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Counting promotes proportional moral evaluation in preschool-aged children

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ABSTRACT

Preschool-aged children show remarkable sophistication in their social evaluation of others, yet struggle struggle with *proportional social evaluation* (evaluating others not only with respect to how much they give, but what proportion they give). Here, we explored whether prompting children to count would enhance using proportion during social social evaluation. Following prior work (McCrink et al., 2010), preschoolers ($N = 130$) completed 4 trials in which they made social evaluations of 2 puppets. The trials pitted puppets whose giving behavior was (1) absolutely (i.e., numerically) equal but proportionally different (one puppet gave 2/8 and another gave 2/4), (2) absolutely different but proportionally equal (2/4 vs. 1/2), (3) in conflict (one puppet gave proportionally more, but the other gave absolutely more; 1/2 vs. 2/8), and (4) whose proportional and absolute giving showed no conflict (3/4 vs. 1/12). Our critical question was whether children would select the poorer puppet (puppet with smaller endowment). Children were assigned to one of four conditions: a Full Counting condition in which they were prompted to count *both* the puppet's initial endowment as well as the stickers the puppet shared, a Partial Counting condition in which they counted only the initial endowment, a No Counting Condition, and a Continuous Condition in which a puppet gave 3/8 of a piece of playdough, rather than 3 of 8 stickers). These results show that encouraging children to count when evaluating sharing decisions promotes proportional reasoning in social evaluations. Additionally, across all conditions, our reaction time measures showed that selecting the poorer puppet was associated with slower reaction times (less automatic) than selecting the richer puppet during the conflict trial. The results are discussed in terms of implications for how cognitive limitations influence children's social reasoning in the context of equity.

1. Introduction

One of the most pervasive aspects of human cognition is the tendency to engage in automatic social evaluation of others. Indeed,

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social evaluation is widespread during early childhood: For example, by the third year of life, children prefer those who help others (Dunfield & Kuhlmeier, 2010), those who share resources equally (Rakoczy, Kaufmann, & Lohse, 2016), and those who share at a cost to themselves (Jara-Ettinger, Gweon, Tenenbaum, & Schulz, 2015). To enable social evaluations, children must attend to a wide variety of features of both acts and of individuals. Prior research has documented that preschoolers are able to take into account intentionality (Woo, Steckler, Le, & Hamlin, 2017), cost (Jara-Ettinger et al., 2015), equality (Schmidt & Sommerville, 2011), and charity (Wörle & Paulus, 2019). In spite of the relative breadth of preschoolers' social evaluations, they have trouble attending to *proportionality* (i.e., appreciating that giving ½ of one's resources is nicer than giving 2/10) when making evaluations of others' giving behavior (McCrink, Bloom, & Santos, 2009). Proportionality is particularly important to consider when reasoning about equity, which involves reasoning not only about a donor's surface action (X gave 2 stickers), but also the type of sacrifice that action represents for that particular individual (X gave away their only 2 stickers). That is, in order to evaluate 2 people with respect to equity concerns, one must attend not only to what those individuals give, but also to the types of resources they have access to. Whereas adults focus on proportional giving when evaluating the generosity of others (Hackel, Mende-Siedlecki, & Amodio, 2020), we argue that cognitive limitations in early childhood make it harder for children to evaluate others on the same terms. In this work, we test the hypothesis that an early disregard for proportionality is driven by a failure to incorporate information about initial endowments with information about items given due to their inabilities to count, track, and individuate items, while subsequently comparing two sets (initial endowment and amount given). To explore this possibility, we investigated whether a brief prompt to engage in counting promotes children's attention to equity-based concerns and enables proportion-based social evaluation.

In a seminal study by McCrink et al. (2010), preschool-aged children were asked to judge two agents across four types of situations. In each case, the two agents began with either the same or varying *initial endowments* (e.g., Agent A had 2 tokens, whereas Agent B had 4 tokens), and each agent gave either the same or varying amounts to the child (e.g., Agent A and Agent B each gave 2 tokens to the child). Then, children were asked to make a social evaluation by indicating which of these two agents was nicer. Although children as young as 4-years of age were able to take proportion into account when proportion did not conflict with absolute number (e.g., children judged Agent A, who gave 100 % of their resources, as nicer than Agent B, who only gave 50 % of their resources), children through 5 years of age had trouble making proportional social evaluations when proportion conflicted with absolute number. That is, children had trouble judging that an agent who gave 2/5 of its resources was nicer than the agent who gave 3/10, because while 2/5 is proportionately greater than 3/10, children seemed more swayed by the absolute amount given, or the numerator (the fact that $2 < 3$) when evaluating the agent's giving behavior.

