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Modeling social norms increasingly influences costly sharing in middle childhood

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Abstract

Prosocial and normative behavior emerges in early childhood, but substantial changes in prosocial behavior in middle childhood may be due to it becoming increasingly influenced by social norms. Here we show that information about what is normative begins influencing children's costly sharing in middle childhood, in a sample of 6-11 year-old German children. Information about what is normative was most influential when indicating what was 'right' (i.e., "the right thing is to choose this"). It was less influential when indicating what was prescribed by a rule (i.e., "there is a rule that says to choose this"), or when it indicated what the majority of people do (i.e., "most people choose this"). These findings support the idea that middle childhood is when social norms begin to shape children's costly sharing, and provide insight into the psychological foundations of the relationship between norms and prosocial behavior.

Keywords: costly sharing; social norms; middle childhood

Modeling social norms increasingly influences costly sharing in middle childhood

Costly prosocial behavior is widespread across human societies and central to their success (Henrich, 2004). The tendency to act in ways that benefit others emerges early in childhood (Eisenberg, Fabes, & Spinrad, 2006; Hamlin, 2013; Kuhlmeier, Dunfield, & O'Neill, 2014; McAuliffe, Blake, Steinbeis, & Warneken, 2017; Silk & House, 2012; Warneken & Tomasello, 2009), but prosocial behavior also changes dramatically between infancy and adulthood (Hay & Cook, 2007; House et al., 2013). One of the most important developmental influences on prosocial behavior and its underlying psychology are likely to be socialization practices and acquired cultural beliefs (Chudek & Henrich, 2011; House, 2016; Köster, Schuhmacher, & Kärtner, 2015), in particular cultural beliefs in the form of learned social norms, which are behavioral standards shared and enforced by a community (Chudek & Henrich, 2011). Adults frequently base their costly sharing on culturally-learned and society-specific social norms (e.g., deciding on the right amount to tip in a restaurant, or to pay in taxes), and norms are important to many models of human prosociality and social psychological development (Bicchieri, 2016; Keller, 2013; Richerson & Boyd, 2005; Rutland, Killen, & Abrams, 2010; Tomasello & Vaish, 2013). Yet, we know little about how children come to model their own prosocial behavior on information about what is normative, an issue with large implications for our understanding of the psychology behind prosociality.

Developmental psychologists have clearly documented prosocial behavior in the form of instrumental and emotional helping in early childhood (Callaghan et al., 2011; Dunfield & Kuhlmeier, 2013; Svetlova, Nichols, & Brownell, 2010), but in cases where being prosocial comes at a personal cost (such as costly sharing) substantial prosociality emerges somewhat later. A good measure of costly sharing is the Dictator Game (hereafter, the "DG"), in which a subject is given an endowment of rewards and allowed to divide that endowment between themselves and another individual, should they wish to. By age 3-5, children generously give their own rewards to others in a DG, but both the number of children who give and the total number of rewards given increases with age (Benenson, Pascoe, & Radmore, 2007; Blake & Rand, 2010; Fehr, Bernhard, & Rockenbach, 2008). Across different kinds of tasks, the overall pattern in children's sharing appears to be one of increasing aversion to unequal/inequitable outcomes between age 3 and 8 (Blake & McAuliffe, 2011; Fehr et al., 2008; McAuliffe, Blake, Kim, Wrangham, & Warneken, 2013). Costly sharing and aversion to inequity seems to be largely similar across societies in early childhood, with societal variation emerging at the transition to middle childhood around 5-8 years of age (Blake et al., 2015; Cowell et al., 2016; House, 2016; Rochat et al., 2009), approximating adult-like patterns of behavior by about 11-14 years of age (House et al., 2013).

The psychological foundations of our understanding of norms also develops early, with children as young as 3 years-old enforcing normative behavior in third-parties (Schmidt & Rakoczy, 2016) and protesting what adults would consider to be moral violations, such as harming others and destroying others' property (Rossano, Rakoczy, & Tomasello, 2011; Vaish, Missana, & Tomasello, 2011). Research on Social Domain Theory shows that by about this same age children also begin to distinguish between moral and conventional norms. 2-5 year olds largely agree with adults on what constitutes a "moral" violation rather than a "conventional" violation (Nucci & Turiel, 1978), and 3-4 year-olds believe that moral violations should be punished more severely (Smetana, 1981; Smetana & Braeges, 1990). 3 year-olds also protest moral violations equally for members of their own group and members of other groups, while protesting conventional violations only for in-group members, suggesting that they (like adults) expect conventional norms to be more group-specific and variable than moral norms (Schmidt, Rakoczy, & Tomasello, 2012).

Young children of this age are also sensitive to descriptive norms based on information about how common a behavior is, which are generally distinguished from injunctive norms based on information about what "ought" to be done (moral and conventional norms would generally fall under this category). Children aged 3-4 years preferentially conform to behaviors that are common (Corriveau & Harris, 2010; Haun & Tomasello, 2011; Haun, van Leeuwen, & Edelson, 2013; Morgan, Laland, & Harris, 2015; Walker & Andrade, 1996), though their facility with using such information increases substantially between 3 and 7 years of age (Morgan et al., 2015).

How do social norms come to influence costly sharing during childhood? Children may begin to base their sharing on learned social norms in middle childhood, the age at which adult-like patterns of societal variation in costly sharing begin to emerge (Blake et al., 2015; Cowell et al., 2016; House et al., 2013; House, 2016). If such societal variation in sharing is caused by individuals conforming to culturally-unique social norms, then we would expect that children should begin to model their costly sharing behavior on social norms at the same age that societal variation in costly sharing emerges (i.e., middle childhood). Note that the claim is not that children are unaware of norms about costly sharing until middle childhood, only that this may be the age at which they increasingly act in accordance with what they know they *ought* to do (Smith, Blake, & Harris, 2013).

In a recent study, American children were more generous in a DG when told by the experimenter that it was normative to give 80% of their rewards to a recipient, and they were less generous when told that it was normative to give 20% (McAuliffe, Raihani, & Dunham, 2017). However, there was no developmental change in how the normative primes influenced sharing between 4 and 9 years of age, and children were not more influenced by injunctive norms ("I think you should give 80% to the other child") than by descriptive norms ("most kids that play this game give 80% to the other child"), a pattern found in a previous study with adults (Raihani & McAuliffe, 2014). The absence of evidence for either developmental change in norm sensitivity or a difference between the types of norms could be a consequence of the normative primes being spoken directly by the experimenter, which could have led children to interpret the primes to some degree as instructions (not simply as the experimenter's opinions or a statement of facts), rather than norms. This could obscure some of the effects that norms have on sharing.

The present study was conducted prior to the publication of the above study, and takes a different approach that reduces these methodological concerns while exploring a wider range of norm primes. We present children with a binary-choice DG, but first prime them with information about whether it is normative to share more (or less) in this game, and we examine how this influences children's willingness to share between 6 and 11 years of age. The question of interest is: what is the age at which children who have been primed to share *more* behave differently than those who have been primed to share *less*? This will indicate that age at which social norms are beginning to influence children's costly sharing in this widely-used experimental task.

Further, we explore how descriptive norms (i.e., what most people do) and injunctive norms (i.e., what ought to be done) prime costly sharing to different degrees. We also investigate whether costly sharing is primed differently by two different injunctive norms: (1) a norm stating what is the *right* thing to do, and (2) a norm stating what a *rule* says to do. This approach allows us to describe the development of children's tendency to model their own costly sharing on what they have learned to be normative behavior, and for the first time we ask how different kinds of injunctive norms influence costly sharing to different degrees.

Method

Participants

We tested 238 German-speaking children (126 female) aged 6-11 years (N=101 6.0-8.5 yrs.; N=137 8.5-11.0 yrs.), with four responses from each participant (952 observations). Testing was conducted in after-school programs in a culturally-homogenous city in eastern Germany, with only 12.8% of the population being first- or second-generation immigrants (Stadt Leipzig, 2015) in comparison to the national average of 20.8% (Statistisches Bundesamt, 2015). 31 children were also invited into a laboratory setting for testing. Children were only selected based on age, no other sampling criteria were included.

Apparatus and Procedure

We employed a binary choice DG, with the subject deciding between two pre-determined ways of dividing an endowment of rewards between themselves and a Recipient. Numerous studies have shown the binary-choice DG to be effective with both young children and adults, with subjects from many different societies, and even with non-human primates, making it an ideal tool for comparing across diverse populations and a prior studies.

Two laminated paper trays, each with a blue and a green circle, were placed in front of a seated subject (Figure 1). Each tray corresponded to one of two payoff outcomes that delivered different quantities of rewards to the Subject and to an anonymous peer Recipient. The experimenter placed rewards on each of the circles, according to pre-determined payoff distributions, hereafter referred to as "ratios" (Table 1). The Subject selected one of the ratios, received the rewards in the blue circle on that tray, and the experimenter would place the rewards in the green circle in a paper bag that would be given to the Recipient. The experimenter retrieved all rewards on the unselected tray, and then laid out the payoff distribution for the next trial. Each experimental session lasted 15 minutes, consisting of four Phases: Familiarization, Priming, Test, and Interview. Sessions were video recorded.

The ratio choices used in the Familiarization Phase were: “2/1 vs. 4/1” and “1/2 vs. 2/6” (ratios are written using the convention: Subject payoff / Recipient payoff). These ratio choices correspond to tests of Advantageous Inequity and Disadvantageous Inequity (respectively). The ratio choices used in the Test Phase were “3/3 vs. 5/1”, which is a DG, and “3/3 vs. 5/5” which we call the Maximizing Game (hereafter ‘MaxG’). Whereas the ratios in the DG impose a conflict of interest for the Subject and Recipient (i.e., the Subject benefits most by 5/1, the Recipient by 3/3), the ratios in the MaxG do not (i.e., both benefit most by 5/5).

Figure 1

Table 1

Familiarization Phase (hereafter, FAM). Subjects were first given a full set of instructions (SOM Section 2) and comprehension questions, one trial of each FAM ratio choice (order counterbalanced across subjects). At all ages nearly all Subjects chose the self-maximizing outcomes in the FAM trials. This indicates that subjects clearly understood the task and desired the rewards, but the results also thus provide little insight into the development of children’s aversion to inequity in this particular kind of task (SOM Section 4).

Before FAM trials, children were shown the four different kinds of rewards that they would receive across different trials (Figure 1A): food (gummie bears), stickers, Low-value coins (worth ‘1’), and High-value coins (worth ‘2’). Coins could be exchanged for prizes at the end of the study, but participants did not know the prices for the prizes and so could not strategize to obtain a target number of coins.

Participants were told that across six trials they would make choices that would deliver rewards to themselves and to six different peer Recipients, each represented by a different paper bag (Figure 1B). Children were told that they would never know the identity of the Recipient, and the recipient would never know their identity. The experimenter then presented the two FAM trials always using the Low-value Coins, and before choosing a ratio subjects answered two comprehension questions about the procedure (SOM Section 4):

Comprehension question 1. "How many rewards would the Subject and Recipient receive if each tray were chosen?" 97% and 100% of Subjects answered correctly on the first and second FAM trials (respectively).

Comprehension question 2. "Would the subject receive any rewards in the Recipient's bag, and did the subject know who would receive the Recipient's rewards?" 100% of subjects answered correctly on the first FAM trial.

Priming Phase. Subjects were shown a video on a laptop (Figure 1C) in which an adult model made a statement (hereafter the 'prime') providing information about the two ratios. In the 'No-Norm DG (3/3)' condition (Table 2) the model stated: "I can choose this one [model points to 3/3], or this one [model points to 5/1]." The prime could influence subjects' choices if they chose whichever ratio the model pointed to first, so in a second treatment we swapped which ratio was pointed to first: in the 'No-Norm DG (5/1)' condition the model stated: "I can choose this one [points to 5/1], or this one [points to 3/3]." By comparing across these conditions, we can test whether children's behavior is different when 3/3 is 'primed' (i.e., when 3/3 is pointed to first, in No-Norm DG [3/3]), or when 5/1 is 'primed' (i.e., when 3/3 is pointed to first, in No-

Norm DG [5/1]). Then, we can add additional normative information to the primes (Norm conditions, see below and Table 2) to ask whether doing so increases the primes' influence on subjects' behavior.

There were three kinds of Norm conditions. In the 'Right Norm DG (3/3)' condition the model stated "the right thing to choose is this one [3/3] and not this one [5/1]." In the 'Right Norm DG (5/1)' condition the model stated: "the right thing to choose is this one [5/1] and not this one [3/3]". Again, across these two treatments we swap whether 3/3 is 'primed' or 5/1 is 'primed', but now this swap changes whether 3/3 or 5/1 is indicated to be the normative choice. This was also true across the other Norm conditions. In the 'Rule Norm DG (3/3)' condition the model stated "there is a rule that says to choose this one [3/3] and not this one [5/1]". In the 'Majority Norm DG (3/3)' condition the model stated "most people choose this one [3/3] and not this one [5/1]." We also included Rule Norm DG (5/1) and Majority Norm DG (5/1) conditions. All conditions and treatments were between-subjects.

Finally, we explored whether this normative information influenced behavior only in a costly sharing context like the DG, or also in the MaxG where there is no conflict of interest between the Subject and the Recipient. In the 'Right Norm MaxG (3/3)' condition the model stated "the right thing to choose is this one [3/3] and not this one [5/5]." In the 'Right Norm MaxG (5/5)" condition the model stated: "the right thing to choose is this one [5/5] and not this one [3/3]". Notice that in the 'Right Norm MaxG (3/3)' condition the model is indicating that choosing 3/3 is normative even though it is a worse outcome for both the Subject *and* the Recipient.

Table 2

Test Phase (hereafter TEST). After viewing the priming video, Subjects were presented with four Test trials (Figure 1D). On each trial Subjects made a binary choice between 3/3 and

5/1 (DG) or 3/3 and 5/5 (MaxG), with the side of presentation being randomized and each trial using a different reward (SOM Section 8 analyzes the influence of reward type). The priming video was only presented once, prior to TEST.

Interview Phase. After the experiment, subjects who were presented with the DG were asked a fixed-order series of questions probing their beliefs about what another individual would choose in the same task (another child, an adult, or their teacher), which outcome their teacher would tell them to choose, and whether the 3/3 and 5/1 outcomes were “fair” or “wrong” (SOM Section 9).

Statistical analyses

Data were binary and analyzed using generalized linear mixed models (GLMM) with a binomial link function. All four choices from TEST were included in a single dataset, with a random effect for Subject ID included in the model. The fixed effect 3/3 PRIMED coded whether or not 3/3 was the primed ratio, and was used to test whether priming influenced children’s choices. Other fixed effects coded for the different conditions (NO-NORM DG, RIGHT DG, RIGHT MaxG, RULE DG, MAJORITY DG), and these were interacted with 3/3 PRIMED to ask how the effect of priming varied across condition. Covariates controlled for potentially confounding differences in sex and age distribution across conditions, and also trial number (SEX, AGE, AGE^2, TRIAL#).

There are many advantages of this regression approach. By including all observations from all conditions in a single analysis with covariates, we increase our statistical power for analyzing each condition and diminish the possibility that any of the results could be driven by small samples or confounding variables. Also, because our primary results are based on a single basic model rather than on different models and repeated statistical tests, the results that we report are more likely to be robust – because they are much less likely to be driven by cherry-picking positive results from models or tests that include different data or combinations of parameters.

Our a priori hypothesis was that the effect of 3/3 being 'primed' would differ across the conditions, with the other Norm conditions (RIGHT, RULE, MAJORITY) showing stronger effects of 3/3 being primed (3/3 PRIMED) than the No-Norm condition. MODEL 1 explores whether the other Norm conditions show a stronger effect of 3/3 PRIMED than does the No-Norm condition, and whether there are differences in the effect of 3/3 PRIMED across the three Norm conditions. MODEL 2 expands this to look at how the effect of 3/3 PRIMED develops, by interacting it with parameters capturing children's ages: AGE and AGE^2. AGE^2 allows us to explore a quadratic (i.e., u-shaped) relationship between age and behavior. MODEL 3 and MODEL 4 investigate how behavior in the test trials is predicted by children's responses to the interview questions. We found no evidence that Subject's choices in TEST were predicted by their SEX, or by their choices in FAM, and do not report those analyses.

For models containing random effects, such of those we use here, the posterior distribution can be most easily estimated by use of Markov chain Monte Carlo. When a model is fit with a variant of Markov chain Monte Carlo, generating model predictions (e.g., model predictions about the behavior of females vs. males) requires processing samples from the posterior distribution. Each sample of parameter values from the posterior can be plugged into the model, producing a predicted value for any observable variable. Since the distribution of the samples approximates the posterior distribution of the parameters, the distribution of predictions generated from these samples will approximate the target predictive distribution. Computational examples of this approach can be found throughout McElreath (2016), and Gelman et al. (2014) contains an authoritative explanation.

Data were analyzed in the R Environment for Statistical Computing (R Development Core Team, 2015). We used a variant of Hamiltonian Monte Carlo (HMC), an algorithm particular good with high dimension models, as implemented in RStan (Stan Development Team, 2015). For discussion of HMC's advantages, see Chapter 12 of Gelman et al. (2014). Models were specified using map2stan (McElreath, 2016), a convenience package for RStan. The model was specified using weakly informative priors, which reduce overfitting and also help the Markov chain to converge to the posterior distribution more effectively than flat priors. See Section 2.9 of Gelman et al. (2014) for an introduction, as well as computational examples in Chapter 8 of McElreath (2016). The posterior distribution we present here is based on 5000 samples from three chains (after 1000 adaptation steps). These samples were sufficient to establish convergence to the target posterior distribution. Running the chains longer produces no change in inference. We assessed convergence through the R-hat Gelman and Rubin statistic. All R-hat values were less than 1.01 (R-hat values greater than 1.01 can indicate that the chain did not converge), and the effective number of samples for all parameters exceeded 1695 (effective numbers of samples much smaller than the actual number of samples can suggest that the chain was not efficient). Readers unfamiliar with diagnosing chain convergence should see Chapter 8 of McElreath (2016) for an introduction and Sections 11.4 and 11.5 of Gelman et al. (2014) for an authoritative treatment.

Results

Prosocial choices in TEST

Table 3 displays the results of MODEL 1, which investigates the effect of 3/3 PRIMED, using the No Norm DG condition as the reference level (i.e., the Intercept; see SOM Section 3 for model structure). As predicted, there was no substantial effect of 3/3 PRIMED in the No Norm DG condition (i.e., children chose 3/3 similarly often whether 3/3 was indicated first or second; Row 6). 3/3 PRIMED had a reliably stronger effect in the Right Norm DG condition (Row 7), and showed a similar pattern in the Right Norm MaxG condition (Row 8), though this effect did not reach the criterion for reliability (i.e., the 95% CIs include zero). In contrast to the Right Norm DG condition, the Majority Norm DG and Rule Norm DG conditions did not show a reliably stronger effect of 3/3 PRIMED than did the No Norm condition (Rows 9-10). This suggests that priming 3/3 or 5/1 influenced children's behavior in the Right Norm DG condition (and perhaps in the Right Norm MaxG condition), but not in the other conditions.

Table 3

A related question is whether children are overall more likely to choose 3/3 in the other Norm DG conditions than in the No Norm DG conditions. Figure 2 compares MODEL 1's estimate of the probability of a 3/3 choice in the No Norm DG, Right Norm DG, Rule Norm DG, and Majority Norm DG conditions. Lines indicate the model's estimated probability of a 3/3 choice and shaded regions indicate the 95% CI for these estimates (i.e., the shaded region within which the true value of each parameter estimate is likely to lie at the 95% confidence level). We plot these estimates separately for when 3/3 was the primed ratio (Figure 2, left), and for when 5/1 was the primed figure (Figure 2, right). Where the line (i.e., the estimate) for one condition lies above and outside the 95% CIs of the line for a second condition, we infer that children chose the 3/3 ratio more often in the first condition than in the second. Note that these are 95% CIs and not standard errors, so model estimates are assumed to be different even if the CIs overlap, so long as the CIs do not overlap the other lines.

When 3/3 was the primed ratio (Figure 2, left), the estimated probability of a 3/3 choice is greater in the Right Norm DG condition than in the No Norm DG condition. In contrast, the probability of a 3/3 choice in the Rule Norm DG and Majority Norm DG is *not* greater than in the No Norm DG condition. When 5/1 was the primed ratio (Figure 2, right), the probability of a 3/3 choice was similar across all four DG conditions. This indicates that children were more likely to choose 3/3 in the Right Norm condition than in the No Norm condition, but only when 3/3 had been primed.

Figure 2

MODEL 2 explores how the effect of 3/3 PRIMED develops (SOM Section 3 for model details), and Figure 3 displays model results for all four DG conditions. Solid red lines represent the model's estimates of the probability that Subjects will make a 3/3 choice when 3/3 was the primed ratio, and closed red dots are the raw data (the mean number of 3/3 choices made by each subject across the four test trials). Dashed blue lines and open blue dots represent the model's estimates, and the raw data, when 5/1 was the primed ratio are the raw data.

