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## Dissociable Mechanisms for Diverse Prosocial Behaviors: Counting Skills Predict Sharing Behavior, but Not Instrumental Helping

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### ABSTRACT

By the preschool age, children exhibit a diversity of prosocial behaviors that include both sharing resources and helping others. Though recent work has theorized that these prosocial behaviors are differentiated by distinct ages of emergence, developmental trajectories and underlying mechanisms, the experimental evidence in support of the last claim remains scant. The current study focuses on one such cognitive mechanism – numerical cognition – seeking to replicate and extend prior work demonstrating the strong link between children's numerical cognition and precise sharing behavior, and further examining its relationship to instrumental helping. In line with theoretical perspectives favoring the differentiation of varieties of prosocial behaviors, we hypothesize that numerical cognition underlies precise sharing, but not precise helping behavior. Eighty-five 3 to 6-year-old children completed two procedurally similar tasks designed to elicit sharing and instrumental helping behavior, in addition to a Give-N task measuring their symbolic counting skills. Despite the procedural similarity, and the implicit norm of providing half (5 out of 10) stickers in both tasks, children's counting proficiency predicted precise sharing, but not precise helping. These results indicate a unique relationship between children's developing numerical cognition and behavioral fairness, providing empirical support for claims that varieties of prosocial behavior are supported by distinct underlying mechanisms.

Humans are unique in the myriad ways we act on behalf of others (e.g., Silk & House, 2011; Warneken & Tomasello, 2009). By the third year of life, children frequently help, inform, share, comfort, and cooperate with others (Dunfield, 2014; Svetlova, Nichols, & Brownell, 2010; Warneken & Tomasello, 2006, 2008, p. 2009). These other-oriented, *prosocial* behaviors are thought to be an integral part of interpersonal competence (e.g., Caputi, Lecce, Pagnin, & Banerjee, 2012). With age and development, the types of prosocial behaviors that are produced – and the contexts in which prosocial sentiments are displayed – diversify (Dirks, Dunfield, & Recchia, 2018). Over the last two decades, much research has been dedicated to identifying the underlying mechanisms that support effective prosocial action (Eisenberg, Spinrad, & Knafo, 2015; Martin & Olson, 2015). In many instances, researchers have, understandably, looked to *social* skills such as perspective taking, goal attribution, and

emotion understanding to help explain the development of prosociality (e.g., Dunfield, 2014). As a result, *cognitive* competencies have received considerably less attention. The aim of the present research is to (a) conceptually replicate work demonstrating an association between numerical cognition and sharing behavior via a pre-registered study, and (b) extend this examination to include instrumental helping in order to better understand the dissociable mechanisms that may predict the development of these uniquely human acts.

One cognitive skill that has been implicated in the development of prosociality in number cognition. Specifically, previous research has demonstrated that numerical cognition is related to *precision* in children's sharing behavior (Chernyak, Harris, & Cordes, 2019; Chernyak, Sandham, Harris, & Cordes, 2016; Jara-Ettinger, Gibson, Kidd, & Piantadosi, 2016). In these tasks, children were given a series of opportunities to allocate resources and then completed a separate numerical cognition assessment in order to test their counting proficiency. As compared with non-proficient counters, children who performed better on counting tasks were more likely to split resources exactly equally among two parties, in both the third- (Chernyak et al., 2016; Sarnecka & Wright, 2013) and first-person (Chernyak et al., 2019) contexts. Critically, this work also found that numerical cognition explained children's tendencies to share resources equally even when accounting for age-related changes, individual differences in motivation, and the understanding of equality as a social norm.

