Children adjust behavior in novel social environments to reflect local cooperative norms inferred from brief exposure

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Abstract

Stark intergroup variation in prosocial behavior, as elicited with economic experiments, is evident even though humans are highly mobile. Conformity to local norms has been posited to play an integral role in the maintenance of this variation. Experiments suggest that adults indeed rapidly infer pro- and antisocial norms in a new or changed social environment and adjust their behavior to reflect the inferred norms. Studies of the ontogeny of prosocial behavior show that by middle childhood, children's prosocial behavior conforms to that of local adults. Furthermore, by this stage, children are susceptible to the manipulation of explicit normative information. However, as yet unknown is whether children concomitantly have the propensity to 1) rapidly infer local cooperative norms in a novel, realistic social environment, 2) extend these inferences to norms for unobserved behaviors, and 3) apply the inferred norms in the same environment. Here, we used a slideshow to introduce children (age nine to eleven) to a novel social environment, Neighborhood X, which differed by condition (Prosocial or Antisocial). We measured perceived cooperative norms in children's Own Neighborhood and in Neighborhood X via questionnaires; norms for Neighborhood X diverged drastically dependent upon condition, a result robust to the exclusion of questions about norms for unobserved behaviors. Children's perceived cooperative norms in Own Neighborhood predicted their prosocial behavior (Dictator Game) in Own Neighborhood. Moreover, even though information about giving behavior was not presented in the slideshow, inferred norms for Neighborhood X predicted children's prosocial behavior in the same milieu. Changes from baseline prosocial behavior, as measured with a separate helping task, did not extend beyond Neighborhood X. Our results are consistent with the hypothesis

that humans have a propensity to rapidly infer and conform to local cooperative norms, thus maintaining group differences in prosocial behavior, and further indicate that this propensity is in operation by middle childhood.

Introduction

Humans are remarkable in their capacity for cooperation with non-kin. Furthermore, stark inter-group differences in cooperation, as evidenced by experimental economic games conducted on a global scale, are apparent [1–3] by middle childhood [4–7]. This persistence of intergroup variation is surprising given how highly mobile humans are [8,9]. A fine-scale example of this phenomenon was illustrated in a longitudinal study by Smith et al. [10], who tracked the movement of Hadza hunter-gatherers from camp to camp. Despite substantial residential mixing, inter-camp variation in experimental public goods contributions was maintained, with individual contributions reflecting those of the camp means. Such behavioral plasticity is consistent with evolutionary models of cooperation that emphasize the primacy of social norms [10], such as the "norm psychology" hypothesis of Chudek and Henrich [11], which proposes that humans possess a suite of cognitive mechanisms and motivations that enable the recognition, recall, adoption, and enforcement of social norms. In support of this hypothesis, field studies suggest that adults do indeed rapidly infer prosocial norms and that the inferred norms affect their immediate behavior [12–14]. However, this propensity has not been assessed in children, even though a comprehensive account of the ontogeny of prosocial behavior is a critical piece in the evolutionary puzzle of cooperation among humans. Here, we assess whether nine- to eleven-year-old children 1) rapidly infer local pro- and antisocial norms through observation of a realistic social environment, 2) extend these inferences to norms for unobserved behaviors, and 3) apply the inferred norms when engaging in a social dilemma in the same environment.

Evidence of normative conformity in adults

Social norms are informal standards of behavior shared by a group. Experimental evidence of conformity to pro- and antisocial norms comes from both field and lab studies; these studies can be further characterized by whether subjects received explicit normative information or had to infer norms from environmental cues. For example, field studies show that adults given written information about others' prosocial behavior demonstrated an increased compliance with prosocial norms (higher rate of reuse of towels at a hotel [15] or limited energy consumption [16]) compared to those subjects who did not receive normative information. In the lab, participants in a Dictator Game (DG) who were told about the generosity of prior players (real or imagined) were more generous in their choices than those who were told about the selfishness of prior players [17,18].

In contrast with the above experiments in which normative information was explicit, a series of field studies conducted by Cialdini, Reno and Kallgren [12] showed that manipulation of the amount of litter in a parking garage was sufficient to induce changes in the rate of littering, presumably because the unwitting participants were conforming to normative information they had extracted from the environment. Cialdini, Reno and Kallgren distinguish between injunctive norms (what most people consider appropriate or "good" behavior) and descriptive norms (what most people actually do); while a heavily-littered environment resulted in an increase in the rate of littering, a single piece of litter in a clean environment (ostensibly calling subjects' attention to an anti-littering injunctive norm) was associated with an even lower rate of littering than a completely clean environment.

Other field and lab studies have found that adults who are exposed to implicit or explicit information about a specific pro- or antisocial norm will generalize that information to other, similarly-valenced behaviors and subsequently apply the inferred norm. For example, Keizer, Lindberg, and Steg [13] demonstrated that environmental evidence of antisocial norms induced an increase in *other* antisocial behaviors (e.g., graffiti adjacent to a sign prohibiting it led to a higher rate of littering in the same location). Such a “cross-norms effect” has also been observed with prosocial behavior; brief exposure to cues of prosocial norm adherence in a naturalistic setting was associated with an increased rate of adherence to other prosocial norms [14]. Similarly, in lab experiments, experience with either a cooperative or non-cooperative “culture,” via an experimental economic game, resulted in divergent levels of general trust and prosocial behavior in subsequent economic games [19].

The ontogeny of normative conformity

The studies sketched above demonstrate that adults are capable of extracting normative information from the social/built environment and, furthermore, generalizing the inferred norms to those that govern other, unobserved behaviors and situations. These critical components of human norm psychology facilitate behavioral plasticity. That is, they enable a newcomer to rapidly approximate local normative behavior in a novel environment—be it an unfamiliar place or institution—without either being given explicit information on norm compliance or spending years witnessing multiple people engaging in every possible social situation.

Although these propensities have not been assessed in children, two lines of evidence, when considered together, indicate that they might be apparent by middle childhood, when group differences in prosocial behavior emerge [4–7]. First, ethnographic and lab studies with children demonstrate that observation and imitation are at least as important for the transmission of norms of sharing as are teaching and direct commands [20–23]. Second, recent work demonstrates that the appearance of intergroup variation in prosocial behavior coincides developmentally with increasing responsiveness to the experimental manipulation of explicit information about prosocial norms.

In a study that included six diverse societies, House et al. [24] exposed children aged four to fifteen to an injunctive norm manipulation before they engaged in a DG. The manipulation consisted of a video recording of a local adult saying that the generous choice (selfish choice) in the DG was “right” and “good to choose” (“wrong” and “bad to choose”); for the control, both options were “OK to choose.” Children in all six societies responded reliably, choosing the generous option more often after the injunctive manipulation relative to the control. These effects emerged between six and eight years of age and increased in strength across childhood, such that by ten years of age, children’s behavior was comparable to that of local adults. Similar results were obtained in a separate study with a German sample [25].

In another norm manipulation DG study with children, McAuliffe, Raihani, and Dunham [26] primed children in the U.S. aged four to nine years with either a generous or a selfish norm. The experimenter told the child either how many candies they thought the child should give to the recipient (injunctive norm) or how many candies they thought most other children who play the game give to the recipient when playing the game (descriptive norm). Although children primed with a generous norm gave more than those who were primed with a selfish one (irrespective of whether it was injunctive or descriptive) the authors did not observe a clear developmental trajectory.

In sum, the results of House et al. [24, 25] and of McAuliffe, Raihani, and Dunham [26] indicate that by middle childhood, children adjust their prosocial behavior to conform to explicit and specific normative information. Furthermore, the results of House et al. [24, 25] suggest that the developmental emergence of group differences in prosocial behavior around middle childhood is precipitated, at least in part, by increasing responsiveness to local prosocial norms. However, a novel approach is warranted in order to determine whether children at this developmental stage are also in possession of the aforementioned critical components of norm psychology: extraction of normative information from the social/built environment; generalization of the inferred norms to those that govern other, unobserved behaviors and situations; and adoption of pro- or antisocial behavior that is in accordance with the local norms.

Thus, in the current study, we used a slideshow to give children (nine to eleven years of age) a tour of a new neighborhood called “Neighborhood X.” We told the children that we had been studying Neighborhood X and that we wanted to know what they thought about the neighborhood. Children were randomly assigned to tour either a Prosocial or an Antisocial Neighborhood X; they subsequently saw photos, accompanied by text descriptions, of people behaving prosocially or antisocially, respectively.

We used a questionnaire to assess children’s perceptions of injunctive and descriptive norms for five behaviors such as recycling or littering (we refer to these behaviors as either *positive* or *negative* to distinguish them from condition). Children answered the questions for their Own Neighborhood first as a baseline measure and then, after the slideshow, for Neighborhood X. Using multilevel models, we created injunctive and descriptive cooperative norm indices from the responses; higher values indicate more cooperative norms.

We also compared prosocial behavior in Own Neighborhood and in Neighborhood X via two Dictator Games (DGs). The children allocated thirteen virtual quarters to themselves and/or another anonymous child in Own Neighborhood (Neighborhood X); after the study, participants received, as promised, a digital prize commensurate with the number of quarters that they had allocated to themselves. To evaluate the specificity of any changes in prosocial behavior following exposure to Neighborhood X, we gave the children the option to help us by engaging in a real-effort encryption task (Helping Task) at the end of the study.

Following the norm psychology account, we predicted that children would describe the Prosocial Neighborhood X as having more cooperative descriptive norms than the Antisocial Neighborhood X and, subsequently, exhibit more generous DG behavior in the Prosocial Neighborhood X than the Antisocial one. Furthermore, we anticipated that changes in descriptive norms in Neighborhood X compared to baseline Own Neighborhood would be correlated with changes in DG giving. Additionally, given the studies conducted with adults that have demonstrated an effect of cooperative descriptive norms on pro- and antisocial behavior in real-world settings [12-16], we expected to see a general pattern, across all neighborhoods, of more cooperative descriptive norms being associated with more generous DG behavior.

Methods

Neighborhood X stimuli

We selected cooperative norm situations (Fig 1; Table 1) which satisfied the following conditions: 1) representation with one or two photos, 2) no physical harm, and 3) symmetry of people and setting for both conditions. Creation and validation of the images and text used to introduce participants to Neighborhood X is treated in the S1 Appendix.

Fig 1. Examples of stimuli used to introduce children to Neighborhood X. Photographs and text from the "litter" (A is for the Prosocial condition, B is Antisocial) and "dropped papers" (C is Prosocial, D is Antisocial) stimuli (see Table 1). Note that the ratio of images to text is different from that which was presented to the participants in that the images were substantially larger than the text.

Table 1. Description of photographic stimuli used in Neighborhood X slideshow.