These "errors" in social evaluation are particularly important in the context of equity. More generally, preschoolers, for example, display a "wealth bias" such that they distribute more to high- rather than low-wealth individuals (Paulus, 2016; Shutts, Brey, Dornbusch, Slywotzky, & Olson, 2016). At the same time, they also tend to incorporate beliefs about need into their resource distributions (Elenbaas, Rizzo, Cooley, & Killen, 2016; Li, Spitzer, & Olson, 2014; Paulus & Leitherer, 2017; Paulus, 2014; Rizzo & Killen, 2016). However, children have considerable trouble combining *both* wealth- and need-based information when making social evaluations of others (McCrink et al., 2010) – a combination that lies at the heart of equity-based moral judgments. This limitation is striking given children's relative sophistication with social evaluation more generally – as a whole, there is evidence that preschoolers attend to cost-based considerations, both in their own behavior and when evaluating the behavior of others (Chernyak & Kushnir, 2013; Chernyak, Trieu, & Kushnir, 2017; Jara-Ettinger et al., 2015; Sommerville et al., 2018).

Children's relatively slow development towards equity-based considerations mimics their general difficulty with proportional information (Lortie-Forgues, Tian, & Siegler, 2015). While even infants display an ability to represent proportional information implicitly (Denison, Reed, & Xu, 2013; Kushnir, Xu, & Wellman, 2010; Wellman, Kushnir, Xu, & Brink, 2016; Xu & Garcia, 2008), preschool-aged children have trouble inhibiting whole number information (i.e., numerator) in order to attend to information about proportional relationships (Ni & Zhou, 2005). Several strategies have been developed to combat this difficulty. For example, when children are presented with proportional information in a *continuous* format (e.g., 3/5 is shown as juice being poured, rather than discrete pieces of cookies being shared), children are more likely to succeed (Boyer & Levine, 2015; Boyer, Levine, & Huttenlocher, 2008; Hurst & Cordes, 2018). Additionally, prior work has suggested that when children first have opportunities to collaborate with one of the agents, they are more likely to attend to that person's proportional, rather than absolute, amount shared (Ng, Heyman, & Barner, 2011).

Building on this work, we investigated whether drawing children's attention to the agents' initial endowments through a counting prompt would promote children's equity-based social evaluation. Our own prior work suggests a strong relationship between children's counting and sharing behavior (Chernyak, Harris, & Cordes, 2019; Chernyak, Sandham, Harris, & Cordes, 2016). We reasoned that counting prompts might also help to draw children's attention to the information relevant to social evaluation (i.e., relationships among stickers shared and the agents' initial endowments). Thus, children were presented with a version of the study by McCrink et al. (2010) in which two agents shared resources with the child, and children were asked to make a social evaluation of the agents by indicating which was nicer and by how much. Children were allocated to one of four conditions. In one condition, we asked children to count both the agent's initial endowment and the number of stickers the agent shared (Full Counting Condition). Because children might already be attending to the number of stickers shared, we contrasted this with a condition in which we prompted children to count only the initial endowment (Partial Counting Condition). A third group of children were not prompted to count at all (Control Condition). Finally, we contrasted these with a fourth condition in which we used a strategy known to improve children's proportional reasoning – we used continuous stimuli (i.e., one continuous block of playdough that was shared) rather than discrete stimuli (i.e., countable stickers). We measured children's explicit social evaluations as well as their latency to make those evaluations (reaction times) to study the extent to which certain social evaluations were intuitive. We were interested in children's tendencies to evaluate the agent who had fewer resources as nicer.

2. Method

2.1. Participants

One-hundred thirty preschoolers (Mean age = 4.84; Range = 3.77–6.05; 64 female) were recruited from a database of child participants, local children's museums, preschools, and public parks in the greater Boston area. Thirteen additional children were tested but excluded due to equipment malfunction ($n = 8$) or experimental error ($n = 5$).

2.2. Procedure

All children first completed a computerized social evaluation task, adapted from McCrink et al. (2010), in which they completed 4 trials, each administered on a tablet touch screen computer. In each trial, children were presented with a pair of agents, each of whom began with an initial endowment of stickers ("This is Lamb. And look, these are Lamb's stickers. And look this is Cow. And look, these are Cow's stickers")[1] . Children were then told that the agents would share some stickers with them. The experimenter then proceeded to the next screen where children viewed each agent sharing a set of stickers with the child.