Sharing is a unique form of prosocial behavior in that it simultaneously pulls at two competing concerns – self-interest in hoarding resources, as well as empathic regard for another, both of which are known to dominate children's thinking (Blake & McAuliffe, 2011; Eisenberg et al., 1993; Fehr, Bernhardt, & Rockenbach, 2008; Paulus, Worle, & Christner, 2020). Numerical cognition provides an important tool for helping to resolve these concerns in a way that is equitable, impartial, and balances these competing concerns to an equal degree. We reason that numerical cognition may support sharing behavior in at least two ways: One possibility is that numerical cognition is recruited during sharing tasks specifically because it allows children to quantify and subsequently resolve competing demands (self-interest and other-regard). That is, by counting resources, children are able to ensure that both demands receive equal attention. Another, more deflationary possibility, is that *any* task that involves quantifiable items (as is *always* the case in sharing tasks) will, by necessity, draw on numerical cognition. On this account, there is no special relationship between numerical cognition and sharing – instead, *any* task that involves quantifiable items (sharing or not) would also draw on numerical cognition.

Like sharing, instrumental helping is an early emerging, common prosocial behavior. Yet, unlike sharing, instrumental helping is usually exclusively other-oriented, requiring children to represent another's goal directed behavior and the barriers to goal completion (Köster, Ohmer, Nguyen, & Kartner, 2016). In most instances, offering help to another can be done with little to no personal cost. Additionally, instrumental helping, as it occurs in naturalistic settings, often involves quantifiable items, if not explicit counting (e.g., to effectively help set the table, one needs to ensure they bring a specific number of place settings, no more no less). Thus, examining the relationship between numerical cognition and instrumental helping could further our understanding of the specific link between numerical cognition and sharing, as well as prosociality more generally.

One problem, however, has been that while prototypical sharing tasks *necessarily* invoke numerical cognition by virtue of having multiple quantifiable items (e.g., mini-dictator games; Fehr et al., 2008), prototypical instrumental helping tasks do not (e.g., a single dropped object, Warneken & Tomasello, 2006). In the most widely used helping tasks, children can effectively help by retrieving the *only* object on the floor and as a result, do not need to draw on numerical cognition. As such, common experimental tasks assessing sharing and helping behavior differ along at least two relevant dimensions: First, sharing tasks (unlike instrumental tasks) involve two *competing* concerns (selfish desire to hoard resources versus empathic concerns about fairness and the other) that can be resolved quantitatively, whereas instrumental helping tasks only make salient one person's need, and can be resolved without incurring much personal cost. Second, sharing tasks use multiple quantifiable items whereas helping tasks typically do not. Because these two factors are confounded in the existing literature, the mechanism underlying the relation between number cognition and precise sharing remains unclear. In our study, we sought to deconfound these two variables by introducing children to a typical sharing and novel instrumental helping task, both of which involve the use of multiple quantifiable items and both of which require a precise, quantifiable response.

The present study focuses on children's *numerical cognition* (i.e., counting proficiency) as it relates to sharing and helping behavior. If numerical cognition serves as a domain general tool for ensuring *precision* in prosocial behavior, we would expect that numerical cognition would be associated with *both* sharing and helping performance when assessed with tasks that involve quantities of multiple quantifiable items. This would support the possibility that the robust association between number cognition and sharing is due to the way in which we measure early sharing and as a result, number cognition would also be associated with any prosocial task that could be solved by attending to quantities. Alternatively, the relationship between sharing and number cognition could be driven by the fairness concerns involved in thinking about oneself in relation to others, and thus invoking quantitative comparison (Sarnecka & Wright, 2013). In this case, we would expect that numerical cognition explains age-related changes in *equal sharing* but not *precise helping*. Specifically, as instrumental helping involves recognizing the goals of another but not explicitly comparing another person's goals with one's own in a quantitative manner, nor trading off between satisfying one's own goals against satisfying the goals of another, it would not require counting skills.

This latter possibility is consistent with current theoretical accounts proposing that prosocial behaviors should be classified as distinct behaviors, each with differentiated underlying mechanisms, developmental trajectories, and neural substrates (e.g., Dunfield, 2014; Hay & Cook, 2007; Paulus, Kühn-Popp, Licata, Sodian, & Meinhardt, 2013; Paulus, 2018; Steinbeis, 2018; Warneken & Tomasello). These theories are further supported by prior work documenting the differences in the early development of sharing and instrumental helping. For example, although both sharing and helping can be elicited in the first two years of life (Dunfield & Kuhlmeier, 2013), early helping appears to be intrinsically motivated, requiring little explicit encouragement (Warneken & Tomasello, 2008), whereas sharing, relies more heavily on cuing (Brownell, Svetlova, & Nichols, 2009), and appears more difficult to motivate even when the recipient's desires are clear (Smith, Blake, & Harris, 2013). Importantly, accurately recognizing another's need and being motivated to act