Neighborhood X Stimulus	Prosocial Stimulus Text	Antisocial Stimulus Text	Number of Actors in Image	Actor Sex
lost letter	We saw that someone had dropped their mail next to the mailbox. We saw this woman pick it up and put it in the mailbox.	We saw that someone had dropped their mail next to the mailbox. We saw this woman look at it and keep walking.	1	Female
library book	We saw this girl put library books back on the shelf after she was finished with them.	We saw this girl ripping pages out of a library book.	1	Female
slide queue	We saw this girl wait her turn to use the slide.	We saw this girl cut in line for the slide.	3	Female
litter	We saw this girl put her cup in the trash can.	We saw this girl litter.	1	Female
dropped cash	We saw this woman drop some money. Another woman picked it up and handed it back to her.	We saw this woman drop some money. Another woman picked it up and put it in her pocket.	2	Female
chewed gum	We saw this boy take his gum out of his mouth and throw it away in a trash can.	We saw this boy take his gum out of his mouth and stick it on the bench.	1	Male
door	We saw this man hold the door for the woman behind him. She was carrying a heavy package.	We saw this man who did not hold the door for the woman behind him. She was carrying a heavy package.	2	Male, Female
candy	We saw this woman take just one candy. The sign said to take one candy.	We saw this woman take a handful of candies. The sign said to take one candy.	1	Female
dog poop	We saw this man clean up after his dog.	We saw this man who didn't clean up after his dog.	1	Male
dropped papers	We saw this woman drop papers on the sidewalk. This man walking by helped her pick them up.	We saw this woman drop papers on the sidewalk. This man walking by did not help her pick them up.	2	Male, Female
graffiti	We saw this woman cleaning up graffiti on a wall at the park.	We saw this woman spraypainting a wall at the park with graffiti.	1	Female

Data collection

The study was pre-approved by the Boston University IRB (Protocol #3501E), and informed consent was given by a parent or guardian of all participants.

Participants

We recruited children aged nine to eleven years from the Boston area, via emails and phone calls to families in a participant database maintained by the Social Development and Learning Lab. We employed exclusionary criteria during recruiting: 1) lack of home access to desktop/laptop computer and internet (the study was conducted online via the Qualtrics software platform), 2) diagnosis of dyslexia, 3) diagnosis of autism, and 4) psychoactive drugs (this criterion because of a potential follow-up genetic study). We further limited participation to children whose biological parents self-identified as Caucasian because the actors in the stimuli photographs would be likely be viewed as Caucasian, and we wanted to maximize the likelihood that participants would make inferences based upon the behavior of the actors rather than focusing on in-group or out-group membership based on race or ethnicity.

Parent survey

Prior to the participation of their child, parents completed a survey about child-rearing. The data were collected for analysis and publication elsewhere; however, some of the data is informative as to the parent's desire for children to behave prosocially, and thus we used those data to assess potential parental interference in the study (S1 Appendix).

Participant experience

In addition to a consent form, parents received a child assent form to go over with their child. Once we had received informed consent from the parent, we randomly assigned each child to the Prosocial or Antisocial condition, and the parents were given a link to the online platform, allowing the child to commence the study, in the their own residence, at the time of their choosing. We told parents that it was important for the child to complete the study by herself in one sitting (expectation of 40-55 minutes), at a laptop or desktop computer, with minimal distractions (e.g. TV, other online activities, other people in the room). Both parents and children were informed that the child could stop participating at any time and would still get a prize.

Prior to using radio buttons and text boxes or Qualtrics features (drag and drop, Heat Map), participants received tutorials, followed by comprehension checks. No researcher was present to guide the child through the study; thus, we assessed participant compliance and engagement with the following measures: time spent on the study, completion of study components, comprehension checks following instructions for the DGs, and assessment of Qualtrics Heat Map data (S1 Appendix). Moreover, we searched for external influences on child responses to questions and instructions for which there was a single correct response and on child behavior in the DGs (S1 Appendix; S1 Fig and S2 Fig).

After answering questions about cooperative norms in Own Neighborhood, completing a self-assessment of their affective state, and completing the first DG with a child in Own Neighborhood (see below), participants were introduced to the Heat Map feature of Qualtrics, which records user clicks on components of images. We used this feature to encourage attention to the Neighborhood X stimuli and assess the salience of different image components. We then introduced them to "Neighborhood X," which we said is near Boston but probably not home to anyone they know. We told them we had been watching the people who lived there and taking notes on them and we wanted to share what we had seen, after which we would then ask them questions about Neighborhood X.

Participants progressed through the slideshow at their own pace. For each of the stimuli, they were instructed to click on "the part of the picture you think is most important." Following exposure to Neighborhood X, participants answered questions about cooperative norms in Neighborhood X, completed another self-assessment of affective state, and completed a second DG with a child in Neighborhood X. They then had the opportunity to complete up to 20 Helping Tasks (see below) before selecting their top choices for digital prizes and viewing a debriefing video on kindness (https://www.randomactsofkindness.org/kindness-videos).

We emailed parents with instructions for redeeming a digital prize(s) the child had selected, along with a debriefing letter to be read with the child, which disclosed the fabricated nature of the images of Neighborhood X.

Cooperative norms

Prior to answering any norms questions, participants read a brief description of "neighborhood" as the area where they live, which includes their neighbors, with whom they may or may not talk/play, and places nearby (e.g., a park). Participants who lived in more than one household were instructed to think about the neighborhood where they live most of the time.

At two points during the experimental session (once prior to each DG), we asked participants about injunctive and descriptive norms for five behaviors. The descriptive norm questions were specific to neighborhood (Own Neighborhood, Neighborhood X) and concerned the behavior of adults as well as children. The five behaviors (recycling, helping an elderly neighbor carry groceries, littering, keeping a library book forever, keeping a package that was supposed to be delivered to another household) were chosen because both children and adults can perform them and, collectively, they represent both positive and negative behaviors directed towards both individuals and the community.

For example, we asked about the injunctive norm for recycling as follows: “What do you think about Recycling? Do you think it's Never OK to Recycle, Always OK to Recycle, or somewhere in between?” A five-point scale was anchored at “Never OK” and “Always OK.” We asked about descriptive norms as follows: “Do you think many adults (kids) in your neighborhood (Neighborhood X) would Recycle?” A five-point scale was anchored at “No One Would” and “Everyone Would.”

Affect

Participants completed a self-assessment of the valence of their current emotional state, using a seven-point smiley/frowny face scale, immediately prior to being introduced to both the first and second DGs.

Dictator games

Participants played two DGs, via the drag and drop feature in Qualtrics; each “Quarter Game” occurred after participants answered questions about the norms in Own Neighborhood (Neighborhood X). In the instructions, participants were told that they would have to decide how many of 13 quarters would go to a child in “Your Neighborhood” (“Neighborhood X”) and how many they would keep for themselves. They were told that this other child would never know their name, and that they would never know who the other child was, either. After answering multiple choice comprehension questions (S1 Appendix), they moved each of 13 quarters (digital images) to one of two boxes: “Other Child's Box” or “Your Box.” Participants were not informed, prior to exposure to Neighborhood X, that they would play a second “Quarter Game.”

At the end of the study, participants selected their top choices for prizes from an array of digital books, songs, and games from Amazon and iTunes. Based on the prices of the prizes and how many quarters the participant had amassed, we ordered one or more prizes to be redeemed by the participant's parent. All quarters allocated to other children were used to buy books to give out to children within the same counties as Own Neighborhood/Neighborhood X. The decision to donate books rather than actual money to children was dictated by our IRB. We collaborated with local libraries to identify appropriate books and give these away to eight to twelve year-old children in the appropriate counties. The quarters given to children in Neighborhood X were applied towards the purchase of books in Suffolk and Middlesex counties, which are the locations of the two neighborhoods in which we photographed the stimuli.

Helping task

To allow us to determine whether any changes in prosocial behavior were specific to Neighborhood X, we gave participants the opportunity to help the experimenters with a real-effort encryption task [27], the "Helping Task." Participants used a new cipher to turn each four or five-letter word into a string of numbers. After each word, participants could either continue or finish the study, with the possibility of encrypting 20 words (they did not know how many encryption tasks there were in total). Fatigue and enjoyment were assessed on a five-point scale by asking how tired/energized participants were prior to the Helping Task and how boring/fun the task was once participants had chosen to finish. After this task, all children watched a short movie showing people behaving kindly towards one another. We did this to ensure that children left the experimental session with positive impression of human behavior.

Cooperative norms

We used multilevel models to analyze participants' responses to the Likert-type items about the acceptability (injunctive norm) and frequency (descriptive norm) of five behaviors (three negative and two positive), treating each participant's responses as repeated measures of the participant's perception of the injunctive or descriptive cooperative norm. This approach allowed us to simultaneously, as in item response theory, estimate variation in responses due to both individual and item (i.e., specific behavior) covariates as well as changes in perceived norms across neighborhoods.

To assess group-level effects of condition and Neighborhood (Own or X) upon injunctive and descriptive cooperative norms, we fit binomial logistic (injunctive norm items) and ordered logit (descriptive norm items) mixed models. Stan [28] is a probabilistic programming language that implements Hamiltonian Monte Carlo sampling. We used Rstan, the R [29] interface for Stan [30], along with the R packages glmer2stan [31] and rethinking [32,33], to summarize parameter estimates and draw samples from the posterior distributions. For both injunctive and descriptive items, we reverse-coded participant responses for negative behavior items in order to create a composite cooperative scale, with one signifying least cooperative, and five signifying most co-operative. Because of minimal variation in responses to injunctive norms items, we collapsed injunctive responses across bins one through four, creating two categories. For all regression analyses, we specified increasingly complex models in a stepwise fashion, assessing improvements in model fit with the deviance information criterion (DIC). Assessed models include those with fixed effects for *Antisocial condition*, *Neighborhood X*, *age*, *gender* (boy), and *adult* (for descriptive norm items; participants were asked about both adults and children performing the behavior). We also assessed models with an interaction between *Antisocial condition* and *Neighborhood X* as well as varying intercepts for participants and items (i.e., behaviors). Given the substantial increase in variance in descriptive item responses for Neighborhood X compared to Own Neighborhood (over 100%), we further allowed the effect of Neighborhood X to vary by participant and by item for the descriptive norm model. That is, we fit models that include varying slopes for Neighborhood X, conditioned on participant as well as survey item. Predictions from the fitted models were visualized with the R package ggplot2 [34]; additional R packages used in data analyses include dplyr [35], lme4 [36], MASS [37], and reshape2 [38].

For binomial and ordered logit regression analyses, we report Odds Ratios. An Odds Ratio, or OR, greater than one indicates that an increase in one unit of the predictor variable is associated with higher odds of, for example, a more cooperative response for the norms questions, or more quarters given in the DG, and an OR between zero and one indicates that an increase in one unit of the predictor variable is associated with lower odds of a more cooperative response or more quarters given.

To estimate individual perceptions of descriptive cooperative norms in Own Neighborhood and Neighborhood X, we amended the model with the lowest DIC by excluding the fixed effect of condition (and thus the interaction between *Neighborhood X* and *Antisocial condition*) (Table 2). Estimates for individual descriptive cooperative norms in Own Neighborhood are thus given by the mean estimate for participant intercept. Estimates for individual descriptive cooperative norms in Neighborhood X are given by the sum of the mean estimate for participant intercept and the mean estimate for the slope of Neighborhood X, conditioned on participant.

