

Humans are, to an unprecedented degree, dependent on flexible and widespread cooperation with unrelated group members and strangers alike. Such cooperation is critically dependent on the existence of a particular and discrete attitude among interacting parties: trust (Fehr, 2009). From small-scale cooperative interactions between dyads and small groups of people, to the workings of large-scale institutions and markets, and even whole nations, trust is an essential ingredient for the establishment and maintenance of mutually cooperative relationships (Fukuyama, 1996). Trust is therefore a major topic of investigation for everyone from social psychologists and behavioral economists to practical philosophers and cognitive scientists.

While trust and trust-related behaviors have received attention in a variety of disciplines, very little is known about the phylogenetic and ontogenetic roots of trust. Thus, in my dissertation, entitled *An empirical investigation of the evolutionary and ontogenetic roots of trust*, I explored the topic of trust from a comparative perspective. The basic idea is that comparing the behavior of human children with one of our closest living relatives, the chimpanzees (*Pan troglodytes*), allows us to draw inferences about the evolution of trust and trust-related behaviors. Applying a comparative methodology to cognitive phenomena (such as trust) goes back to the founder of evolutionary theory, Charles Darwin. In *The Descent of Man* (1871), Darwin argued that evolutionary analysis is not only suitable to explain features of the human body such as legs, arms, and ears, but also cognitive mechanisms such as memory, intelligence, and trust. Thus, my dissertation asks: which, if any, trust-related behaviors show evolutionary continuities between chimpanzees and human children? Which, if any, trust-related behaviors are unique to the human lineage?

And, finally, how and when do these trust-related behaviors emerge across human ontogeny?

The current perspective considers trust as fundamental to the success of any collaborative interaction. Within this framework, trust can be described as consisting most fundamentally of two distinct, albeit interrelated, processes. These are trust-evaluation and trust-enhancement (Hardin, 2002).

Given that agents have to collaborate with others in order to reach their goals, they have to identify trustworthy partners by engaging in *trust-evaluation*, an assessment of the trustworthiness of potential interaction partners. Agents evaluate the trustworthiness of potential partners either directly by interacting with them, or indirectly, by observing their behavior toward third parties or receiving information about the partner's reputation via gossip.

However, agents not only have to selectively identify but also to reliably recruit trustworthy partners. Agents know that they not only evaluate others' trustworthiness, but that they are also simultaneously being evaluated by others, and so they adjust their behavior in order to affect those judgments. Agents thus attempt to appear trustworthy, and engage in *trust-enhancement* behaviors. One main mechanism of trust-enhancement is reputation management, the tendency to control the impressions one makes on others. In the present dissertation, I investigated the evolutionary and ontogenetic roots of trust-evaluation and trust-enhancement behaviors.

Regarding trust-evaluation, it is unclear to what extent one of our closest living relative, the chimpanzee, engages in assessments of others' trustworthiness, and, based on such assessments, forms trusting relationships with some, but not other,

conspecifics. Study 1 of the current dissertation addressed this question. From an ontogenetic perspective, we know that young children engage in trust-evaluation from a young age onwards (Hamlin, Wynn, & Bloom, 2007). We do not know, however, whether young children also share such trust-related information in a prosocial manner, a behavior that has been called prosocial gossip (Feinberg, Willer, Stellar, & Keltner, 2012). This question was addressed in Study 2 of the present dissertation.

Regarding trust-enhancement, a previous study indicates that while chimpanzees do not seem to care about their reputations, already preschoolers help more and steal less when in the presence of an audience (Engelmann, Herrmann, & Tomasello, 2012). However, it is unclear precisely to what extent young children manage their reputations, or rather, simply behave so as to avoid punishment. Study 3 of this dissertation explored whether already preschoolers show a real concern for their reputation. In addition, the precise mechanisms underlying prosocial, and thus trust-enhancement, behaviors remain unclear. While some maintain that genuine prosocial motivations underlie such behaviors, others argue that prosocial actions are fully explainable in strategic terms (Haley & Fessler, 2005). Thus, given that Study 3 finds remarkably strategic prosociality in preschoolers, Study 4 asks whether prosocial behavior in preschoolers is fully reducible to such strategic incentives. In other words, do young children merely attempt to appear prosocial, or are they actually prosocial?