prosocially are only two facets of effective prosocial behavior. The ability to *produce* an appropriate prosocial intervention – which we focus on in this present manuscript – likely relies on additional cognitive abilities. By examining the relation between number cognition and the precise production of two varieties of prosocial behavior, we can better understand whether the association between number cognition and sharing is a unique feature of the competing concerns endemic to sharing tasks, or whether it is a general artifact of the types of tasks we use to assess sharing and fairness concerns.

To test this open theoretical question we examined the extent to which numerical cognition, as measured by performance on a Give-N task (Wynn, 1990, 1992), predicts the accuracy with which 3–6-year old children help and share. We have created two structurally comparable helping and sharing tasks, in which addressing an experimenter's need involves either retrieving five out-of-reach stickers to complete a puzzle (helping task) or giving up five stickers to create an equal distribution (sharing task). In both tasks, attention to numerical quantities could support the production of an effective prosocial behavior. If numerical cognition is recruited on any task that could be solved using precise quantities then Give-N performance should be associated with both tasks. In contrast, if numerical cognition is uniquely associated with sharing behavior then we should observe a correlation between Give-N performance and performance on the sharing task but not the helping task.

## Method

### Participants

A total of 85 preschoolers (*Mean Age* = 4.25 years, *Range* = 3.01– 5.66 years) participated in the task. Forty-nine percent of parents filled out an optional demographics form. Of these, 43% identified their child as White, 21% identified as Asian, and 36% identified as multi-racial. Forty-seven percent of parents also provided information about their annual family income. Of these parents, a majority (62.5%) reported their annual family income as over \$120,000, 20% reported their income being within \$90,000 – \$119,000, 15% reported an annual income between \$60,000 – \$89,000, and the remaining 2.5% reported an annual income of \$30,000 – \$59,000.

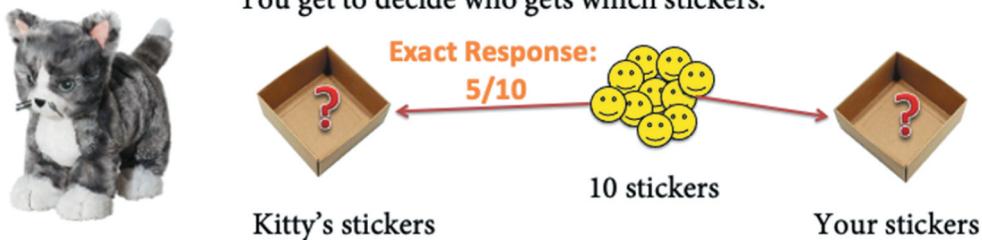
### Procedure

The preregistered procedure for this study can be found here: <https://aspredicted.org/blind.php?x=kv5fr9>. All children completed three tasks (described below): two prosocial tasks (order counterbalanced) followed by a numerical cognition assessment.

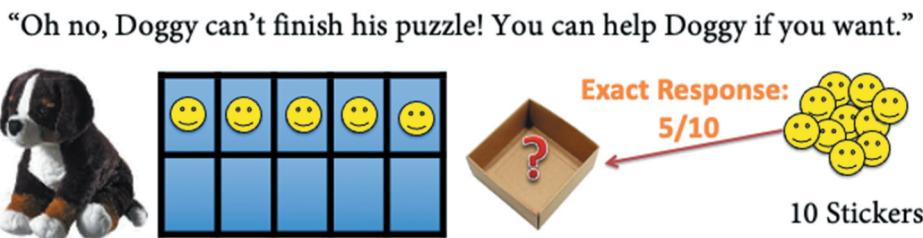
### Prosocial behavior tasks

Children completed two prosocial tasks (referred to as the *sharing task* and the *helping task*) in a counterbalanced order. In both tasks, children were endowed with 10 stickers and given the opportunity to share or help with a subset of the stickers. During all tasks, experimenters and children sat across from each other at a table, and all tasks took place on the table. Tasks were adapted from prior work (e.g., Chernyak & Kushnir, 2013; Dunfield, Kuhlmeier,

### Sharing Task



### Instrumental Helping Task



**Figure 1.** Comparison of sharing and helping tasks, where the goal was to present the puppet with 5 out of 10 stickers.