We also specified and fit mixed ordinal logistic regression models for a subset of the descriptive norms data for which there was no explicit information in the slideshow; i.e., we analyzed data for three of the five behaviors (recycling, helping an elderly neighbor carry groceries, and keeping a package that was supposed to be delivered to another household), excluding data for two behaviors (littering and keeping a library book forever). We proceeded with model selection as outlined above but did not fit models with varying intercepts for behavior items or slopes for Neighborhood on behavior because of the reduced number of behavior items in the dataset. Rather, we created a fixed effect for the sole negative behavior.

Affect

We used multilevel ordered logit regression, proceeding as above, to evaluate the effect of condition upon affect before and after the Neighborhood X slideshow.

Prosocial behavior in the DGs

In order to assess the effect of condition and descriptive norms upon prosocial behavior in the DGs, we fit multilevel ordered logit models, proceeding in a stepwise fashion as described above but without parameters specific to survey items. Some of our research questions were better served by modeling subsets of DG behavior data; that is, for clarity of interpretation, the effect of descriptive norms on DG behavior was also analyzed separately for the two neighborhoods. Similarly, to investigate the effect of the number of years the child had lived in their own neighborhood on DG giving, we analyzed data from Own Neighborhood alone, while we assessed the effect of negative affect on DG giving in Neighborhood X alone. Single-level ordered logit regression was conducted with the R package MASS [37]; Akaike Information Criterion (AIC) [39] was used for model selection.

We used ordinary least squares regression to investigate a relationship between change in descriptive norms between neighborhoods (i.e., the mean estimate for the slope of Neighborhood X, conditioned on participant, as detailed above) and a change in the number of quarters given.

Prosocial behavior in the Helping Task

We assessed effects of condition and descriptive cooperative norms (both Own Neighborhood and Neighborhood X) on prosocial behavior in the Helping Task (i.e., number of helping tasks correctly completed) via Poisson regression with forward stepwise model selection and AIC. Covariates considered included *age*, *gender* (boy), and *helping task fun* (five-point scale for how fun the task was). We also investigated a relationship between the number of quarters given in each DG and the number of helping tasks completed in the same manner.

Results

Cooperative norms in Own Neighborhood and Neighborhood X

The 99 children (48 male; 34 nine-year-olds, 43 ten-year-olds, and 22 eleven-year-olds) in the final dataset (S1 Appendix) characterized Own Neighborhood as highly cooperative. Most of the children believed that more than half of their neighbors would behave positively and that few of their neighbors would behave negatively; they also perceived of adults in Own Neighborhood as more cooperative than children (Fig 2; Table 2).

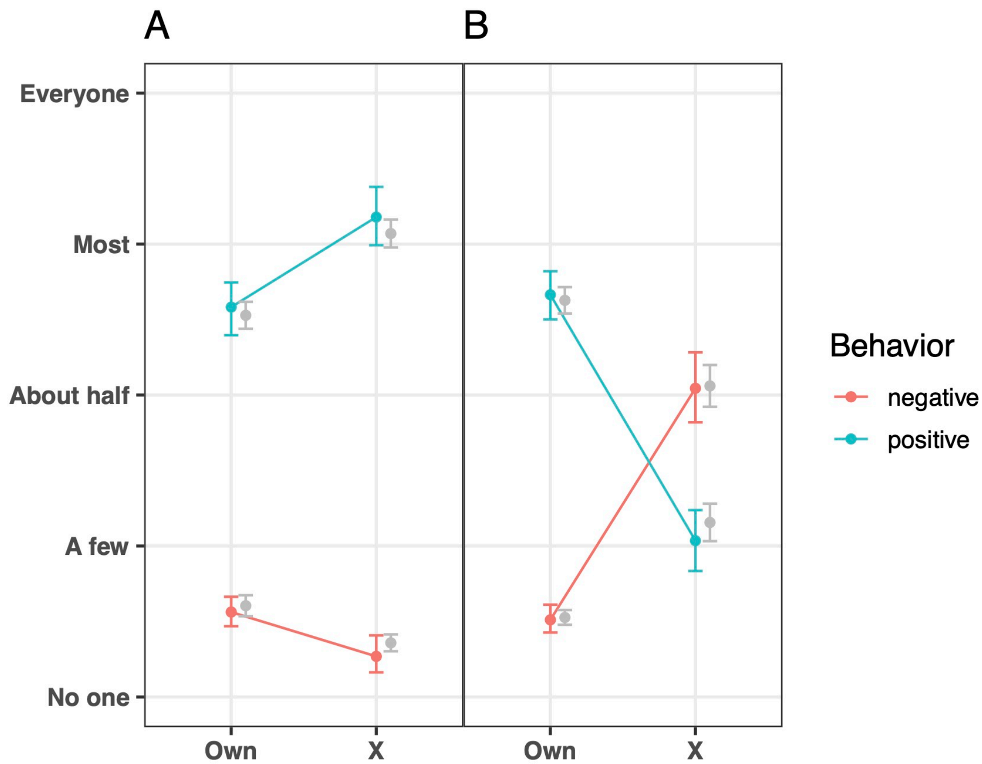

Fig 2. Descriptive cooperative norms by Neighborhood and condition: Prosocial (A) or Antisocial (B). As described in the Methods section, negative behaviors were reverse-coded to create a composite cooperative index for regression analyses; this action was reversed for plotting. Tick marks along the y-axis indicate which proportion of the neighborhood participants believe would perform the behavior, and tick marks along the x-axis indicate Neighborhood. Means and standard errors of responses are plotted in gray alongside model predictions (mean and 95% CI) (see Table 2, Model 2).

	Model 1			*Model 2*			*Model 3*		
	Est.	**SD**	**OR**	**Est.**	**SD**	**OR**	**Est.**	**SD**	**OR**
Fixed effects									
Participant age, years	-0.24	0.06	0.79 (0.70,0.88)	-0.31	0.18	0.73 (0.52,1.04)	-0.28	0.18	0.76 (0.53,1.07)
Neighborhood X	0.79	0.12	2.20 (1.75, 2.83)	1.47	0.93	4.35 (0.70,28.79)	-1.41	1.10	0.24 (0.03,1.72)
Antisocial condition	0.15	0.12	1.16 (0.92,1.46)	0.25	0.29	1.28 (0.72,2.27)			
Adult actor	0.65	0.08	1.92 (1.63,2.27)	1.16	0.10	3.19 (2.61,3.90)	1.15	0.10	3.16 (2.59,3.86)
*Neighborhood X * Antisocial condition*	-3.44	0.18	0.03 (0.02,0.05)	-5.91	0.54	0.00 (0.00,0.01)			
Variance components									
Participant intercepts				1.28			1.26		
Slopes for Nhood X, conditioned on Participant				2.41			4.01		
Correlation				-0.36			-0.29		
Behavior intercepts				7.39			7.62		
Slopes for Nhood X, conditioned on Behavior				2.28			2.41		
Correlation				-0.23			-0.17		
DIC	4775			3461			3463		

Table 2. Descriptive cooperative norms dependent upon condition and neighborhood (Models 1 and 2) or neighborhood but not condition (Model 3). Ordered logit regression. Higher values indicate more cooperative perceived norms. “Behavior” refers to the five positive

or negative behaviors in the norms survey. “Adult actor” indicates that the survey question was about adults (rather than children) performing the behavior. Predictions derived from Model 2 are depicted in Fig 2. Individual descriptive norms in Own Neighborhood, and individual changes in perceived norms between Own Neighborhood and Neighborhood X, are provided by the estimated participant intercepts and estimated slopes for Neighborhood X, conditioned on participants, from Model 3. The sum of these values provides individual descriptive cooperative norms in Neighborhood X. Parentheses contain 95% confidence intervals for odds ratios (OR); standard deviations of the distributions of varying intercepts and slopes are given as estimates for the variance components. Estimated cutpoints are not included in the table.

Perceived descriptive cooperative norms in Neighborhood X, however, diverged sharply dependent upon condition. Children assigned to the Antisocial condition believed that, unlike the cooperative residents of Own Neighborhood, about half of the residents of Neighborhood X would behave negatively, and far fewer residents would behave positively (Fig 2; Table 2). In contrast, those in the Prosocial condition viewed the residents of Neighborhood X as behaving more positively, and slightly less negatively, than the residents of Own Neighborhood (Fig 2; Table 2). The coinciding increased variation in descriptive cooperative norms in Neighborhood X, relative to Own Neighborhood, is revealed by comparison of the variance in slopes for the effect of Neighborhood X, conditioned on participant, to the variance in intercepts for participants (Table 2).

The observed divergence of cooperative norms in Neighborhood X following condition remained when only those three behaviors (survey items) for which participants received no explicit information from the slideshow were considered. That is, we noted the same pattern when redoing the analyses with data from descriptive norm questions about recycling, helping an elderly neighbor carry groceries, and keeping a package that was supposed to be delivered to another household (littering and keeping a library book forever were excluded) (S3 Fig; S1 Table).

By contrast, injunctive norms do not appear to have been influenced by Neighborhood X. Echoing the highly cooperative descriptive norms observed in Own Neighborhood, participants condoned highly cooperative injunctive norms. This did not change after the slideshow; inclusion of covariates *Neighborhood X* and *Antisocial condition* do not improve model fit, and inspection of the coefficients for the fitted model specifying an interaction between *Neighborhood X* and *Antisocial condition* shows that the covariates are not particularly informative about responses to injunctive norms survey items (S2 Table).

Prosocial behavior in Own Neighborhood and Neighborhood X

Baseline prosocial behavior in Own Neighborhood, as assessed with the DG, indicates a remarkably prosocial sample of children (Fig 3; S3 Table). Of the 99 subjects, 72 gave away at least six of thirteen quarters, and 40 chose to give away more than they kept for themselves (seven or more quarters). This high level of baseline prosociality is in concordance with highly cooperative injunctive norms (S2 Table) as well as the stable, bi-parental home lives and high socioeconomic status of the study population (S1 Appendix) [35]. Approximately half of the children (49) had spent their entire lives thus far in the same neighborhood, with only approximately one-third (30) having spent less than two-thirds of their lives there; accordingly, we did not see a robust effect of the number of years the child had lived in the neighborhood on DG behavior (the standard error for *years in neighborhood* is 1.73 times the size of the estimated coefficient for the ordered logit regression model).

