

## Supplementary Materials

### 1. Full Methods

### 2. Additional Figures

- ***Figure S2. Direct Reciprocity Across Trials***
- ***Figure S3. Proportion of Participants Engaging in Direct Reciprocity***
- ***Figure S4. Proportion of Participants Engaging in Group Reciprocity (Study 2)***

### 3. Additional Tables

- ***Table S1. Regression models for Studies 1 and 2***
- ***Table S2. Regression models for Studies 3 and 5***
- ***Table S3. Regression models for Study 4***

## 1. Full Methods

### Study 1

**Initial Trial.** The first trial was meant to establish the rules of the game and gain a measure of children's direct reciprocity before any group context was introduced. Children were shown four computerized confederates depicted at the top of the screen as avatars and described as the "other children" (ordering of the four animal avatars was randomly selected) as well as their own avatar on the bottom. After a series of questions to ensure children understood which avatar represented them and which one represented the confederates, children were told that the game would involve giving and receiving stickers. The experimenter then placed a wooden box in front of the child and computer (described as the child's box) and stated that any stickers the child earned during the game would be placed into the wooden box and would be theirs to keep and take home. Children completed one of two conditions (the Giving Condition was run initially run as a separate study, and the Stealing Condition was run as a second study, once data collection for the Giving Condition was complete).

**Group Assignment.** Immediately following the initial trial, children were then told that the next round of the game would be played with new children (i.e., new confederates) that were different from the ones they had just played with. Children were shown four new animal avatar confederates -- two wearing green and two wearing blue. The sides of the two colors (whether green characters were on the right or left) were randomly assigned.

Following procedures used in prior work (Rhodes et al., 2017), children were assigned to groups via their stated preferences for a food and an activity. Each group was given a label ("Zarpies" and "Gorps"), and children were told that the distinguishing characteristic of each group was the group's stated preferences. Children were then asked two questions to determine

which group they should be assigned to (“Do you like cookies or cupcakes more?” and “Do you like swimming or playing outside more?”). Regardless of the child’s answer, children were told that one of the groups (either Zarpies or Gorps) shared the child’s exact preferences and that they therefore also belonged to that group (e.g., “Zarpies also like swimming more, so you must definitely be a Zarpie”). The assignment of the child’s group and whether the child’s group members were presented on the left or right of the screen were randomized. To reinforce group assignment, children were given a necklace/scarf and hat of the color corresponding to their assigned group. The colored necklace/scarf and hat were placed on the child in real life and subsequently appeared on the participant’s avatar in the game. Children were then asked a series of questions to ensure they a) understood which group they belonged to, b) could point to their in-group members, c) could point to their out-group members, and d) understood that these confederate children were different from the ones they had previously interacted with. Almost no children had trouble with these questions, but corrective feedback was provided as necessary.

Children then completed two trials (an *in-group trial* and an *out-group trial*), the ordering of which was counterbalanced:

**In-Group Trial.** The sequence of events in the in-group trial mimicked what occurred during the initial trial, with the constraint that the benefactor or malefactor was in the child’s in-group. As in the initial trial, children went through an initial phase and then a reciprocating phase in which they either had to give a sticker to or take a sticker from one of the four confederate children.

**Out-Group Trial.** In this trial, children were again told they would be playing with different children. A set of new animal avatars was shown, and again, children were tested to ensure they understood which confederates were in their in-group and which were in their out-

groups. For this trial, the benefactor/malefactor was an out-group member. After they received a sticker or had theirs stolen, children engaged in giving or stealing in the reciprocating phase.

**Perceptual Similarity Control Trial.** After one final simulated delay, the last round consisted of a trial in which children were told there would be no more groups. Any group-based markers were taken away (the hat and scarf) from both the child and the child's avatar, and the child was then shown four new confederates. The confederates appeared in two groupings of two perceptually similar characters (i.e., two pink and two yellow) but neither pairing was described as a group. We included this trial to test whether any potential group-based reciprocity (i.e., giving to/stealing from the benefactor's/malefactor's in-group but not the benefactor/malefactor him/herself) may be attributed to perceptual similarity between the benefactor and his/her in-group rather than genuine group-based thinking. Thus, this trial served as a potential comparison of children's tendency to give back to perceptually similar agents if we had found evidence of group-based reciprocity. In order to avoid confusing the child by switching to and from group assignment, this trial was always presented last.