STUDY 1: TRUST AND TRUST-EVALUATION IN

CHIMPANZEES

(Engelmann, Herrmann, Tomasello, 2015; *Proceedings of the Royal Society: Biological Sciences*)

In Study 1, I investigated the evolutionary roots of trust and, more specifically, trust-evaluation. While many of modern humans' most important social interactions rely on trust, including most notably among strangers, little is known about the evolutionary roots of human trust. The fact that chimpanzees show cooperative abilities in a wide range of circumstances is indicative of the possibility that individuals are able to form trusting relationships. This is suggested by research from the field where chimpanzees form coalitions and long-term alliances (Goodall, 1986; Watts, 1998), patrol their territory in groups (Mitani & Watts, 2001), share food with related and unrelated group members (Boesch & Boesch-Achermann, 2000; Wittig et al., 2014), and engage in group hunts (Boesch, 1994). However, some researchers have proposed that such cooperative behaviors might be the result of harassment rather than trusting attitudes (e.g., Gilby, 2006). Thus, I presented chimpanzee with a modified version of the human trust game from behavioral economics (see Figure 1). Chimpanzees had a choice between pulling a no-trust rope (resulting in immediate access to low-quality food) and a trust rope (thereby allowing a partner access to high-quality food, which he could then send a part of - a part he himself could not access - back). In line with the human research, trust was operationalized as a decision by the "investor" to send the high-quality food to the partner.

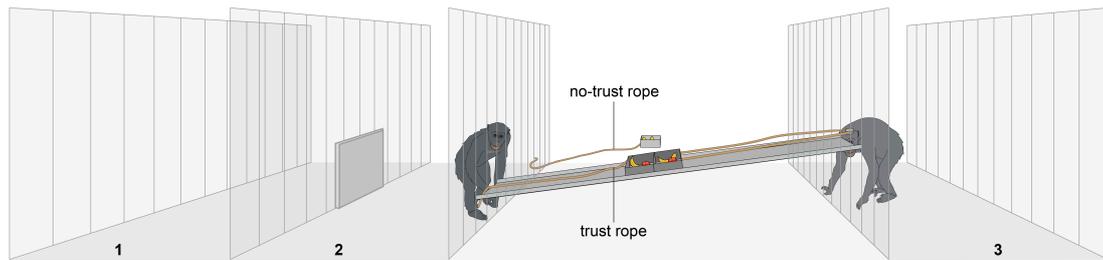


Figure 1. Modified version of the human trust game.

In Experiment 1, I investigated whether chimpanzees show spontaneous trust in conspecifics in a novel context. Chimpanzees engaged in two conditions. During both conditions, subjects were located in room 2 and could pull either the trust or the no-trust rope. During control conditions, room 3 was empty. During test conditions, a partner was present in room 3. If chimpanzees trust their partner to reciprocate by sending part of the high quality food back, they should pull the trust rope more in the test compared to the control condition. Results show that chimpanzees, without any previous experience in the current setup, trust members of their own social group and pull the trust rope significantly more in the test compared to the control condition (see Figure 2).

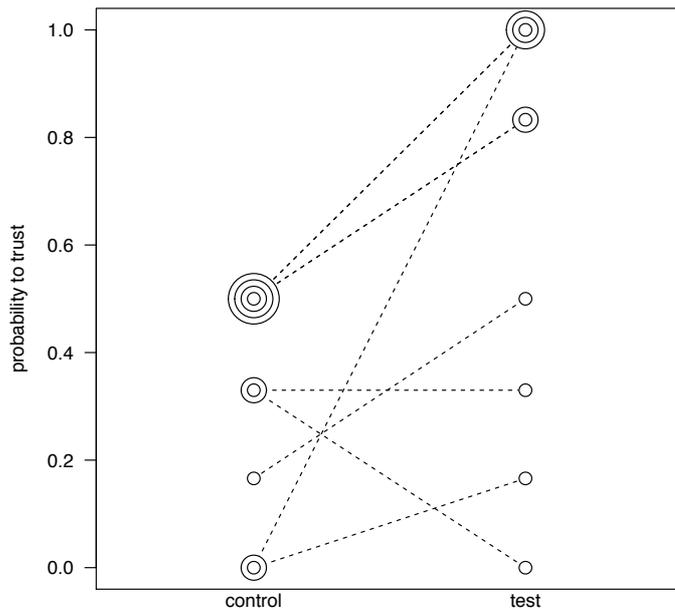


Figure 2. Results of Experiment 1. Probability to pull the trust rope for each individual in the test and control condition. Each circle represents the average behavior of one individual in the respective conditions. Dashed lines connect the results of a given subject in the control condition to the same subject's results in the test condition (each subject participated both in the control and the test condition with 6 trials per condition).