Trials represented 4 distinct within-subject conditions (following McCrink et al.'s (2010) study): a) a *baseline trial* in which the proportions shared were also evaluatively consistent with the absolute number of stickers shared (3/4 vs. 1/12) – that is, the agent who shared a greater absolute number of stickers was also the one who shared a greater proportion; b) an *absolutely equal trial* in which the number of stickers shared was constant across the two puppets, but the initial endowment, and therefore the proportion, differed (2/4 vs. 2/8); c) a *proportionally equal trial* in which the number of stickers shared varied across the two puppets, but the proportion shared remained constant (1/2 vs. 2/4); and d) a *conflict trial* in which the absolute number and proportion varied, and were in conflict with one another (i.e., the agent sharing the greater absolute number shared the smaller proportion; 1/2 vs. 2/8). Proportions were chosen such that the ratio among the two numerators, two denominators, and overall proportions was *at least* 1:2, a ratio that even infants have been documented to be able to be able to discriminate (Halberda & Feigenson, 2008; Xu & Spelke, 2000). As in the original study by McCrink et al. (2010), the baseline trial was always presented first whereas the order of the rest of the three trials, the characters involved, and the sides on which the proportions appeared (and the side of the character that had fewer stickers) were counterbalanced across participants. See Fig. 1.

Furthermore, children were allocated to 4 between-subjects conditions: a Full Counting Condition, in which the experimenter counted and also prompted children to count both the puppet's initial endowment immediately after being shown it, as well as count the number of stickers shared after sharing occurred; a partial Counting Condition, in which only the puppet's initial endowment was counted by the experimenter and participant; a No Counting (Control) Condition with no counting prompts; and a Continuous Condition (in which stimuli were continuous pieces) with no counting prompts.

Following the social evaluation task, children completed a counting task to assess their counting skills (modeled after Give-a-Number (Wynn, 1992)). In this task, children were presented with a set of items (ducks) and asked to provide varying set sizes of ducks as a measure of their overall counting proficiency. In particular, children were asked to provide 1, 3, 6, 8, and 10 ducks and place them into a bucket. The number of correct responses as well as the highest number obtained was recorded. Our analyses showed no effects of children's performance on this task on their social evaluations. Additionally, the modal response was to answer correctly on every single trial ($n = 65$ of 130 children did so), and there were no differences in the distribution of responses across conditions. Therefore, this task is not further considered or analyzed here. See Supplementary Data for a breakdown of knower levels.

2.3. Dependent measures

Following the presentation of each trial, children were asked to indicate which agent was nicer by tapping on a picture of the agent on the tablet, and then to verbally indicate whether the agent they chose was "a little nicer" or a "a lot nicer". Of particular interest was whether children would select the poorer agent (the agent with a smaller initial endowment, which also happened to be the agent who shared the greater proportion of resources on all trials except the proportionally equal trial) across trials. We thus calculated a 4-point Social Evaluation Score indicating the degree of positive evaluation of the poorer agent - a score of 1 indicated that children selected the richer agent as being "a lot nicer" and a score of 4 indicated that children selected the poorer agent as being "a lot nicer" (a score of 2 indicated that children selected the richer agent as being "a little nicer" and a score of 3 indicated that children selected the poorer agent as being "a little nicer"). Thus, a higher score indicates a greater preference for the agent with the smaller initial endowment (and thus a greater overall preference for proportionality). A small subset of children refused to provide a response, or their response was inaudible on some trials ($n = 70$ of 520 total trials) – data for that particular trial was coded as missing, but the rest of children's responses were included in analyses.[2]

We also recorded children's reaction times to select which agent was nicer. After the experimenter asked the child to indicate which agents was nicer, she immediately pressed a key to begin the timer. Reaction time was measured as the latency between when the experimenter finished the question and when the child indicated his/her response. Data, protocol, and stimuli are available at https://

[1] The word "playdough", rather than "stickers" was used in the Continuous Condition.

[2] Missing data were similar across trials: 15 in the Proportionally Equal Trial; 17 in the Absolutely Equal Trial; and 19 each in the Baseline and Conflict Trials.