### Study 3

**Gender Trials.** Children completed 2 Gender Trials – a Gender In-Group Trial and a Gender Out-Group Trial, in which the benefactor was either within the child's in-group, or in the child's out-group, respectively. As in all previous games described, children were told they would interact with a new set of children after each trial. Thus, different confederates were used in the In-Group and Out-Group Trials.

In each trial, children were shown four computerized confederates, and told that two were boys, and two were girls. To make clear group distinctions, each confederate was marked with either a triangle or square, and children were told that boys (or girls) were marked with triangles

and girls (or boys) were marked with circles (see Panel B of Figure S1 below). We opted to use shapes instead of known gendered markers (e.g., pink vs. blue) in order to avoid potential interactions with children's own preferences and individual beliefs about the objectivity of such markers.

*Group Assignment.* Children were then shown a circle and triangle and asked which one they were – a boy or a girl. Once children had made their selection (all children self-identified their gender in a manner consistent with what was reported on their parental consent form), the child's computerized confederate was given the corresponding marker (e.g., a circle if circles represented girls and the child stated she was a girl).

**Nationality Trials.** In the Nationality Trials, two of the confederates were described as being from the “United States” and two from a “country far away called Fiji”. Group members were marked with the corresponding flags of the countries (see Panel A of Figure S1 below). As in the gender trials, children were asked to self-identify with one of the countries (the one child who did not self-identify with the United States was excluded) and the rest of the procedures mimicked the Gender Trials.

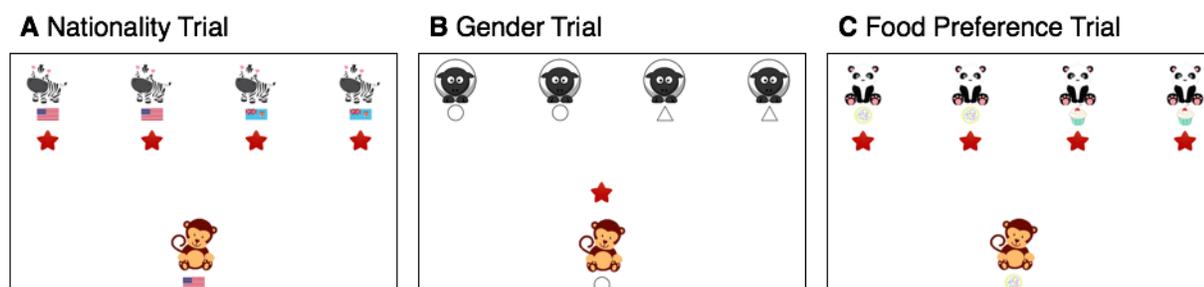
**Food Trials.** We included one minimal group that was used in the previous studies. This group was assigned based on children's stated food preferences and were marked as such (Figure S1, Panel C). Two confederates were described as “liking cupcakes more” and two were described as “liking cookies more”. Children were asked to self-identify with which food item they liked more and the child's avatar was given the corresponding marking.

Group assignment in all trials was emphasized by re-iterating the child's group membership throughout the game (“These children (are girls/are from the United States/like cookies more), just like you! These children (are boys/are from Fiji/like cupcakes more), *not* like

you!”). All other procedures in all trials mimicked the Giving Condition of Study 2, which assessed voluntary positive reciprocity. The six trials were presented in three blocks (Food, Gender, and Country) of 2 trials (an In-Group Trial and an Out-Group Trial) within each block. We counterbalanced the ordering of the blocks, ordering of trials within blocks, placement of ingroup vs. outgroup confederates on the child’s left vs. right, and types of animal characters used as confederates.