O’Connell, & Kelley, 2011; Warneken & Tomasello, 2006), but with critical modifications: Namely, because we were interested in potential differences between the tasks, we attempted to equate language, structure, and quantitative requirements as much as possible.

**Sharing task.** Participants were introduced to and familiarized with a dog puppet (“Doggy”) or a cat puppet (“Kitty”). The participants were then told that the puppet is feeling very sad because they didn’t get any stickers. Children were then provided with a pile of 10 stickers, and prompted to share any amount of stickers with the puppet or keep all of the stickers for themselves (e.g., “You get to decide who gets which stickers.”). The children were not encouraged to share the stickers in any specific way. The number of stickers shared was coded. If children did not distribute all of the stickers, they were prompted to either keep or share the remaining stickers (“And what do you want to do with these stickers?”) until all of the stickers had been distributed.

**Helping task.** As in the sharing task, participants had access to 10 stickers that they could use to help the puppet. Children were introduced to a different puppet (whichever was not used in the sharing task) and initially watched the puppet complete a familiarization trial in which they saw the puppet complete a puzzle with 4 stickers. That is, the participants watched as the puppet completed the puzzle by placing one sticker in each open place. Once all four pieces were in place and the puzzle was completed, the puppet expressed joy at its success (“*Yay I finished my puzzle!*”) in order to underscore the puppet’s motivation to

finish the puzzle, and clearly mark the completion of the puppet's goal. The puppet then attempted to complete a longer, second puzzle, requiring 10 stickers. The puppet retrieved a box of 15 total stickers (the puzzle required 10), and successfully placed 5 of the required stickers on the puzzle, thus leaving 5 of 10 spaces puzzle pieces missing and thus incomplete. When reaching for the sixth sticker, the puppet accidentally flipped the box, knocking a box that had 10 total stickers remaining in front of the child, out of reach of the puppet. The puppet exclaims in distress ("Oh no! I can't finish my puzzle.") and the child is then prompted to help the puppet by providing stickers ("You can help[kitty/doggy] if you want!"). Children were allowed to provide as many stickers as they wanted, and the trial was ended if they either indicated that they were finished retrieving stickers, or retrieved all 10 stickers. If children failed to respond within 10 seconds (either by giving stickers or by indicating that they didn't wish to), they were re-prompted. If children still did not respond, the trial concluded. We thus matched the helping task to the sharing task in two ways: 1) In both cases, children were tasked with dividing up a pile of 10 stickers, 2) The "goal" in both cases was to provide 5 of those 10 stickers to the experimenter (marked either through the norm of equal sharing in the sharing task or explicitly, through demarcating the 5 missing puzzle spaces in the helping task).

### **Numerical cognition task**

Children then completed a symbolic counting task (Give-N task; Wynn, 1992, 1990). In the task, children are asked to provide  $N$  objects, where  $N$  ranged from 1–6. After a brief familiarization trial confirming that they understood the task ("Can you place a duck into the pond?"), children completed a series of test trials in which they were asked to place  $N$  ducks into the pond. Test trials begin with children being asked to provide one duck ("Can you give me **one** duck?"), and end with verbal confirmation that the child finished the task to their satisfaction ("Is this **one** duck?"). If the child responds in the negative, the experimenter prompts them to fix it ("Can you fix it?"). If the child affirms their answer, the experimenter moves to the next trial and repeats these steps: a correct answer results in asking for  $N + 1$  objects and the wrong answer results in asking for  $N-1$  objects. The trials continue in this manner until the child has correctly provided  $N$  ducks twice and failed to provide  $N + 1$  ducks twice, or has successfully completed the  $N = 6$  trial twice.