A robust effect of 3/3 PRIMED develops in the Right Norm DG condition after about 7.5 years of age. There is perhaps also a small effect of 3/3 PRIMED in the Majority Norm DG condition after about 9.5 years of age, and the weakness of this effect appears to be due to substantial variability in the probability of 3/3 choices when 5/1 was primed, revealed by the wide CI. This variability is likely caused by large differences in how children respond to the primes across the four types of rewards (see SOM Section 8).

A separate control condition demonstrated that 7 year-olds attend to and learn from the videos, by showing that children of this age successfully reported the information presented in the videos (SOM Section 7).

Figure 3

Figure 4 displays the results of Model 2 for both the Right DG and the Right MaxG conditions. Just as in the Right DG condition, an effect of 3/3 primed develops in the Right MaxG condition, but perhaps a bit later in childhood after about 9.5 years of age (see SOM Section 6 for analysis of potential age differences).

Figure 4

Interview responses predict choices in TEST

MODEL 3 (Table 4) shows that children were *more* likely to choose 3/3 if they believed that choosing 5/1 (the self-maximizing outcome) was wrong (Row 5) or that choosing 5/1 was unfair (Row 6). However, children were not as reliably influenced by their beliefs about whether 3/3 (the more prosocial outcome) was fair or wrong (Rows 7-8). MODEL 4 (Table 5) shows that children were also more likely to choose 3/3 when they believed that their teacher would tell them to choose that one (Row 7). However, children were not as reliably influenced by whether they believed another child or their teacher would choose 3/3 themselves (Rows 5-6). See SOM Section 9 for further analysis of how these effects develop. Additional analyses did not find evidence that subjects' judgments of whether 5/1 and 3/3 were wrong or fair reliably predicted the effect of 3/3 PRIMED in TEST.

Table 4

Table 5

Discussion

We found that by 7.5-9 years of age children had begun to clearly model their own costly sharing on what an adult said was the normative way to share, and that this tendency increased between 6 and 11 years of age. Note that our results do not necessarily preclude social norms from influencing costly sharing at younger ages, an effect that could be better resolved using methods with larger sample sizes, smaller costs associated with sharing, and stronger norm primes – but nonetheless we expect that such methods would also show an *increasing* influence of norms on sharing during middle childhood.

This primary finding fits our prediction that social norms would begin to strongly shape costly sharing in middle childhood, but, interestingly, there were larger differences than expected in how the different kinds of norms influenced children's choices. The stronger influence of Right Norms relative to Majority Norms is the first demonstration of an asymmetry in the influence of injunctive and descriptive norms in children's sharing, and is consistent with a prior finding that injunctive norms are more influential than descriptive norms on adults' behavior in a DG (Raihani & McAuliffe, 2014). However, there is also evidence that descriptive norms can be more influential than injunctive norms on adults' DG behavior (Bicchieri & Xiao, 2009), suggesting that whether injunctive or descriptive norms are more influential depends greatly on the specific details of the context and the norm primes.

This could be why the results of the present study differ from those of a prior study that found injunctive and descriptive norms to be equally influential on DG choices by 4-9 year-old children (McAuliffe, Raihani, et al., 2017). In that study the experimenter directly spoke the primes to the subjects, which we speculate could have led subjects to think of the primes as instructions rather than norms. The present study may have better preserved the perceived normative content of the primes by presenting the them through videos of unfamiliar third-parties who do not directly indicate to the subjects what they should do.

Another way in that the framing and content of the primes may matter has to do with the uniformity of the descriptive norm. For example, the phrase "everyone chooses 3/3" would likely be more influential than the phrase "most people choose 3/3". Indeed, prior work shows that children as young as age 3 are predominantly influenced by unanimous behavior by others, while older children are increasingly influenced by smaller pluralities (Morgan et al., 2015). Also, learning that peers, parents, or prestigious/knowledgeable people made a choice could be more influential than learning about an anonymous average other person (Chudek, Heller, Birch, & Henrich, 2012; Kline, Boyd, & Henrich, 2013).

Content effects may also account for our finding that the Right Norm was more influential than the Rule Norm. Despite the fact that both are kinds of injunctive norms, it is possible that they fall at different points on the Moral/Conventional distinction. Researchers studying Social Domain Theory have done much work to describe children's understanding of moral and conventional norms, particularly transgressions of these norms. Moral norms and transgressions relate to rights and welfare (for example, personal loss or injury); while conventional norms and transgressions relate to rules and regulations that structure social interactions and organizations (Nucci & Turiel, 1978; Smetana & Braeges, 1990). This literature finds that children's understanding of moral and conventional norms develop differently, and that by 3.5 years of age children "judge[d] moral transgressions to be more independent of rules and authority, more generalizably wrong, and more serious than conventional transgressions." (Smetana & Braeges, 1990, p. 341).

This suggests that by 3-4 years of age children distinguish moral and conventional norms, and that they will likely perceive greater pressure to conform their costly sharing to moral norms, even though they might judge transgressions of both moral and conventional norms to be negative. Based on the above definitions, our Right Norm and Rule Norm primes would be relatively better categorized as moral and conventional (respectively), providing a plausible account of why the Right Norm had a more reliable influence on costly sharing than did the Rule

Norm. However, there are other dimensions of the moral/conventional distinction that are not specifically referenced by our primes (e.g., generalizability/context dependence, authority dependence, harm), and future studies could use our methods to explore these other dimensions to elaborate further how our primes and results relate to the literature on the moral/conventional distinction. For example, the Right Norm prime did not directly reference justice, welfare, or harm (though consequences cashed out in these terms may be implied by the phrase 'this is the right thing to do'). Future studies using primes that directly reference justice, welfare, and harm will more clearly situate the norm in the moral domain (reviewer suggestion). With a similar approach future studies will also be able to nail down exactly how, and how much, injunctive and descriptive norms influence behavior.

Importantly, social norms are not exclusively relevant for sharing, which is consistent with our finding that Right Norms motivated both costly sharing *and* behavior that created worse outcomes for everyone (i.e., selecting 3/3 over 5/5 in the MaxG). This illustrates the flexibility and power of social norms, which can motivate many behaviors that are either positive or negative (or even irrational). The lesson is that even though our findings reveal the emerging influence of social norms on sharing in middle childhood, this is likely just one part of a broader developmental trend towards children conforming to social norms across many domains of behavior as they approach adolescence and adulthood.

Interestingly, prior studies have shown that middle childhood is also the age at which societal variation in costly sharing first emerges (Cowell et al., 2016; House et al., 2013; Rochat et al., 2009). Our results support the idea that societally-varying forms of costly sharing appear in middle childhood at least in part due to children beginning to conform more strongly to local norms about prosocial behavior. An additional point of empirical support comes from another recent study, which found that with increasing age 4-9 year-old American children became more likely to give exactly 50% in a DG, even though the experimenter presented them with norm primes indicating that they should give either 80% or 20% (McAuliffe, Raihani, et al., 2017). This suggests that during middle childhood American children may be increasingly applying an internalized “equal split” norm in costly sharing situations. Importantly, this bias toward 50% splits may be culturally variable, as watching a model give 90% in a DG motivated majorities of Indian children aged 5-8 to give more than 50% of their endowment, but motivated very few American children to do so (Blake, Corbit, Callaghan, & Warneken, 2016).

Finally, based on our interview we found that children who judged the self-maximizing ratio (5/1) to be wrong and unfair were also more likely to have chosen the more-prosocial ratio (3/3) in TEST, but we observed no such influence of judgments about the prosocial ratio (3/3). This may mean that the relevant content of German children’s social norms centers on avoiding negative sanctions for being selfish. Furthermore, children who judged that their teacher would tell them to choose the more-prosocial ratio were also more likely to have chosen that ratio in TEST, but there was no influence of children’s judgments about the likely *actual* behavior of other children and adults. German children may thus be more motivated by what they believed was expected of them than by what they believe others actually do, consistent with our finding that injunctive norms were more reliably influential on sharing than were descriptive norms. These findings are consistent with a wide range of evidence showing that a desire to avoid punishment for selfishness is an important motivator (though by no means the only motivator) of prosocial behavior in children and adults (Lergetporer, Angerer, Glätzle-Rützler, & Sutter, 2014; Mathew & Boyd, 2011; McAuliffe, Jordan, & Warneken, 2015).

What aspects of psychological development cause these age-related changes in behavior? Humans may have an evolved norm psychology that facilitates social coordination and accurate cultural transmission through cognitive mechanisms that help individuals to follow local social norms (Chudek & Henrich, 2011; Rakoczy & Schmidt, 2013), information that varies greatly across societies (Graham et al., 2011; Henrich, Heine, & Norenzayan, 2010), and which children must follow if they are to be successful members of their cultural communities. The development of costly sharing may thus be linked to the ontogenesis of human norm psychology.

However, many different aspects of psychological development are likely at work. Increasing inhibitory control during middle childhood could enable children to better adjudicate conflicts between their immediate desires and their understanding of what constitutes normative behavior, and there is evidence for age-related increases in children's inhibitory control in binary-choice sharing tasks such as those used here (Thompson, Barresi, & Moore, 1997). Similarly, increasing competence with representing others' mental states during middle childhood may facilitate children's ability to understand what others expect them to do, and the elaboration of the self-conscious emotions (e.g., guilt and shame) in middle childhood may be important for motivating conformity to social norms (House, 2018).

These and other plausible developmental phenomena (e.g., improved lingustic skills, changing social relationships as with peers and adults, etc.) likely do play a role in the development of normative influences on costly sharing. However, they do not necessarily contradict the norm psychology perspective, which primarily argues that human psychology and its development have likely evolved such that one of the many functions of our domain-specific and domain-general cognitive mechanisms is to help us follow adaptive local social norms.

Summary

Here, we have shown that children become increasingly likely to conform to social norms about sharing in middle childhood, but that different kinds of norms influence children's costly sharing to different degrees. The results hint that the growing influence of norms on sharing is part of a wider expansion of the influence of norms on behavior in middle childhood, and future studies will be able to use these methods to further elaborate how different kinds of norms shape costly sharing and prosocial psychology across development.

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Figures

Figure 1

Apparatus and procedure used in the current study. (A) Children are shown the four kinds of rewards that they can receive in the study. (B) They are shown six different bags, and told that for each of the six choices that they make the rewards sent to the Recipient will be put into a different bag, and each bag will be given to a different child. (C) Children are shown a normative priming video. (D) Children make their choices on all four Test trials.

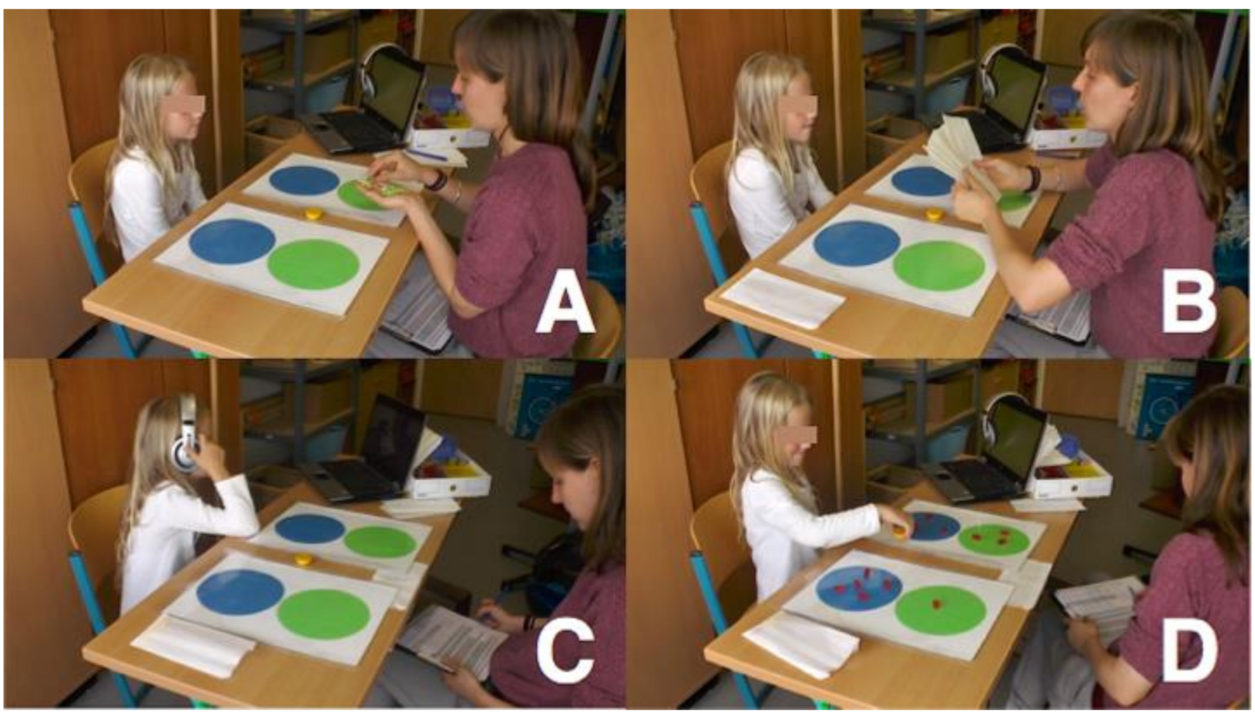


Table 1

Payoff distributions (i.e., ratios) used in the current study.

Phase	Payoff Choice	Ratio 1 Subject/Recipient	Ratio 2 Subject/Recipient
FAM	Advantageous Inequity Game (AIG)	2/1	4/1
FAM	Disadvantageous Inequity Game (DIG)	1/2	2/6
TEST	Dictator Game (DG)	3/3	5/1
TEST	Maximizing Game (MaxG)	3/3	5/5

Table 2

Experimental conditions. Each row is a between-subjects sample (N=23 or 24).

Ratio choice	Norm condition	Treatment (i.e., primed ratio)	Prime (i.e., adult model's statement)
3/3 vs. 5/1 Dictator Game (DG) 5/1 = 5 for Subject 1 for Recipient	No Norm DG	(3/3)	"I can choose (3/3), or (5/1)."
		(5/1)	"I can choose (5/1), or (3/3)."
	Majority Norm DG	(3/3)	"Most people choose (3/3), and not (5/1)."
		(5/1)	"Most people choose (5/1), and not (3/3)."
	Rule Norm DG	(3/3)	"There is a rule that says to choose (3/3), and not (5/1)."
		(5/1)	"There is a rule that says to choose (5/1), and not (3/3)."
	Right Norm DG	(3/3)	"The right thing to do is choose (3/3), and not (5/1)."
		(5/1)	"The right thing to do is choose (5/1), and not (3/3)."
3/3 vs. 5/5 Maximizing Game (MaxG)	Right Norm MaxG	(3/3)	"The right thing to do is choose (3/3), and not (5/5)."
		(5/1)	"The right thing to do is choose (5/5), and not (3/3)."

Table 3

Results of MODEL 1. 3/3 PRIMED captures whether 3/3 was the 'primed' ratio (3/3 PRIMED=1) or 5/1 was the 'primed' ratio (3/3 PRIMED=0). Row 6 gives the gives the effect of 3/3 PRIMED for the No Norm condition. Rows 7-10 use interactions to ask whether the effect of 3/3 PRIMED is stronger in each of the Norm conditions, relative to the No Norm condition. N=238.

Row	Model Parameter	Estimate	Lower 95% CI	Upper 95% CI	Odds Ratio	SD
1	Intercept (No Norm condition)	-0.99	-1.95	-0.02		0.49
2	RIGHT NORM DG (Dummy)	-0.43	-1.42	0.58		0.51
3	RIGHT NORM MaxG (Dummy)	-1.08	-2.12	-0.06		0.52
4	MAJORITY NORM DG (Dummy)	-0.09	-1.08	0.92		0.51
5	RULE NORM DG (Dummy)	0.07	-0.93	1.03		0.50
6	**3/3 PRIMED (No Norm condition)**	**0.35**	**-0.47**	**1.20**	**1.42**	0.43
7	**3/3 PRIMED * Right Norm DG condition**	**1.38**	**0.15**	**2.65**	**3.97**	0.64
8	**3/3 PRIMED * Right Norm MaxG condition**	**0.81**	**-0.44**	**2.11**	**2.24**	0.65
9	**3/3 PRIMED * Majority Norm DG condition**	**0.02**	**-1.25**	**1.26**	**1.02**	0.64
10	**3/3 PRIMED * Rule Norm DG condition**	**0.40**	**-0.85**	**1.66**	**1.50**	0.64
11	SEX	0.23	-0.41	0.87		0.33
12	TRIAL#	-0.21	-0.36	-0.05		0.08
13	AGE	1.17	0.81	1.53		0.18
14	AGE^2	0.17	-0.22	0.56		0.20
15	Random Intercept (Subject ID)	1.96	1.55	2.41		0.22

Figure 2

Probability of 3/3 choices by the Subject in TEST, in the Norm DG conditions: Right Norm DG, Majority Norm DG, Rule Norm DG, No Norm DG. Model estimates are plotted as lines, with shaded regions representing 95% confidence intervals. Results are plotted separately for when 3/3 was the primed ratio (left graph) and when 5/1 was the primed ratio (right graph). All graphs, n=238.

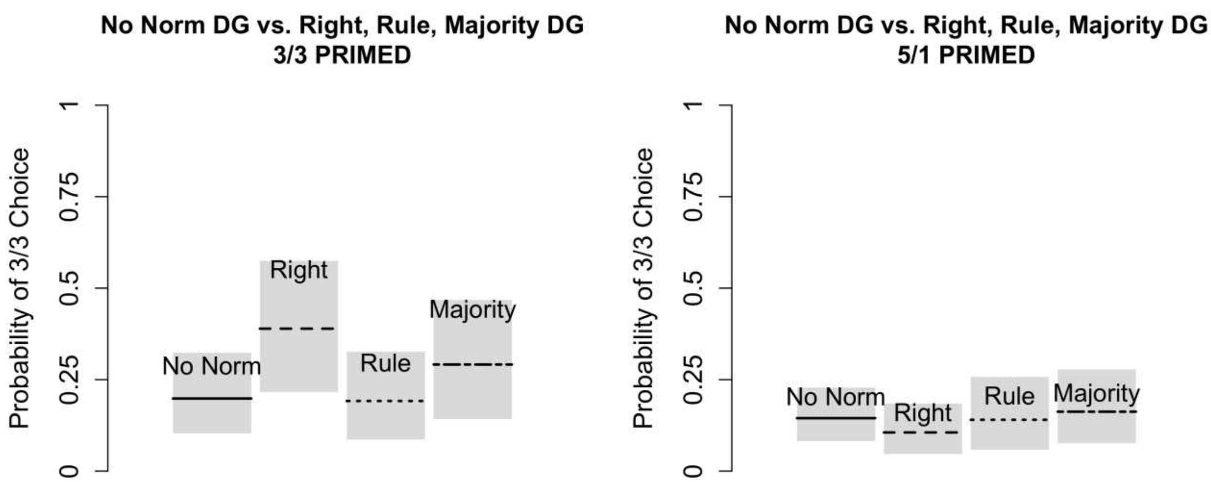


Figure 3

Probability of 3/3 choices by the Subject in TEST, in the Norm DG conditions: Right Norm DG, Majority Norm DG, Rule Norm DG, No Norm DG. Model estimates are plotted as lines, with shaded regions representing 95% confidence intervals. Dots represent raw data, the average numbers of 3/3 choices for a single subject (a dot at y=.5 indicates a subject chose 3/3 on 50% of trials). Results are plotted separately for when 3/3 was the primed ratio (red solid lines and closed dots) and when 5/1 was the primed ratio (blue dashed lines and open circles). All graphs, n=238.