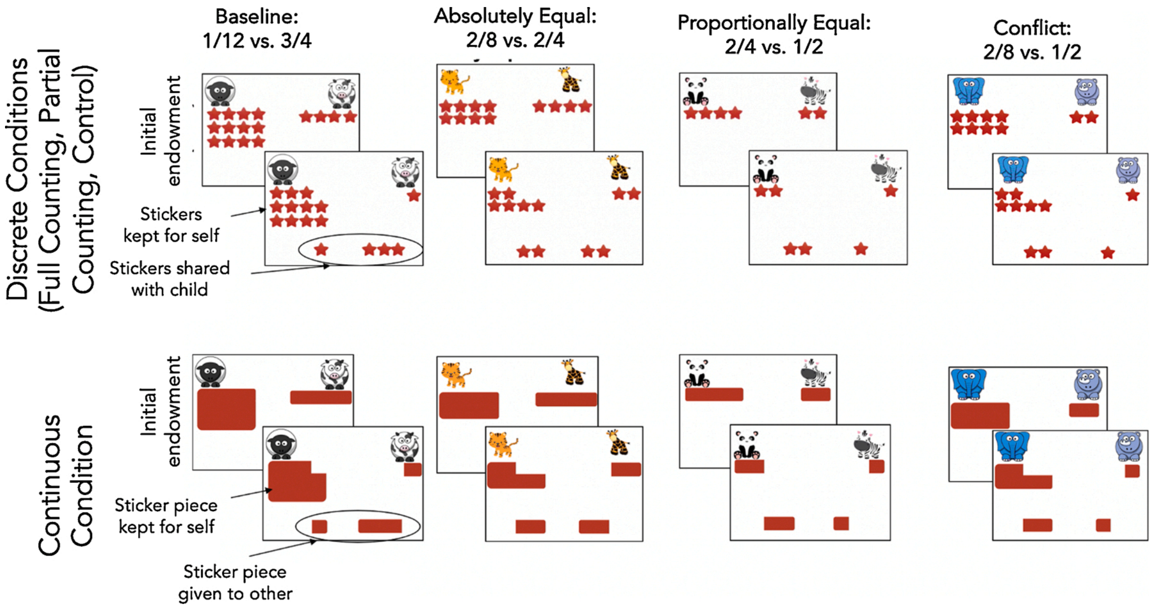

Fig. 1. Example of Stimuli and Trials in the Social Evaluation Task.
Note. Examples of stimuli used. The first panel shows the initial endowment. The second panel shows the stickers each animal kept for itself (top) and stickers shared with child (bottom).

osf.io/b7cp6/?view_only=d69085776f39456699772c3e458956bf.

3. Results

There were no effects of Gender, so data were collapsed across this variable. Our main research goal was to investigate the trials and conditions under which children would attend to equity-based social evaluation (selection of the poorer puppet). We ran a mixed linear model, using children's Social Evaluation Score as a response variable, and Age, Trial Type, Condition as the predictors. Subject ID was entered as a random effect. The results showed an effect of Condition, $\chi^2(3) = 8.314$, $p = 0.040$, an effect of Trial Type, χ^2 (3) = 80.641, $p < .001$, an Age x Trial Type interaction, χ^2 (3) = 14.627, $p = 0.002$, and no other significant effects (all p's > .46).

Fig. 2 below displays the Trial Type x Age interactions. As can be seen in Fig. 2 as children got older, they became *less* likely to select the poorer agent in the conflict and proportionally equal trial, but *more* likely to do so in the baseline and absolutely equal trial. This pattern of performance appears to be explained by developmental change in children's chance/baseline responding – although younger children tended to select agents at random, older children showed a prototypical, whole-number bias: they made social evaluations based on the absolute number of stickers agents gave, but not the proportional number.

Most critically, we found a significant Condition effect. To explore this Condition effect, we ran post-hoc tests in which we compared each condition to the No Counting Control. Compared with the No Counting condition, children were more likely to select the poorer puppet in the Continuous Condition, $t(222.98) = 2.608$, $p = 0.009$[3], and the Full Counting Condition, $t(218.91) = 2.443$, $p = 0.015$, but not the Partial Counting Condition, $t(219.94) = -0.809$, $p = 0.419$. See Figure 3. Thus, both fully counting initial endowments and stickers given as well as continuous stimuli promoted children's proportional (equity-based) social evaluation. The fact that there was no interaction of Condition and Trial Type suggests that the effect of Condition held across all trial types.

We also looked at children's reaction times. In particular, we were interested in how children's responses varied across trial types and across the agent they selected (i.e., the poorer or the richer agent). In order to avoid biasing our model with children who were very slow to make a decision, we natural log-transformed all reaction times. We ran a mixed linear model using log Reaction Time as the response and Age, Trial Type, Condition, Agent Selected, and all interactions as the predictors. We entered Subject ID as a random effect. The results revealed a significant effect of Trial Type, χ^2 (3) = 52.864, $p < .001$, a significant interaction of Trial Type x Agent Selected, χ^2 (3) = 19.296, $p < .001$, and no other significant effects (all p's > .15). Notably, the main effect of Condition and the interactions involving this variable were all non-significant.

To investigate the interaction of Trial Type x Agent Selected, post-hoc tests looked at the effect of Agent Selected within each trial (see Fig. 4 below).

Within the baseline trial, children who selected the poorer agent (i.e., who shared the higher absolute number and highest

[3] We followed a conservative approach of using a Welch's t-test which does not assume equal variances. Conclusions remain identical (all statistically significant results remain significant) if using the traditional Student t-test.