Following prior work (Wynn, 1992, 1990), children were given a score corresponding to the highest trial that they reliably completed (0–6). Additionally, following prior work (LeCorre & Carey, 2007), children were grouped into two categories: 1) Cardinal Principle knowers (proficient counters), i.e. children who successfully completed the task by providing  $N = 6$  twice and 2) Subset-Knowers (non-proficient counters), i.e. children who failed to provide six objects. Below we report results based on Knower Level, analyses comparing Cardinal Principle Knowers and Subset-Knowers can be found in the supplemental materials.

## **Results**

Our analysis plan followed our pre-registered analysis, with one notable exception: we found an unexpected, strong effect of Task Order, and thus added Task Order and all interactions with Task Order into our analyses. Our main analyses remain as pre-registered

(<https://aspredicted.org/blind.php?x=kv5fr9>), while potential alternative explanations for participant behavior are tested through exploratory analyses. Analyses were conducted in R Studio (R Studio Team 2016). Data, analysis code, and protocols are available at [https://osf.io/jcp2m/?view\\_only=0aeff3d814084edcb1809eefe342a627](https://osf.io/jcp2m/?view_only=0aeff3d814084edcb1809eefe342a627).

There were no effects of gender so we collapsed all data across this dimension. Nearly all children engaged in both prosocial behaviors (defined as giving at least 1 sticker): 80/85 (94%) helped and 82/85 (96%) of children shared. There was no difference between rates of engaging in these two behaviors, McNemar's  $\chi^2(1) = 0.0125, p = .724$ . There was, however, a difference in sharing/helping precisely (defined as giving 5 out of 10 stickers): a greater proportion of children (29/85; 34%) shared exactly 5 stickers in the sharing task than in the helping task (11/85; 13%), McNemar's  $\chi^2(1) = 9.031, p = .003$ . On average, children gave 6.847 stickers ( $SD = 3.634$ ) in the helping task, and 5.259 stickers ( $SD = 2.26$ ) in the sharing task. There was no correlation between stickers given in the two tasks,  $p > .75$ , which suggests that in spite of the structural similarities, children did in fact respond differently.

Our first research question was whether numerical cognition would predict preciseness in sharing and/or helping. Prior work finds that children's sharing behavior becomes more *exact* as children get older (Chernyak et al., 2019). Therefore, we quantified preciseness continuously as the proportional difference between exact sharing (giving 5 of 10 stickers) and the number of stickers actually provided by the child (calculated as  $|\text{number of stickers given} - 5|/5$ ), which we refer to as a Deviation from Precise Sharing/Helping Score. We next ran a Generalized Estimating Equation Model (Halekoh, Højsgaard, & Yan, 2006) using Deviation from Precise Sharing/Helping Score as the response and Knower Level, Task Type, Task Order and all interactions as predictors. Additionally, we included Age as a covariate, in order to ensure that any effects of Knower Level were not simply driven by age. The results showed a significant effect of Knower Level and Order of Task. Additionally, all possible interactions were significant. Most notably, the 3-way interaction of Order x Knower Level x Task Type was significant, as well as our a priori predicted Knower Level x Task Type interaction. This interaction is displayed in Figure 1, details of the analysis are provided in Table 1.