### Figure S1. Stimuli for Studies 3 and 5.

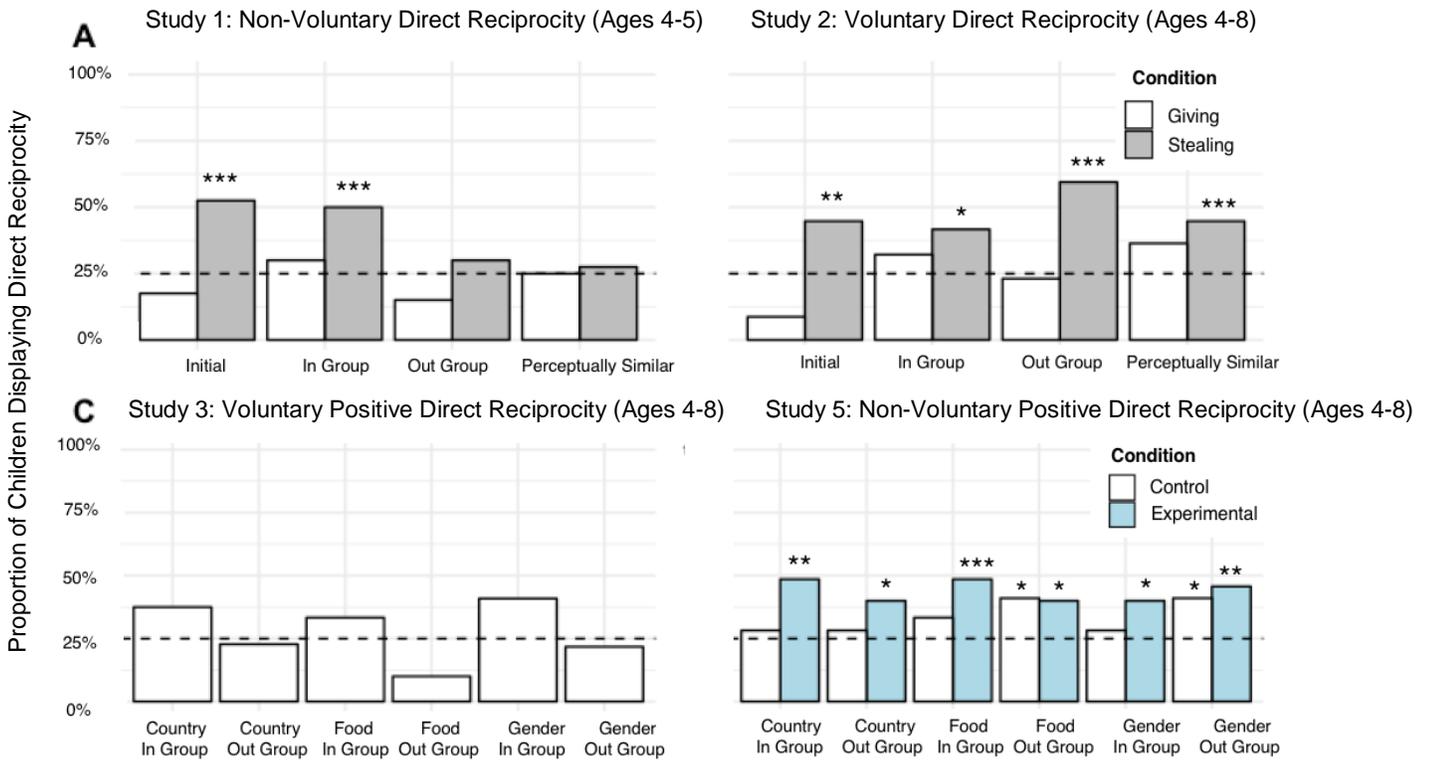
Example stimuli used in each trial type of Studies 3 and 5. Group members are marked using corresponding flags (nationality trials), shapes (gender trial), or food preference (food preference trials). Participant child also has a marker corresponding to his/her group