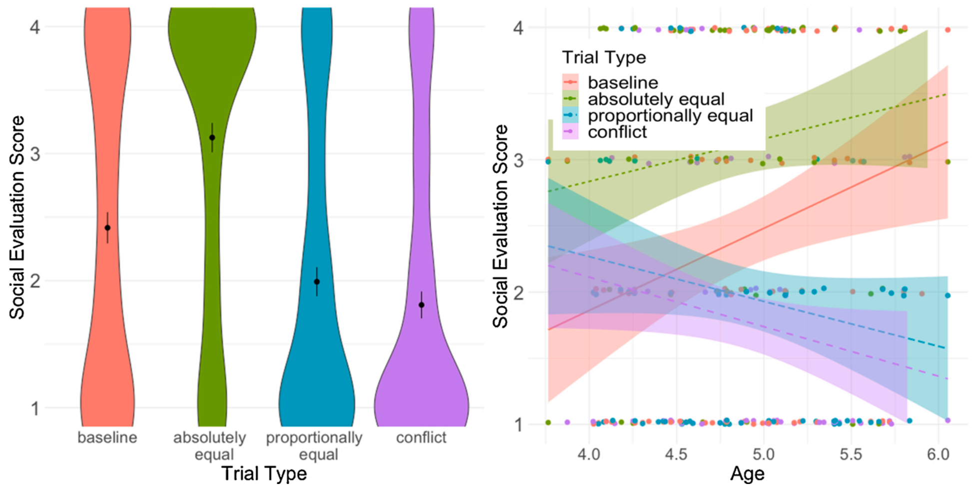

Fig. 2. Children's Selection of the Poorer Agent Across Trial Types and Ages.
Note. Left panel shows mean responses and distributions of individual responses via violin plots across trials. Bars represent +/− 1 standard error. Right panel shows predicted responses across trial types and ages. Scale reflects tendency to evaluate the poorer agent as nicer (1 = said richer agent was a lot nicer to 4 = said poorer agent was a lot nicer).

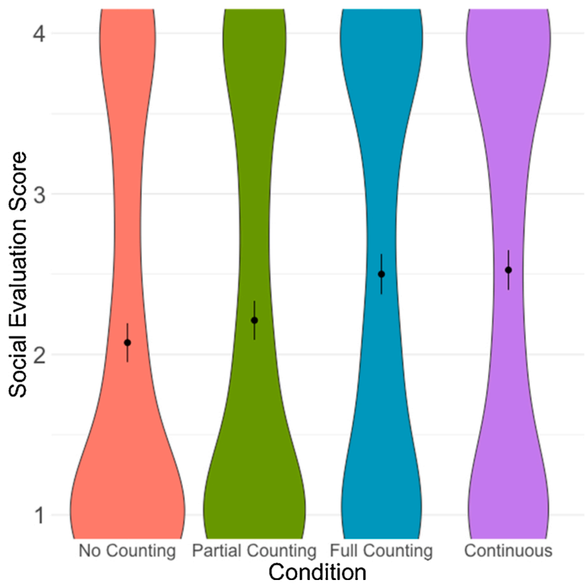

Fig. 3. Children's Selection of the Poorer Agent Across Conditions.
Note. Points represent means and bars represent +/− 1 standard error. Scale reflects tendency to evaluate the poorer agent as nicer (1 = said richer agent was a lot nicer to 4 = said poorer agent was a lot nicer).

proportion; $n = 91$) took a shorter time to do so than children who selected the richer agent (who gave a smaller absolute number and proportion; $n = 39$), $t(77.533) = 3.828$, $p < 0.001$, indicating that selecting the puppet who both gave more absolute numbers of stickers and a greater proportion was associated with a more intuitive response. In contrast, within the conflict trial, children who chose the poorer agent (who was the higher proportional giver, but the lower absolute giver; $n = 38$) took longer to respond than children who selected the richer agent (who was the lower proportional giver, but the higher absolute giver; $n = 90$), $t(91.856) = 4.140$, $p < .001$ suggesting that proportional moral evaluation may be more difficult when it conflicts with the absolute number of stickers given. The other two trial types did not show significant differences in reaction times for agent selection (both p's > .30).

4. Discussion

Our results show that prompting children to count promotes attention to equity-based concerns, and in particular, to social evaluations based on the *proportion* that an individual gives, rather than on the absolute amount. These results replicate prior work