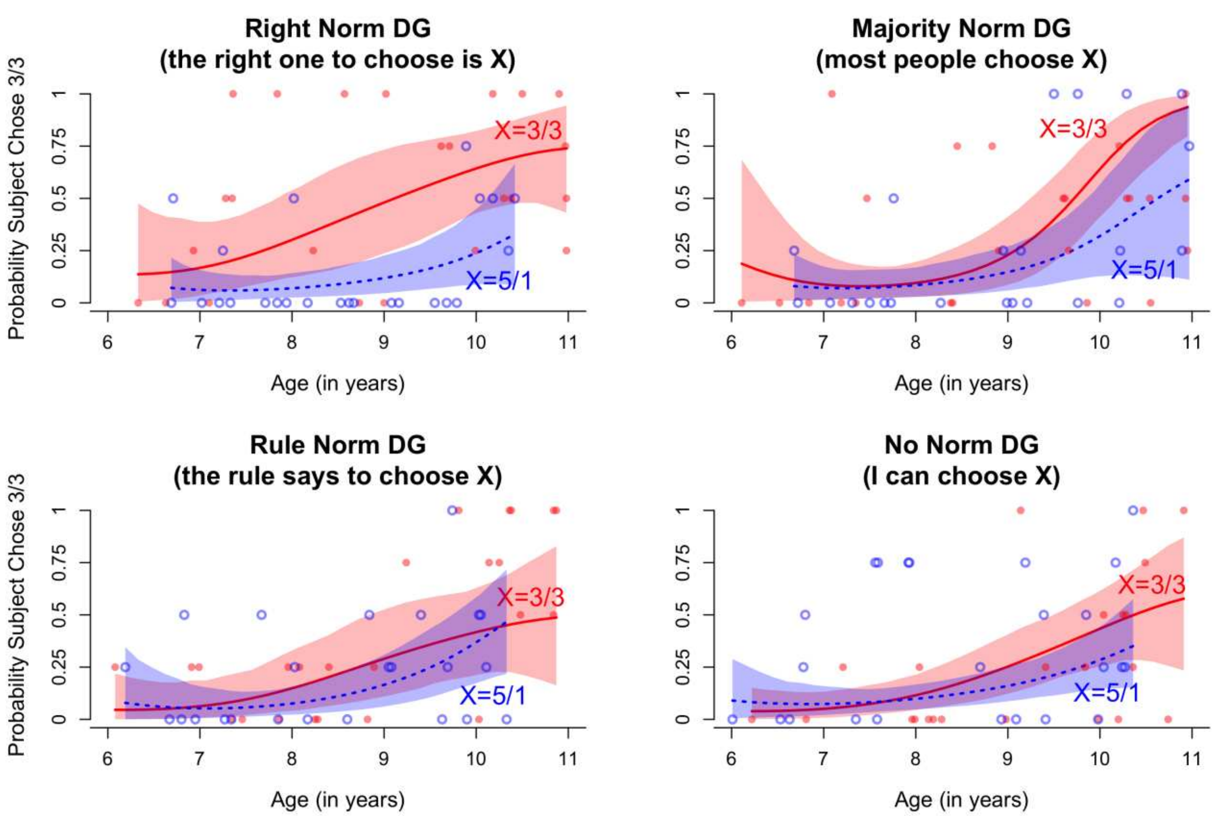


Figure 4

Probability of 3/3 choices by the Subject in TEST, in the Right Norm DG and Right Norm MaxG conditions. Model estimates are plotted as lines, with shaded regions representing 95% confidence intervals. Dots represent raw data, the average numbers of 3/3 choices for a single subject (a dot at y=.5 indicates a subject chose 3/3 on 50% of trials). Results are plotted separately for when 3/3 was the primed ratio (red solid lines and closed dots) and when 5/1 was the primed ratio (blue dashed lines and open circles). All graphs, n=238.

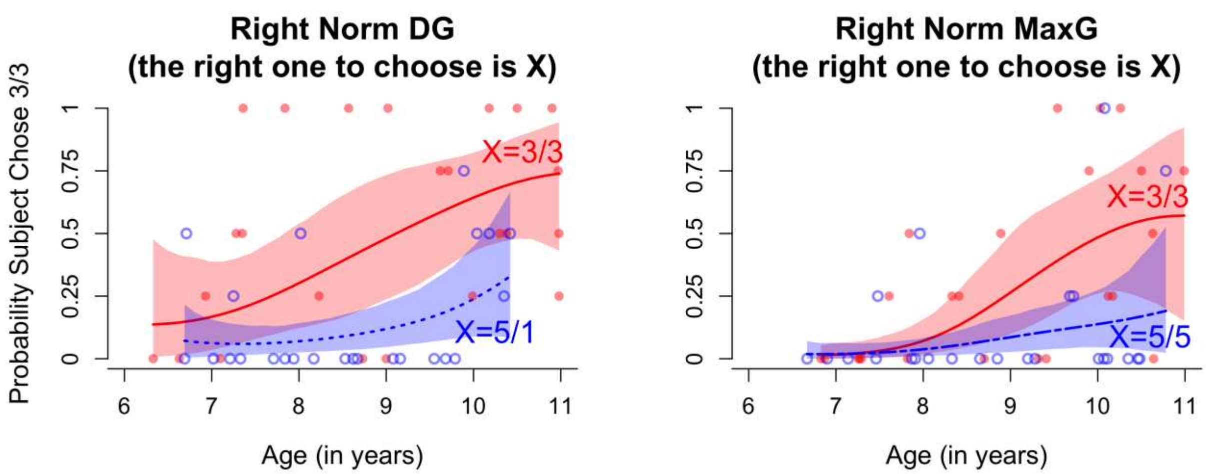


Table 4

Results for MODEL 3. 3/3 PRIMED (Row 4) controls for the overall effect of whether 3/3 or 5/1 was primed. Rows 5-8 ask whether Subjects' judgments about whether 5/1 and 3/3 were "wrong" or "fair" predict their choices of 3/3 in TEST ("yes" responses coded as "1"). N=160 children who answered the interview questions.

Row	Model Parameter	Estimate	Lower 95% CI	Upper 95% CI	Odds Ratio	SD
1	Intercept	-0.73	-2.05	0.45		0.64
2	Sex	0.26	-0.43	0.94		0.35
3	Trial Number	-0.24	-0.43	-0.07		0.09
4	3/3 PRIMED	0.90	0.21	1.59		0.35
5	**5/1 was Wrong**	**1.54**	**0.69**	**2.40**	**4.66**	0.43
6	**5/1 was Fair**	**-1.02**	**-1.95**	**-0.03**	**0.36**	0.49
7	**3/3 was Wrong**	**-0.86**	**-1.93**	**0.19**	**0.42**	0.54
8	**3/3 was Fair**	**-0.17**	**-1.24**	**0.98**	**0.84**	0.57
9	Random Intercept (Subject ID)	1.73	1.26	2.20		0.24

Table 5

Results for MODEL 4. 3/3 PRIMED (Row 4) controls for the overall effect of whether 3/3 or 5/1 was primed. Rows 5-8 ask whether Subjects' judgments about whether others would choose "3/3" or "5/1" (or whether their teacher would tell them to choose 3/3 or 5/1) predict their choices of 3/3 in TEST (responses of "3/3" are coded as "1"). N=144 children who answered the interview questions.

Row	Model Parameter	Estimate	Lower 95% CI	Upper 95% CI	Odds Ratio	SD
1	Intercept	-2.02	-3.19	-0.91		0.59
2	Sex	0.30	-0.47	1.03		0.38
3	Trial Number	-0.29	-0.48	-0.09		0.10
4	3/3 PRIMED	0.70	-0.03	1.46		0.38
5	**Which would other child choose**	**0.80**	**-0.15**	**1.73**	**2.23**	0.48
6	**Which would teacher choose**	**0.60**	**-0.30**	**1.53**	**1.82**	0.47
7	**Which would teacher tell Subject to choose**	**1.06**	**0.09**	**2.01**	**2.89**	0.49
8	Random Intercept (Subject ID)	1.86	1.35	2.39		0.27

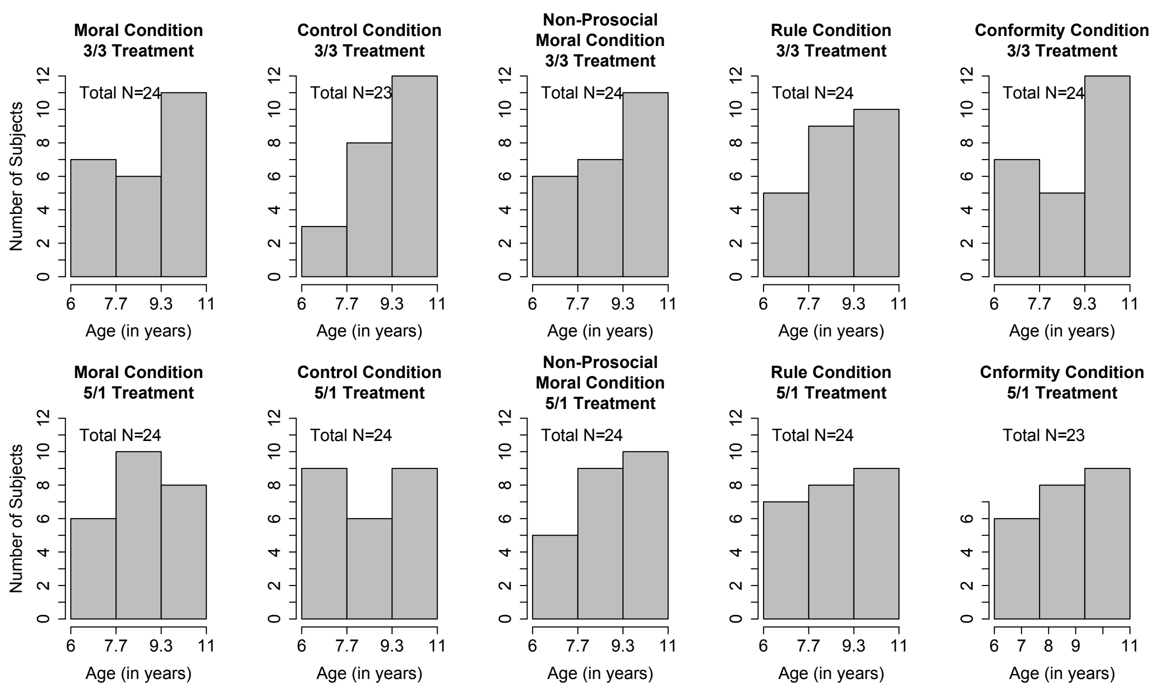
Supplementary Materials for:

Normative primes influence costly sharing in middle childhood

SOM Section 1: Details about Participants and Apparatus

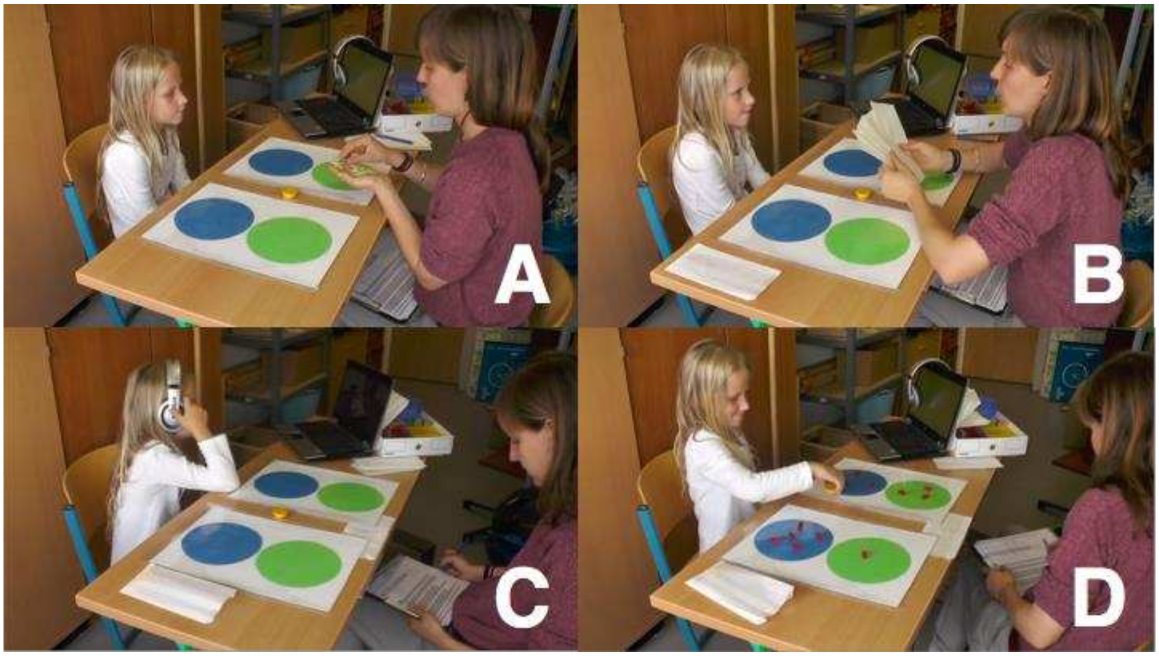
Participants were 238 German-speaking children aged 6-11 years (see Figure 3 for age distributions). Note that all of these subjects are combined into one dataset, so all of these subjects are contributing to all of the analyses (i.e., if one age sample seems small, this is not the only data that is contributing to the inferences).

Figure 3: Age Distributions for the different samples.



Testing was mostly conducted in after-school programs located within schools in a city in eastern Germany. 31 children were invited into a laboratory for testing, and these children were about equally distributed across the Right Norm DG (7), Rule Norm DG (7), Majority Norm DG (8), and No Norm DG (9) conditions. Each experimental session lasted 15 minutes, and consisted of four Phases: Familiarization, Priming, Test, and Interview. Sessions were video recorded. The apparatus consisted of two large laminated paper trays, each with a blue and green circle, placed in front of a seated subject (Figure 4).

Figure 4: Apparatus and procedure used in the current study.



The experimenter placed rewards on each of the circles, according to pre-determined payoff distributions (Table 7). The Actor was then permitted to select one tray. The Actor would then receive the rewards in the blue circle on that tray, and the experimenter placed the rewards in the green circle in a paper bag that would be given to the Recipient. All rewards on the unselected tray were then retrieved by the experimenter and returned to reservoir of rewards, and the experimenter then laid out the payoff distribution for the next trial.

Table 7: Payoff distributions used in the current study.

Payoff #	Phase	Payoff Choice	Outcome 1	Outcome 2
1	Familiarization	Advantageous Inequity Game	2/1	4/1
2	Familiarization	Disadvantageous Inequity Game	1/2	2/6
3	Test	Dictator Game	3/3	5/1
4	Test	Maximizing Game	3/3	5/5

SOM Section 2: English Translation of Study Script

Introduction (prior to entering testing area; instructions provided by Experimenter 2)

Hello! We brought you some things. You can participate [in the activity].

You're going to get gummy bears, stickers, and coins. You can use the coins to buy something from the little shop I brought with me today.

Do you want to see it [the shop]?

[E2 shows some red and yellow coins and the "shop" to the child]

The yellow coins are worth 1 point and the red coins are worth 2 points. So the red coins are worth twice as much as the yellow ones. You can use them to buy something from here. The small things cost less and the big things cost more.

[Child enters room where E1 is waiting]

Introduction (after entering testing area; instructions provided by Experimenter 1)

Hi! Thanks for participating!

[Experimenter 2] already explained that you can get coins that you can use to buy something from the shop. The red ones are worth twice as much as the yellow ones.

[E1 shows some red and yellow coins to the child]

You can also have these glow-in-the-dark stars to take home with you.

[E1 shows some glow-in-the-dark stars to the child]

And you can have gummy bears, too.

[E1 shows some gummy bears to the child]

[Experimenter takes one of the bags and places it opposite the child]

Here is your bag. You can write your name on it.
You can put everything you get into the bag.

You can choose six times. Each time you choose, you will get something, and another child at your school [or: another child in Leipzig; for the minority of children tested in the laboratory] will get something, too.

[Experimenter brings out six bags]

Six other children at this school /(in Leipzig) will get one of these bags. Right now, I don't know who will get which bag, but we will find out later when we will pick the names by chance. These children won't know that they got the bags from you because they will be chosen by chance. So don't forget, each of these bags is for some other child here at this school /(in Leipzig).

Instructions – Familiarization Trial 1

First, let me tell you how this is all going to work.

[Experimenter lays out coins]

In just a minute, you can choose between these two papers. You can choose whichever one you want.

[pointing to the first paper]

If you choose this paper, you get everything in the blue circle, and everything in the green circle goes into the bag.

[pointing to the second paper]

If you choose this paper, you get everything in the blue circle, and everything in the green circle goes into the bag.

Comprehension questions – Familiarization Trial 1

Can you tell me how it works?

(If child fails to explain, repeat explanation)

How many things do you get if you choose this paper?

[pointing to the first paper]

How many things do you get if you choose this paper?

[pointing to the second paper]

How many things does the other child get if you pick this paper?

[pointing to the first paper]

And how many things does the other child get if you pick this paper?

[pointing to the second paper]

[If child answers a question incorrectly, experimenter repeats: If you choose this paper, you get everything in the blue circle, and everything in the green circle goes into the bag for the other child.]

[pointing to the other child's bag]

After you choose, do you get this bag, or not?

Who gets the bag? (If necessary: Will another child from your school / (in Leipzig) get it?)

Will the child who gets the bag know that you gave them the things?

[If child answers a question incorrectly, experimenter repeats: Each bag goes to a different child at your school / (in Leipzig), not you. We don't know which bag will go to which child. We'll find that out later when we pick the names by chance.]

Instructions – Familiarization Trial 2

For the next choice, we'll use another bag and another child from your school / (in Leipzig) will get everything that's inside.

You can choose whichever paper you want, just like last time. But remember, you can only choose one.

Comprehension questions – Familiarization Trial 2

[pointing to the first paper]

How many things do you get if you choose this paper?

How many things go into the bag for the other child?

[If child answers a question incorrectly, experimenter repeats: If you choose this paper, you get everything in the blue circle, and everything in the green circle goes into the bag.]

[pointing to the second paper]

How many things do you get if you choose this paper?

How many things go into the other bag for the other child?

[If child answers a question incorrectly, experimenter repeats: If you choose this paper, you get everything in the blue circle, and everything in the green circle goes into the bag.]

[pointing to the recipient's bag]

Does the same child who got the bag from the last choice get this bag too, or does a different child get this bag?

[If child answers incorrectly, experimenter repeats: Each bag goes to a different child at your school / (in Leipzig), not you. We don't know which bag will go to which child. We'll find that out later when we pick the names by chance.]

Instructions – Test Trials

For the next choice, we have a different bag that will go to a different child.

But first, I'm going to show you a short video. This video is just for you, so you will use headphones. Let me know when the video is over, because I can't hear it.

[Video shows an experimenter laying out the rewards in front of an Adult (the Adult Model), sitting in the same position that the child Subject is currently sitting in.]

The experimenter in the video then says:

"Remember, you can only choose one paper."

The Adult Model then utters the priming statement for that Condition:

Right Norm DG / MaxG conditions:	The right thing to do is to choose this one, and not this one.
Majority Norm DG condition:	Most people choose this one, and not this one.
Rule Norm DG condition:	The rules say to choose this one, and not this one.
No Norm DG condition:	I can choose this one or this one.
Frog Control condition (SOM Section 7):	I can choose this one or this one, [The Adult Model picks up a toy Frog sitting on the table] and I must put the Frog on the one that I choose.

Post-experiment Interview:

(Interview is conducted after the last Test Trial.)

I'm going to put a few more coins on the table, as an example, because I want to ask you a few more questions.

[experimenter lays out payoffs corresponding to those used in the Test Trials]

1) Soon, another child will come and play the same game. He or she will sit here where you're sitting and get everything in the blue circle. And a different child will get everything in the green circle.
2) Which paper do you think the next child will choose? Why?

[Pointing to the option that subject said the other child would choose]

3) Would it be wrong to choose this one? Why?

[Pointing to the other option, which subject said the other child would NOT choose]

4) Would it be wrong to choose that one? Why?

[Pointing to the option that subject said the other child would choose]

5) Would it be fair to choose this one? Why?

[Pointing to the option that subject said the other child would NOT choose]

6) Would it be fair to choose this one? Why?

7) If there were a grown-up sitting here instead of you, which do you think he would pick? Why?
8) Do you have a male teacher or female teacher? [This question is only included to ensure that the following questions use the appropriately-conjugated form of the German word for "teacher" (Lehrer/Lehrerin)]
9) If your teacher were sitting here instead of you, which do you think he / she would pick? Why?
10) Which paper would your teacher tell you to pick?