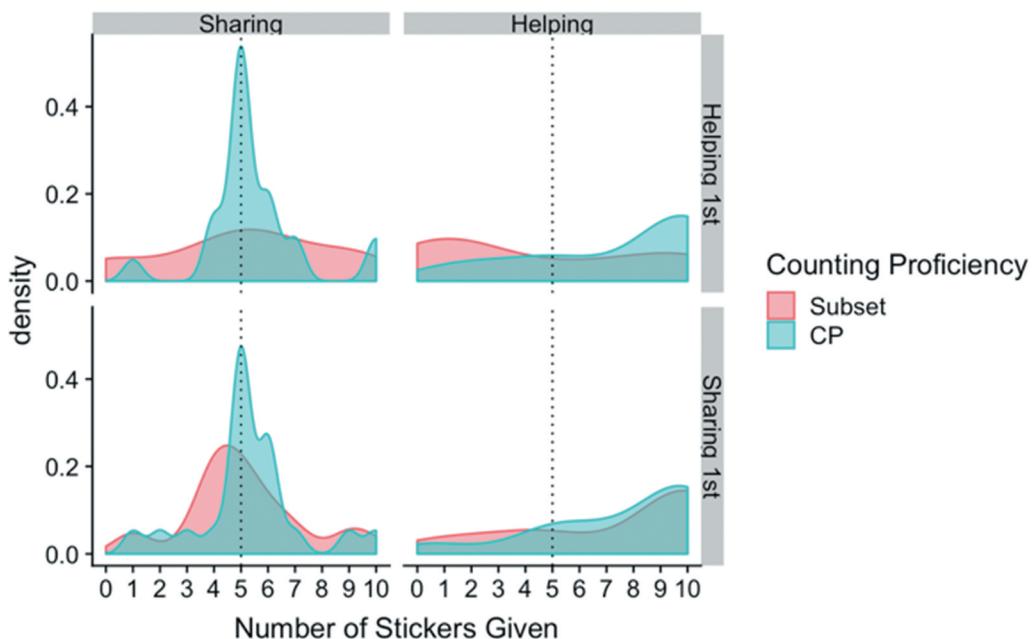
To formally investigate these interactions, we separated the data by task type and differentially explored the effect of Age, Knower Level, and Task Order on precise sharing and precise helping separately. We did this by first running a linear regression, including only trials measuring helping behavior using Deviation from Precise Helping as the

**Table 1.** Unstandardized regression coefficients (standard errors in parentheses) for models predicting sharing/helping behavior.

	Dependent Variable		
	Deviation from Equality	Exact Response	Stickers Given
Age	-0.025 (0.049)	0.523 (0.326)	<b>0.866* (0.394)</b>
Knower Level (0-6)	<b>-0.100*** (0.027)</b>	0.464 (0.278)	-0.420 (0.339)
Task Type (1 = helping)	-0.040 (0.197)	-0.088 (1.850)	<b>-4.697* (2.166)</b>
Order of Task (1 = sharing first)	<b>-0.551*** (0.184)</b>	2.910 (1.675)	-1.361 (1.974)
Knower Level x Task Type	<b>0.090* (0.040)</b>	-0.358 (0.383)	<b>1.145** (0.403)</b>
Knower Level x Order	<b>0.104** (0.037)</b>	-0.610 (0.318)	0.217 (0.367)
Task Type x Order	<b>0.657** (0.252)</b>	-2.087 (2.292)	<b>7.381** (2.676)</b>
Knower Level x Task Type x Order	<b>-0.129* (0.053)</b>	0.635 (0.472)	<b>-1.237* (0.513)</b>
Constant	<b>0.921*** (0.192)</b>	<b>-5.223*** (1.553)</b>	3.728 (2.063)
Observations	170	170	170

Note: \* $p < 0.05$

\*\* $p < 0.01$ ; \*\*\* $p < 0.001$



**Figure 2.** Number of stickers given as a function of counting proficiency, task type, and order. For ease of presentation, we show data broken down by proficient counters (CP knowers) and non-proficient counters (subset knowers).

response and Age, Knower Level, Task Order, as well as the Knower Level x Task Order interaction, as the predictors. Overall there were no significant effects of any of the predictors on precise helping. As shown in Figure 2, children tended to be imprecise in their helping behavior regardless of their counting abilities.

In contrast, and consistent with past work, children's numerical cognition did predict the precision of their sharing behavior. We re-ran the model, including only trials measuring sharing behavior with Deviation from Precise Sharing as the response, and with the same predictors. There was a significant effect of Knower Level x Task Order (see Table 2). This indicates that the effect of Task Order x Knower Level x Task Type interaction in the first

**Table 2.** Unstandardized regression coefficients (standard errors in parentheses) for models predicting deviation from sharing behavior for helping and sharing trials separately.