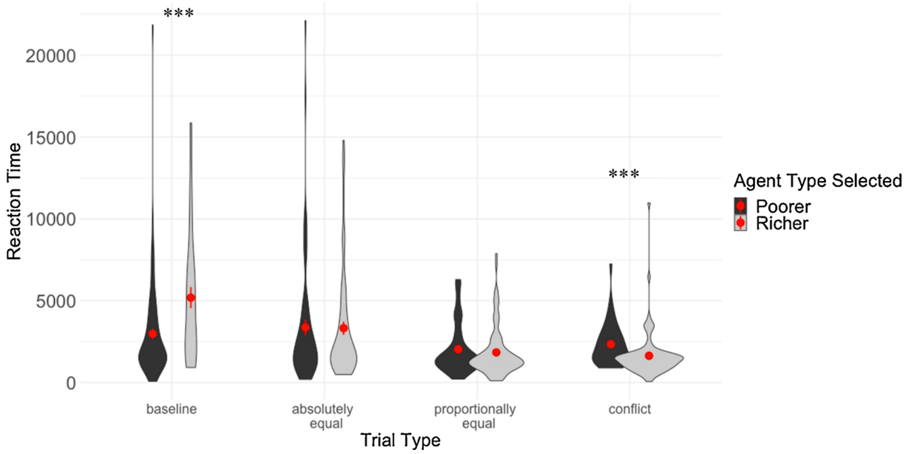

Fig. 4. Reaction Times (in milliseconds) as a Function of Trial Type and Agent Selected.
Note. Points represent means and bars represent +/− 1 standard error. Bars $^{***}p < .001$.

showing that children generally have trouble attending to equity concerns in their social evaluations (McCrink et al., 2010). We extend this work by showing two strategies that help shape children's attention to equity: prompting children to attend to relations between giving behavior and initial endowment through a counting prompt, and through using continuous stimuli.

These results are important to consider in light of preschoolers' general difficulties with equity-based concerns: Although preschoolers are sensitive to the notion that those with fewer resources ought to be allocated more (Wörle & Paulus, 2018), they have trouble doing so when those with fewer resources also give less to others (McCrink et al., 2009). We find similar effects here: preschoolers showed the most difficulty selecting the poorer puppet on the conflict and proportionally equal trials, in which the absolute amount given was inconsistent with the proportion. However, our results show that strategies that draw children's attention to relations between resources given and the puppet's initial endowment – as our Full Counting and Continuous Conditions did – scaffolded this ability (though notably, preschoolers were still not at ceiling levels). We thus propose that in addition to the social motivations that underlie the slow development of equity concerns, preschoolers' social reasoning is also underpinned by cognitive constraints.

It is important to better understand the mechanism through which counting served as a scaffold for children's equity-based judgments. One possibility may be that children tend to ignore initial endowments and focus only on the number of stickers allocated to the child, and that counting draws children's attention to the initial endowment. However, given prior work showing that children of this age can and do attend to recipients' neediness and "poverty" status (Malti et al., 2015; Paulus, 2014), and that partial counting, which presumably also drew children's attention to the initial endowment, was insufficient in improving children's equity-based judgments, we find this possibility unlikely. Another possibility may be that counting helps children's social evaluation skills more generally, by providing them with a tool enabling them to recognize each character's unequal sharing. Given that the majority of our children were cardinal principle knowers who already had at least some proficiency in symbolic counting, we believe this is also unlikely to be the case. Moreover, prior work finds that children's counting skills predict their sharing behavior, but not their evaluations/recognition of others' sharing (Chernyak et al., 2019). Instead, given that only full counting and not partial counting conditions improved children's equity-based reasoning, we propose that counting draws children's attention to relationships between quantities (i.e., the relationship between the initial endowment and stickers given) – a skill set that children generally have trouble with at this age, but one that is amenable to being taught (Hurst & Cordes, 2019). The fact that our continuous condition mimicked the effects of full counting echoes prior work showing that continuous displays are helpful for proportional reasoning at this age (Boyer et al., 2008; Hurst & Cordes, 2018) and reinforces the proposal that counting may have helped to inhibit children's whole-number bias (which was blocked in the continuous condition, where whole numbers were not used) in favor of attending to the relationship between endowments (wealth) and stickers given (donations) – a relationship that lies at the heart of equity-based social reasoning about others.

Our work suggests that children may devote little attention to initial endowment when making social evaluations. It is important for future work to identify the other types of information that children attend to when reasoning about equity. One possibility may be that children who were sensitive to equity concerns attended, not to proportion given, but rather to the *number* of stickers that characters kept (giving credit to those who kept fewer stickers, rather than to those who give away larger proportions). Given that stickers kept, however, was the same across several of the trials (e.g., the poorer character kept one sticker in the baseline, conflict, and proportionally equal trials), but nonetheless rates of choosing the proportional giver varied across these trial types, we believe this was unlikely to be the case. Instead, we believe our data are consistent with prior findings of whole number biases in the context of proportional reasoning tasks and social evaluation tasks (Hurst & Cordes, 2018; McCrink et al., 2010). Future work may also focus on how children's own social groups and socio-economic status may interact with their judgments of equity from others (Elenbaas & Killen, 2019).