SOM Section 3: Details about Models

Model 1 Formula:

Subject_chose_3/3 ~ 1 + (1 |Subject_ID) + Sex + Trial_Number + Age + Age_Squared + 33PRIMED * (RIGHT_NORM_DG + RIGHT_NORM_MaxG+ MAJORITY_NORM_DG + RULE_NORM_DG)

```
Model.1 <- map2stan(alist(
Subject_chose_3/3 ~ dbinom( 1 , p ), logit(p) <- Intercept + b_33PRIMED + b_SEX*SEX +
b_TRIAL_NUMBER*TRIAL_NUMBER + b_AGE*AGE + b_AGE_SQUARED*AGE_SQUARED +
b_33PRIMED*33PRIMED + b_RIGHT_NORM_DG*RIGHT_NORM_DG +
b_RIGHT_NORM_MaxG*RIGHT_NORM_MaxG+ b_MAJORITY_NORM_DG*MAJORITY_NORM_DG +
b_RULE_NORM_DG*RULE_NORM_DG +
b_33PRIMED_X_RIGHT_NORM_DG*33PRIMED*RIGHT_NORM_DG +
b_33PRIMED_X_RIGHT_NORM_MaxG*33PRIMED*RIGHT_NORM_MaxG+
b_33PRIMED_X_MAJORITY_NORM_DG*33PRIMED*MAJORITY_NORM_DG +
b_33PRIMED_X_RULE_NORM_DG*33PRIMED*RULE_NORM_DG + v_Intercept[Subject_ID],

Intercept ~ dnorm(0,1), b_SEX ~ dnorm(0,1), b_TRIAL_NUMBER ~ dnorm(0,1), b_AGE ~ dnorm(0,1),
b_AGE_SQUARED ~ dnorm(0,1), b_33PRIMED ~ dnorm(0,1), b_RIGHT_NORM_DG ~ dnorm(0,1),
b_RIGHT_NORM_MaxG~ dnorm(0,1), b_MAJORITY_NORM_DG ~ dnorm(0,1), b_RULE_NORM_DG ~
dnorm(0,1), b_33PRIMED_X_RIGHT_NORM_DG ~ dnorm(0,1), b_33PRIMED_X_RIGHT_NORM_MaxG~
dnorm(0,1), b_33PRIMED_X_MAJORITY_NORM_DG ~ dnorm(0,1), b_33PRIMED_X_RULE_NORM_DG ~
dnorm(0,1), v_Intercept[Subject_ID] ~ dnorm(0,sigma_Subject_ID), sigma_Subject_ID ~
dcauchy(0,2)))
```

Model 1 Output:

Model Parameter	Mean	StdDev	lower 0.95	upper 0.95	n_eff	Rhat
Intercept	-0.99	0.49	-1.95	-0.02	7369.28	1.00
b_SEX	0.23	0.33	-0.41	0.87	6528.73	1.00
b_TRIAL_NUMBER	-0.21	0.08	-0.36	-0.05	12379.83	1.00
b_AGE	1.17	0.18	0.81	1.53	4747.42	1.00
b_AGE_SQUARED	0.17	0.20	-0.22	0.56	7022.62	1.00
b_33PRIMED	0.35	0.43	-0.47	1.20	5577.13	1.00
b_RIGHT_NORM_DG	-0.43	0.51	-1.42	0.58	7365.96	1.00
b_RIGHT_NORM_MaxG	-1.08	0.52	-2.12	-0.06	8259.83	1.00
b_MAJORITY_NORM_DG	-0.09	0.51	-1.08	0.92	7445.47	1.00
b_RULE_NORM_DG	0.07	0.50	-0.93	1.03	5943.90	1.00
b_33PRIMED_X_RIGHT_NORM_DG	1.38	0.64	0.15	2.65	7109.55	1.00
b_33PRIMED_X_RIGHT_NORM_MaxG	0.81	0.65	-0.44	2.11	8222.59	1.00
b_33PRIMED_X_MAJORITY_NORM_DG	0.02	0.64	-1.25	1.26	7171.60	1.00
b_33PRIMED_X_RULE_NORM_DG	0.40	0.64	-0.85	1.66	7055.27	1.00
sigma_Subject_ID	1.96	0.22	1.55	2.41	1920.59	1.00

Model 2 Formula:

Subject_chose_3/3 ~ 1 + (1 |aid) + Sex + Trial_Number + Age*33PRIMED*(RIGHT_NORM_DG + RIGHT_NORM_MaxG+ MAJORITY_NORM_DG + RULE_NORM_DG) + Age_Squared*33PRIMED*(RIGHT_NORM_DG + RIGHT_NORM_MaxG+ MAJORITY_NORM_DG + RULE_NORM_DG)

Model.2 <- map2stan(alist(
Subject_chose_3/3 ~ dbinom(1 , p), logit(p) <- Intercept + b_SEX*SEX + b_TRIAL_NUMBER*TRIAL_NUMBER + b_AGE*AGE + b_33PRIMED*33PRIMED + b_RIGHT_NORM_DG*RIGHT_NORM_DG + b_RIGHT_NORM_MaxG*RIGHT_NORM_MaxG+ b_MAJORITY_NORM_DG*MAJORITY_NORM_DG + b_RULE_NORM_DG*RULE_NORM_DG + b_AGE_SQUARED*AGE_SQUARED + b_AGE_X_33PRIMED*AGE*33PRIMED + b_AGE_X_RIGHT_NORM_DG*AGE*RIGHT_NORM_DG + b_AGE_X_RIGHT_NORM_MaxG*AGE*RIGHT_NORM_MaxG+ b_AGE_X_MAJORITY_NORM_DG*AGE*MAJORITY_NORM_DG + b_AGE_X_RULE_NORM_DG*AGE*RULE_NORM_DG + b_33PRIMED_X_RIGHT_NORM_DG*33PRIMED*RIGHT_NORM_DG + b_33PRIMED_X_RIGHT_NORM_MaxG*33PRIMED*RIGHT_NORM_MaxG+ b_33PRIMED_X_MAJORITY_NORM_DG*33PRIMED*MAJORITY_NORM_DG + b_33PRIMED_X_RULE_NORM_DG*33PRIMED*RULE_NORM_DG + b_33PRIMED_X_AGE_SQUARED*33PRIMED*AGE_SQUARED + b_RIGHT_NORM_DG_X_AGE_SQUARED*RIGHT_NORM_DG*AGE_SQUARED + b_RIGHT_NORM_MaxG_X_AGE_SQUARED*RIGHT_NORM_MaxG*AGE_SQUARED + b_MAJORITY_NORM_DG_X_AGE_SQUARED*MAJORITY_NORM_DG*AGE_SQUARED + b_RULE_NORM_DG_X_AGE_SQUARED*RULE_NORM_DG*AGE_SQUARED + b_AGE_X_33PRIMED_X_RIGHT_NORM_DG*AGE*33PRIMED*RIGHT_NORM_DG + b_AGE_X_33PRIMED_X_RIGHT_NORM_MaxG*AGE*33PRIMED*RIGHT_NORM_MaxG+ b_AGE_X_33PRIMED_X_MAJORITY_NORM_DG*AGE*33PRIMED*MAJORITY_NORM_DG + b_AGE_X_33PRIMED_X_RULE_NORM_DG*AGE*33PRIMED*RULE_NORM_DG + b_33PRIMED_X_RIGHT_NORM_DG_X_AGE_SQUARED*33PRIMED*RIGHT_NORM_DG*AGE_SQUARED + b_33PRIMED_X_RIGHT_NORM_MaxG_X_AGE_SQUARED*33PRIMED*RIGHT_NORM_MaxG*AGE_SQUARED + b_33PRIMED_X_MAJORITY_NORM_DG_X_AGE_SQUARED*33PRIMED*MAJORITY_NORM_DG*AGE_SQUARED + b_33PRIMED_X_RULE_NORM_DG_X_AGE_SQUARED*33PRIMED*RULE_NORM_DG*AGE_SQUARED + v_Intercept[Subject_ID],

Intercept ~ dnorm(0,1), b_SEX ~ dnorm(0,1), b_TRIAL_NUMBER ~ dnorm(0,1), b_AGE ~ dnorm(0,1), b_33PRIMED ~ dnorm(0,1), b_RIGHT_NORM_DG ~ dnorm(0,1), b_RIGHT_NORM_MaxG~ dnorm(0,1), b_MAJORITY_NORM_DG ~ dnorm(0,1), b_RULE_NORM_DG ~ dnorm(0,1), b_AGE_SQUARED ~ dnorm(0,1), b_AGE_X_33PRIMED ~ dnorm(0,1), b_AGE_X_RIGHT_NORM_DG ~ dnorm(0,1), b_AGE_X_RIGHT_NORM_MaxG~ dnorm(0,1), b_AGE_X_MAJORITY_NORM_DG ~ dnorm(0,1), b_AGE_X_RULE_NORM_DG ~ dnorm(0,1), b_33PRIMED_X_RIGHT_NORM_DG ~ dnorm(0,1), b_33PRIMED_X_RIGHT_NORM_MaxG~ dnorm(0,1), b_33PRIMED_X_MAJORITY_NORM_DG ~ dnorm(0,1), b_33PRIMED_X_RULE_NORM_DG ~ dnorm(0,1), b_33PRIMED_X_AGE_SQUARED ~ dnorm(0,1), b_RIGHT_NORM_DG_X_AGE_SQUARED ~ dnorm(0,1), b_RIGHT_NORM_MaxG_X_AGE_SQUARED ~ dnorm(0,1), b_MAJORITY_NORM_DG_X_AGE_SQUARED ~ dnorm(0,1), b_RULE_NORM_DG_X_AGE_SQUARED ~ dnorm(0,1), b_AGE_X_33PRIMED_X_RIGHT_NORM_DG ~ dnorm(0,1), b_AGE_X_33PRIMED_X_RIGHT_NORM_MaxG~ dnorm(0,1), b_AGE_X_33PRIMED_X_MAJORITY_NORM_DG ~ dnorm(0,1), b_AGE_X_33PRIMED_X_RULE_NORM_DG ~ dnorm(0,1), b_33PRIMED_X_RIGHT_NORM_DG_X_AGE_SQUARED ~ dnorm(0,1), b_33PRIMED_X_RIGHT_NORM_MaxG_X_AGE_SQUARED ~ dnorm(0,1), b_33PRIMED_X_MAJORITY_NORM_DG_X_AGE_SQUARED ~ dnorm(0,1), b_33PRIMED_X_RULE_NORM_DG_X_AGE_SQUARED ~ dnorm(0,1), v_Intercept[Subject_ID] ~ dnorm(0,sigma_Subject_ID), sigma_Subject_ID ~ dcauchy(0,2)))

Model 2 Output:

Model Parameter	Mean	StdDev	lower 0.95	upper 0.95	n_eff	Rhat
Intercept	-1.00	0.53	-2.04	0.03	10252.96	1.00
b_SEX	0.29	0.35	-0.39	1.00	11111.55	1.00
b_TRIAL_NUMBER	-0.21	0.08	-0.37	-0.05	15000.00	1.00
b_AGE	0.85	0.37	0.11	1.56	7288.95	1.00
b_33PRIMED	0.53	0.52	-0.50	1.54	9837.57	1.00
b_RIGHT_NORM_DG	-0.45	0.61	-1.68	0.72	11680.03	1.00
b_RIGHT_NORM_MaxG	-0.82	0.62	-2.04	0.38	11600.35	1.00
b_MAJORITY_NORM_DG	-0.11	0.60	-1.24	1.11	12169.43	1.00
b_RULE_NORM_DG	-0.19	0.59	-1.34	0.97	11011.17	1.00
b_AGE_SQUARED	0.14	0.37	-0.56	0.89	9197.20	1.00
b_AGE_X_33PRIMED	0.47	0.47	-0.45	1.38	9600.97	1.00
b_AGE_X_RIGHT_NORM_DG	0.11	0.55	-0.99	1.18	10052.70	1.00
b_AGE_X_RIGHT_NORM_MaxG	0.24	0.59	-0.86	1.45	11898.19	1.00
b_AGE_X_MAJORITY_NORM_DG	0.51	0.53	-0.52	1.56	9755.50	1.00
b_AGE_X_RULE_NORM_DG	0.25	0.56	-0.87	1.34	10242.00	1.00
b_33PRIMED_X_RIGHT_NORM_DG	1.52	0.73	0.08	2.94	12875.77	1.00
b_33PRIMED_X_RIGHT_NORM_MaxG	0.72	0.74	-0.74	2.16	13376.60	1.00
b_33PRIMED_X_MAJORITY_NORM_DG	0.25	0.73	-1.19	1.66	12737.75	1.00
b_33PRIMED_X_RULE_NORM_DG	-0.11	0.72	-1.54	1.24	15000.00	1.00
b_33PRIMED_X_AGE_SQUARED	-0.30	0.47	-1.22	0.62	10173.80	1.00
b_RIGHT_NORM_DG_X_AGE_SQUARED	0.11	0.58	-1.00	1.25	11231.92	1.00
b_RIGHT_NORM_MaxG_X_AGE_SQUARED	-0.50	0.62	-1.70	0.72	12460.28	1.00
b_MAJORITY_NORM_DG_X_AGE_SQUARED	0.07	0.52	-0.93	1.08	11210.63	1.00
b_RULE_NORM_DG_X_AGE_SQUARED	0.22	0.54	-0.83	1.28	9962.34	1.00
b_AGE_X_33PRIMED_X_RIGHT_NORM_DG	-0.35	0.66	-1.59	0.99	11366.39	1.00
b_AGE_X_33PRIMED_X_RIGHT_NORM_MaxG	0.45	0.72	-0.92	1.88	15000.00	1.00
b_AGE_X_33PRIMED_X_MAJORITY_NORM_DG	-0.68	0.66	-1.96	0.65	11962.63	1.00
b_AGE_X_33PRIMED_X_RULE_NORM_DG	0.35	0.67	-1.00	1.64	12527.34	1.00
b_33PRIMED_X_RIGHT_NORM_DG_X_AGE_SQUARED	-0.06	0.64	-1.32	1.21	12669.50	1.00
b_33PRIMED_X_RIGHT_NORM_MaxG_X_AGE_SQUARED	0.10	0.72	-1.29	1.53	15000.00	1.00
b_33PRIMED_X_MAJORITY_NORM_DG_X_AGE_SQUARED	-0.19	0.63	-1.39	1.05	12675.44	1.00
b_33PRIMED_X_RULE_NORM_DG_X_AGE_SQUARED	0.74	0.63	-0.48	2.00	11995.59	1.00
sigma_Subject_ID	2.08	0.24	1.62	2.55	1973.08	1.00

Model 2.rewards formula:

Subject_chose_3/3 ~ 1 + (1 |aid) +

(1+ Age*33PRIMED*(RIGHT_NORM_DG + RIGHT_NORM_MaxG+ MAJORITY_NORM_DG + RULE_NORM_DG) + Age_Squared*33PRIMED*(RIGHT_NORM_DG + RIGHT_NORM_MaxG+ MAJORITY_NORM_DG + RULE_NORM_DG)| Reward_Type) +
Sex + Trial_Number + Age*33PRIMED*(RIGHT_NORM_DG + RIGHT_NORM_MaxG+ MAJORITY_NORM_DG + RULE_NORM_DG) + Age_Squared*33PRIMED*(RIGHT_NORM_DG + RIGHT_NORM_MaxG+ MAJORITY_NORM_DG + RULE_NORM_DG)

Model.2.rewards <- map2stan(alist(

Subject_chose_3/3 ~ dbinom(1 , p), logit(p) <- Intercept + b_SEX*SEX +
b_TRIAL_NUMBER*TRIAL_NUMBER + b_AGE*AGE + b_33PRIMED*33PRIMED +
b_RIGHT_NORM_DG*RIGHT_NORM_DG + b_RIGHT_NORM_MaxG*RIGHT_NORM_MaxG+
b_MAJORITY_NORM_DG*MAJORITY_NORM_DG + b_RULE_NORM_DG*RULE_NORM_DG +
b_AGE_SQUARED*AGE_SQUARED + b_AGE_X_33PRIMED*AGE*33PRIMED +
b_AGE_X_RIGHT_NORM_DG*AGE*RIGHT_NORM_DG +
b_AGE_X_RIGHT_NORM_MaxG*AGE*RIGHT_NORM_MaxG+
b_AGE_X_MAJORITY_NORM_DG*AGE*MAJORITY_NORM_DG +
b_AGE_X_RULE_NORM_DG*AGE*RULE_NORM_DG +
b_33PRIMED_X_RIGHT_NORM_DG*33PRIMED*RIGHT_NORM_DG +
b_33PRIMED_X_RIGHT_NORM_MaxG*33PRIMED*RIGHT_NORM_MaxG+
b_33PRIMED_X_MAJORITY_NORM_DG*33PRIMED*MAJORITY_NORM_DG +
b_33PRIMED_X_RULE_NORM_DG*33PRIMED*RULE_NORM_DG +
b_33PRIMED_X_AGE_SQUARED*33PRIMED*AGE_SQUARED +
b_RIGHT_NORM_DG_X_AGE_SQUARED*RIGHT_NORM_DG*AGE_SQUARED +
b_RIGHT_NORM_MaxG_X_AGE_SQUARED*RIGHT_NORM_MaxG*AGE_SQUARED +
b_MAJORITY_NORM_DG_X_AGE_SQUARED*MAJORITY_NORM_DG*AGE_SQUARED +
b_RULE_NORM_DG_X_AGE_SQUARED*RULE_NORM_DG*AGE_SQUARED +
b_AGE_X_33PRIMED_X_RIGHT_NORM_DG*AGE*33PRIMED*RIGHT_NORM_DG +
b_AGE_X_33PRIMED_X_RIGHT_NORM_MaxG*AGE*33PRIMED*RIGHT_NORM_MaxG+
b_AGE_X_33PRIMED_X_MAJORITY_NORM_DG*AGE*33PRIMED*MAJORITY_NORM_DG +
b_AGE_X_33PRIMED_X_RULE_NORM_DG*AGE*33PRIMED*RULE_NORM_DG +
b_33PRIMED_X_RIGHT_NORM_DG_X_AGE_SQUARED*33PRIMED*RIGHT_NORM_DG*AGE_SQUARED +
b_33PRIMED_X_RIGHT_NORM_MaxG_X_AGE_SQUARED*33PRIMED*RIGHT_NORM_MaxG*AGE_SQUARED +
b_33PRIMED_X_MAJORITY_NORM_DG_X_AGE_SQUARED*33PRIMED*MAJORITY_NORM_DG*AGE_SQUARED +
b_33PRIMED_X_RULE_NORM_DG_X_AGE_SQUARED*33PRIMED*RULE_NORM_DG*AGE_SQUARED +
v_Subject_ID_Intercept[Subject_ID] + v_Reward_Type_Intercept[Reward_Type] +
v_Reward_Type_Age[Reward_Type]*AGE + v_Reward_Type_33PRIMED[Reward_Type]*33PRIMED +
v_Reward_Type_RIGHT_NORM_DG[Reward_Type]*RIGHT_NORM_DG +
v_Reward_Type_RIGHT_NORM_MaxG[Reward_Type]*RIGHT_NORM_MaxG+
v_Reward_Type_MAJORITY_NORM_DG[Reward_Type]*MAJORITY_NORM_DG +
v_Reward_Type_RULE_NORM_DG[Reward_Type]*RULE_NORM_DG +
v_Reward_Type_Age_Squared[Reward_Type]*AGE_SQUARED +
v_Reward_Type_Age_X_33PRIMED[Reward_Type]*AGE*33PRIMED +
v_Reward_Type_Age_X_RIGHT_NORM_DG[Reward_Type]*AGE*RIGHT_NORM_DG +
v_Reward_Type_Age_X_RIGHT_NORM_MaxG[Reward_Type]*AGE*RIGHT_NORM_MaxG+
v_Reward_Type_Age_X_MAJORITY_NORM_DG[Reward_Type]*AGE*MAJORITY_NORM_DG +
v_Reward_Type_Age_X_RULE_NORM_DG[Reward_Type]*AGE*RULE_NORM_DG +
v_Reward_Type_33PRIMED_X_RIGHT_NORM_DG[Reward_Type]*33PRIMED*RIGHT_NORM_DG +
v_Reward_Type_33PRIMED_X_RIGHT_NORM_MaxG[Reward_Type]*33PRIMED*RIGHT_NORM_MaxG+
v_Reward_Type_33PRIMED_X_MAJORITY_NORM_DG[Reward_Type]*33PRIMED*MAJORITY_NORM_DG + v_Reward_Type_33PRIMED_X_RULE_NORM_DG[Reward_Type]*33PRIMED*RULE_NORM_DG +
v_Reward_Type_33PRIMED_X_AGE_SQUARED[Reward_Type]*33PRIMED*AGE_SQUARED +
v_Reward_Type_RIGHT_NORM_DG_X_AGE_SQUARED[Reward_Type]*RIGHT_NORM_DG*AGE_SQUAR

ED +
v_Reward_Type_RIGHT_NORM_MaxG_X_AGE_SQUARED[Reward_Type]*RIGHT_NORM_MaxG*AGE_SQUARED +
v_Reward_Type_MAJORITY_NORM_DG_X_AGE_SQUARED[Reward_Type]*MAJORITY_NORM_DG*AGE_SQUARED +
v_Reward_Type_RULE_NORM_DG_X_AGE_SQUARED[Reward_Type]*RULE_NORM_DG*AGE_SQUARED +
v_Reward_Type_Age_X_33PRIMED_X_RIGHT_NORM_DG[Reward_Type]*AGE*33PRIMED*RIGHT_NORM_DG +
v_Reward_Type_Age_X_33PRIMED_X_RIGHT_NORM_MaxG[Reward_Type]*AGE*33PRIMED*RIGHT_NORM_MaxG+
v_Reward_Type_Age_X_33PRIMED_X_MAJORITY_NORM_DG[Reward_Type]*AGE*33PRIMED*MAJORITY_NORM_DG +
v_Reward_Type_Age_X_33PRIMED_X_RULE_NORM_DG[Reward_Type]*AGE*33PRIMED*RULE_NORM_DG +
v_Reward_Type_33PRIMED_X_RIGHT_NORM_DG_X_AGE_SQUARED[Reward_Type]*33PRIMED*RIGHT_NORM_DG*AGE_SQUARED +
v_Reward_Type_33PRIMED_X_RIGHT_NORM_MaxG_X_AGE_SQUARED[Reward_Type]*33PRIMED*RIGHT_NORM_MaxG*AGE_SQUARED +
v_Reward_Type_33PRIMED_X_MAJORITY_NORM_DG_X_AGE_SQUARED[Reward_Type]*33PRIMED*MAJORITY_NORM_DG*AGE_SQUARED +
v_Reward_Type_33PRIMED_X_RULE_NORM_DG_X_AGE_SQUARED[Reward_Type]*33PRIMED*RULE_NORM_DG*AGE_SQUARED,