The findings of Experiment 1 indicate that chimpanzees show spontaneous trust in their group members in a novel experimental setting. The main question I set out to address, from the perspective of trust-based cooperation, was whether chimpanzees engage in trust-evaluation and selectively interact with some, but not other, chimpanzees. In other words, do chimpanzees show blind trust and indiscriminately trust their group mates, or, alternatively, engage in trust-evaluation and selectively trust more trustworthy individuals? This question was explored in Experiment 2. To this end, chimpanzees interacted with trustworthy partners (who always reciprocated and sent the food back) and untrustworthy partners (that never reciprocated and thus never sent the food back). In a within-subjects design, chimpanzees interacted for 12 trials with a trustworthy and a non-trustworthy partner.

Results show that chimpanzees do not engage in blind trust, but rather flexibly adjust their trust levels to their trustworthiness of their partners (see Figure 3).

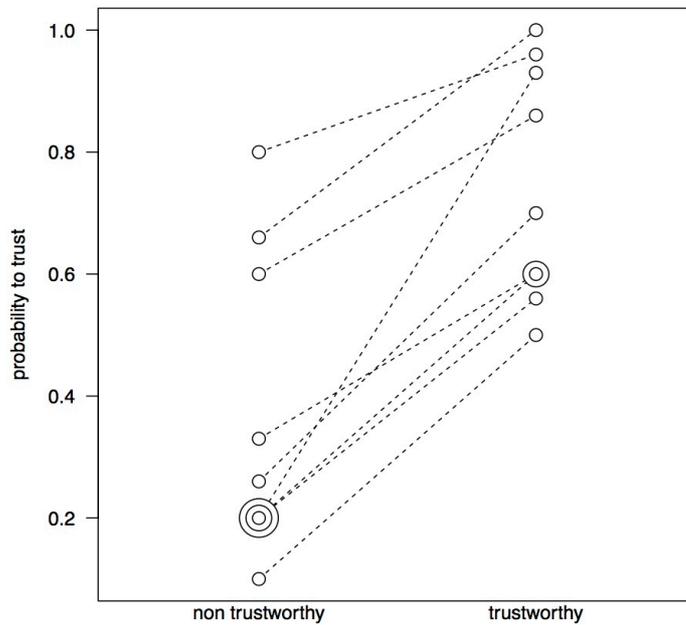


Figure 3. Results of Experiment 2. Probability to trust for each individual when confronted with a trustworthy and a non-trustworthy partner. Each circle represents the average behavior of one individual.

If chimpanzees engage in trust-evaluation, one would expect their trust over time to increase when interacting with a trustworthy partner and to decrease when interacting with an untrustworthy partner. Thus I explored the interaction between trial number and behavior of the partner and found it to be highly significant (see Figure 4). This result further supports the finding that chimpanzees engage in trust-evaluation and selectively increase their trust in trustworthy individuals and decrease their trust in individuals that do not prove trustworthy.