	Helping Trials (1)	Sharing Trials (2)
Age	-0.017 (0.072)	-0.034 (0.063)
Knower Level (0-6)	-0.012 (0.041)	<b>-0.097** (0.036)</b>
Order of Task (1 = sharing first)	0.106 (0.241)	<b>-0.550* (0.209)</b>
Knower Level x Task Type	-0.025 (0.048)	<b>0.104* (0.042)</b>
Constant	<b>0.858** (0.275)</b>	<b>0.945*** (0.240)</b>
Observations	85	85
Log Likelihood	-34.100	-22.300
Akaike Inf. Crit.	78.200	54.600

Note: \* $p < 0.05$

\*\* $p < 0.01$ ; \*\*\* $p < 0.001$

model was primarily driven by the interaction between Task Order x Knower Level on participants' precise sharing behavior. The results indicate that participants with a lower knower level were more likely to share precisely when presented with the sharing task first, and were more likely to share imprecisely when presented with the helping task first. Children with a higher knower level were more likely to share precisely regardless of task order.

To summarize: First, as expected, numerical cognition predicted children's sharing behavior, but not their helping behavior. That is, compared with children who were not yet proficient counters, children who were proficient counters were more likely to share resources equally during the sharing task, but were no more likely to exhibit preciseness in helping behavior. We also found an unexpected effect of task order: non-proficient counters were more likely to share resources equally when they had received the sharing task first.

Consistent with our pre-registration, we also ran our models using a binomial response of exact sharing/helping. As seen in [Table 3](#) (Model 2), we did not see any effects. We interpret this to suggest that too few children displayed exact sharing behavior (in fact, children gave 5 of 10 stickers on only 40 of 170 possible trials). Therefore, children's numerical cognition predicts their abilities begin to approach and approximate equality, rather than necessarily reach it completely, a finding consistent with prior work (Chernyak et al., [2019](#)).

### ***Exploratory analyses: examining alternative helping strategies***

Arguably, one possibility may be that children interpreted the "correct" answer in the helping scenario to be giving the puppet back all 10 stickers, rather than 5. Although we took several steps to ensure that this was not the case (including a pretest trial in which we made clear the goal was to complete the puzzle). We re-ran our analyses to test for whether that may have been the case and found no evidence for it (see *Supplementary Analyses* for full model details). When running the same models predicting *exactness of helping* redefined as 10 stickers, we found the same predicted results: namely, a main effect of Task Type, with children being more likely to provide an exact response in the sharing task than the helping task, and a Knower Level x Task Type interaction, with knower level impacting children's responses in the sharing task, but not the helping task. As shown in [Figure 2](#), children's

**Table 3.** Unstandardized regression coefficients (standard errors in parentheses) for models predicting overall number of stickers given for helping and sharing trials separately.

	Helping Trials (1)	Sharing Trials (2)
Age	<b>1.530*</b> ( <b>0.661</b> )	0.207 (0.450)
Knower Level	0.542 (0.379)	-0.238 (0.258)
Order of Task (1 = sharing first)	<b>5.930**</b> ( <b>2.210</b> )	-1.280 (1.510)
Knower Level x Task Type	<b>-1.040*</b> ( <b>0.445</b> )	0.232 (0.303)
Constant	-2.850 (2.530)	<b>5.610**</b> ( <b>1.720</b> )
Observations	85	85
Log Likelihood	-223.000	-190.000
Akaike Inf. Crit.	455.000	390.000

Note: \* $p < 0.05$

\*\* $p < 0.01$ ; \*\*\* $p < 0.001$

responses tended to be evenly distributed across the range of possible responses, rather than clustered around 10 stickers. Thus, any results of knower level on exact sharing, but not exact helping, could not be explained by our *a priori* definition of exact helping.

We also checked whether overall sharing and helping behavior (coded as number of stickers shared or helped with) would be predicted by numerical cognition. Based on prior work, we did *not* expect numerical cognition to predict generosity (i.e., number of stickers given), but rather, only approximations to fairness; we had no strong hypotheses for helping. We again ran our initial Generalized Estimating Equation, this time using Number of Stickers Given as the response variable, and differentially explored the effects Age, Knower Level, and Task Order on stickers given for each task (see *Supplementary Analyses for full model details and follow-up analyses*). Consistent with prior work showing that older children give more stickers, we found a significant effect of Age in the helping task. As shown in [Figure 2](#), proficient counters who received the helping task first gave more stickers during the helping task compared to non-proficient counters. In contrast, counting ability did not seem to predict helping with more stickers when receiving the sharing task first. There were also no significant effects of counting ability on overall giving during the sharing task.