Intercept ~ dnorm(0,1), b_SEX ~ dnorm(0,1), b_TRIAL_NUMBER ~ dnorm(0,1), b_AGE ~ dnorm(0,1), b_33PRIMED ~ dnorm(0,1), b_RIGHT_NORM_DG ~ dnorm(0,1), b_RIGHT_NORM_MaxG~ dnorm(0,1), b_MAJORITY_NORM_DG ~ dnorm(0,1), b_RULE_NORM_DG ~ dnorm(0,1), b_AGE_SQUARED ~ dnorm(0,1), b_AGE_X_33PRIMED ~ dnorm(0,1), b_AGE_X_RIGHT_NORM_DG ~ dnorm(0,1), b_AGE_X_RIGHT_NORM_MaxG~ dnorm(0,1), b_AGE_X_MAJORITY_NORM_DG ~ dnorm(0,1), b_AGE_X_RULE_NORM_DG ~ dnorm(0,1), b_33PRIMED_X_RIGHT_NORM_DG ~ dnorm(0,1), b_33PRIMED_X_RIGHT_NORM_MaxG~ dnorm(0,1), b_33PRIMED_X_MAJORITY_NORM_DG ~ dnorm(0,1), b_33PRIMED_X_RULE_NORM_DG ~ dnorm(0,1), b_33PRIMED_X_AGE_SQUARED ~ dnorm(0,1), b_RIGHT_NORM_DG_X_AGE_SQUARED ~ dnorm(0,1), b_RIGHT_NORM_MaxG_X_AGE_SQUARED ~ dnorm(0,1), b_MAJORITY_NORM_DG_X_AGE_SQUARED ~ dnorm(0,1), b_RULE_NORM_DG_X_AGE_SQUARED ~ dnorm(0,1), b_AGE_X_33PRIMED_X_RIGHT_NORM_DG ~ dnorm(0,1), b_AGE_X_33PRIMED_X_RIGHT_NORM_MaxG~ dnorm(0,1), b_AGE_X_33PRIMED_X_MAJORITY_NORM_DG ~ dnorm(0,1), b_AGE_X_33PRIMED_X_RULE_NORM_DG ~ dnorm(0,1), b_33PRIMED_X_RIGHT_NORM_DG_X_AGE_SQUARED ~ dnorm(0,1), b_33PRIMED_X_RIGHT_NORM_MaxG_X_AGE_SQUARED ~ dnorm(0,1), b_33PRIMED_X_MAJORITY_NORM_DG_X_AGE_SQUARED ~ dnorm(0,1), b_33PRIMED_X_RULE_NORM_DG_X_AGE_SQUARED ~ dnorm(0,1), v_Subject_ID_Intercept[Subject_ID] ~ dnorm(0,sigma_Subject_ID), sigma_Subject_ID ~ dcauchy(0,2),

c(v_Reward_Type_Intercept,v_Reward_Type_Age,v_Reward_Type_33PRIMED,v_Reward_Type_RIGHT_NORM_DG,v_Reward_Type_RIGHT_NORM_MaxG,v_Reward_Type_MAJORITY_NORM_DG,v_Reward_Type_RULE_NORM_DG,v_Reward_Type_Age_Squared,v_Reward_Type_Age_X_33PRIMED,v_Reward_Type_Age_X_RIGHT_NORM_DG,v_Reward_Type_Age_X_RIGHT_NORM_MaxG,v_Reward_Type_Age_X_MAJORITY_NORM_DG,v_Reward_Type_Age_X_RULE_NORM_DG,v_Reward_Type_33PRIMED_X_RIGHT_NORM_DG,v_Reward_Type_33PRIMED_X_RIGHT_NORM_MaxG,v_Reward_Type_33PRIMED_X_MAJORITY_NORM_DG,v_Reward_Type_33PRIMED_X_RULE_NORM_DG,v_Reward_Type_33PRIMED_X_AGE_SQUARED,v_Reward_Type_RIGHT_NORM_DG_X_AGE_SQUARED,v_Reward_Type_RIGHT_NORM_MaxG_X_AGE_SQUARED,v_Reward_Type_MAJORITY_NORM_DG_X_AGE_SQUARED,v_Reward_Type_RULE_NORM_DG_X_AGE_SQUARED,v_Reward_Type_Age_X_33PRIMED_X_RIGHT_NORM_DG,v_Reward_Type_Age_X_33PRIMED_X_RIGHT_NORM_MaxG,v_Reward_Type_Age_X_33PRIMED_X_MAJORITY_NORM_DG,v_Rew ard_Type_Age_X_33PRIMED_X_RULE_NORM_DG,v_Reward_Type_33PRIMED_X_RIGHT_NORM_DG_X_AGE_SQUARED,v_Reward_Type_33PRIMED_X_RIGHT_NORM_MaxG_X_AGE_SQUARED,v_Reward_Type_33PRIMED_X_MAJORITY_NORM_DG_X_AGE_SQUARED,v_Reward_Type_33PRIMED_X_RULE_NORM_DG_X_AGE_SQUARED)[Reward_Type] ~ dmvnorm2(0,sigma_Reward_Type,Rho_Reward_Type), sigma_Reward_Type ~ dcauchy(0,2), Rho_Reward_Type ~ dlkjcorr(2)))

Model 3 Formula:

formula = Subject_chose_3/3 ~ 1 + (1 |aid) + Sex + Trial_Number + 33PRIMED + (Other_Child_Would_Choose + Teacher_Would_Choose + Teacher_Would_Want_Subject_To_Choose)

Model.3 <- map2stan(alist(

Subject_chose_3/3 ~ dbinom(1 , p), logit(p) <- Intercept + b_SEX*SEX + b_TRIAL_NUMBER*TRIAL_NUMBER + b_33PRIMED*33PRIMED + b_Other_Child_Would_Choose*Other_Child_Would_Choose + b_Teacher_Would_Choose*Teacher_Would_Choose + b_Teacher_Would_Want_Subject_To_Choose*Teacher_Would_Want_Subject_To_Choose + v_Intercept[Subject_ID],

Intercept ~ dnorm(0,1), b_SEX ~ dnorm(0,1), b_TRIAL_NUMBER ~ dnorm(0,1), b_33PRIMED ~ dnorm(0,1), b_Other_Child_Would_Choose ~ dnorm(0,1), b_Teacher_Would_Choose ~ dnorm(0,1), b_Teacher_Would_Want_Subject_To_Choose ~ dnorm(0,1), v_Intercept[Subject_ID] ~ dnorm(0,sigma_Subject_ID), sigma_Subject_ID ~ dcauchy(0,2)),data= testdata_trim_teacherwant, iter=50, chains=1)

Model 3 Output:

	Mean	StdDev	lower 0.95	upper 0.95	n_eff	Rhat
Intercept	-2.02	0.59	-3.19	-0.91	7713.60	1.00
b_SEX	0.30	0.38	-0.47	1.03	5462.33	1.00
b_TRIAL_NUMBER	-0.29	0.10	-0.48	-0.09	9450.43	1.00
b_33PRIMED	0.70	0.38	-0.03	1.46	5924.28	1.00
b_Other_Child_Would_Choose	0.80	0.48	-0.15	1.73	5951.04	1.00
b_Teacher_Would_Choose	0.60	0.47	-0.30	1.53	6637.84	1.00
b_Teacher_Would_Want_Subject_To_Choose	1.06	0.49	0.09	2.01	7204.39	1.00
sigma_Subject_ID	1.86	0.27	1.35	2.39	1494.34	1.00

Model 3.age Formula:

formula = Subject_chose_3/3 ~ 1 + (1 |aid) + Sex + Trial_Number + 33PRIMED + Age * (Other_Child_Would_Choose + Teacher_Would_Choose + Teacher_Would_Want_Subject_To_Choose)

```
Model.3.age <- map2stan(alist(

Subject_chose_3/3 ~ dbinom( 1 , p ), logit(p) <- Intercept + b_SEX*SEX +
b_TRIAL_NUMBER*TRIAL_NUMBER + b_33PRIMED*33PRIMED + b_AGE*AGE +
b_Other_Child_Would_Choose*Other_Child_Would_Choose +
b_Teacher_Would_Choose*Teacher_Would_Choose +
b_Teacher_Would_Want_Subject_To_Choose*Teacher_Would_Want_Subject_To_Choose +
b_AGE_X_Other_Child_Would_Choose*AGE*Other_Child_Would_Choose +
b_AGE_X_Teacher_Would_Choose*AGE*Teacher_Would_Choose +
b_AGE_X_Teacher_Would_Want_Subject_To_Choose*AGE*Teacher_Would_Want_Subject_To_Choose +
v_Intercept[Subject_ID],

Intercept ~ dnorm(0,1), b_SEX ~ dnorm(0,1), b_TRIAL_NUMBER ~ dnorm(0,1), b_33PRIMED ~
dnorm(0,1), b_AGE ~ dnorm(0,1), b_Other_Child_Would_Choose ~ dnorm(0,1),
b_Teacher_Would_Choose ~ dnorm(0,1), b_Teacher_Would_Want_Subject_To_Choose ~ dnorm(0,1),
b_AGE_X_Other_Child_Would_Choose ~ dnorm(0,1), b_AGE_X_Teacher_Would_Choose ~ dnorm(0,1),
b_AGE_X_Teacher_Would_Want_Subject_To_Choose ~ dnorm(0,1), v_Intercept[Subject_ID] ~
dnorm(0,sigma_Subject_ID), sigma_Subject_ID ~ dcauchy(0,2)),data= testdata_trim_otherchoice,
iter=50, chains=1)
```

Model 3.age Output:

	Mean	StdDev	lower 0.95	upper 0.95	n_eff	Rhat
Intercept	-1.85	0.62	-3.09	-0.67	9258.79	1.00
b_SEX	0.63	0.40	-0.17	1.39	6892.88	1.00
b_TRIAL_NUMBER	-0.23	0.11	-0.43	-0.02	12735.01	1.00
b_33PRIMED	0.03	0.41	-0.80	0.83	7116.64	1.00
b_AGE	0.64	0.45	-0.27	1.50	6177.03	1.00
b_Other_Child_Would_Choose	0.85	0.49	-0.12	1.79	8045.32	1.00
b_Teacher_Would_Choose	0.50	0.47	-0.39	1.46	8625.22	1.00
b_Teacher_Would_Want_ Subject_To_Choose	0.58	0.52	-0.43	1.59	9004.49	1.00
b_AGE_X_Other_Child_Would_Choose	0.52	0.49	-0.44	1.47	8117.83	1.00
b_AGE_X_Teacher_Would_Choose	0.02	0.45	-0.86	0.88	7933.63	1.00
b_AGE_X_Teacher_Would_Want_ Subject_To_Choose	0.41	0.48	-0.58	1.32	8137.16	1.00
sigma_Subject_ID	1.77	0.29	1.22	2.35	1626.32	1.00

Model 4 Formula:

formula = Subject_chose_3/3 ~ 1 + (1 |aid) + Sex + Trial_Number + 33PRIMED + (51_would_be_Wrong + 33_would_be_Wrong + 51_would_be_Fair + 33_would_be_Fair)

```
Model.4 <- map2stan(alist(

Subject_chose_3/3 ~ dbinom( 1 , p ), logit(p) <- Intercept + b_SEX*SEX +
b_TRIAL_NUMBER*TRIAL_NUMBER + b_33PRIMED*33PRIMED +
b_51_would_be_Wrong*51_would_be_Wrong + b_33_would_be_Wrong*33_would_be_Wrong +
b_51_would_be_Fair*51_would_be_Fair + b_33_would_be_Fair*33_would_be_Fair +
v_Intercept[Subject_ID],

Intercept ~ dnorm(0,1), b_SEX ~ dnorm(0,1), b_TRIAL_NUMBER ~ dnorm(0,1), b_33PRIMED ~
dnorm(0,1), b_51_would_be_Wrong ~ dnorm(0,1), b_33_would_be_Wrong ~ dnorm(0,1),
b_51_would_be_Fair ~ dnorm(0,1), b_33_would_be_Fair ~ dnorm(0,1), v_Intercept[Subject_ID] ~
dnorm(0,sigma_Subject_ID), sigma_Subject_ID ~ dcauchy(0,2)
),data= testdata_trim_judgement, iter=50, chains=1)
```

Model 4 Output:

	Mean	StdDev	lower 0.95	upper 0.95	n_eff	Rhat
Intercept	-0.73	0.64	-2.05	0.45	7492.97	1.00
b_SEX	0.26	0.35	-0.43	0.94	5843.73	1.00
b_TRIAL_NUMBER	-0.24	0.09	-0.43	-0.07	15000.00	1.00
b_33PRIMED	0.90	0.35	0.21	1.59	6725.39	1.00
b_51_would_be_Wrong	1.54	0.43	0.69	2.40	6034.02	1.00
b_33_would_be_Wrong	-0.86	0.54	-1.93	0.19	8548.48	1.00
b_51_would_be_Fair	-1.02	0.49	-1.95	-0.03	8631.31	1.00
b_33_would_be_Fair	-0.17	0.57	-1.24	0.98	8341.17	1.00
sigma_Subject_ID	1.73	0.24	1.26	2.20	1474.47	1.00

Model 4.age Formula:

formula = Subject_chose_3/3 ~ 1 + (1 |aid) + Sex + Trial_Number + 33PRIMED + Age * (51_would_be_Wrong + 33_would_be_Wrong + 51_would_be_Fair + 33_would_be_Fair)

```
Model.4.age <- map2stan(alist(

Subject_chose_3/3 ~ dbinom( 1 , p ), logit(p) <- Intercept + b_SEX*SEX +
b_TRIAL_NUMBER*TRIAL_NUMBER + b_33PRIMED*33PRIMED + b_AGE*AGE +
b_51_would_be_Wrong*51_would_be_Wrong + b_33_would_be_Wrong*33_would_be_Wrong +
b_51_would_be_Fair*51_would_be_Fair + b_33_would_be_Fair*33_would_be_Fair +
b_AGE_X_51_would_be_Wrong*AGE*51_would_be_Wrong +
b_AGE_X_33_would_be_Wrong*AGE*33_would_be_Wrong +
b_AGE_X_51_would_be_Fair*AGE*51_would_be_Fair +
b_AGE_X_33_would_be_Fair*AGE*33_would_be_Fair + v_Intercept[Subject_ID],

Intercept ~ dnorm(0,1), b_SEX ~ dnorm(0,1), b_TRIAL_NUMBER ~ dnorm(0,1), b_33PRIMED ~
dnorm(0,1), b_AGE ~ dnorm(0,1), b_51_would_be_Wrong ~ dnorm(0,1), b_33_would_be_Wrong ~
dnorm(0,1), b_51_would_be_Fair ~ dnorm(0,1), b_33_would_be_Fair ~ dnorm(0,1),
b_AGE_X_51_would_be_Wrong ~ dnorm(0,1), b_AGE_X_33_would_be_Wrong ~ dnorm(0,1),
b_AGE_X_51_would_be_Fair ~ dnorm(0,1), b_AGE_X_33_would_be_Fair ~ dnorm(0,1),
v_Intercept[Subject_ID] ~ dnorm(0,sigma_Subject_ID), sigma_Subject_ID ~ dcauchy(0,2)),data=
testdata_trim_judgement, iter=50, chains=1)
```

Model 4.age Output:

	Mean	StdDev	lower 0.95	upper 0.95	n_eff	Rhat
Intercept	-0.67	0.65	-1.92	0.62	8402.99	1.00
b_SEX	0.34	0.34	-0.35	1.01	6946.76	1.00
b_TRIAL_NUMBER	-0.25	0.10	-0.44	-0.07	13068.42	1.00
b_33PRIMED	0.69	0.34	0.00	1.32	7702.39	1.00
b_AGE	0.84	0.55	-0.26	1.92	7065.16	1.00
b_51_would_be_Wrong	1.54	0.42	0.72	2.36	7591.09	1.00
b_33_would_be_Wrong	-0.50	0.55	-1.57	0.58	8307.73	1.00
b_51_would_be_Fair	-0.82	0.49	-1.82	0.10	8528.69	1.00
b_33_would_be_Fair	-0.34	0.59	-1.52	0.80	8542.58	1.00
b_AGE_X_51_would_be_Wrong	-0.11	0.45	-0.99	0.77	7528.87	1.00
b_AGE_X_33_would_be_Wrong	0.23	0.58	-0.90	1.38	9717.93	1.00
b_AGE_X_51_would_be_Fair	-0.58	0.46	-1.51	0.30	8978.64	1.00
b_AGE_X_33_would_be_Fair	0.13	0.54	-0.94	1.20	6778.48	1.00
sigma_Subject_ID	1.58	0.24	1.13	2.05	1539.15	1.00

Model 5 Formula:

formula = Subject_chose_3/3 ~ 1 + (1 |aid) + Sex + Trial_Number + Age * Familiarization_Trial_Advantageous_Payoff + Age_Squared * Familiarization_Trial_Advantageous_Payoff

```
Model.5 <- map2stan(alist(

Subject_chose_3/3 ~ dbinom( 1 , p ), logit(p) <- Intercept + b_SEX*SEX +
b_TRIAL_NUMBER*TRIAL_NUMBER + b_AGE*AGE +
b_Familiarization_Trial_Advantageous_Payoff*Familiarization_Trial_Advantageous_Payoff +
b_AGE_SQUARED*AGE_SQUARED +
b_AGE_X_Familiarization_Trial_Advantageous_Payoff*AGE*Familiarization_Trial_Advantageous_Payof
f +
b_Familiarization_Trial_Advantageous_Payoff_X_AGE_SQUARED*Familiarization_Trial_Advantageous
_Payoff*AGE_SQUARED + v_Intercept[Subject_ID],

Intercept ~ dnorm(0,1), b_SEX ~ dnorm(0,1), b_TRIAL_NUMBER ~ dnorm(0,1), b_AGE ~ dnorm(0,1),
b_Familiarization_Trial_Advantageous_Payoff ~ dnorm(0,1), b_AGE_SQUARED ~ dnorm(0,1),
b_AGE_X_Familiarization_Trial_Advantageous_Payoff ~ dnorm(0,1),
b_Familiarization_Trial_Advantageous_Payoff_X_AGE_SQUARED ~ dnorm(0,1),
v_Intercept[Subject_ID] ~ dnorm(0,sigma_Subject_ID), sigma_Subject_ID ~ dcauchy(0,2)
), data= famdata_trim, iter=50, chains=1)
```

Model 5 Output:

	Mean	**StdDev**	**lower 0.95**	**upper 0.95**	**n_eff**	**Rhat**
Intercept	-0.13	0.62	-1.36	1.07	7372.78	1.00
b_SEX	0.35	0.36	-0.34	1.06	11773.47	1.00
b_TRIAL_NUMBER	-0.44	0.29	-1.01	0.12	4155.20	1.00
b_AGE	-0.43	0.43	-1.26	0.41	7489.50	1.00
b_Familiarization_Trial_Advantageous_Payoff	-1.36	0.40	-2.12	-0.57	1484.59	1.00
b_AGE_SQUARED	-0.35	0.43	-1.18	0.50	7231.44	1.00
b_AGE_X_Familiarization_Trial_Advantageous_Payoff	0.35	0.29	-0.20	0.93	6177.44	1.00
b_Familiarization_Trial_Advantageous_Payoff_X_AGE_SQUARED	0.26	0.29	-0.30	0.82	7094.06	1.00
sigma_Subject_ID	1.54	0.48	0.48	2.43	182.97	1.03

Model 6 Formula:

formula = choice33_dv ~ 1 + (1|aid) + Sex + Age * (Teacher_Would_Choose + Adult_Would_Choose + Teacher_Would_Want_Subject_To_Choose)

```
Model.6 <- map2stan(alist(

Subject_chose_3/3 ~ dbinom( 1 , p ), logit(p) <- Intercept + b_SEX*SEX + b_AGE*AGE +
b_Teacher_Would_Choose*Teacher_Would_Choose + b_Adult_Would_Choose*Adult_Would_Choose +
b_Teacher_Would_Want_Subject_To_Choose*Teacher_Would_Want_Subject_To_Choose +
b_AGE_X_Teacher_Would_Choose*AGE*Teacher_Would_Choose +
b_AGE_X_Adult_Would_Choose*AGE*Adult_Would_Choose +
b_AGE_X_Teacher_Would_Want_Subject_To_Choose*AGE*Teacher_Would_Want_Subject_To_Choose +
v_Intercept[Subject_ID],

Intercept ~ dnorm(0,1), b_SEX ~ dnorm(0,1), b_AGE ~ dnorm(0,1), b_Teacher_Would_Choose ~
dnorm(0,1), b_Adult_Would_Choose ~ dnorm(0,1), b_Teacher_Would_Want_Subject_To_Choose ~
dnorm(0,1), b_AGE_X_Teacher_Would_Choose ~ dnorm(0,1), b_AGE_X_Adult_Would_Choose ~
dnorm(0,1), b_AGE_X_Teacher_Would_Want_Subject_To_Choose ~ dnorm(0,1),
v_Intercept[Subject_ID] ~ dnorm(0,sigma_Subject_ID), sigma_Subject_ID ~ dcauchy(0,2)), data=
other_choice_data, iter=50, chains=1)
```