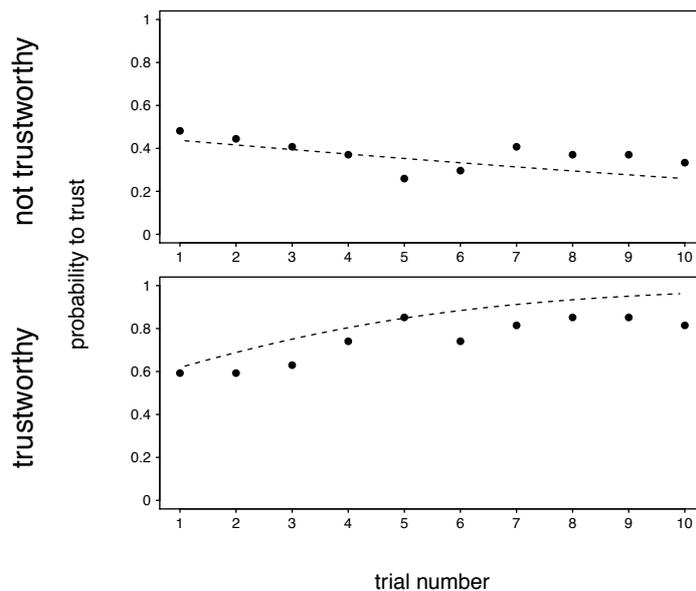


Figure 4. Results of Experiment 2. Interaction between partner behavior and trial number.

Chimpanzees' probability to trust when faced with a trustworthy or non-trustworthy partner as a function of trial number.

The results of Study 1 of my dissertation demonstrate that chimpanzees can form trusting relationships with unrelated conspecifics. In Experiment 1, subjects showed spontaneous trust in group members in a 'one-shot' situation, although subjects had never interacted with their partners in the current situation before. They also showed that they are not indiscriminately trustful but rather flexibly adjust their trust levels to the trustworthiness of their partner (Experiment 2). Combining these results, one might argue that chimpanzees show a version of 'generous tit-for-tat' (Nowak, 1990; Nowak & Sigmund, 1992), that is, they enter a cooperative situation with an initial propensity to trust their partner but then flexibly reciprocate the partner's behavior. If the partner proves trustworthy, trust levels remain high, but if the partner proves untrustworthy trust levels decrease. These initial findings about trust-evaluation were supported by a recent study (which was not part of my PhD) in which we could show that chimpanzees show greater trust in their friends than their

non-friends (Engelmann & Herrmann, 2016). Taken together, these results suggest that trust-evaluation and trust in reciprocity are not unique to humans, but rather have their evolutionary roots in the social interactions of humans' closest primate relatives.

STUDY 2: PROSOCIAL GOSSIP IN PRESCHOOLERS

(Engelmann, Herrmann, Tomasello, invited revision)

While Study 1 investigated the evolutionary roots of trust-evaluation, Study 2 turned to the ontogenetic foundations of trust-evaluation. Trusting interactions depend on individuals reliably identifying cooperators and avoiding cheaters. For such systems to work, individuals need reliable information about others' trustworthiness. Such information can be gained through direct interactions with potential partners or the observation of interactions between third parties. However, especially in large-scale groups, agents might not have access to information about a potential partner's trustworthiness based on first-hand interactions or observations. In the absence of such information, prosocial gossip can inform agents about other people's trustworthiness. Gossip is commonly defined as the sharing of evaluative information about absent third parties (Dunbar, 1996; Feinberg et al., 2012). Prosocial gossip is doing this in order to benefit the recipients of this information, especially to help them find trustworthy partners and avoid uncooperative ones (Feinberg et al, 2012). Very little is known about whether and how young children engage in prosocial gossip.

In the current study, I investigated prosocial gossip in 3- and 5-year-old preschoolers. Participants engaged in a sharing game with a specific rule about how many items to share. Children played the game with two puppets, one who consistently shared less than prescribed and one who shared the correct amount (negativity bias condition) or one who consistently shared more than prescribed and one who shared the correct amount (positivity bias condition). I then measured whether children passed on information about the puppets' behavior (in the puppets' absence) to a same aged peer (a confederate) who could only play the game with one

of the two puppets and thus had to pick one. For a sketch of the setup, please refer to Figure 5.