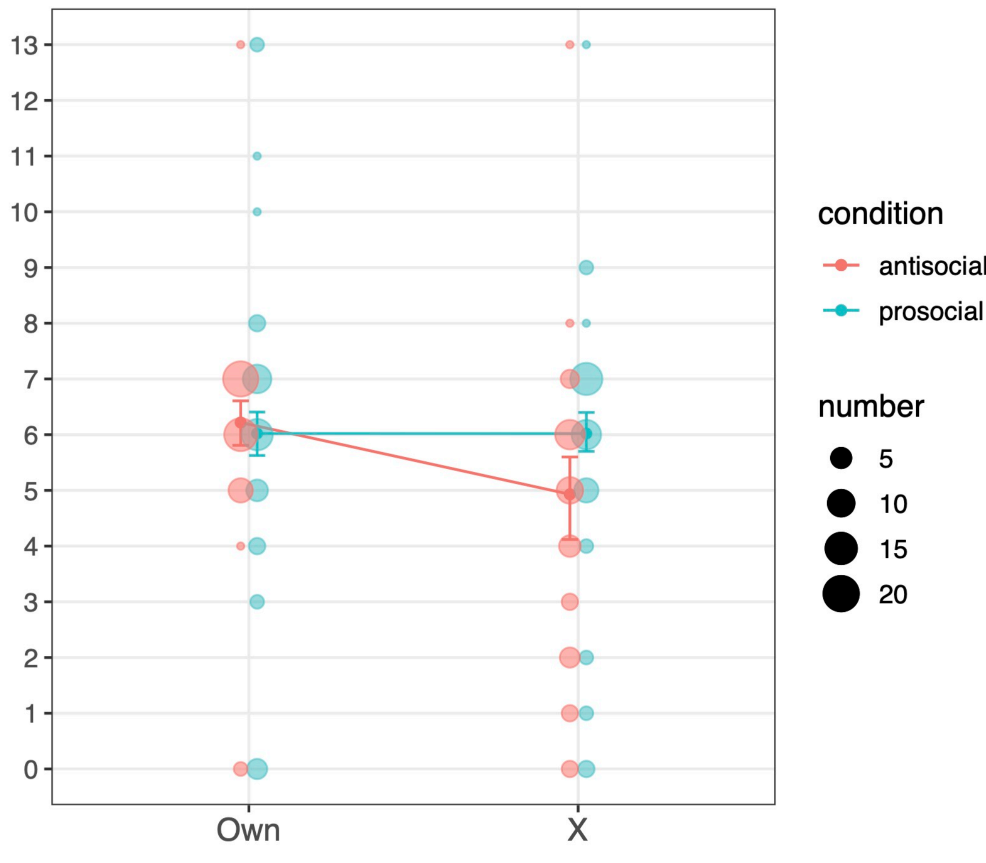

Fig 3. Quarters given in DGs by Neighborhood and condition. Lines and error bars show model predictions (mean and 95% CI for Model 2 in S3 Table) for number of quarters given in DG (y-axis) dependent upon interaction of Neighborhood (x-axis) and condition. Observations

(99 participants) plotted alongside model predictions; bubble size corresponds to number of children who gave away that many quarters.

Prosocial behavior in Neighborhood X, however, deviated from that in Own Neighborhood for those children assigned to the Antisocial condition. Children in the Antisocial condition gave fewer quarters to a child in Neighborhood X (median = 5, MAD = 1) than did children in the Prosocial condition (median = 6, MAD = 1), and they gave fewer quarters to a child in Neighborhood X than they gave to a child in Own Neighborhood (median = 6, MAD = 1) (Fig 3). Considering DG behavior only within Neighborhood X, the odds that a child in the Antisocial condition gave fewer quarters than a child in the Prosocial condition are 242% higher (OR 3.42, 95% CI [1.64,7.15]; Model 2 from S3 Table fit to data from Neighborhood X only). For children assigned to the Prosocial condition, there is not a robust difference between the number of quarters given to a child in Neighborhood X compared to a child in Own Neighborhood (Fig 2; OR for a child in the Prosocial condition giving more quarters in Neighborhood X than Own Neighborhood is 0.93, 95% CI [0.39,2.25]; ordered logit model with varying intercepts for participants and covariates *boy* and *Neighborhood X*).

Descriptive cooperative norms and prosocial behavior

In spite of the relative homogeneity of the sample with respect to Own neighborhood descriptive cooperative norms, we observed a positive relationship between perceived descriptive cooperative norms at baseline and the number of quarters given in the DG. That is, children who viewed their neighbors as more cooperative gave more quarters to another child in Own Neighborhood. An increase of one standard deviation (SD) or more above the mean for descriptive norms is associated with a median of seven out of thirteen quarters (MAD = 1) given in the DG, compared with an overall median of six quarters (MAD = 1) in Own Neighborhood. Likewise, an increase of one SD in descriptive cooperative norms is associated with a 189% increase in the odds of giving more quarters in Own Neighborhood (OR 2.89, 95% CI [1.08, 7.69] for ordered logit model with covariates of *gender* (boy) and *descriptive norms*). In other words, the odds are 2.89 times greater that a child who perceives of their neighborhood as highly cooperative (one SD above the mean) gave away more quarters in Own Neighborhood compared to a child who described their neighborhood as average with respect to cooperation.

Echoing the pattern that we saw at baseline in Own Neighborhood, children who viewed residents of Neighborhood X as more cooperative gave more quarters to a child in Neighborhood X. An increase of one SD in descriptive cooperative norms in Neighborhood X is associated with a 49% increase in the odds of giving more quarters in Own Neighborhood (OR 1.49, 95% CI [1.13, 1.96] for ordered logit model with covariates *gender* (boy) and *descriptive norms*).

When results from both Own Neighborhood and Neighborhood X are considered together, we see a strong influence of descriptive cooperative norms on prosocial behavior in the DG. Across both neighborhoods and conditions, for each one SD increase in descriptive cooperative norms, there is a 146% increase in the odds that a child gave away more quarters in the DG (OR 2.46, 95% CI [1.65,3.70]) (S3 Table, Model 1). This pattern persists, albeit with diminished strength (OR 1.86, 95% CI [1.03, 3.39]), when the covariates *Neighborhood X* and *Antisocial condition* are added to the model (S3 Table, Model 3).

In accordance with the observed relationship between descriptive norms and DG behavior, as well as the observed changes in perceived descriptive cooperative norms between Own Neighborhood and Neighborhood X, larger changes in descriptive norms are associated with larger changes in the number of quarters given in the DG. That is, children who perceived more of a difference in cooperation between Own Neighborhood and Neighborhood X concomitantly altered their DG behavior more. The quadratic relationship between change in descriptive cooperative norms and change in the number of quarters given accounts for 17% of the variation in behavioral change (between Own Neighborhood and Neighborhood X) in the DG ($R^2 = 0.17$, 95% CI [0.06, 0.38]; CI based on 1000 bootstrap replications) (Fig 4).

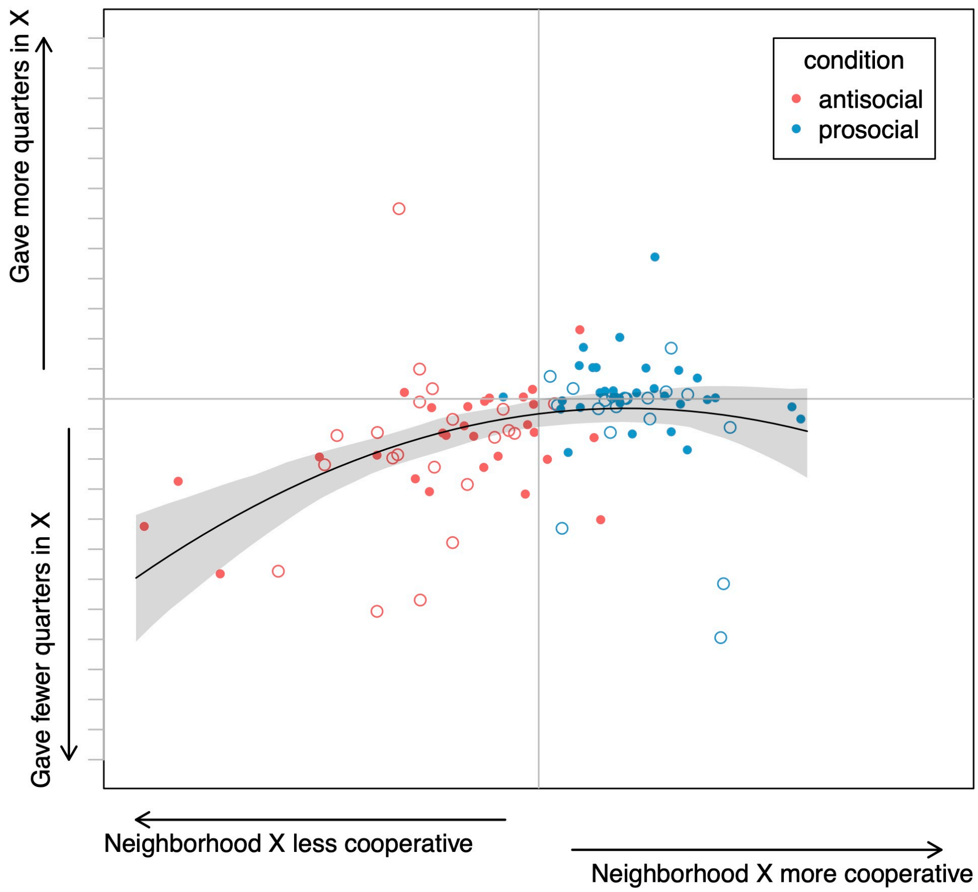

Fig 4. Relationship between change in perceived descriptive cooperative norms (from Own Neighborhood to Neighborhood X) and change in number of quarters given in DG. Change in descriptive cooperative norms plotted against change in number of quarters given in DG. Whether Neighborhood X is "more" or "less" cooperative, and whether participant gave more or fewer quarters in Neighborhood X, are relative to Own Neighborhood. Number of quarters given in Own Neighborhood was subtracted from the number given in X; each tick mark represents one quarter. Open circles indicate participants who gave away over half of their endowment

(seven or more quarters) in Own Neighborhood; data from all participants represented. Prediction line based on model with sole covariate being the quadratic change in norms; shaded area 95% CI.

Affect and prosocial behavior

We assessed whether condition-dependent differences in prosocial behavior in Neighborhood X could be attributed solely to negative affect (potentially brought about by viewing the uncooperative behaviors in the slideshow). After the Neighborhood X slideshow, children in the Antisocial condition were indeed sadder according to the seven-point smiley/frowny face scale (median response of four (MAD=1) than were children in the Prosocial condition (median response of three (MAD=1)). Ordered logit regression analyses reveal a robust, positive effect of condition, with *Antisocial condition* associated with a 207% increase in the odds that child reported more negative affect (OR 3.07, 95% CI [1.46,6.46]). Moreover, sadder children gave fewer quarters (OR 0.70, 95% CI [0.52,0.94]). However, once descriptive cooperative norms are included in the model, affect in Neighborhood X is no longer a useful predictor of the number of quarters given (OR 0.81, 95% CI [0.58,1.13]), while descriptive norms still are (OR 1.13, 95% CI [1.00,1.27]). This suggests that the perception of norms in Neighborhood X, rather than affect, was the main driver of the quantity of quarters given in Neighborhood X.