Model 6 Output:

	Mean	StdDev	lower 0.95	upper 0.95	n_eff	Rhat
Intercept	-1.56	0.28	-2.11	-1.01	6866.74	1.00
b_SEX	-0.13	0.30	-0.73	0.43	8942.76	1.00
b_AGE	0.09	0.23	-0.36	0.55	8174.94	1.00
b_Teacher_Would_Choose	2.21	0.29	1.67	2.80	6990.51	1.00
b_Adult_Would_Choose	2.36	0.30	1.77	2.92	6836.61	1.00
b_Teacher_Would_Want_Subject_To_Choose	2.71	0.31	2.09	3.30	5837.54	1.00
b_AGE_X_Teacher_Would_Choose	0.59	0.28	0.04	1.14	10852.26	1.00
b_AGE_X_Adult_Would_Choose	0.97	0.29	0.39	1.53	10592.02	1.00
b_AGE_X_Teacher_Would_Want_Subject_To_Choose	0.84	0.30	0.24	1.40	11164.26	1.00
sigma_Subject_ID	1.47	0.21	1.07	1.87	1969.83	1.00

Model 7 Formula:

formula = Subject_chose_Yes ~ 1 + (1|aid) + Sex + Trial_Number + Age * Other_Child_Would_Choose * (51_would_be_Wrong + 33_would_be_Wrong + 51_would_be_Fair + 33_would_be_Fair)

```
Model.7 <- map2stan(alist(

Subject_chose_Yes ~ dbinom( 1 , p ), logit(p) <- Intercept + b_SEX*SEX +
b_TRIAL_NUMBER*TRIAL_NUMBER + b_33PRIMED*33PRIMED + b_AGE*AGE +
b_51_would_be_Wrong*51_would_be_Wrong + b_33_would_be_Wrong*33_would_be_Wrong +
b_51_would_be_Fair*51_would_be_Fair + b_33_would_be_Fair*33_would_be_Fair +
b_AGE_X_51_would_be_Wrong*AGE*51_would_be_Wrong +
b_AGE_X_33_would_be_Wrong*AGE*33_would_be_Wrong +
b_AGE_X_51_would_be_Fair*AGE*51_would_be_Fair +
b_AGE_X_33_would_be_Fair*AGE*33_would_be_Fair + v_Intercept[Subject_ID],

Intercept ~ dnorm(0,1), b_SEX ~ dnorm(0,1), b_TRIAL_NUMBER ~ dnorm(0,1), b_33PRIMED ~
dnorm(0,1), b_AGE ~ dnorm(0,1), b_51_would_be_Wrong ~ dnorm(0,1), b_33_would_be_Wrong ~
dnorm(0,1), b_51_would_be_Fair ~ dnorm(0,1), b_33_would_be_Fair ~ dnorm(0,1),
b_AGE_X_51_would_be_Wrong ~ dnorm(0,1), b_AGE_X_33_would_be_Wrong ~ dnorm(0,1),
b_AGE_X_51_would_be_Fair ~ dnorm(0,1), b_AGE_X_33_would_be_Fair ~ dnorm(0,1),
v_Intercept[Subject_ID] ~ dnorm(0,sigma_Subject_ID), sigma_Subject_ID ~ dcauchy(0,2))
```

Model 7 Output:

	Mean	**StdDev**	**lower 0.95**	**upper 0.95**	**n_eff**	**Rhat**
Intercept	-0.67	0.65	-1.92	0.62	8402.99	1.00
b_SEX	0.34	0.34	-0.35	1.01	6946.76	1.00
b_TRIAL_NUMBER	-0.25	0.10	-0.44	-0.07	13068.42	1.00
b_33PRIMED	0.69	0.34	0.00	1.32	7702.39	1.00
b_AGE	0.84	0.55	-0.26	1.92	7065.16	1.00
b_51_would_be_Wrong	1.54	0.42	0.72	2.36	7591.09	1.00
b_33_would_be_Wrong	-0.50	0.55	-1.57	0.58	8307.73	1.00
b_51_would_be_Fair	-0.82	0.49	-1.82	0.10	8528.69	1.00
b_33_would_be_Fair	-0.34	0.59	-1.52	0.80	8542.58	1.00
b_AGE_X_51_would_be_Wrong	-0.11	0.45	-0.99	0.77	7528.87	1.00
b_AGE_X_33_would_be_Wrong	0.23	0.58	-0.90	1.38	9717.93	1.00
b_AGE_X_51_would_be_Fair	-0.58	0.46	-1.51	0.30	8978.64	1.00
b_AGE_X_33_would_be_Fair	0.13	0.54	-0.94	1.20	6778.48	1.00
sigma_aid	1.58	0.24	1.13	2.05	1539.15	1.00

SOM Section 4: Details about Familiarization Phase

In the Familiarization phase, children were presented with instructions and comprehension questions, along with two binary choices in which they obtained rewards. These two trials were primarily intended to just familiarize children with the procedure, but the payoffs were also structured to test children's aversion to Advantageous and Disadvantageous inequity. The order of these trials was counterbalanced across subjects.

At the beginning of the Familiarization phase, children were shown the four different kinds of rewards they would receive (Figure 4A). They were then told that they would be making choices that would deliver those rewards to themselves, and to a peer Recipient from their school. However, they would not know who the Recipient was.

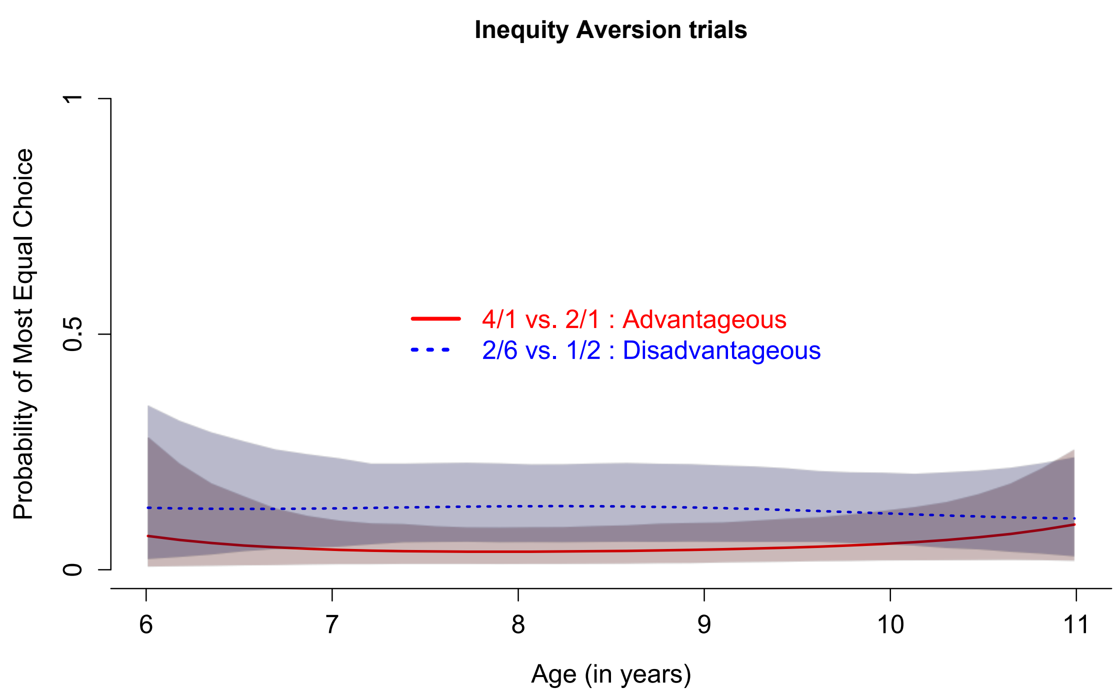
They were then shown six different paper bags (Figure 4B), and told that every time they made a choice the rewards that were to go to the Recipient would be placed in a different bag, and each bag would go to a different peer from their school. In other words, for each of their six choices (two choices in Familiarization, four choices in Test) they would be delivering rewards to a different Recipient. The experimenter then laid out the rewards corresponding to one of the to Familiarization payoff distributions (always using the Low-value Coins as rewards). The experimenter then asked a series of comprehension questions that probe the Subject's understanding of the procedure (see SOM Section 2 for details):

1. How many rewards would the Actor and Recipient receive if each tray were chosen?
    a. On the first Familiarization trial, 97% of Subjects correctly described how many rewards they and the Recipient would receive for each of the two payoff outcomes.
    b. On the second Familiarization Trial, 100% of Subjects correctly described how many rewards they and the Recipient would receive for each outcomes.
2. Would the subject receive any rewards in the Recipient's bag? Did the subject know who would receive the Recipient's rewards?
    a. On the first Familiarization Trial, 100% of Subjects correctly responded that they would not receive the Recipient's bag, and that they did not know who would.

Incorrect answers led the experimenter to repeat the relevant instructions. The Actor was then allowed to choose between the different payoff outcomes. The procedure was then repeated for the second familiarization trial.

Actors generally chose the self-maximizing outcome (4/1 or 2/6; see Figure 5), even though this created a more-unequal outcome for them and the Recipient than if they had chosen the alternative outcomes (2/1 or 1/2). This bias towards self-maximizing outcomes was consistent across age. This indicates that subjects must have clearly understood the task, because they showed a systematic bias towards one kind of outcome. This also indicates that children generally desired the rewards. However, it is inconsistent with children showing a general aversion to inequity, or to Inequity Aversion increasing with age. This is somewhat surprising, given the growing evidence for an aversion to inequity in young children (LoBue et al. 2011; Blake & McAuliffe 2011; McAuliffe et al. 2013; Fehr et al. 2008; Kogut 2012; Shaw & Olson 2012).

Figure 5: Model predictions (from Model 5) for Actors' choices in the Familiarization Trials (i.e., the Inequity Game payoff distributions). Blue corresponds to Disadvantageous Inequity Trials (y-axis reflects the probability of a 1/2 choice), and red corresponds to Advantageous Inequity Trials (y-axis reflects the probability of a 2/1 choice). Shaded regions represent 95% confidence intervals.



That said, Actors were generally more likely to choose more-equitable outcomes in the Disadvantageous Inequity Trials (relative to the Advantageous Inequity Trials).

This suggests that Actors were more averse to Recipients obtaining relatively more than them, and they were less averse to themselves obtaining more than the Recipient. This is consistent with what we would expect given that individuals likely have stronger preferences concerning their own payoffs than those concerning the payoffs of others. The difference between children's aversion to Disadvantageous and Advantageous inequity appears only between about age 7 and 9.5 years. However, it should be noted that even though the relative cost of the more-equitable outcome is the same in both the Advantageous and Disadvantageous Inequity Trials (50%), the absolute cost is higher in the Advantageous Trial (2 Coins) than in the Disadvantageous Trials (1 Coin). It is possible that this difference in absolute cost could explain the differences in behavior across the two trials.

Overall, the very-low rates of preference for more-equal outcomes is difficult to square with prior work on the development of Inequity Aversion. Incidentally, it is also inconsistent with the idea that the developmental increases in prosociality that we observe in the present study's Test Trials is due to developmental increases in aversion to inequity. Part of the explanation for the low rates of aversion to inequity in the present study is likely to be that it was not designed specifically designed to test Inequity Aversion (remember, these were the Familiarization Trials, not the Test Trials). Our task and payoffs are more complicated than payoffs used in prior studies of this phenomenon, and at this point Subjects may still have been getting used to the procedure.

SOM Section 5: Details about Priming Phase

In the Priming phase, children watched a video on a laptop (Figure 4C), which depicted an Adult (the Adult Model) participating in the identical task as the subjects (Figure 6). The Adult Model was always of the same sex as the Subject child.

Across the 5 different Norm Conditions, children were presented with nearly identical videos, which differed only in the content of the statement that the adult model made during the video (Table 2, main text). The model never instructed the watching child which option to choose, and never actually made a choice. They instead simply commented on the two choices, either by providing information about which choice was normative (Right, Rule, Majority), or by providing no such information (No Norm Condition).

Figure 6: Screen shot of one of the videos that Actors watched, depicted in Figure 4C. The video looked virtually the same in all Conditions, all that changed was the statement made by the Adult Model.

The 5 Norm Conditions were presented between-subjects. Each Condition also included two between-subjects Treatments, which differed in whether the 3/3 outcome was identified as the normative choice (Table 2, main text). For example, in the Right Norm DG (3/3) treatment the Model said “The right one to choose is this one (3/3), and not this one (5/1)”, while in the Right Norm DG (5/1) treatment the model said “The right one to choose is this one (5/1), and not this one (3/3).”

Differences across Treatments would indicate that the normative information in the video prime influences children's own choices of 3/3, and thus their sharing behavior. Variation in the effect of Treatment across the different Norm Conditions would indicate how different kinds of normative framings (and payoff distributions) influence Actor's choices of the 3/3 outcome.

SOM Section 6: Details about Test Phase Design and Results

In the Test phase, children were presented with four binary-choice trials, each with a different reward type. For the Right Norm DG, Rule Norm DG, Majority Norm DG, and No Norm DG conditions this was a 3/3 vs. 5/1 choice. For the Right Norm MaxG condition it was a 3/3 vs. 5/5 choice. The four reward types that children received were: gummie bears, glow-in-the-dark star stickers, low-value coins, and high value coins. Coins could be used to purchase items in a "store" that was brought to the school. Low-value coins were worth "1", and high-value coins were worth "5". To simplify the models and clarify prediction, primary analyses collapse the different reward types. Though there are some important ways in which reward type influences children's choices, Actors behaved relatively similarly across the different reward types. Differences in children's behavior across reward types are analyzed in SOM Section 8.

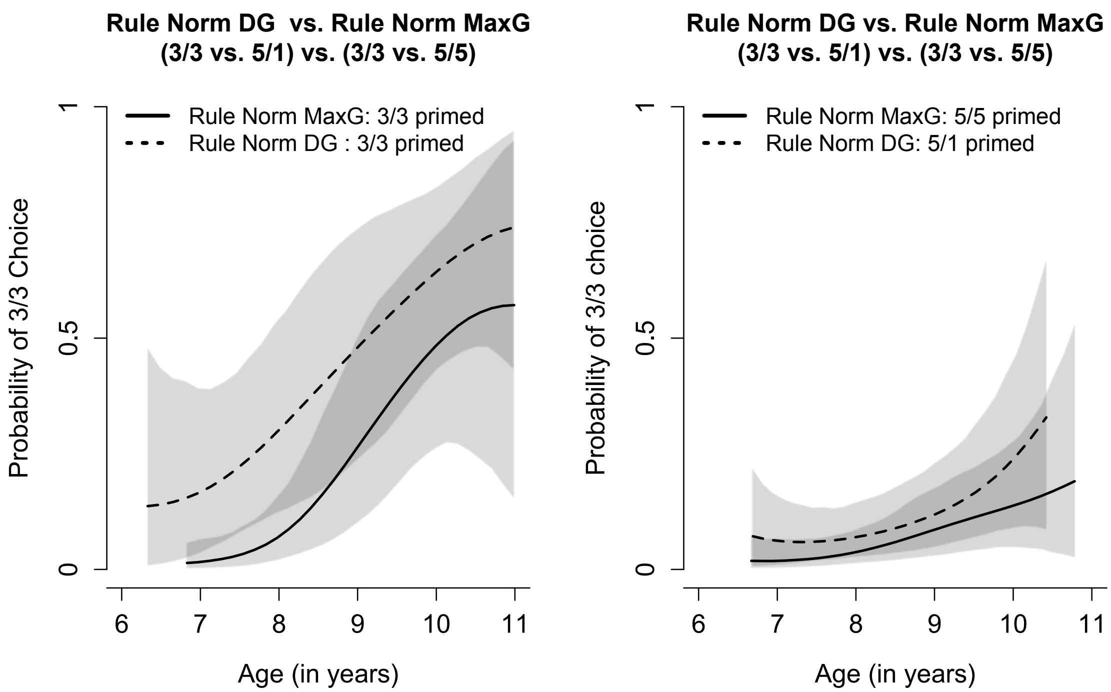
As predicted, Actors indeed behaved differently across the Treatments (i.e., where either 3/3 or 5/1 was the primed ratio), and the effect of Treatment varied across Conditions (main text, Figure 3 and Figure 4). Specifically, children were more likely to choose 3/3 in the Right Norm DG (3/3) condition/treatment (i.e., "the right thing to choose is [3/3], and not [5/1]") than in the Right Norm DG (5/1) condition/treatment (i.e., "the right thing to choose is [5/1], and not [3/3]"). This pattern emerges as early as 7.5-9 years of age.

Though a similar effect of Treatment is not evident for the Majority Norm DG condition in Figure 3 (main text), this result may be due to differences in how information about majority behavior influences behavior across reward types (see SOM Section 8). This is the only situation where the type of reward appears to matter substantially, and it appears that a robust effect of Treatment in the Majority Norm DG condition exists only for the Low-value Coins. In general, this suggests that primes in the Majority Norm DG condition are overall less-effective than primes in the Right Norm DG condition, but further work will be needed to determine whether and why this is connected to reward type.

Additionally, though there is no evidence of a substantial effect of Treatment in the models for the Rule Norm condition (main text, Figure 1), comparing the means using t-tests suggests that there may be an effect of Treatment for the very oldest children in the sample. Again, the overall pattern of results suggests that primes in the Rule Norm DG condition are overall less-effective than primes in the Right Norm DG condition, but further work will be needed to determine with certainty whether there is an effect of Treatment at all in the Rule Norm DG condition at the oldest ages.

We also see an effect of Treatment in the Right Norm MaxG condition (main text, Figure 4), suggesting that children's sensitivity to morally-framed normative information is not specific to cooperative situations. However, closer examination suggests that the similarity in the model predictions for the Right Norm DG and Right Norm MaxG conditions emerges a bit later, after about 8-8.5 years of age. Prior to this point, Actors in the Right Norm MaxG (3/3) treatment are much less likely to choose 3/3 than are Actors in the Right Norm DG (3/3) treatment (Figure 7).

Figure 7: Model predictions (from Model 2) of children's choices in the Right Norm DG and MaxG treatments. Grey regions represent 95% confidence intervals.



These results tell us much about the development of prosocial behavior, and the relationship between prosocial development and normativity. Overall, German children aged 6 are very unlikely to select 3/3 (the prosocial outcome) over 5/1 (the selfish outcome). However, with increasing age they become substantially more prosocial. This indicates that, during this range of ages, children in this population are developing more costly prosocial behavior.

At the earliest ages, children show no sensitivity to normative information. If you provide them with information indicating that either the prosocial or selfish choices are more normative, they are about equally likely to choose the prosocial choice themselves. By 7.5 years of age such a sensitivity to normative information emerges, along with evidence that different kinds of normative information have different influences on children's choices in a cooperative dilemma. Information framed in terms of what is right (Right Norm condition) influences children's prosocial behaviors more strongly than information framed in terms of how frequent a choice is (Majority Norm condition), and information framed as a rule (Rule Norm condition). This suggests that, from at least 7.5 years on, children's prosocial behavior is becoming sensitive to indirect information about normative cooperative behavior, but particularly to normative information with a relatively more moral framing (i.e., a norm that discusses what is 'right').

Crucially, the influence of social norms is not tied to cooperative contexts. This information influences children's likelihood of choosing 3/3 both in a cooperative context where it is the most prosocial outcome (Right Norm DG condition), and in a non-cooperative context where choosing 3/3 is worse for both the Actor and the Recipient, and thus makes little sense (Right Norm MaxG condition). After about 8.5 years of age, there is no evidence of any differences in how normative information influences children's choices in the Right Norm DG and MaxG conditions. However, at earlier ages, children are clearly more likely to select 3/3 in the Right Norm DG condition.

This suggests that younger children may treat normative information as a potentially important cue, but not a sufficient reason (on its own) to select 3/3. Children aged 5 years and older understand contingent reciprocity in these kinds of experimental tasks (House, Henrich, et al. 2013), and would thus be capable of understanding that there can be strategic reasons to choose 3/3 in a cooperative dilemma. However, when not in a cooperative dilemma (Right Norm MaxG condition) there is no clear reason for selecting 3/3, and younger children may thus simply ignore the normative information. With age, though, children become more likely to conform to the norm regardless of context, even when the behavior it encourages makes little sense.

Overall, these findings are strong evidence for the content-free, highly promiscuous normativity that we would expect based on the norm psychology perspective on prosocial development. Children show evidence of becoming sensitive to information about normative behavior in cooperative dilemmas, and evidence for this sensitivity emerges in middle childhood, the age at which we begin to see evidence of societal variation in prosocial development and cooperative behavior. Yet, importantly, we also see evidence that the influence of normative information is similar across cooperative and non-cooperative contexts. However, this similarity emerges only after about 8.5 years, and before this age children are perhaps less promiscuously normative, and more strategically normative. This might indicate a transitional period were children are first beginning to figure out why one ought to follow norms, and they haven’t yet adopted the stance of conforming to norms even if their functions are not immediately obvious.

