis. Therefore, this thesis contributes to an evolutionary developmental approach to peer cooperation by combining two experimental paradigms, the cultural diffusion chains and collaborative tasks, to investigate whether cooperation between young children would spread across pairs.

Regarding the method used, it was found that it is possible to combine a cultural transmission paradigm with collaborative tasks to investigate the mechanisms of learning and transmission of cooperation between peers. These findings support the current evidence on children's early cooperative tendencies, but also show how these tendencies and social learning processes might ensure that cooperation spread in groups of children. They also raise interesting questions to examine regarding how the task structure might affect children's reproduction of their peers' actions.

The potential uses for the cultural transmission paradigm, in combination with cooperative tasks, are various. There are different ways of observing cultural transmission in the laboratory (Mesoudi, 2007; Mesoudi & Whiten, 2008), and a variety of questions that could be addressed regarding children's social learning of cooperation. For example, one can examine how cooperation in certain tasks might lead to better or worse spread of outcomes in a group of children; or whether cooperation will remain the chosen strategy for the children, or children will switch to other strategies, and so on. Nevertheless, the greater complexity of these potential designs must lead to new challenges and innovative approaches in the analyses and interpretation of this data.

Social learning in a collective cooperative dilemma

A focus on collaboration as a strategy to obtain resources, as proposed here, must take into account how children make decisions when their interests are in conflict with others. How children

choose to copy information from others in a collaborative context may be strategic. The use of social dilemmas combined with methods to study social learning mechanisms and biases between children can contribute to a better understanding of children's social learning of collaborative decisions. This has relevant implications for the understanding of how children make decisions in interactive settings, how social interaction impacts on children's individual decisions, and whether, and if so how, they learn from peers in such situations.

Economic games, as explained in chapter II and IV, have been widely applied to the investigation of children's decisions. They offer an interesting alternative to investigating interactive decisions in a controlled manner (by asking children to make decisions one at a time, for example, but in relation to the performance of others in the experiment). However, only a few studies have investigated children's interactions in social dilemmas beyond dyadic interactions; and fewer have used social dilemmas to explicitly investigate the effect of social learning on children's decisions. Nevertheless, one can argue that social dilemmas with repeated interactions might involve some degree of social learning; but research questions are usually focused on the development of reciprocity and reputation concerns, that is, how people react to others' actions in social interactions, rather than, say, mechanisms of imitation or instruction. Therefore, there are interesting avenues for research on social learning and economic decisions among children.

Cross-cultural comparisons of sharing decisions after collaboration and the use of moderating variables

There have been recent criticisms to the use of limited samples in psychology to support theories of universal traits (Henrich et al., 2010; Nielsen et al., 2017). Moreover, the manner in which psychologists approach other cultures in their theories have been criticised (Kline et al., 2018). Other demographic variables must also be taken into account; thus socio-economic status

was chosen, given that it has been shown to play a role on prosocial development (Pepper & Nettle, 2017; Rochat et al., 2009), while also controlling for age, sex, and individual differences.

This thesis aimed to compare children from two cities in different countries with similar market integration but diverse social indicators and history. The effect of culture was investigated in two ways. First, the effect of culture was assessed in interaction with a measure of socio-economic status (type of schools, in chapter VI), and the immediate context (characteristics of the task), while controlling for age group and sex. This assessed whether culture would affect older children more than younger ones, and whether girls would behave differently than boys across cultures. Second, the effects of individual characteristics and mothers' social preferences on children's decisions were assessed, while controlling for culture and another measure of socio-economic status, reported by the mothers (in chapter VII). By using a number of different measures that are predicted to influence children's behaviour, it was found that there were no cultural differences regarding children's performance, or if they do exist, their effects were not salient for this particular task. It is important, however, to emphasise that culture does not necessarily equal nationality; in addition there might be greater differences within the countries investigated than between the groups from the sample used. Thus, this method raises interesting questions regarding the use of culture as an independent variable.