Our reaction time results also show differences among children's puppet selections within the two "extreme" conditions (the easiest and hardest condition). In the baseline trial, where proportion given and absolute number were *not* in conflict, children were faster to respond when positively evaluating the poorer puppet as compared to the richer puppet. That is, providing a "correct" response when both absolute number and proportion were consistent was associated with faster responding than providing an "incorrect" response. In the conflict trial, where proportion and absolute number *were* in conflict with one another, children were faster to respond when positively evaluating the *richer* agent (i.e., the higher absolute giver, but lower proportional giver). This latter result suggests that evaluating on the basis of absolute number (rather than proportion) may reflect an intuitive response, whereas responding on the basis of equity-concerns may reflect a response that requires cognitive control. Arguably, children who selected the poorer agent in conflict trials inhibited a whole-number bias typically present at this age (Hurst & Cordes, 2018). This whole number bias would dictate that they choose the richer person (who gave an absolutely higher number of stickers) over the poorer person (who gave a larger proportion, but a smaller absolute number). This result is consistent with the fact that equity-based reasoning, relative to other forms of social and moral evaluation, appears relatively later in development (Elenbaas et al., 2016; Rizzo & Killen, 2016). Future work could directly investigate the mechanisms for these developmental changes in equity-based reasoning by investigating corresponding changes in cognitive control.

We believe our findings speak to two bodies of work, previously studied separately. First, recent work in resource distribution finds that though preschool-aged children are attentive to merit, equity, and equality concerns, their behavior does not always align with these stated concerns (Chernyak et al., 2019; Rizzo & Killen, 2016; Rizzo, Elenbaas, Cooley, & Killen, 2016; Smith, Blake, & Harris, 2013). A second body of work finds that preschool-aged children have trouble processing proportional information more generally (Boyer & Levine, 2015; Boyer et al., 2008). We propose that preschoolers' apparent inability to attend to equity concerns stems from their general difficulty in processing proportional information. Nevertheless, we find that even a short counting prompt increases the rate of equity-based responding. Our findings suggest, therefore, that one way to align young children's social norms with their actual resource distribution is to draw their attention to important numerical information. Overall, we propose that children's numerical skills serve as an important foundation for their higher-order social concerns.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.cogdev.2020.100969.

References

Boyer, T. W., & Levine, S. C. (2015). Prompting children to reason proportionally: Processing discrete units as continuous amounts. *Developmental Psychology, 51*(5), 615–620.
Boyer, T. W., Levine, S. C., & Huttenlocher, J. (2008). Development of proportional reasoning: Where young children go wrong. *Developmental Psychology, 44*(5), 1478–1490.
Chernyak, N., & Kushnir, T. (2013). Giving preschoolers choice increases sharing behavior. *Psychological Science, 24*(10), 1971–1979.
Chernyak, N., Harris, P. L., & Cordes, S. (2019). Explaining moral hypocrisy: Numerical cognition promotes equal sharing behavior in preschool-aged children. *Developmental Science, 22*(1), Article e12695.
Chernyak, N., Sandham, B., Harris, P. L., & Cordes, S. (2016). Numerical cognition explains age-related changes in third-party fairness. *Developmental Psychology, 52*(10), 1555–1562.
Chernyak, N., Trieu, B. Y., & Kushnir, T. (2017). Preschoolers' selfish sharing is reduced by prior experience with proportional generosity. *Open Mind, 1*(1), 42–52.
Denison, S., Reed, C., & Xu, F. (2013). The emergence of probabilistic reasoning in very young infants: Evidence from 4.5-and 6-month-olds. *Developmental Psychology, 49*(2), 243–249.
Dunfield, K. A., & Kuhlmeier, V. A. (2010). Intention-mediated selective helping in infancy. *Psychological Science, 21*(4), 523–527.
Elenbaas, L., & Killen, M. (2019). Children's perceptions of economic groups in a context of limited access to opportunities. *Child Development, 90*(5), 1632–1649.
Elenbaas, L., Rizzo, M. T., Cooley, S., & Killen, M. (2016). Rectifying social inequalities in a resource allocation task. *Cognition, 155*, 176–187.
Hackel, L. M., Mende-Siedlecki, P., & Amodio, D. M. (2020). Reinforcement learning in social interaction: The distinguishing role of trait inference. *Journal of Experimental Social Psychology, 88*, Article 103948.
Halberda, J., & Feigenson, L. (2008). Developmental change in the acuity of the "number sense": The approximate number system in 3-, 4-, 5-, and 6-year-olds and adults. *Developmental Psychology, 44*(5), 1457–1465.
Hurst, M. A., & Cordes, S. (2018). Attending to relations: Proportional reasoning in 3- to 6-year-old children. *Developmental Psychology, 54*(3), 428–439.
Hurst, M. A., & Cordes, S. (2019). Talking about proportion: Fraction labels impact numerical interference in non-symbolic proportional reasoning. *Developmental Science, 22*(4), Article e12790.
Jara-Ettinger, J., Gweon, H., Tenenbaum, J. B., & Schulz, L. E. (2015). Children's understanding of the costs and rewards underlying rational action. *Cognition, 140*, 14–23.
Kushnir, T., Xu, F., & Wellman, H. M. (2010). Young children use statistical sampling to infer the preferences of other people. *Psychological Science, 21*(8), 1134–1140.
Li, V., Spitzer, B., & Olson, K. R. (2014). Preschoolers reduce inequality while favoring individuals with more. *Child Development, 85*(3), 1123–1133.
Lortie-Forgues, H., Tian, J., & Siegler, R. S. (2015). Why is learning fraction and decimal arithmetic so difficult? *Developmental Review, 38*, 201–221.
Malti, T., Gummerum, M., Ongley, S., Chaparro, M., Nola, M., & Bae, N. Y. (2015). "Who is worthy of my generosity?" Recipient characteristics and the development of children's sharing. *International Journal of Behavioral Development, 40*(1), 31–40.