## 2. Additional Figures

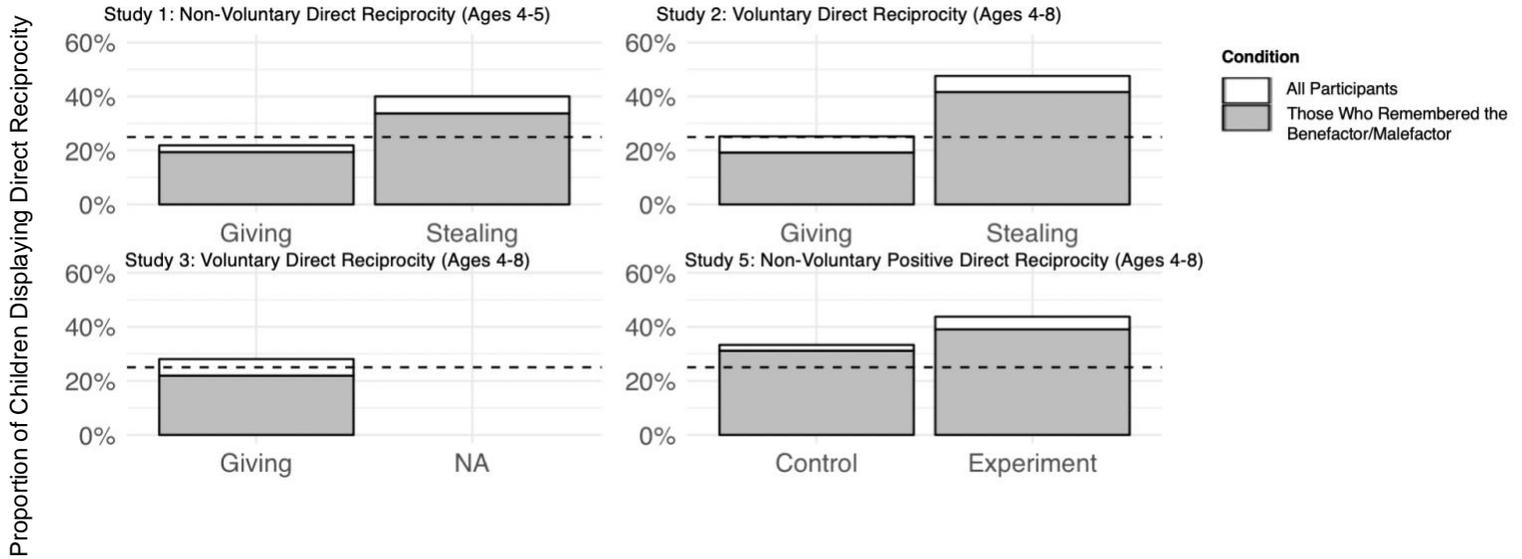
**Figure S2. Direct Reciprocity Across Trials**

Proportion of children who displayed direct reciprocity (gave back to/stole from the benefactor/malefactor). White and dark bars represent positive and negative reciprocity, respectively. Dashed lines indicate chance responding. Asterisks represent significant deviations from chance: \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ .



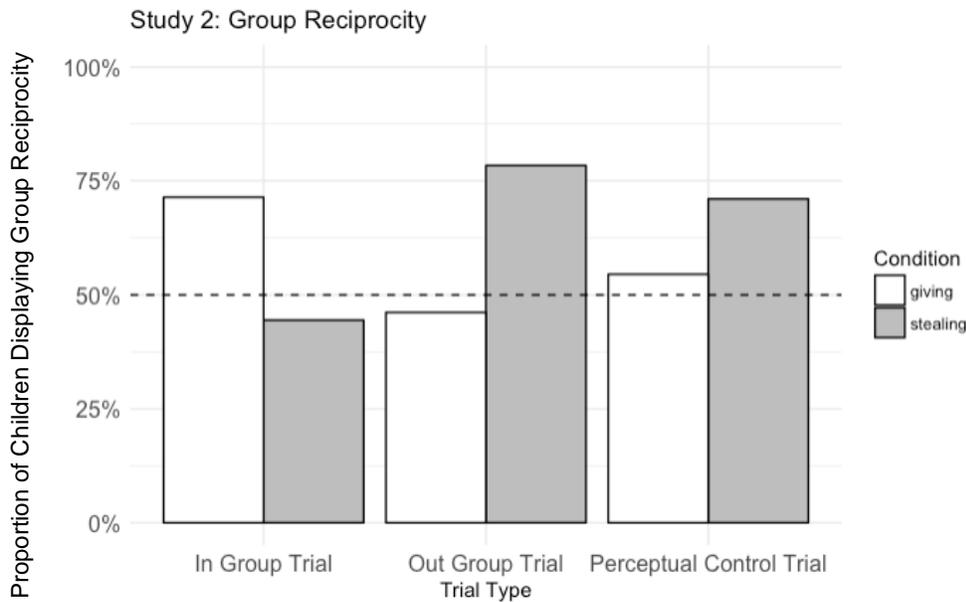
**Figure S3. Proportion of Participants Engaging in Direct Reciprocity**

Proportion of participants engaging in direct reciprocity as a function of condition and whether they remembered the benefactor/malefactor.



**Figure S4. Proportion of Participants Engaging in Group Reciprocity (Study 2)**

Proportion of children in Study 2 who displayed group reciprocity (gave back/stole from the benefactor's/malefactor's group). Dashed lines indicate chance responding.