Specificity of behavioral change

The inclusion of a real-effort encryption task (ostensibly performed to help the scientists conducting the experiment) allowed us to investigate the specificity of prosocial behavioral changes following introduction to Neighborhood X. We used Poisson regression to model the number of tasks correctly completed in the Helping Task. Neither the addition of *Antisocial condition* nor of *descriptive norms* for Neighborhood X improve model fit (AIC of 764 for each model compared to AIC of 762 for baseline model, derived from stepwise model selection, with covariates *gender* (boy), *age*, and *helping task fun* (five-point scale)). Furthermore, for both *Antisocial condition* and *descriptive norms*, the estimated coefficients were larger than the standard errors. On the contrary, however, a clear relationship between behavior in the Helping Task and descriptive norms and DG behavior in Own Neighborhood was observed (S1 Appendix). Overall, these results indicate that the effect of Neighborhood X on prosocial behavior did not extend outside of Neighborhood X.

Discussion

The children in our study demonstrated clear plasticity in prosocial behavior upon introduction to Neighborhood X, and our analyses suggest that this behavioral modification was precipitated by the recognition of different cooperative norms governing behavior in Neighborhood X. Children in the Prosocial condition described Neighborhood X as far more cooperative than children in the Antisocial condition did. When asked whether they wanted to allocate quarters to a child from Neighborhood X, those in the Prosocial condition gave about the same amount that they gave to a peer from Own Neighborhood (which was generally perceived of as highly cooperative), but children in the Antisocial condition gave less. Descriptive cooperative norms predicted DG behavior in both Own Neighborhood and Neighborhood X, and the change in descriptive cooperative norms between the two neighborhoods accounted for 17% of the variation in change in the number of quarters given.

Importantly, children did not receive information about DG or other sharing/giving behavior in Neighborhood X, and the effect of condition on inferred norms in Neighborhood X is robust to exclusion of survey items about behaviors the children observed in the slideshow; these results are akin to the cross-norm effect described by Keizer and colleagues [13,14]. Thus, it appears that the children extracted a general understanding of the cooperative norms operating within Neighborhood X and extended those norms to unobserved behaviors or situations. Taken together, our results indicate that key components of a human norm psychology, including the rapid inference and adoption of cooperative norms in a novel milieu, are in operation by middle childhood.

While our main interest was in evaluating a change in perceived norms and prosocial behavior in Neighborhood X relative to Own Neighborhood, our finding that descriptive cooperative norms in Own Neighborhood predicted DG behavior in Own Neighborhood—as well as behavior in the Helping Task, which was conducted after the Neighborhood X component of the study—is also of note. These results are consistent with studies that have shown that, by middle childhood, children's prosocial behavior in experimental games is influenced by norms of game play [24–26] and reflects the choices local adults make [4,24], as well as research that has demonstrated an effect of local descriptive or injunctive norms on prosocial and antisocial behavior in adults [12–17,41–43]. However, to our knowledge, this is the first study to show that variation in prosocial behavior in children is, at least in part, explained by variation in perceived descriptive cooperative norms in their own milieu.

One shortcoming of our study is the lack of diversity in the participant pool with respect to Own Neighborhood. That is, the children who participated in the current study were predominantly White, from stable, bi-parental homes of high socioeconomic status (S1 Appendix) and, following their own assessments, highly prosocial neighborhoods. While we observed that these children from highly cooperative neighborhoods rapidly adopted less cooperative norms, the reverse might not be true. That is, given that humans demonstrate a bias, across a host of domains, towards that which is negative [44,45], and given that disadvantage is associated with a lower rates of trust [46], children who have grown up in unstable, uncooperative, or impoverished environments might be less likely to adopt more cooperative norms.

There is also reason to think that, with age, there could be an increased effect of condition on those from less cooperative backgrounds. In a recent comprehensive study, Westhoff and colleagues [47] used economic games to investigate development changes in the adjustment of behavior to lab “environments” that vary in their level of cooperation with respect to the game play of others. Of note with respect to the current study, while participants of all ages (age eight to twenty-three) readily adjusted their behavior to be less cooperative in uncooperative environments, adolescents and adults were more adept at adjusting their behavior to more cooperative environments. This difference was driven by a greater tolerance of disadvantageous inequity for adolescents and older participants. In addition, while the behavior of adults and older adolescents quickly stabilized after an initial learning phase in a new environment, children and young adolescents continued to update their expectations of the environment and were more likely to alter their behavior based on a single, recent unexpected interaction. This leaves open the possibility that if adolescents and adults were to participate in the current study, their behavior in Neighborhood X would be more consistent with their behavior in Own Neighborhood, irrespective of perceived descriptive norms.

Clearly, extension of the current study to encompass a greater range of ages would bring to light developmental changes in the propensity for children and adolescents to recognize and adopt local norms in a novel social environment. Ideally, this would be done in concert with an extension of the study to children of more diverse backgrounds, in order to tease apart potential interactions among development, the effect of social environment of origin, and condition (Prosocial or Antisocial). However, given associations between residential mobility and socioeconomic status on the one hand, and collective efficacy (social cohesion and informal social control) on the other [48], it may be difficult to include children from backgrounds which are diverse with respect to cooperation without simultaneously introducing, for example, socioeconomic discrepancies between Own Neighborhood and Neighborhood X.

A related extant question is whether children in the study considered the residents of Neighborhood X and, critically, the child with whom they played a DG in Neighborhood X, as part of an out group. Norm manipulation studies have demonstrated that the extent to which a subject identifies with the reference group for a particular prosocial norm is of consequence [15,49]. While the current study was explicit as to whom the reference group for the norm manipulation was (i.e., the neighborhood), groups may be construed in many ways, and, given the cooperative backgrounds of the children in the current study, those in the Prosocial condition could have identified with residents of Neighborhood X on the basis of their similarly cooperative behavior, while those in the Antisocial condition might not have. Even at a young age, children demonstrate an in-group bias in resource allocation tasks [50,51], and thus it is possible that children in the antisocial condition gave fewer quarters to children in Neighborhood X because they considered them members of an out-group. This possibility could be evaluated via the creation of in- and out-group markers that are not based on cooperative norms, followed by manipulation of all combinations of group markers and cooperative norms. Future work could also incorporate questions about the extent to which participants identify with residents of Neighborhood X, for example, in an attempt to tease apart potential in-group/out-group effects on DG behavior.

Conclusion

Using a novel methodology, we found that by middle childhood, children have the propensity to 1) rapidly infer the local pro- and antisocial norms of a new social environment, 2) extend these inferences to norms for unobserved behaviors, and 3) apply the inferred cooperative norms when engaging in a social dilemma in the same social environment. Our results are consistent with the norm psychology hypothesis, which proposes that humans possess evolved cognitive and motivational mechanisms for the acquisition, application, and enforcement of local norms [11]. Of theoretical importance, norm psychology could, in concert with transmission biases [11], facilitate the maintenance of intergroup differences in prosocial behavior despite migration, which would enable the cultural group selection of cooperation [52–54].

Future studies, based on the methodology we present here, could investigate developmental changes in the recognition and adoption of pro- or antisocial norms in a novel social environment; one potentially rich source for such research is children who immigrate to a new country (or, perhaps, even move neighborhoods, cities, or states). Another avenue of inquiry could address potential biases stemming from the baseline level of prosociality in a subject's social environment of origin, or from a subject's identification (or lack thereof) with the residents of Neighborhood X.