SOM Section 7: Did 7-year-olds attend to the videos?

It is possible that the 6-7 year-old children in our sample simply did not pay attention to our priming videos, and that is why they were not influenced by the normative information in the priming statement. To explore this possibility we ran a small sample of 16 7 year-olds in a different version of the No Norm DG condition, called the Frog Control.

During the Frog Control the experimental procedure and apparatus is the same as in the No Norm DG condition with only a few exceptions. The apparatus and setup is identical, except a toy duck and a toy frog are placed in the center of the testing area (as depicted in Figure 8). However, these toys were not mentioned during the instructions.

In the No Norm DG condition, the Adult Model states in the priming video: "I can choose this one or this one."

In the Frog Control, the Adult Model also states: "I can choose this one or this one", The only difference at this point in the video is that the video also includes the same toy duck and toy frog in the center of the testing area (Figure 8).

Figure 8: First part of the video for the Frog Control, identical to the video in the No Norm DG condition.

At this point, the video for the No Norm DG condition simply ended, but the video for the Frog Control continued. Now the Adult Model reached over and picked up the toy Frog (Figure 9) and stated: "…and I must put the Frog on the one that I choose."

Figure 9: Second part of the Frog Control video, which differs from the No Norm DG condition.

The experiment then continued just as in the No Norm DG condition. Once more, note that at no point did the Experimenter instruct the Subject to do anything with the toy frog. The only information about whether and how to use the frog came from the Adult Model's statement in the priming video.

8 out of 16 Subjects spontaneously used the frog when selecting one of the two choices, on at least one of the four Test Trials.

At the end of the Test Phase, the experimenter asked the Subject: "What did the man/woman in the video say?"

Of the 8 Subjects who did not spontaneously use the frog in the Test Trials, 7 spontaneously referenced the frog in their descriptions of the Adult Model's statement.

For the 1 Subject who neither spontaneously used nor referred to the frog, we asked explicitly: "Did the man/woman say something about the frog?" This Subject then accurately reported what the Adult Model's statement had been.

Out of 16 7-year-old Subjects, 15 either spontaneously used or referenced the frog correctly, even though this information could only have come from the priming video. The 1 remaining Subject also likely acquired this information from the video. This makes it unlikely that 7-year-olds' insensitivity to the normative information in the priming videos is due to them being inattentive to the videos. It is likely that these children watched the videos, listened to the Adult Model's statements, and heard the normative information. They were simply indifferent to that information.

SOM Section 8: Analyzing how Actors' behavior is influenced by Reward type

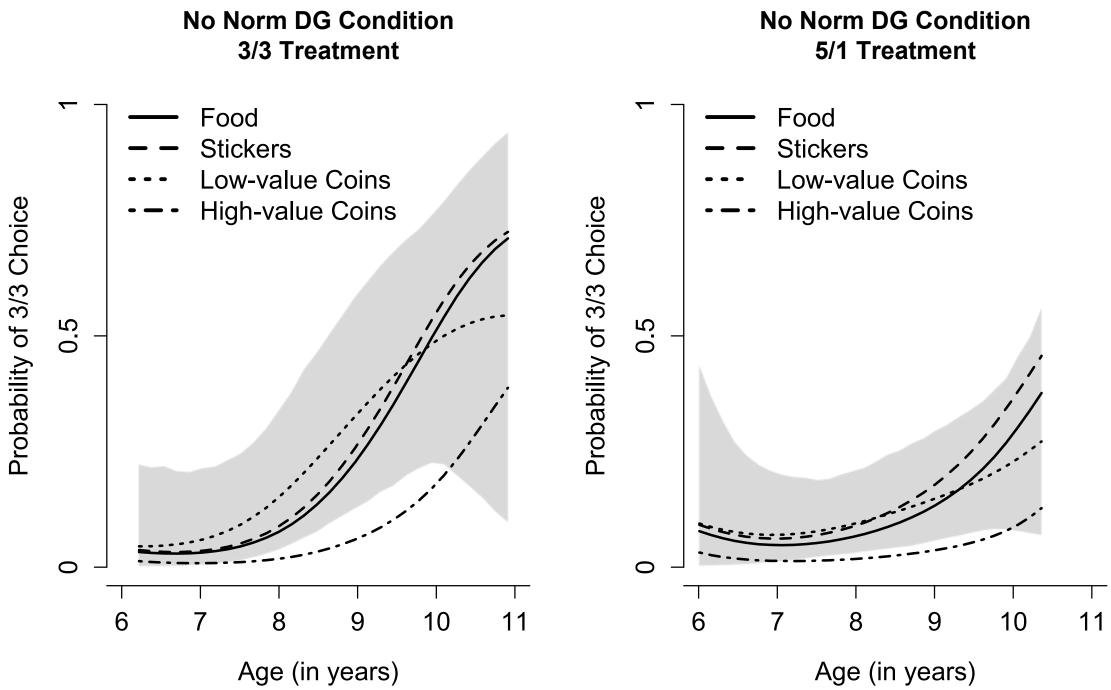
For each of the four trials during the Test Phase, children made the same binary choice in terms of the payoff distribution (3/3 vs. 5/1, or 3/3 vs. 5/5), but the choices were made with different kinds of rewards: gummie bears (Food), glow-in-the-dark star stickers (Stickers), yellow tokens worth 1 unit in a "store" that was brought to the school (Low-value Coins), and red tokens worth 2 units (High-value Coins). We used different rewards because it makes it easier to presenting each subject with multiple trials (using the same rewards in the same task might lead the subject to think that their prior choice was 'wrong' somehow). A second motivation for using different rewards is that it allows us to explore whether children's prosocial behavior responds differently to the different kinds of rewards.

Different studies of prosocial development frequently use very different kinds of rewards, which range from food to stickers to tokens/money. It is still an open question whether the kind of reward matters (Food, Stickers, Coins), and whether the value of the reward matters (Low-value Coins, High-value Coins). If we find that different kinds of rewards, or different reward values, qualitatively change the developmental patterns that we observe, then this would greatly impact our understanding and interpretation of the current study and prior studies of the development of prosocial behavior.

For the primary analyses in the main text, the models collapse these four reward types. However, here we analyze how children's behavior differs across them, using a mixed effects regression model that includes random effects/slopes for each of the different reward types. This allows us to plot separately the model's estimates for each reward type. Figure 10 plots the model's estimates for each reward type, for the No Norm DG condition only. This is useful because the No Norm DG condition provides no normative information, and is thus our most pure test of children's prosocial behavior.

We can see that in both the 3/3 Treatment and the 5/1 Treatment, the development of prosocial behavior follows the same pattern regardless of whether the rewards are Food, Stickers, or Low-value Coins. Children were relatively less likely to be prosocial with the High-value Coins, but the overall developmental trajectory is qualitatively similar. This is important because it indicates that children's behavior largely doesn't vary regardless of the kind of reward that is used. The value of the reward does impact children's absolute rates of prosocial behavior, but it largely doesn't change the effects of Condition and Treatment that we have reported.

Figure 10: Model predictions (from Model 2.rewards) for Actors' choices in the No Norm DG condition. Comparing predictions across rewards, within treatments. Grey regions represent the 95% Confidence intervals for the Low-value Coin rewards.

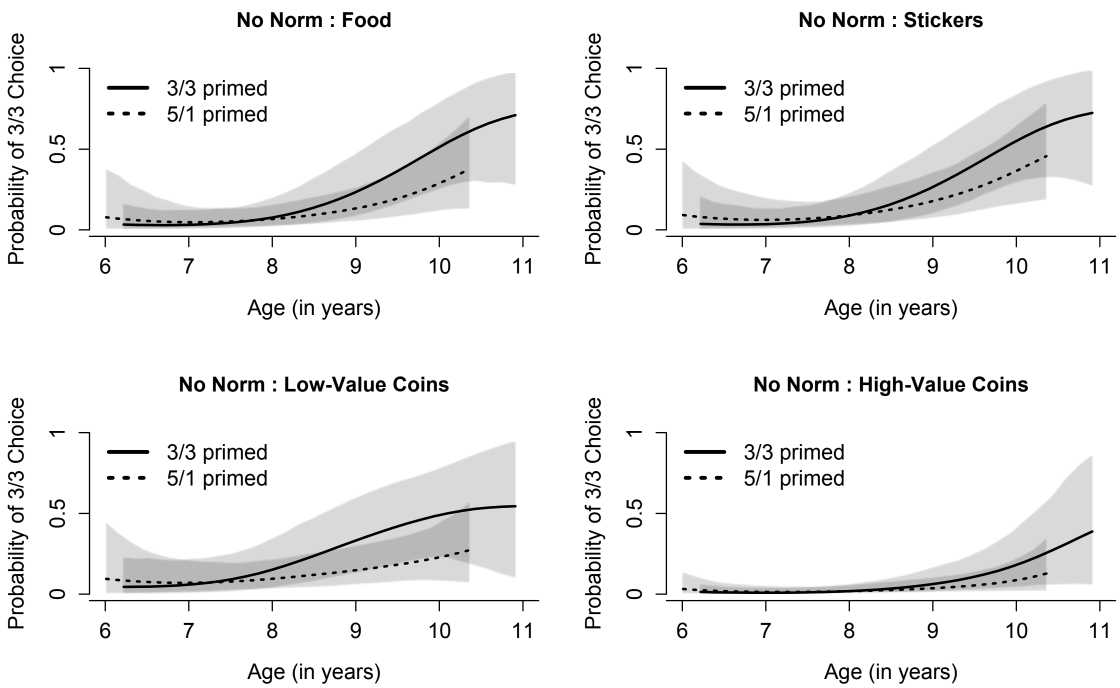


This same result can also be seen in Figure 11, which presents the same model results as in Figure 10, except now directly comparing the different Treatments for each reward type. Children show an increasing tendency to be prosocial in all reward types, but do not substantially distinguish between the Treatments for any rewards. It is true that for the Low-value Coins, at about age 9.5 years, children may be less likely to select 3/3 in the 5/1 Treatment, but this is not a substantial effect and it is not consistent with the other rewards. This would need replication, and if it is it would suggest a slight order/primacy effect in children of this age, whereby they are somewhat more likely to select the outcome that is indicated first. A similar overall pattern is observed in the Rule Norm DG condition (Figure 14), with children being relatively unlikely to distinguish the Treatments for any of the rewards, but there perhaps being a slight treatment effect at about age 9 years for the Low-value Coins. The similarities across the Control and Rule Norm DG conditions suggest that an order effect might drive the effect of Treatment in the Rule Norm DG condition, as well.

Similar developmental patterns are also observed across reward types in the Right Norm DG condition (Figure 12). Qualitatively similar patterns can be seen across reward types in the Right Norm MaxG condition (Figure 13), though the differences across Treatments aren't reliable for the Stickers and High-value Coins rewards.

Intriguingly, in the Majority Norm DG Condition there is a robust effect of Treatment for Low-value Coins, but not for the other reward types (Figure 15).

Figure 11: Model predictions (from Model 2.rewards) for Actors' choices in the No Norm DG condition, separately for the different rewards. Comparing predictions across treatments, for each reward type. Grey regions represent 95% confidence intervals.



Overall, this analysis suggests that children generally respond similarly to the different rewards, as there are relatively few differences across Food, Stickers, and Low-value Coins. Children are less likely to be prosocial when presented with High-value Coins, but they nonetheless display relatively similar effects of Treatment.

The major exception is in the Majority Norm DG condition, and it is not clear why the effect of Treatment should be limited to the Low-value Coins. However, Figure 16 indicates that variation across reward types is limited to the 5/1 Treatment. In the 5/1 Treatment, children are much less prosocial for the Coins (in this, we see a qualitatively similar pattern across the Low- and High-value Coins) than they are for the Food and Stickers. By contrast, in the 3/3 Treatment, there is little apparent variation in how prosocial children are across the different rewards. This suggests that being told that "most people choose 5/1" is relatively ineffective at reducing prosocial distributions of Food and Stickers, but it is very effective at reducing prosocial distributions of the Coins. Overall, this analysis explains why the confidence intervals are enormous for the Majority Norm DG (5/1) condition Treatment in Figure 2, but not so for the Majority Norm DG (3/3) condition Treatment.

Whatever the reason for this variation in behavior across reward types, this effect of Treatment for the Low-value Coins in the Majority Norm DG condition is as robust as anything seen in the other Conditions. This indicates that the lack of an effect of Treatment in the Majority Norm DG condition in Table 3 and Figure 2 (main text) is not due to information about majority choices necessarily being less influential than information about what is right to do. Instead, it is more likely due to information about what the majority does being influential only with Low-value Coins. Interestingly, the slight hints of effects of Treatment in the Rule Norm and No Norm DG conditions are also with the Low-value Coins. Though we do not have a clear idea of why this might be the case, it could potentially be due to the fact that children had more experience with the Low-value Coins, as these were the rewards used in the Familiarization Trials, as well. In any case, these results suggest that future research might focus on using Coins (i.e., focus on using tokens as proximate rewards), as this appears to be the reward that produces the most robust effects of Treatment across different framings for normative information.

Figure 12: Model predictions (from Model 2.rewards) for Actors' choices in the Right Norm DG condition, separately for the different rewards. Comparing predictions across treatments, for each reward type.

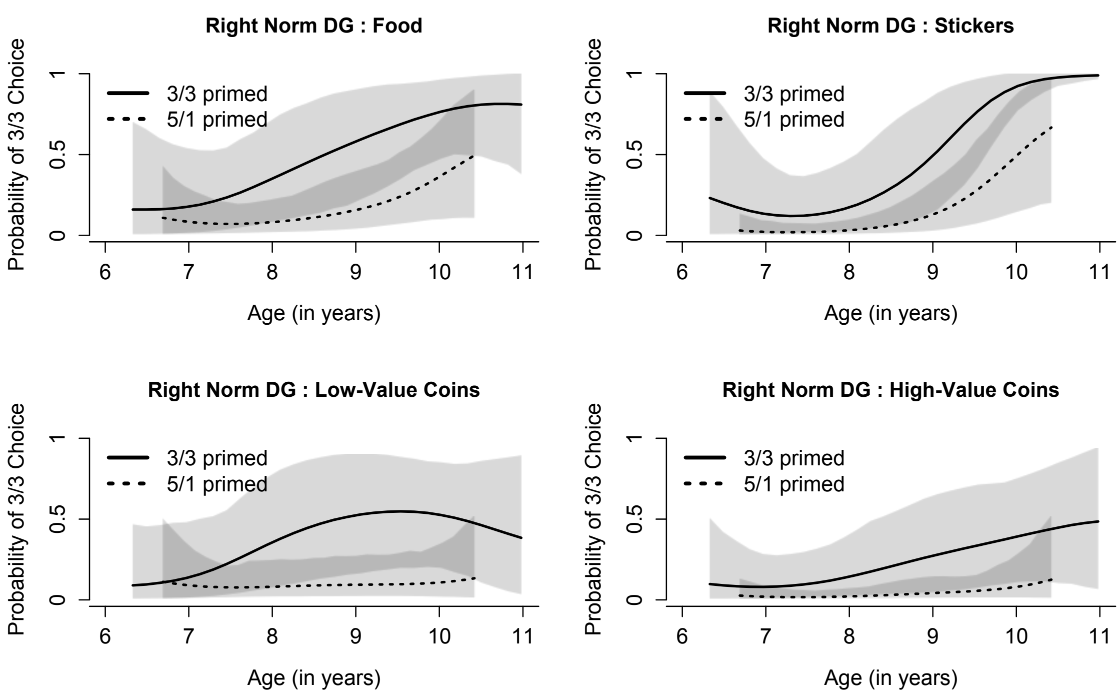


Figure 13: Model predictions (from Model 2.rewards) for Actors' choices in the Right Norm MaxG condition, separately for the different rewards. Comparing predictions across treatments, for each reward type.

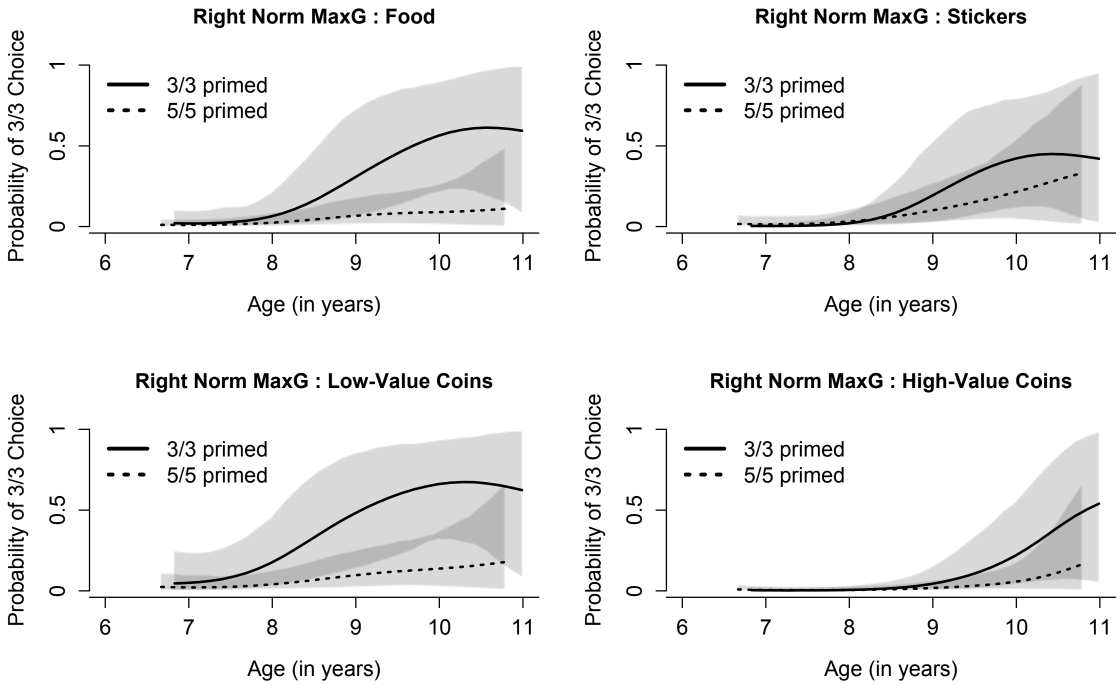


Figure 14: Model predictions (from Model 2.rewards) for Actors' choices in the Rule Norm DG condition, separately for the different rewards. Comparing predictions across treatments, for each reward type.

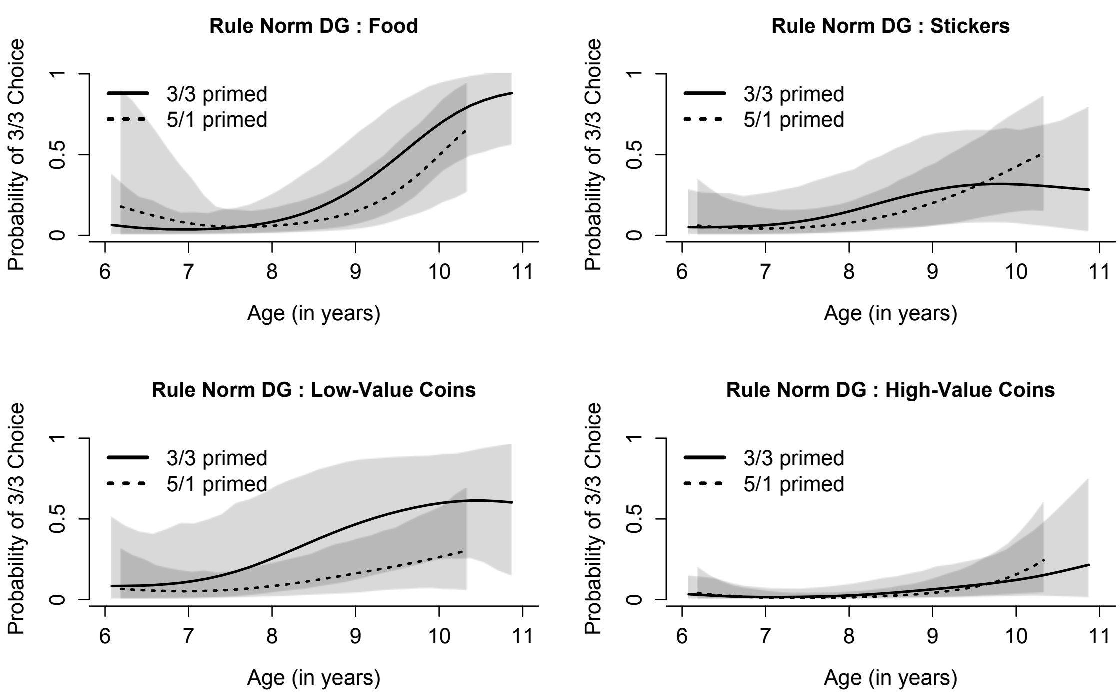


Figure 15: Model predictions (from Model 2.rewards) for Actors' choices in the Majority Norm DG condition, separately for the different rewards. Comparing predictions across treatments, for each reward type.