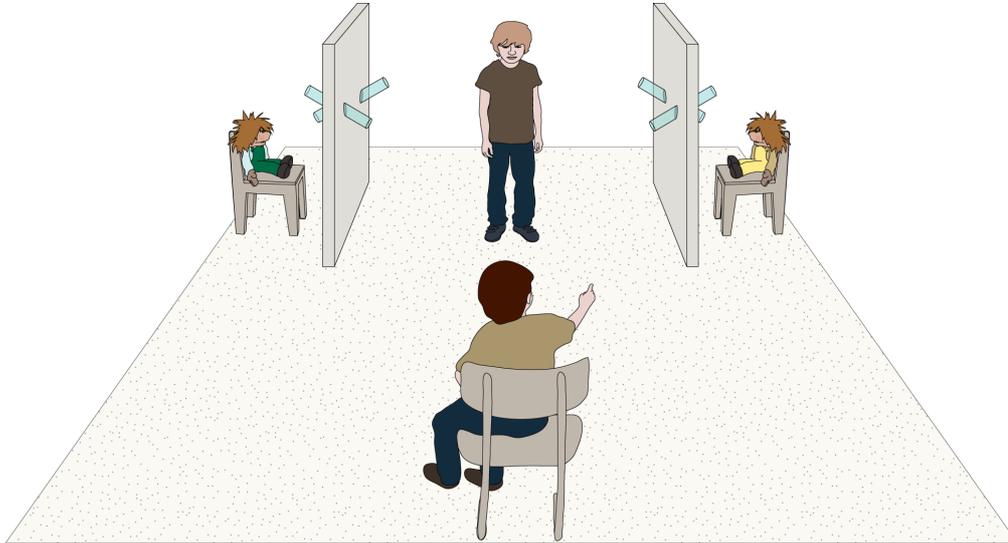


Figure 5. Experimental setup during the test phase. The participant is seated on the chair while the confederate stands in between the two games (puppets are depicted for clarity only. They were outside the room at this point of the study).

While I did not detect a difference between the two conditions (negativity and positivity bias condition), I found that 5-year-old children spontaneously engaged in prosocial gossip to guide a peer towards the more cooperative partner. By contrast, 3-year-old children were less likely to offer such evaluative information, though they still showed a willingness to inform in a non-evaluative manner by providing social information (by, for example, pointing to the more cooperative partner). Please refer to Figure 6 for the results. While both 3- and 5-year old children informed a peer, only the older children engage in prosocial gossip by providing evaluative information about the trustworthiness of potential partners.

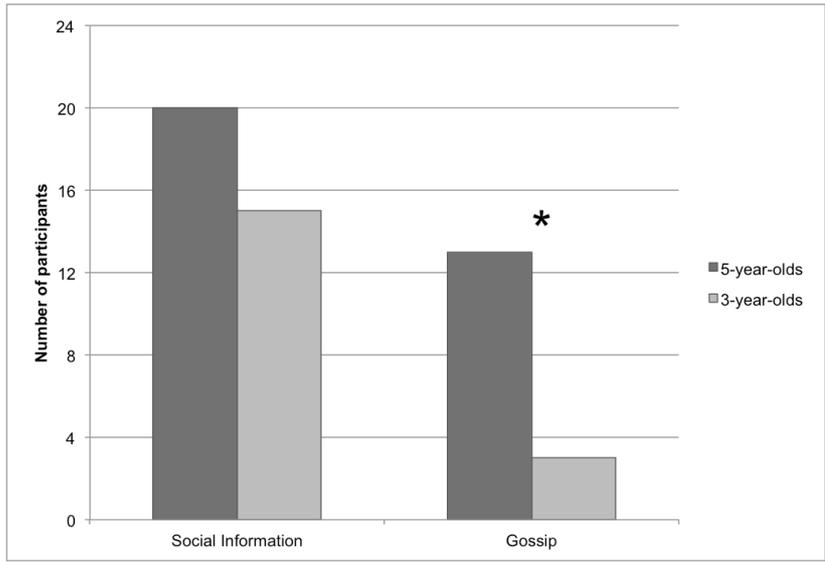


Figure 6. Number of participants that shared social information and engaged in gossip in Study 1.

Asterisks indicate significant differences between conditions (*p = .001).