McCrink, K., Bloom, P., & Santos, L. R. (2009). Children's and adults' judgments of equitable resource distributions. *Developmental Science, 13*(1), 37–45.
McCrink, K., Bloom, P., & Santos, L. R. (2010). Children's and adults' judgments of equitable resource distributions. *Developmental Science, 13*(1), 37–45.
Ng, R., Heyman, G. D., & Barner, D. (2011). Collaboration promotes proportional reasoning about resource distribution in young children. *Developmental Psychology, 47*(5), 1230–1238.
Ni, Y., & Zhou, Y.-D. (2005). Teaching and learning fraction and rational numbers: The origins and implications of whole number bias. *Educational Psychologist, 40*(1), 27–52.
Paulus, M. (2014). The early origins of human charity: Developmental changes in preschoolers' sharing with poor and wealthy individuals. *Frontiers in Psychology, 5*, 344.
Paulus, M. (2016). Friendship trumps neediness: The impact of social relations and others' wealth on preschool children's sharing. *Journal of Experimental Child Psychology, 146*, 106–120.
Paulus, M., & Leitherer, M. (2017). Preschoolers' social experiences and empathy-based responding relate to their fair resource allocation. *Journal of Experimental Child Psychology, 161*, 202–210.
Rakoczy, H., Kaufmann, M., & Lohse, K. (2016). Young children understand the normative force of standards of equal resource distribution. *Journal of Experimental Child Psychology, 150*, 396–403.
Rizzo, M. T., & Killen, M. (2016). Children's understanding of equity in the context of inequality. *British Journal of Developmental Psychology, 34*(4), 569–581.
Rizzo, M. T., Elenbaas, L., Cooley, S., & Killen, M. (2016). Children's recognition of fairness and others' welfare in a resource allocation task: Age related changes. *Developmental Psychology, 52*(8), 1307–1317.
Schmidt, M. F. H., & Sommerville, J. A. (2011). Fairness expectations and altruistic sharing in 15-month-old human infants. *PloS One, 6*(10), Article e23223.
Shutts, K., Brey, E. L., Dornbusch, L. A., Slywotzky, N., & Olson, K. R. (2016). Children use wealth cues to evaluate others. *PloS One, 11*(3), Article e0149360.
Smith, C. E., Blake, P. R., & Harris, P. L. (2013). I should but I won't: Why young children endorse norms of fair sharing but do not follow them. *PloS One, 8*(3), Article e59510.
Sommerville, J. A., Enright, E. A., Horton, R. O., Lucca, K., Sitch, M. J., & Kirchner-Adelhart, S. (2018). Infants' prosocial behavior is governed by cost-benefit analyses. *Cognition, 177*, 12–20.
Wellman, H. M., Kushnir, T., Xu, F., & Brink, K. A. (2016). Infants use statistical sampling to understand the psychological world. *Infancy, 21*(5), 668–676.
Woo, B. M., Steckler, C. M., Le, D. T., & Hamlin, J. K. (2017). Social evaluation of intentional, truly accidental, and negligently accidental helpers and harmers by 10-month-old infants. *Cognition, 168*, 154–163.
Wörle, M., & Paulus, M. (2018). Normative expectations about fairness: The development of a charity norm in preschoolers. *Journal of Experimental Child Psychology, 165*, 66–84.
Wörle, M., & Paulus, M. (2019). Normative foundations of reciprocity in preschoolers. *Journal of Experimental Child Psychology, 188*, Article 104693.
Wynn, K. (1992). Children's acquisition of the number words and the counting system. *Cognitive Psychology, 24*(2), 220–251.
Xu, F., & Garcia, V. (2008). Intuitive statistics by 8-month-old infants. *Proceedings of the National Academy of Sciences, 105*(13), 5012–5015.
Xu, F., & Spelke, E. S. (2000). Large number discrimination in 6-month-old infants. *Cognition, 74*(1), B1–B11.