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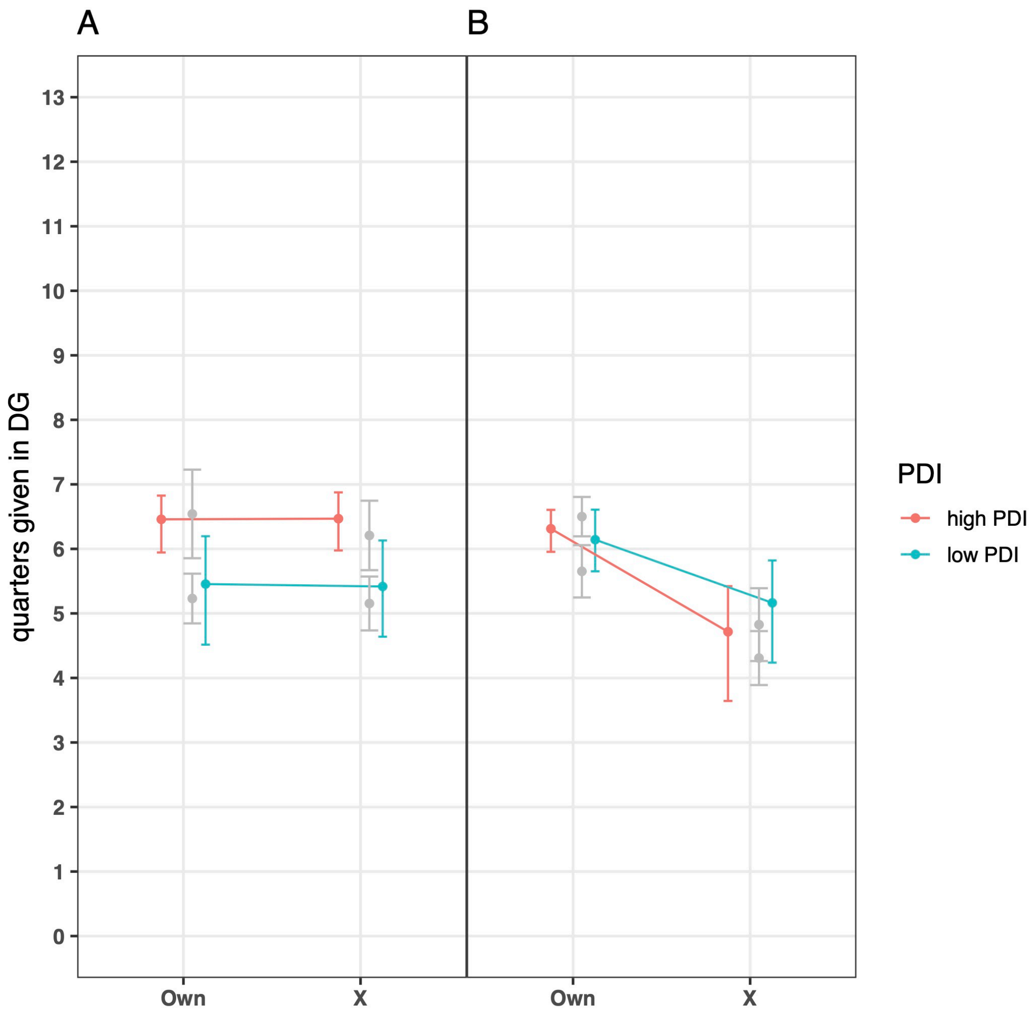
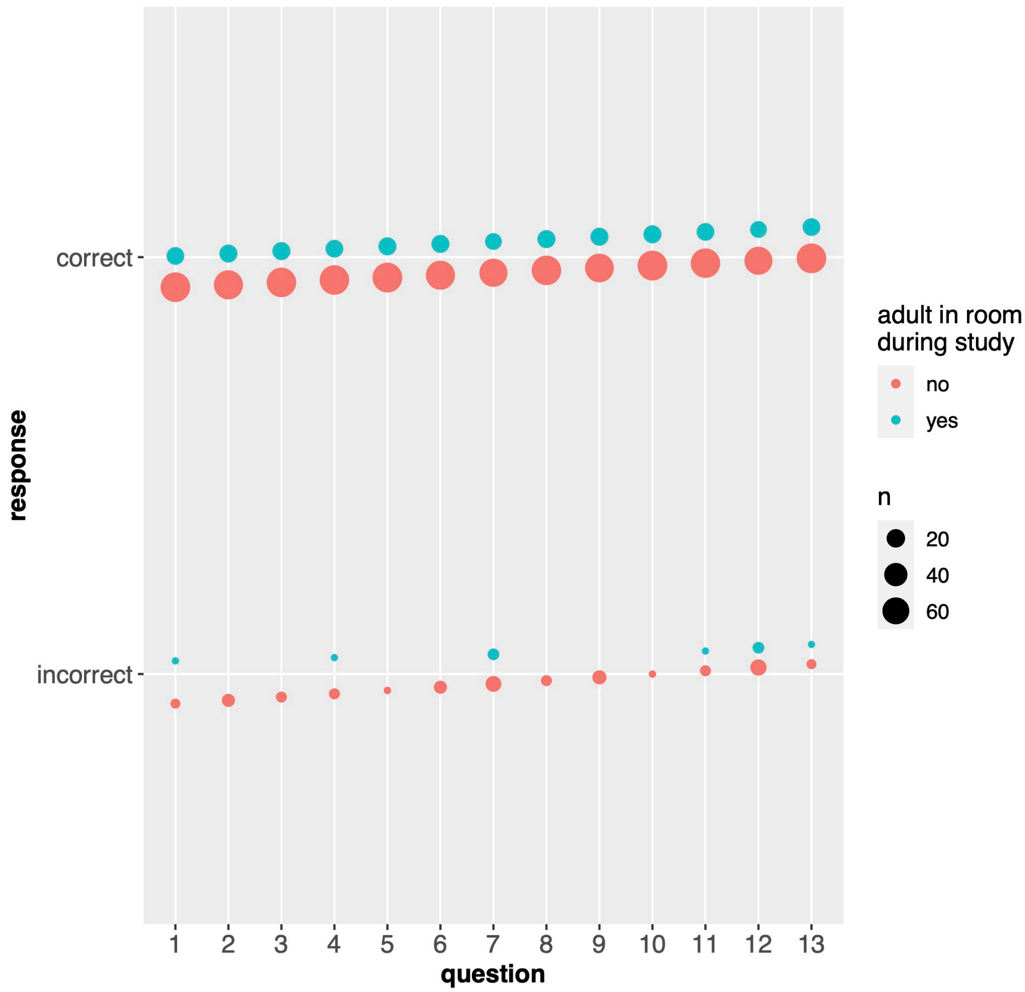
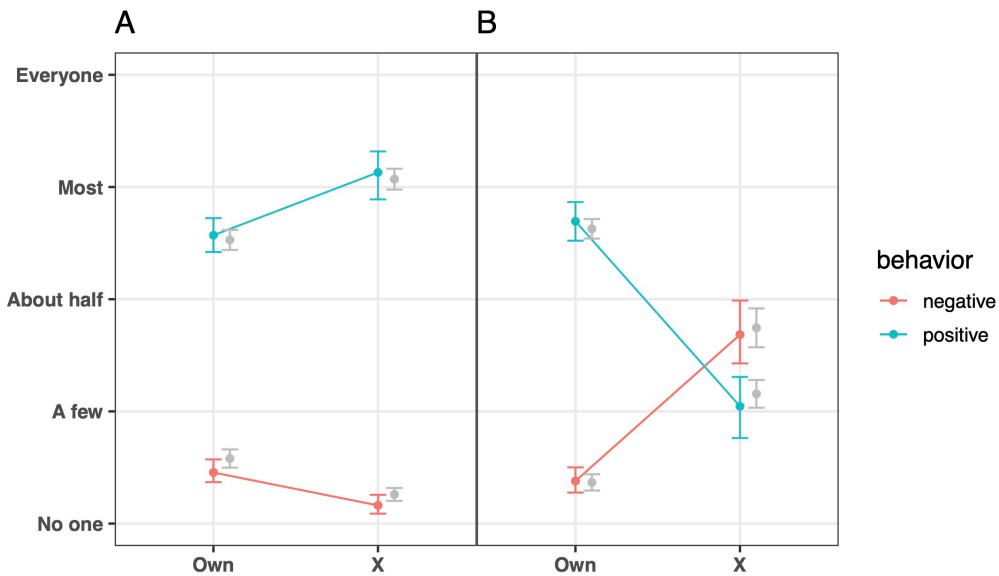


S1 Fig. Influence of parental desire for prosocial behavior on DG contributions by condition: Prosocial (A) or Antisocial (B). Model predictions (mean and 95% CI) for number of quarters given in the DGs as dependent upon parental desire for child prosociality (PDI). High and low PDI refers to above- and below-median values for PDI, respectively. The model specifies an interaction among *PDI*, *Antisocial condition*, and *Neighborhood X* (S1 Appendix). Means and standard errors of number of quarters given are plotted in gray alongside model predictions.



S2 Fig. Adult presence in room and number of correct/incorrect child responses. Counts of outcomes for each of 13 questions for which the response could be assigned a “correct/incorrect” value. Missing responses were treated as incorrect. As ordered, the 13 questions/instructions are: child’s age; child resides in multiple neighborhoods; successful use of drag and drop feature at first attempt during tutorial; number of balloons observed in box in during drag and drop tutorial; number of quarters in quarter game, Own Neighborhood (ON); identification (self/other) of re-cipient of quarters dragged to “Other Child’s Box” (ON); other child in quarter game lives in ON (true/false) (ON); quarters can be used to get digital prizes at end of study (true/false) (ON); successful clicking on target at first attempt during HeatMap tutorial; number of quarters in quarter game in Neighborhood X (NX); identification (self/other) of recipient of quarters dragged to “Other Child's Box” (NX); other child in quarter game lives in NX (true/false) (NX); quarters can be used to get digital prizes at end of study (true/false) (NX).



S3 Fig. Subset of descriptive cooperative norms for which children received no information in slideshow. Model predictions (mean and 95% CI) for descriptive cooperative norms dependent upon the interaction of Neighborhood (Own or X) and A) Prosocial or B) Antisocial condition, using the three survey items for which there was no explicit information in the slideshow. Tick marks indicate the proportion of the neighborhood who would perform the behavior (y-axis) and the Neighborhood (x-axis). Means and standard errors of actual responses are plotted in gray alongside model predictions.

	Model 1			*Model 2*		
	Estimate	**SD**	**OR**	**Estimate**	**SD**	**OR**
Fixed effects						
Participant age, years	-0.18	0.18	0.84 (-0.55,1.20)	-0.12	0.19	0.89 (0.61,1.27)
Neighborhood X	1.67	0.39	5.31 (0.90,11.47)			
Antisocial condition	0.40	0.31	1.49 (-0.21,2.72)			
Adult actor	1.60	0.13	4.95 (1.35,6.42)	1.60	0.13	4.95 (3.78,6.49)
*Neighborhood X * Antisocial condition*	-5.61	0.58	0.00 (0.00,0.01)			
Negative behavior	2.98	0.16	19.69 (2.67,27.39)	2.99	0.17	19.89 (14.44,27.66)
Variance components						
Participant intercepts	1.24			1.24		
Slopes for Neighborhood X, conditioned on Participant	2.33			4.02		
Correlation	-0.32			-0.33		
DIC	2333			2337		

S1 Table. Descriptive cooperative norms modeled as dependent upon an interaction between condition and neighborhood for a subset of the norms survey data. Ordered logit regression. Dataset includes only those questions for which there was no information in the slideshow. Higher values indicate more cooperative norms. “Negative behavior” refers to the single negative behavior in the data subset. Predictions from Model 1 depicted in S3 Fig.

	Est.	SD	OR
Fixed effects			
Intercept	2.16	0.97	8.67 (1.63,75.94)
Neighborhood X	0.62	0.29	1.86 (1.07,3.35)
Antisocial condition	0.02	0.41	1.02 (0.45,2.34)
*Neighborhood X * Antisocial condition*	-0.45	0.40	0.64 (0.29,1.38)
Variance components			
Participant intercepts	1.45 (0.22)		
Behavior intercepts	1.59 (1.47)		

S2 Table. Injunctive cooperative norms modeled as dependent upon condition and neighborhood. Binomial logistic regression; an increase is associated with the more cooperative norm. Model selection indicated strong support for varying intercepts for participants and behaviors, however, none of the specified fixed effects (including those shown here) improved model fit. Parentheses contain either standard errors (variance components) or 95% confidence intervals (OR).

	Model 1			*Model 2*			*Model 3*		
	Est.	**SD**	**OR**	**Est.**	**SD**	**OR**	**Est.**	**SD**	**OR**
Fixed effects									
Boy	-1.26	0.71	0.28 (0.07,1.13)	-1.37	0.81	0.25 (0.05,1.19)	-1.43	0.82	0.24 (0.05,1.17)
Descriptive norms	0.90	0.21	2.46 (1.65,3.70)				0.62	0.30	1.86 (1.03,3.39)
Neighborhood X				-0.05	0.40	0.95 (0.43,2.10)	-0.71	0.52	0.49 (0.17,1.31)
Antisocial condition				0.49	0.87	1.63 (0.31,9.30)	0.50	0.88	1.65 (0.29,9.49)
*Neighborhood X * Antisocial condition*				-3.04	0.65	0.05 (0.01,0.17)	-1.81	0.86	0.16 (0.03,0.90)
Variance components									
Participant intercepts	3.15 (0.42)			3.68 (0.51)			3.79 (0.52)		
DIC	645			607			603		

S3 Table. Number of quarters given in DG modeled as dependent upon estimates of individuals' perceived descriptive cooperative norms in the respective neighborhoods (Own and X) as well as condition. Ordered logit regression. An increase in descriptive norms indicates a more cooperative norm. Parentheses contain either standard errors (variance components) or 95% confidence intervals (OR). Predictions from Model 2 plotted in Fig 3.

S1 Appendix: Stimuli, summary of dataset, prosocial behavior in Helping Task

Neighborhood X Stimuli

Creation

With the help of volunteers and research assistants associated with the Social Development and Learning Lab (SDLL), we photographed all stimuli in two neighborhoods within Boston and Cambridge (Fig 1). The use of fabricated images of behavior to introduce Neighborhood X enabled us to retain as much ecological validity as possible while also controlling for confounding variables that are often correlated with cooperative norms, such as poverty [1]. We selected cooperative norm situations (Table 1) which satisfied the following conditions: 1) representation with one or two photos, 2) no physical harm, and 3) symmetry of people and setting for both conditions. We endeavored to include situations involving children and adults as well as situations involving consequences for both a single individual and the public good.