STUDY 3: STRATEGIC TRUST-ENHANCEMENT IN YOUNG CHILDREN

(Engelmann, Over, Herrmann, Tomasello, 2013; *Developmental Science*)

While Studies 1 and 2 investigated one aspect of trust, trust-evaluation, Study 3 turned to trust-enhancement. I investigated the ontogenetic foundations of trust-enhancement behaviors, and, more specifically, the extent to which young children care about their reputation in a flexible and strategic way. Caring about one's reputation is one form of trust-enhancement. Importantly, the strategic management of reputation requires not only that we care whether people are watching but also who is watching (Goffman, 1959). One crucial factor for reputation management is indirect reciprocity: people may invest in their reputations in order to indirectly benefit from the generosity of others. The strategic management of reputation requires that we reliably identify situations in which we can benefit from creating a specific image, such as being seen as a generous person, and that we seek to look generous and trustworthy in front of those people who are subsequently in a position to help us. A second crucial factor for reputation management is group membership: people may be more concerned about their reputation with ingroup members. Ingroup members play an important role in our lives for a variety of reasons (Turner, 1991). From an evolutionary point of view, group members depend on each other for their survival - as exemplified by vital coalitionary behaviors such as collaborative foraging and group defense (Marlowe, 2005). This interdependence makes it in individuals' direct interest to appear trustworthy to members of their own social group.

In Study 3, I had two aims. My first aim was to investigate whether 5-year-old children strategically invest in their reputations in an indirect reciprocity framework.

My second aim was to investigate whether 5-year-olds are sensitive to the group membership of the observer and, in particular, whether they show an increased concern for their reputation when observed by an ingroup member compared to an outgroup member. In all conditions, children were given stickers and asked to divide them between themselves and an anonymous and absent recipient (a mini-dictator game, (Blake & Rand, 2010)). While they did this, they were watched by an unknown peer observer, and the value of this peer observer to the participant was manipulated in two ways. To manipulate opportunities for indirect reciprocity, the observer was told (in the presence of the participant) that after the participant had shared out her stickers, she could share some of her stickers with the participant. I predicted that subjects would share more of their own stickers in the indirect reciprocity condition compared to the condition without opportunities for indirect reciprocity. To manipulate group membership, the participant and the peer observer were either allocated to the same minimal group or to different minimal groups (Dunham, Baron, & Carey, 2011). I predicted that participants would share more stickers when observed by an ingroup member compared to an outgroup member. For a picture of the setup, please refer to Figure 7.



Figure 7. Setup in the ingroup observer condition (a) and the outgroup observer condition (b). Only the instructions varied in the indirect reciprocity conditions, the setup remained the same.

Figure 8 presents the average number of stickers donated in the respective conditions. I found a main effect of the indirect reciprocity manipulation – participants gave more when they were likely to benefit from a positive reputation in the second interaction. In addition, my analyses revealed a main effect of group membership demonstrating that participants donated more stickers in the ingroup condition than the outgroup condition.

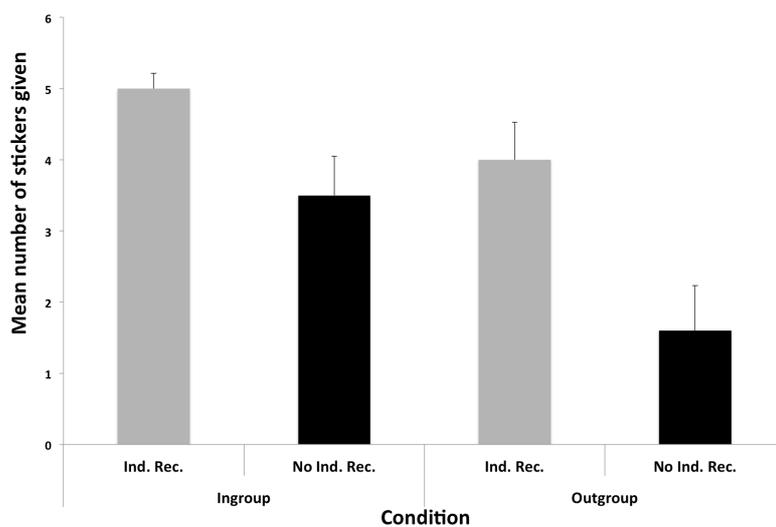


Figure 8. Mean number of stickers given to the anonymous recipient in the four conditions.

This is the first research to conclusively show the flexible and strategic nature of young children's attempts to appear trustworthy by engaging in reputation management. These results contrast with previous accounts (Banerjee, 2002) arguing that social evaluation concern develops only as a consequence of various experiences during the course of the primary school years. Not only is such a concern present in preschoolers, but it also leads to strategic behavior hitherto only associated with adult reputation management.