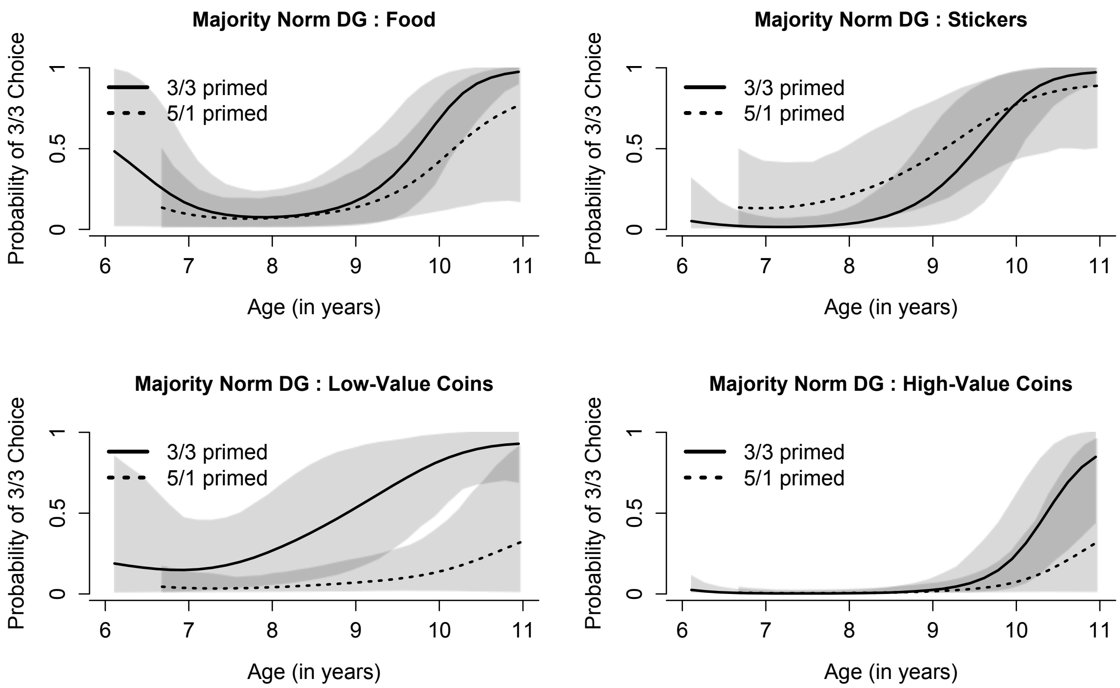
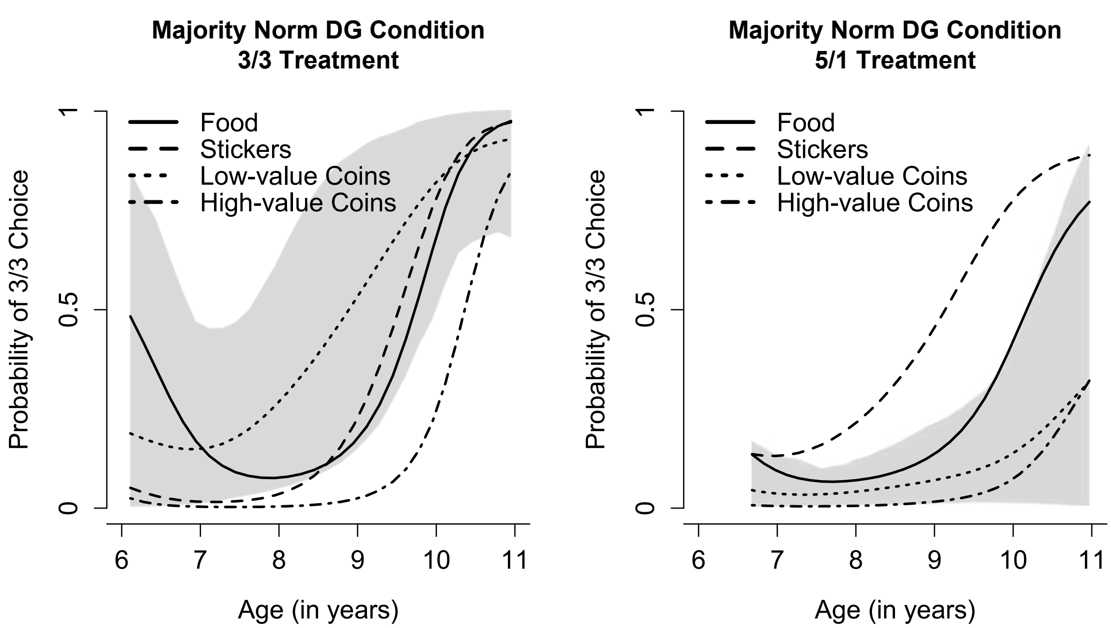


Figure 16: Model predictions (from Model 2.rewards) for Actors' choices in the Majority Norm DG condition. Comparing predictions across rewards, within treatments. Grey regions represent the 95% Confidence intervals for the Low-value Coin rewards.



SOM Section 9: Interview Phase

After the test phase, in the Interview phase children were asked a series of questions about the reward choices, always presented in this fixed order (Table 8). The questions were standardized in this way to try, as much as possible, to create a conversational structure that wasn't awkward also not overly leading.

Table 8: Interview questions. See SOM Section 2 for script.

Question #	Question
1	What would another child choose?
2	Would this choice be Wrong?
3	Would the other choice be Wrong?
4	Would this choice be Fair?
5	Would the other choice be Fair?
6	What would an adult choose?
7	What would your teacher choose?
8	What would your teacher want YOU to choose?

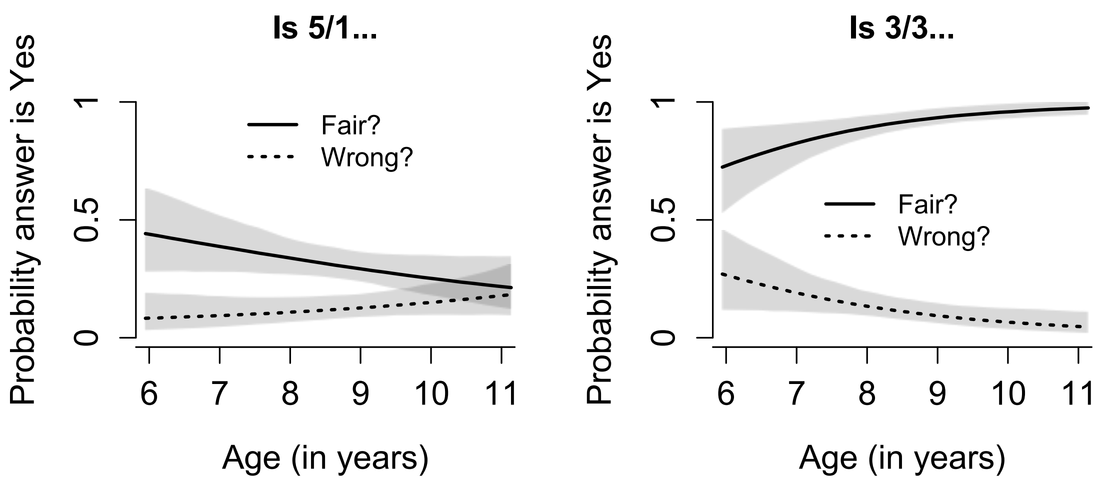
The interview asked children to predict what others (another child, an adult, and their teacher) would choose if presented with the same cooperative dilemma that they have been give. It also asks children to predict what their teacher would want them to choose. We modeled Actors' predictions about whether others would choose 3/3 or 5/1, together with their predictions that their teacher would want them to choose 3/3 or 5/1. Not all Actors were able to provide a response to all questions, and we excluded Actors who did not respond to both questions, and Actors in the Right Norm MaxG condition. The model estimates are plotted in Figure 17.

Figure 17: Actor's predictions (from Model 6) about the likely prosocial behavior of other children, adults, and teachers. Also, their predictions about what their teacher would want them to choose. Grey regions represent 95% confidence intervals. Both panels, n=158.

The interview also asked Actors to judge whether it would be "wrong" or "fair" for another child to choose 3/3 or 5/1. We recoded Actors' answers to interview questions 2-4 (Table 8) to represent their judgments of whether 3/3 and 5/1 were "wrong" or "fair" choices for another child to make. Models used these judgments as the data, and controlled for whether Actors had predicted another child would choose 3/3 or 5/1. We excluded data from Actors who did not give all four of these judgments, and who were in the Right Norm MaxG condition.

In general, at the youngest ages Actors were more likely to say that both 5/1 and 3/3 were fair, and less likely to say that they were wrong (Figure 18). With increasing age, this pattern strengthened dramatically for 3/3, and by the oldest ages almost all children said that 3/3 was fair, and almost none said that it was wrong (right panel, Figure 18). In contrast, with increasing age this pattern diminished substantially for 5/1. At the oldest ages, children were equally unlikely to say that 5/1 was fair or that it was wrong (left panel, Figure 18).

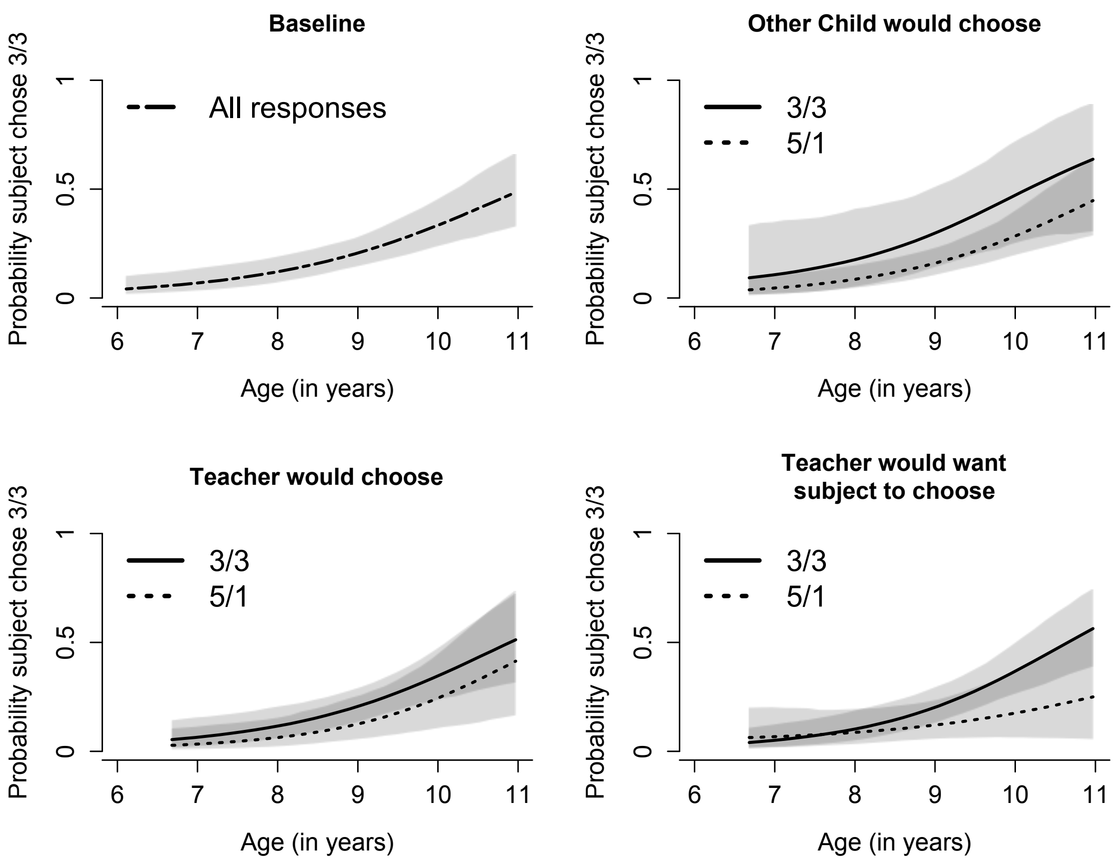
Figure 18: Children's evaluations (from Model 7) of whether it was "wrong" or "fair" for another child to choose 3/3 or 5/1. Grey regions represent 95% confidence intervals. Both panels, n=196.



To model how Actors' responses to the interview questions predicted their actual choices in the Test Trials, we again excluded data from children who did not answer all the relevant interview questions, and those in the Right Norm MaxG condition. This substantially reduced the dataset, so to increase degrees of freedom we collapsed the data from the different Conditions and Treatments, and removed age interactions. These parameters are not directly relevant to asking whether children's beliefs about 3/3 and 5/1 predict their prior prosocial choices.

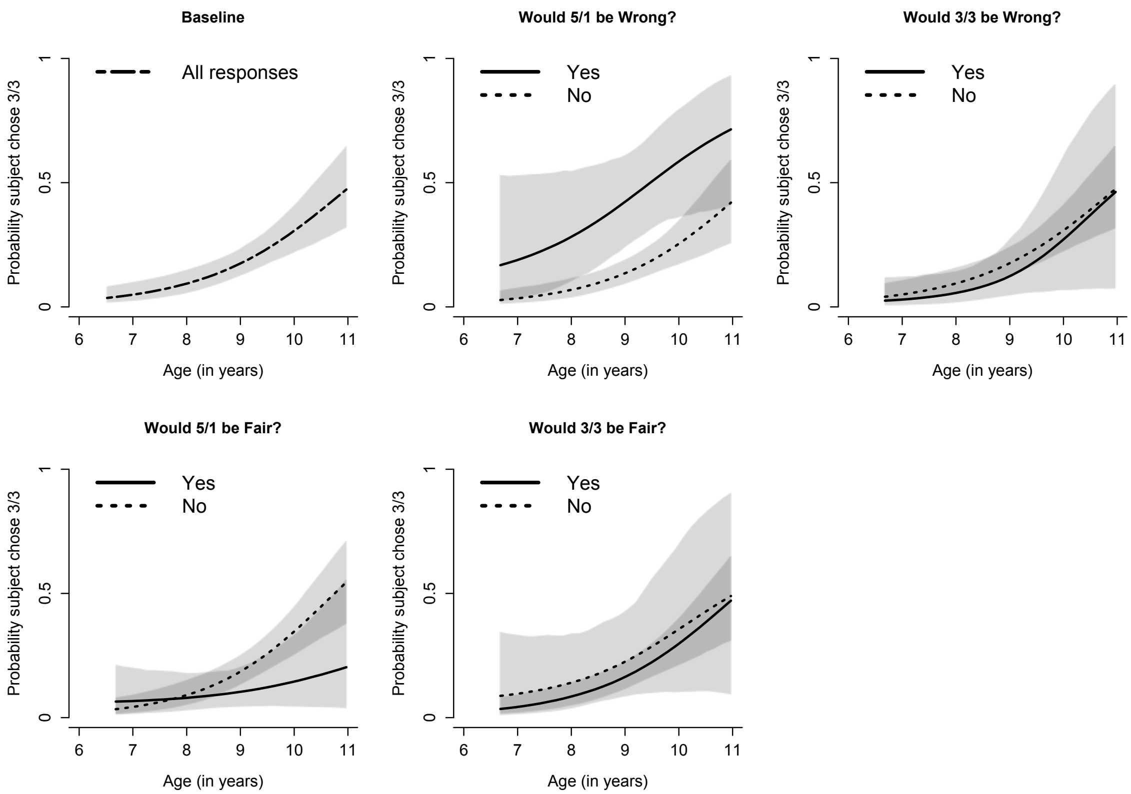
Actors' judgments of whether or not others would choose 3/3 did predict their own choices of 3/3. Actors were not reliably more likely to choose 3/3 if they believed that another child would choose 3/3, or that their teacher would choose 3/3 (Table 4, main text). However, Actors were more likely to choose 3/3 if they believed their teacher would want *them* to choose 3/3. Additional models including age interactions suggest that this tendency emerges around 9.5 years of age (Figure 19).

Figure 19: How children's beliefs about the prosocial behavior of others impacts their prosocial behavior in the Test Trials, across development (from Model 3.age). Grey regions represent 95% confidence intervals. All panels, n=128.



Actor's judgments of whether 3/3 and 5/1 were "wrong" and "fair" also predicted their own choices of 3/3. Actors were substantially more likely to choose 3/3 if they believed that 5/1 was wrong (Table 5, main text). They were also less likely to choose 3/3 if they thought that 5/1 was fair. Additional models including age interactions suggest that judgments of the "wrongness" of 5/1 begin to influence Actor's choices of 3/3 as early as 7/5 years, while the influence of judgments of the "fairness" of 5/1 emerge by about 9.5 years (Figure 20). Surprisingly, judgments of the “wrongness” and “fairness” of 3/3 do not appear to reliably predict Actor’s choices of 3/3 in this task.

Figure 20: How children’s beliefs about beliefs about whether 3/3 and 5/1 are “wrong” or “fair” impacts their prosocial behavior in the Test Trials, across development (from Model 4.age). Grey regions represent 95% confidence intervals. All panels, n=128.



These results also give us important insight into the role of children’s explicit beliefs in prosocial development. Children show no confidence at any age that their peers would be prosocial in our Dictator Game task, and probably greatly underestimate how prosocial their peers actually are (at least at the oldest ages in the sample). Children’s beliefs about the likely prosocial behavior of their peers also don’t reliably predict their own prosocial choices.

In contrast, with increasing age children show a dramatic increase in their expectations of prosocial behavior by their teacher and other adults. Children also show an identical developmental pattern in their beliefs about whether their teacher (and, perhaps by extension, all other adults) would want them to be prosocial. However, children’s own prosocial behavior is reliably predicted not by their beliefs about whether or not their teacher would themselves be prosocial, but instead by their beliefs about whether their teacher would want them to be prosocial. This pattern emerges by about 9.5 years, and strongly suggests that at least some substantial part of the developmental change in prosocial behavior that we have observed is due to children's changing beliefs about what adults in their community expect them to do.

Children's beliefs about the "wrongness" and "fairness" of the outcomes are also very important. Remember that these beliefs are based on questions about whether it would be "wrong" or "fair" for another child (not the subject) to choose 3/3 or 5/1. Children are more likely to judge 3/3 as a "fair" choice, and less likely to judge it as a "wrong" choice. With increasing age, 3/3 is judged as both more-fair and less wrong, and at the oldest ages there is very little variation in these judgments. Similarly, at the youngest ages in our sample 5/1 is more likely to be judged as "fair" than it is likely to be judged as "wrong." However, with increasing age this difference disappears, and at the oldest ages children are equally unlikely to affirm that 5/1 is either "fair" or "wrong." This contradicts the intuitive idea that selfish outcomes are *not* "fair" because it they *are* "wrong."

What is surprising is that children's judgments of whether 3/3 is fair or wrong do not reliably predict children's own prosocial behavior. Given the data, this must be true: children are far from universally prosocial in this task, despite being nearly universal in their judgments that 3/3 is fair and not wrong. Instead, children's beliefs about the selfish outcome appear to most clearly predict children's prosocial behavior. Children that believe the selfish outcome is "wrong" are more likely to be prosocial, a pattern that emerges by 7-7.5 years of age. Those that believe that the selfish outcome is "fair" are less likely to be prosocial, though the pattern is relatively weaker and emerges by about 9.5 years. While it is certainly intuitive that children's beliefs about the prosocial outcome would impact their prosocial behavior, these results indicate that in the present experiment children's prosocial behavior is more strongly shaped by their beliefs about the selfish outcome.

This provides important insight into the development of children's beliefs about prosocial and selfish behavior, and how these beliefs shape the course of prosocial development. Children's own prosocial choices are predicted most clearly by what they believe their teachers (and perhaps all other adults) would want them to choose in our cooperative dilemma, and not as reliably by what they expect peers and adults to actually choose in the task. The influence of their predictions of their teacher's preferences emerges at about 9.5 years, closer to the onset of children's willingness to conform to normative information regardless of context or sensibleness, than to the onset of children's sensitivity to normative information in general (at about 7-7.5 years). This is consistent with the idea that there is a period of strategic normativity prior to about age 9.5, while after age 9.5 children shift towards a more promiscuous normativity, wherein they strongly conform to both information about normative behavior and their perceptions of the behavior expected by reliable social models (adults, teachers).

We also show that, unexpectedly, children's beliefs about the "fairness" and "wrongness" of the prosocial outcome are not predictive of their own prosocial choices. This is not because children were confused about the questions, they reported mutually coherent beliefs that the prosocial outcome is both fair and not wrong. Children show less coherence in their beliefs about the status of the selfish outcome: with increasing age they are increasingly likely to report it is neither fair *nor* wrong. Yet, again children are not confused, as their beliefs about the "fairness" and "wrongness" of the selfish outcome reliably predict their actual prosocial choices in a sensible manner. Children appear to have been drilled into a uniform belief that being prosocial is both fair and not wrong, but we cannot detect that this belief influences children's prosocial behavior (though we would not be surprised if it did, to at least some degree). Instead, children's beliefs about the "fairness" and "wrongness" of the selfish outcome are less uniform, and these beliefs have a substantial impact on their prosocial choices.