How does children's sensitivity to context in collaborative settings add to an evolutionary approach to the development of human cooperation?

This thesis attempted to integrate evidence across a variety of fields in developmental psychology literature (educational, social, developmental and comparative psychology), and propose new experimental approaches to the investigation of current theories on the development of human cooperation and culture. Drawing from these theories, there have been a number of experiments on children's development of cooperative and cultural learning skills (Tomasello &

Gonzalez-Cabrera, 2017; Warneken, 2018; Whiten et al., 2009). Nevertheless, hypotheses concerning the relationship between cooperation and cultural learning are only beginning to be explored in experimental settings (Dean et al., 2012; Flynn & Whiten, 2010; Göckeritz et al., 2014; Hardecker, Schmidt, & Tomasello, 2017). This research contributes to the start of a conversation regarding the combination of different approaches to investigate these hypotheses.

It is common for recent theories to claim that humans possess early and indiscriminate cooperative skills, that is young children shows generalised helping, comforting, and collaborative skills. This is at odds with evidence which claims that children possess early conditional cooperation skills, that is, that they are selective in choosing their cooperative partners from early on (Wynn, Bloom, Jordan, Marshall, & Sheskin, 2018). However, both approaches need to account for the influence of environment and individual characteristics in modulating the development of cooperation. Thus, this research has implications to the understanding of the particularities of children's behaviour in collaborative interactions. More specifically, to how children respond to social influence and their social and cultural environment when making collaborative decisions.

Conclusion

This thesis has attempted to demonstrate how contextual variables and individual differences affect children's social learning of collaborative actions. Recently, the role of conflict and inequality has been downplayed in experiments, probably because human's collaborative skills are so impressive compared to that of other primates (Tomasello, 2018). However, the evidence on children's collaborative skills might be misleading. While it is true that children are very cooperative, this is part of a set of skills that humans develop to achieve more, and better, resources. Hence, when conflicts of interest arise, younger children have a hard time figuring out collaborative solutions.

This research contributes to a better understanding of children's learning of collaborative strategies, across different social and cultural groups. Children are keen to reproduce cooperative actions. However, when the interactions involve some potential conflict of interest, and in the absence of social control (anonymity), children younger than eight years will prefer options that keep or increase their pay-off, even if at their partners' expense, and that they will use social information available to do so. This pattern is consistent across individual characteristics, gender, socio-economic status, and the two cultures investigated. Conversely, older children are better at achieving fairer distribution of resources, which supports previous evidence on the development of distributive justice. To conclude, evolutionary developmental theories on human cooperation will benefit from integrating different methods, drawing from the experimental literature on cultural transmission, economic games, and cross-cultural psychology. This combination of approaches hopefully will bring a more nuanced perspective on the effect of context on the early development of collaborative skills between peers.

General Appendix I

Table 1

CrediT Taxonomy categories.

#	Role	Definition
1	*Conceptualization*	Ideas; formulation or evolution of overarching research goals and aims.
2	*Data curation*	Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later re-use.
3	*Formal analysis*	Application of statistical, mathematical, computational, or other formal techniques to analyse or synthesize study data.
4	*Funding acquisition*	Acquisition of the financial support for the project leading to this publication.
5	*Investigation*	Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection.
6	*Methodology*	Development or design of methodology; creation of models.
7	*Project administration*	Management and coordination responsibility for the research activity planning and execution.
8	*Resources*	Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools.
9	*Software*	Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components.
10	*Supervision*	Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team.
11	*Validation*	Verification, whether as a part of the activity or separate, of the overall replication/reproducibility of results/experiments and other research outputs.
12	*Visualization*	Preparation, creation and/or presentation of the published work, specifically visualization/data presentation.
13	*Writing – original draft*	Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation).
14	*Writing – review & editing*	Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including pre- or post-publication stages.

Note. Source: https://casrai.org/credit/.

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