Study 4: Young children do the right thing even if their peers do not

(Engelmann, Herrmann, Rapp, Tomasello, invited revision)

Study 3 showed that children act prosocially in order to strategically present themselves as trustworthy to valuable partners. Study 4 explores whether children's prosocial behavior is fully reducible to such strategic motivations. In other words, is children's prosociality fully explainable in strategic terms or are children also intrinsically motivated to act prosocially? In Study 4, across two experiments, I pitted children's prosocial and strategic motivation against each other. In both experiments, participants were introduced to two same-age confederates who were playing a game with exciting rewards. Children were told that it was the confederates' decision whether the participants could also play the game later on (this was included to elicit reputational concern in the participants). Participants and confederates were then handed a cereal bar, which, depending on condition, either did not belong to them (Experiment 1) or belonged to them (Experiment 2), and were shown two boxes: one belonged to them and one to an absent child, who was either hungry and thus in need (test condition) or not (control condition). Both confederates then engaged in an antisocial act and placed their food in their own box. I coded whether children would go with the majority by also placing the cereal bar in their own box, or, alternatively, would choose the prosocial act and place the food in the child's box. When it was the participants' turn to decide, they were under threefold strategic pressure: to act prosocially, they had to: give up their own food; refuse to conform to a majority; accept the possibility of forgoing the chance to be allowed to play a game with rewards later on. For a sketch of the setup please refer to Figure 9.

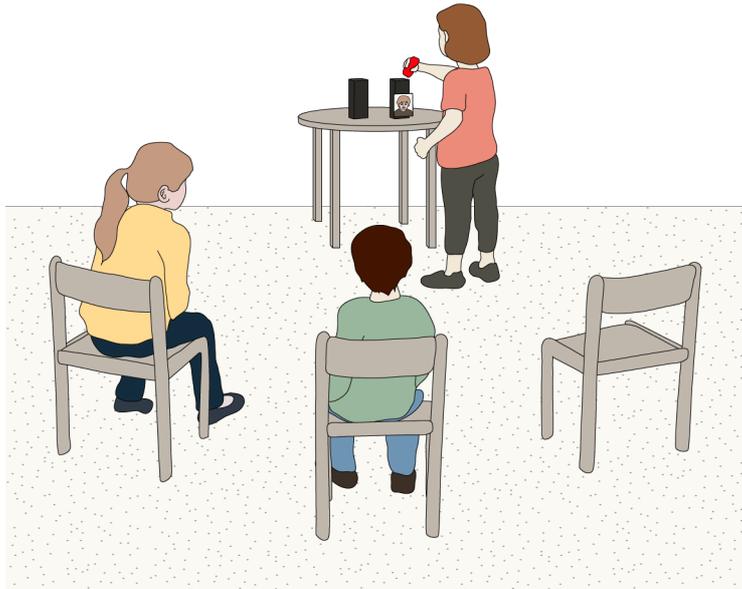


Figure 9. Experimental setup in Experiment 1 and 2. The two confederates were seated on the left and center chair, the subject on the chair on the right. The box displaying a picture and everything that it contained belonged to an absent child, the other box to the three children (the group box).

Figure 10 presents the percentage of participants going against the majority in Experiment 1 and 2. In both experiments, significantly more children acted against the majority in the test (when the recipient was hungry) compared to the control condition (when the recipient was not hungry). More specifically, across both experiments, 58% of children acted against the majority in the test condition and 12.5% of children did so in the control condition (see Figure 10).

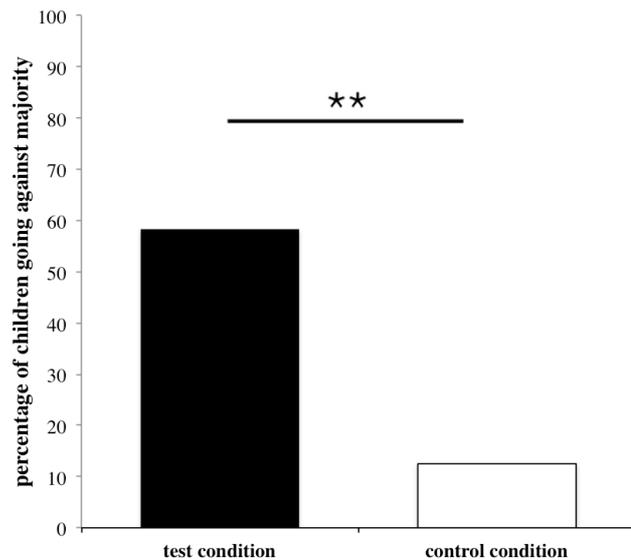


Figure 10. Percentage of participants going against the majority in Experiment 1 and 2. Asterisks indicate significant differences between conditions (** $p < .01$).