### 3. Additional Tables

**Table S1.** Parameter estimates (and standard errors) of models predicting direct reciprocity and group-based reciprocity in Studies 1 and 2, and target behaviors in Study 2.

	DV = Direct Reciprocity (Giving to/Stealing from the Benefactor/Malefactor)		DV = Target Behavior (Opting to Give or Steal)	DV = Group-Based Reciprocity (Giving to/Stealing from the Benefactor's/Malefactor's Group)	
	Study 1	Study 2	Study 2	Study 1	Study 2
Intercept	-0.548 (1.653)	-2.028 (1.087)	<b>-4.353</b> <b>(1.942)*</b>	0.993 (1.286)	0.938 (0.826)
In Group Trial	0.275 (0.372)	0.386 (0.437)	0.456 (0.555)	0.467 (0.345)	-0.362 (0.372)
Out Group Trial	-0.777 (0.402)	0.794 (0.438)	0.301 (0.550)	-0.484 (0.331)	0.018 (0.380)
Perceptual Similarity Control Trial	-0.524 (0.391)	0.578 (0.441)	-0.148 (0.544)	--	--
Initial trial	--	--	--		
Condition (1= Stealing)	<b>1.081</b> <b>(0.377)**</b>	<b>1.200</b> <b>(0.425)**</b>	<b>5.517</b> <b>(1.023)***</b>	<b>0.650</b> <b>(0.293)*</b>	0.261 (0.309)
Age	-0.161 (0.336)	0.044 (0.157)	<b>0.751</b> <b>(0.319)*</b>	-0.182 (0.259)	-0.079 (0.120)

*Note.* Initial trial (direct reciprocity; target behavior) and perceptual similarity control (group-based reciprocity) were used as the reference groups. Significant effects are in bold. \*  $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$

Note: For Study 2, additional models including all interaction effects showed a significant Condition x Trial Type interaction,  $\chi^2(2) = 11.206, p = 0.004$ , when predicting group-based reciprocity. Follow-up analyses showed that this was driven by in-group bias, that appeared when group members acted in group stereotypical ways (when in-group members gave and out-group members stole): children were generally more likely to give to in-group members in the in-group trial, and steal from out-group members in the out-group trial. A figure displaying this interaction is shown in Figure S4 above.

Table S2. Parameter estimates (and standard errors) of models predicting direct reciprocity and group-based reciprocity in Studies 3 and 5, and target behaviors in Study 3.

	DV = Direct Reciprocity (Giving to the Benefactor)		DV = Target Behavior (Opting to Give/Steal)	DV = Group-Based Reciprocity (Giving to the Benefactor's Group)	
	Study 3	Study 5	Study 3	Study 3	Study 5
Intercept	-1.093 (1.605)	<b>-3.671</b> <b>(1.265)**</b>	-2.356 (2.568)	1.428 (1.227)	-1.505 (1.020)
Gender Block	0.571 (0.539)	-0.132 (0.287)	0.407 (0.420)	0.022 (0.467)	0.367 (0.269)
Country Block	0.501 (0.539)	-0.312 (0.289)	0.509 (0.422)	-0.417 (0.467)	0.073 (0.267)
Food Preference Block	--	--	--	--	--
In Group Trial Type (1 = In Group)	<b>1.023</b> <b>(0.438)*</b>	-0.119 (0.236)	0.136 (0.343)	<b>1.389</b> <b>(0.384)***</b>	<b>0.535</b> <b>(0.220)*</b>
Condition (1= Experimental)		<b>0.932</b> <b>(0.465)*</b>			0.440 (0.375)
Age	-0.155 (0.250)	<b>0.431</b> <b>(0.181)*</b>	0.409 (0.423)	-0.304 (0.193)	0.185 (0.146)

Note. Food Block was used as a reference group. Significant effects are in bold.

\*  $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$

Table S3. Parameter Estimates (and Standard Errors) of Models Predicting Direct Reciprocity Norm Endorsement in Study 4

	Study 4
Intercept	<b>-3.839</b> <b>(1.498)*</b>
Trial Type (1=Other-Norm Trial)	-0.506 (0.459)
Age	<b>0.525</b> <b>(0.214)*</b>

Note. Significant effects are in bold. \*  $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$