Validation

Twenty-four children (15 male) ages eight to 11 years, inclusive, were recruited at Boston Common, a large public park in downtown Boston, and at the at the Social Development and Learning Lab at Boston University. Participant age was chosen based on the ages we expected to focus on for the main (online) study but included 8-year-olds as well to increase the participant pool, as visitors to Boston Common are predominantly younger children. Research assistants approached families who were visiting the park accompanied by children that appeared to be in the appropriate age range. The families were asked to participate in a 15-20 minute study in the park that required their children to look at and rate (with respect to acceptability and frequency of behaviors) pictures of people either violating or upholding cooperative norms. Participants picked out a small toy valued at $1.50-$3.00 as a thank-you gift.

The acceptability of each behavior was assessed by asking subjects “What do you think about this behavior?” Answers were constrained to a five-point scale, anchored at “Very bad” and “Very good.” The frequency of each behavior was assessed by asking subjects “Do you think many people would do this?” Answers were constrained to a five-point scale, anchored at “No one would” and “Everyone would.” Data on the frequency of the behaviors is limited to 22 subjects as two children responded only “yes” or “no” when asked “Do you think many people would do this?”

Prompted by qualitative assessment of subject responses, we changed the text for two of the eleven norm stimuli to further clarify the Prosocial nature of the depicted behavior. We did this while the stimuli validation study was ongoing. We altered the Prosocial graffiti situation, which depicts a women painting over graffiti on a wall, so that it reads “We saw this woman cleaning up graffiti on a wall at the park” rather than “We saw this woman painting over graffiti on a wall at the park." The Prosocial gum situation, which depicts a boy throwing his gum away (rather than sticking it on a bench), was changed from "We saw this boy take his gum out of his mouth and throw it away" to "We saw this boy take his gum out of his mouth and throw it away in a trash can." We have data on the acceptability and frequency of the Prosocial situation with altered text for eleven and ten subjects, respectively.

To confirm that the participants assigned Prosocial situations a positive rating and Antisocial situations a negative rating, we fit binomial generalized linear models to the data. For each Prosocial situation, ratings were categorized as one (good, very good) or zero (okay, bad, very bad), and for each Antisocial situation, ratings were categorized as one (bad, very bad) or zero (okay, good, very good). Because of quasi-complete separation for some of the situations, we fit the models with the bias-reduction method of [2], as implemented in the R [3] package brglm [4]. Data plotting and model fitting were conducted with the R packages ggplot2 [5]and rethinking [6,7], respectively.

Visualization of the data revealed that the ratings were strongly patterned according to whether the situations were Prosocial or Antisocial, with Prosocial situations primarily rated as good/very good and Antisocial situations primarily rated as bad/very bad. This pattern is even starker when only the ratings assessed subsequent to minor editing of the text for two situations, *graffiti* and *chewed gum*, as described above, are considered, which suggests that the revisions we made to these stimuli were appropriate. Formal analysis, via fitting of binomial generalized linear models, confirmed that the Prosocial framing had a robust positive effect on the log odds that the situation was rated as good/very good (i.e., the estimated logit coefficients and 95% CI for all Prosocial stimuli were positive), and the Antisocial framing had a robust positive effect on the log odds that the situation was rated as bad/very bad (i.e., the estimated logit coefficients and 95% CI for all Antisocial stimuli were negative). Neither the age nor the sex of the participant appears to have affected the given rating.

Data cleaning and validation: Final dataset

One hundred and five children between the ages of 9 and 11 years, inclusive, participated in the online session over a period of eight months. Sessions were completed, on average, 18.2 days after either the mother (98) or father completed the online questionnaire (five parent surveys were completed subsequent to the child session). For unknown reasons, four recruited children never participated in the online session although their parents completed the questionnaire.

Child participants largely met the recruitment criteria, as indicated by their parents in the online questionnaire. One hundred of the parents confirmed that both biological parents were Caucasian, and all parents confirmed that their children had not been diagnosed with autism or dyslexia. Three parents reported that their children were taking psychoactive drugs (one of these children is included in the final dataset).

One hundred and one of the children completed the full session. The four children who did not complete the entire session either stopped for unknown reasons (two) or encountered a technical problem with a webpage (two). All four of these children completed the pre-stimuli questions (this included a questionnaire about generalized trust, the data for which were not included in the current paper), and one also completed the first (Own Neighborhood) DG. Only one of these children was exposed to the stimuli (Prosocial condition), so for three of the four incomplete sessions, failure to complete the session cannot be attributed to the stimuli. One of the two children who encountered a problem with a webpage attempted to complete the session on two separate occasions but encountered the same problem both times.

Of the 101 children who completed the entire session, two are excluded from the final dataset. One child started the session but had to leave for school immediately after viewing the stimuli. We provided an abbreviated version of the session for him, which he commenced over seven hours later, but he viewed the stimuli twice and play the two DGs at different times. The other child completed the full session without obstacle; however, there was a discrepancy in the number of quarters he indicated should be given to the other child in the first DG (i.e., his text response did not match his drag and drop response).

Of the final dataset, there are four participants for whom further comment is required. Two children started the survey on a smartphone or tablet. These initial attempts were abandoned due to technical difficulties and the children both restarted the session on a laptop or desktop computer (one started over within minutes, and the other started over on the subsequent day). Neither of these two children viewed the stimuli in their initial attempts, and thus while their initial attempts are not included in the final dataset, their subsequent complete sessions are.

Two different children were unable to successfully use a drag and drop interface in both the trial prior to the DGs and in the DGs; one of these children was also unable to successfully click on an object in both the trial and the stimuli set. It is possible that the children were frustrated by the experience, and this frustration could affect their responses; however, potential frustration should be captured by our affect measure. Data from both of these children are retained in the final dataset as they were able to use the text boxes to allocate quarters in the DGs.

Thus, the final dataset includes 99 children. There are data for 49 participants in the Antisocial condition, 25 of which are girls, and 50 participants in the Prosocial condition, 25 of which are girls. There are data for nine or ten participants of each sex, in each condition, for all ages except the following: 11-year-olds (five or six participants for each condition, both sexes), 9-year-old boys in the Antisocial condition (five participants), and 10-year-old boys in the Antisocial condition (13 participants).

The final dataset includes three sibling pairs, one of which is a pair of fraternal twins. All three sibling pairs were assigned to opposite conditions, and the parents were instructed to keep the siblings separate and not let them communicate until both had completed the study; two pairs completed the session simultaneously, and the siblings in the third pair completed it consecutively, without a time lag. Parents who had more than one child participate answered only the child-specific questions in the questionnaire multiple times.

The study population, as represented by participants in the final dataset, is remarkable with respect to the stability of their home lives. Ninety-two point nine percent of the participants reside with both of their parents. The majority of the participants also reside in homes or apartments owned by their parent(s) (87.9%) and have resided in the same neighborhood since infancy (56.6%). Only 15.2% of participants have lived in their neighborhoods for less than five years; of these, only 20% (three participants) moved neighborhoods more than once in the past five years.

Missing data

For the final dataset, very few questions were left unanswered. For questions about descriptive and injunctive norms in Own Neighborhood, 0.5% and 0% of questions, respectively, were left unanswered. For questions about descriptive and injunctive norms in Neighborhood X, 1.6% and 0.4% of questions, respectively, were left unanswered. Note that participants were unable to proceed to the next page without completing the text box portion of each DG.

Child experience

Children took, on average, 46 minutes and 56 seconds (σ = 31 minutes, 28 seconds) to complete the session, including prize selection and viewing of the debriefing video (approximately 5 minutes, 30 seconds). The shortest session was completed in 20 minutes and 27 seconds. Session length was recorded as greater than one hour for 13 children. Of these 13 participants, eight left the browser open on either the prize selection or debriefing video webpage for over ten minutes (two participants never navigated past these final webpages, resulting in sessions automatically shut down by Qualtrics after four hours). Excluding these eight participants, the longest session was 95 minutes, 5 seconds.

Approximately one-fifth of the participants (21.2%) said another person was in same room at start of study (2.0% of these participants indicated the other person was an adult). Only three of these indicated that the person was talking with them about the study. We investigated whether the presence of another person in the room influenced the children's responses; see *External influences on child responses* below.

Children were shown a sampling of potential digital prizes at the start of the session and asked how much they liked these prizes; they were also told that the final selection would depend on their choices during the study as well as the digital devices to which they have access (this question was posed on a subsequent webpage and not during viewing of the sample prizes). About half of the children (50.5%) indicated they saw prizes they liked, and only 8.3% did not see any they liked, with the rest unsure.

At the end of the session, children selected, via drag and drop, images of their top three choices for prizes. Every child received at least one, if not two, of their top three choices for prizes. We gave children as many of their top choices as possible as long as the total amount was within approximately one dollar of the child's total earnings from the session. Prize choice was strongly patterned, with a few prizes extremely popular, which suggests that we offered prizes that many of the participants liked. The most popular items were the games (apps) Minecraft (17) and Plants Vs Zombies (17). A subset of the books on offer was very popular as well: *Ungifted* by Gordon Korman (12), books from the Percy Jackson and Heroes of Olympus series by Rick Riordan (11), and *Boy* by Roald Dahl (7). MP3s were relatively unpopular.

Engagement with stimuli

Two measures enable an assessment of how engaged participants were with the stimuli (exposure to Neighborhood X): 1) Heat Map data collected with Qualtrics, which shows whether and where on the image(s) the participant clicked, and 2) time spent viewing the stimuli.

For each stimulus, subjects were instructed to “Click on the part of the picture you think is most important.” Of the 99 participants in the full dataset, 91 clicked on all stimuli at least one time. One individual never clicked on any of the stimuli (as mentioned above, the same individual failed to use the drag and drop interface), and another individual failed to click on the majority of stimuli (seven of eleven stimuli). The remaining six individuals who did not click on all stimuli only failed to click on one stimulus (five individuals) or two stimuli. Thus, almost all of participants interacted with almost all of the stimuli as directed.

To assess whether the participants were attending to the aspects of the stimuli relevant to social behavior, we randomly selected nine participants for each condition and visually reviewed where upon each image they clicked. For the Antisocial stimuli, only one of 99 assessed clicks was not on the actor, the human recipient of action, or one of the objects (e.g. candy, mail, litter or trash can) mentioned in the text (the child clicked on the fire hydrant in the dropped mail stimulus). Similarly, for the Prosocial stimuli, only one of 99 assessed clicks was not on the actor, recipient of action, or one of the objects mentioned in the text (the child clicked on a grassy area next to dog poop in the dog poop stimulus).

Thus, it appears that the children chose as “most important” those aspects of the stimuli which we also considered relevant. Because of a lack of variation in whether the participant clicked on a relevant aspect of the stimuli, we did not consider this variable in downstream analyses.