In Study 4, I investigated preschoolers' behavior in a moral dilemma situation. Would children follow an immoral majority, or, alternatively, do the right thing even in the face of personal rewards and/or peer pressure? Although they had to forgo various strategic benefits, I found that in the test conditions of both studies 58% of children were willing to sacrifice these benefits in order to act prosocially. This result suggests that children's prosociality is not fully explainable in terms of a strategic motivation to appear trustworthy to valuable partners. The current results do not suggest that preschoolers' prosociality is not motivated by strategic concerns, such as a concern to get the approval of peers (see Engelmann et al., 2013). They do suggest, however, that strategic concerns are not the whole story (Sperber & Baumard, 2012). Children are genuine, that is, intrinsically motivated, prosocial actors in that they (sometimes) do what they themselves judge the right thing to do, independent of either personal rewards or the behavior of a majority.

Conclusion and Discussion

Trust is indispensable for many complex forms of cooperation. Indeed, in the absence of trust, many crucial collaborative interactions are bound to break down (Fehr, 2009). Given that collaborative interactions have played, and of course continue to play, a fundamental role in human evolution and human social life, investigating the mechanisms underlying cooperation – such as trust – represents an exciting field of work. This dissertation has explored the phylogenetic and ontogenetic roots of trust, focusing on its two main component parts, trust-evaluation and trust-enhancement. The results suggest that both chimpanzees as well human children engage in a variety of trust-evaluation behaviors, and, based on these behaviors, are able to establish and maintain trusting relationships

In Study 1, I investigated whether chimpanzees engage in trust-evaluation and as a consequence flexibly adapt their trust levels to the trustworthiness of their partner. Study 2 looked at trust-evaluation from an ontogenetic perspective. While previous research indicates that young children engage in trust-evaluation and, for example, selectively interact with agents that had previously helped third parties (Olson & Spelke, 2008), nothing is known about whether young children also pass such information on. Study 2 thus looked at the occurrence of prosocial gossip in preschoolers. Studies 3 and 4 investigated another trust-related behavior, namely trust-enhancement. Engelmann and colleagues (2012) had shown that while chimpanzee's behavior is not affected by the presence of an audience, already young children engage in trust-enhancement behaviors, and for example steal less in the presence of an audience. Study 3 aimed at extending this finding by looking at whether young children show strategic audience sensitivity in their trust-enhancement behaviors and so, for instance, behave more prosocially when they are observed by an

ingroup compared to an outgroup member. In Study 4, I took a look at the motivation underlying children's trust-enhancement behaviors. Specifically, this study aimed at teasing apart two motivational hypotheses: are all trust-enhancement behaviors strategic in nature, or, alternatively, are they motivated by genuine prosociality?

Taken together, the empirical studies of this dissertation provide a novel and interdisciplinary overview of the evolutionary and ontogenetic roots of trust and trust-related behaviors. In particular, regarding the evolutionary origins of trust, the present findings indicate that trust did not evolve to meet socio-ecological challenges specific to the human lineage, but rather suggests deep evolutionary roots for trust in primate bonding. Regarding the ontogenetic foundations of trust and related behaviors, the present dissertation shows that young children do not only engage in various forms of trust-evaluation, but also pass such information on to others in instances of prosocial gossip. Concerning the second main component of trust, trust-enhancement behaviors, the current results propose that already young children attempt to appear trustworthy and thus invest in their reputation in strategic and flexible ways. However, the current results also suggest also that such prosocial action is not fully reducible to strategic concerns. Human children feel not only pressure from outside to conform to prosocial norms, e.g. in the form of reputational pressures, but also a pressure from within to conform to norms that they identify with.

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