The median time children spent viewing all 11 stimuli is 2 minutes, 44 seconds (MAD = 60 seconds). Median time spent viewing the stimuli is 39 seconds longer for participants who viewed the antisocial stimuli (2 minutes, 51 seconds; MAD = 34 seconds) than those who viewed the prosocial stimuli (2 minutes, 12 seconds; MAD = 34 seconds). Negative binomial regression analysis confirms that children in the Antisocial condition spent 17.3% (95% CI [3.0%, 33.7%]) longer viewing the stimuli than those in the Prosocial condition and that older children spent less time on the stimuli (11.8% less time per year; 95% CI [19.4%, 3.6%]). The total number of words in the stimuli for the Antisocial Neighborhood X is 163, as opposed to 174 for the stimuli used for the Prosocial Neighborhood X, so it is unlikely that the longer time children in the Anti-social condition spent viewing the stimuli was due to greater reading time. A robust association between sex and time spent viewing stimuli was not observed.

Computer competence and comprehension of the Dictator Game

Prior to viewing the stimuli, participants were given a brief tutorial on using test boxes and radio buttons, and all participants then successfully used text boxes and radio buttons.

Participants were also given a brief tutorial on clicking on a target on the screen. Following the tutorial, 91 of the 99 participants in the final dataset correctly clicked on a trial target, two did not click on anything (one of these, as mentioned above, never successfully used the drag and drop interface either), and six clicked off-target.

For both DGs, participants were instructed to indicate the number of quarters to be allocated to themselves and the other child via both text boxes and drag and drop of images of quarters. Prior to the first DG, participants were given a brief tutorial of the drag and drop interface, followed by a trial. Three participants failed to successfully complete the trial drag and drop (participants were given only one try). Of these, one subsequently successfully allocated quarters via drag and drop but, as described above, two failed to use the drag and drop interface and indicated quarter allotments only via text boxes.

Prior to both DGs, participants were given instructions for the game and then asked a series of questions to assess their understanding of the game. Each time, one child (a different child each time) indicated the wrong number of quarters in the game (13 is the correct answer) via multiple choice. Prior to the first DG, 93.9% of participants correctly answered on the first try, via multiple choice, that the quarters put in the Other Child's Box would go to Another Child, not to themselves. Of the six participants who did not respond correctly, three were asked again (this check was not implemented until approximately five weeks after commencement of the study), and two of these three answered correctly on the second try. Participants who answered this question correctly on the first or second try (95) were then asked if the child lived in his/her neighborhood; of these, 11 (11.1%) answered incorrectly, and one did not answer.

Prior to the second DG, 95 of the 99 participants (95.9%) correctly answered, on the first try, via multiple choice, that the quarters put in Other Child's Box would go to Another Child, not to themselves. Of the four who did not respond correctly, one was asked again (see above), and this child answered correctly on the second try. Participants who answered this question correctly were then asked if the child lived in Neighborhood X; of these, 13.7% answered incorrectly, and one child did not answer. Of concern is whether children responded "No" to this question, or the corresponding Own Neighborhood question, because of disbelief, rather than error or lack of understanding of instructions. If this were true, we would expect older children to be less gullible. However, there is a lack of evidence from multilevel logistic regression that the child's age, sex, the condition to which she was assigned, or the neighborhood to which the question referred (i.e., Own Neighborhood or Neighborhood X) affected whether this question was answered correctly (for all fixed effects coefficients--age, sex, condition, neighborhood--the estimated standard errors were substantially larger than the mean estimates).

Additionally, the webpages for both DGs, which the participants viewed subsequent to answering the DG comprehension questions, contained two additional textual indicators of the other child's neighborhood (either Own Neighborhood or Neighborhood X). One indicator was in the instructions above the quarter drag and drop interface: "Check to be sure you know… which box is for the Other Child in Your Neighborhood" (or "the Child in Neighborhood X" for the second DG). The other indicator was placed below the drag and drop interface, next to the text box in which participants were to enter how many quarters to allocate to another child. Participants were prompted to indicate how many quarters were allocated to "the Other Child in Your Neighborhood" (or "the Child in Neighborhood X").

Two children incorrectly answered the question of whether the quarters put in the Other Child's Box would go to Another Child prior to both DGs. Both of these children took the study before a change was implemented wherein the question would be posed again if participants answered incorrectly. However, both answered all other test questions correctly for both DGs, and moreover, both demonstrated consistency in the number of quarters allocated to themselves and another child via drag and drop and via text boxes, so we infer that these children understood which amount was being allocated to themselves and which amount was being allocated to another child.

Prior to both DGs, 3.0% of children incorrectly indicated, via multiple choice, that they could not use the quarters in the game to get one or more digital prizes.

Overall, the remarkably high consistency between drag and drop and text responses for both DGs (there was one inconsistency, as mentioned above, out of 194 potential inconsistencies; this child answered all other test questions correctly but was excluded from the final dataset) suggests general comprehension of the quarter distribution schema. The high consistency between drag and drop and text responses also suggests that the participants were carefully attending to their actions in these tasks.

Triangulation of child age

As a separate check of child engagement with the study, computer comprehension, and accurate merging of data from the child sessions and parent surveys, we checked for consistency in child age from three different sources. At the start of the study, children entered their age in a text box to assess their familiarity with the use of text boxes. This value was checked against the child's age as calculated from our records of the child's date of birth and the date the child participated in the online session. The child's data of birth according to our records (database of children recruited to the SDLL) were then checked against the birth month and birth year as entered by the parent.

Three child participants in the full dataset gave incorrect ages; one of these entered an age that was wildly incorrect (2 years) and likely a typo, and the other two entered ages that were within five months of their true age, which thus may represent cognitive mistakes or wishful thinking. A fourth inconsistency was found that is likely due to error in our records, as the parent and child gave concordant information that differed from what we had on record.

External influence on child responses

Because we did not observe the child's participation in this study, we conducted a series of analyses to search for an effect of external influences on child responses. We assessed 1) whether parental desire for prosocial behavior in children is predictive of DG giving, and 2) whether the presence of another person in the room during the study is predictive of correct responses to questions or of 3) DG giving.

Parental desire for child prosociality

As mentioned in the **Methods** section of the main text, parents were asked to complete a survey prior to the participation of their child. With respect to child-rearing, we asked parents, "In your opinion, how important is it for children to develop or learn the following?" Parents responded via a seven-item scale, with one corresponding to "Not at all important" and seven corresponding to "Extremely important." Three of the nine items on this questionnaire are pertinent to prosociality: "Learn to help others," "Learn to care for the well-being of others," and "Learn to cheer up others."

We created a "parental desire for child prosociality index" (PDI), using an approach similars to the descriptive norm indices. That is, we treated these three questions as repeated measures of parental desire for child prosociality and analyzed the data using binomial logistic regression models (given the paucity of variation in responses, we collapsed responses across the lower six bins of the scale) in R [3] with the packages glmer2stan [8], Rstan [9], and rethinking [6,7], with varying intercepts for individual parents and a fixed effect for *boy* as well as for two of the three questions. Each parent's score for the PDI is the mean estimate of the parent's intercept.

We then assessed a potential effect of PDI on behavior in the DG, using multilevel ordered logit regression, starting with the base model previously used to asses the affect of condition on DG behavior (S3 Table, Model 2). Model fit, as assessed with the deviance information criterion (DIC), improved when a three-way interaction among *PDI*, *Antisocial condition*, and *Neighborhood X* was added (DIC of 607 for the base model compared to DIC of 603). This effect of PDI could result from parental teaching, shared environment, shared genes, or real-time parental influence in the study. Our concern is whether there was real-time parental influence in the study; the plotted predictions suggest that this was not the case, because the effect of condition on DG behavior is still clearly present when PDI is considered; indeed, there is a greater (negative) change in DG behavior between Own Neighborhood and Neighborhood X for those children whose parents' score for the PDI was above the median, perhaps indicative of greater disillusionment (S1 Fig).

When *descriptive norms* are added to the model with *PDI*, the estimated OR for *descriptive norms* is approximately the same as before (S3 Table, Model 3) (OR 1.86, 95% CI [1.02,3.50]).

Presence of another person in room

Twenty-one children indicated that there was another person in the room during the online study; of these, all but two indicated that the person was an adult, and all but three indicated that the person was not interacting with them.

In order to assess the potential influence of another person on the child's responses, we looked for an effect of *adult in room* on both the probability that the child answered questions in the online study correctly and on the number of quarters given in the DGs. There were eleven questions in the online study for which there was a single correct answer or response. These include: the age (in years) of the child at the time of the study, whether the child lived in more than one neighborhood (here, the "correct" answer is the parent's response to this question), how many balloons were in the box (for the drag and drop tutorial), how many quarters were in the quarter game; who gets the quarters in the box labeled "Other Child," whether the Other Child lives in Own Neighborhood or not, and whether the quarters can be used to get digital prizes at the end of the study. The last four questions were asked for the DG in Neighborhood X as well. In addition to these eleven questions, children twice had to follow instructions to demonstrate that they comprehended a Qualtrics user function (drag and drop and Heatmap--ie, clicking on a target), with a resulting response that was clearly either correct or incorrect. Counts of incorrect/correct responses, color-coded by the presence of a person/adult in the room, are illustrated in S2 Fig.

To investigate an effect of *adult in room* on correct responses for these thirteen questions, we used the R [3] package lme4 [10] to conduct multilevel binomial regression analyses, with varying intercepts for individual children. We used the Akaike Information Criterion (AIC) [11] to evaluate improvements in model fit. The inclusion of *adult in room* did not improve model fit (AIC of 523 compared to AIC of 522 for base model with varying intercepts for individuals), and the estimated standard error was over eighty times the point estimate for the coefficient; similarly, none of the other investigated covariates (*boy*, *age*) improved model fit. This suggests that when other people were in the room during the study, they were not influencing children's answers to these questions. However, the occurrence of incorrect responses being relatively rare (S2 Fig), we would be unable to detect a small effect.

To assess whether the presence of an adult in the room is predictive of DG giving, we added fixed-effect terms for the presence of an adult in the room to the multilevel ordered logit model previously used to assess the effect of condition on DG giving (S3 Table, Model 2). DIC for the model with *adult in room* is the same as the for the model without (607). The standard deviation for *adult in room* is over twice as large as the mean estimate for the coefficient (OR 1.58, 95% CI [0.20, 13.33]). Thus, we do not discern a reliable effect of an adult's presence during the study on

DG behavior.

Prediction of prosocial behavior in the Helping Task

We observed a positive association between descriptive cooperative norms in Own Neighborhood and the number of Helping Tasks completed. Addition of *descriptive norms* for Own Neighborhood improves model fit (AIC is 744, compared to 762 for baseline model), and a one SD increase in descriptive cooperative norms in Own Neighborhood is associated with an expected 20% increase (95% CI [11%, 30%]) in the number of Helping Tasks completed. In concordance with this result, the number of quarters given in the DG in Own Neighborhood, but not in Neighborhood X, is also informative about the number of Helping Tasks completed (AIC of 738 for model with *quarters given* in Own Neighborhood versus 762 for model with *quarters given* in Neighborhood X; compare to 762 for baseline). An additional quarter given in Own Neighborhood is associated with an 9% increase (95% CI [5%, 14%]) in the number of Helping Tasks completed. Thus, participants who were more prosocial in the DG in Own Neighborhood were more prosocial in the Helping Task as well, irrespective of their behavior in Neighborhood X.

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