## Discussion

Consistent with prior work, we demonstrate that numerical cognition serves as an important and unique constraint underlying precise sharing behavior (Chernyak et al., [2019](#)). Overall, Cardinal Principle knowers were significantly more likely to allocate resources in an exactly equal split compared to Subset knowers in a sharing task. Additionally, although numerical cognition was associated with children's precise *sharing*, we found no evidence that numerical cognition affected the precision of *helping* behavior. Despite the structural similarity of the tasks, and the fact that attending to quantity was a relevant feature of both measures, age and numerical cognition predicted exact sharing, but not exact helping behavior, nor overall helpfulness (i.e., total number of stickers retrieved). This pattern of results indicates that numerical cognition does not support prosocial behavior in general, but rather that number cognition is uniquely recruited to resolve the competing demands (self versus other) of sharing.

Overall, children who were better counters were more likely to share precisely equally. Children without fully developed counting skills not only shared unequally, but were more likely to share amounts that greatly deviated from equality. Unlike sharing, regardless of how we coded "correct" helping (i.e., precise helping, total number of stickers retrieved, or offering any help at all), children's performance on the helping task was completely independent of their counting ability. We find the association we observed between number cognition and sharing, but not helping, particularly compelling because the two tasks were so structurally similar. As we note in the introduction, most commonly-used instrumental helping tasks involve retrieving a single quantifiable item such as a dropped object, thus rendering numerical cognition irrelevant. In our work, we instead used a task that was as structurally similar as possible to the sharing task, required a precise numerical response, and also similarity to naturalistic contexts in which helping occurs (e.g., setting a dinner table). In such real world helping contexts, attending to specific quantities should result in more precise behavior from the helper; setting the table before a meal would not be

considered complete until every person had a place setting with the right number and set of utensils. We argue that in these cases, people may and do rely on one-to-one correspondence or matching strategies, which could have been used to solve the helping task as well. By making the tasks as structurally similar as possible, and requiring almost equivalent behavioral responses, while mirroring the real-world context in which helping occurs, we demonstrate that numerical cognition does not generally underlie precision in prosocial behaviors, nor is it a marker for general cognitive development. We instead claim that the relationship between numerical cognition and equal sharing behavior is unique. However, it is important to consider a number of alternative possibilities.

One possibility is that the helping task was generally harder. This is unlikely to be the case as helping is generally one of the first prosocial behaviors to emerge (Callaghan et al., 2011), occurs flexibly in response to need (Martin & Olsen, 2015), requires little explicit cueing (Warneken, 2013), and appears intrinsically motivated (Brownell et al., 2009; Warneken & Tomasello, 2008). Moreover, comparisons of overall frequencies of prosocial behaviors across our two tasks were similar: nearly every child helped (94%) or shared stickers (96%) across the two tasks. Alternatively, it is possible, as suggested above, that helping, unlike sharing, has multiple “correct” responses. In sharing, the most appropriate response involved splitting the available resources into two equal piles. In contrast, arguably, helping had at least two appropriate responses depending on which goal(s) the participant was attending to: completing the puppet’s puzzle (giving 5 stickers) or helping to return the dropped stickers to the experimenter (giving 10 stickers). If the participant was attending to the puppet’s salient, immediate goal of completing the puzzle, then the most correct response is to retrieve exactly 5 stickers. To further emphasize *this* goal, we specifically primed the participants with goal completion: before they engaged in the helping tasks themselves, participants first observed the puppet attentively solving a smaller puzzle. Yet, it remains possible that participants were attending to the more general goal of returning everything that was dropped, in which case the precise response would be to retrieve all 10 stickers. Although the modal helping response was to retrieve 10 stickers, this response was produced by less than half of participants (44.7%). Indeed, participants tended to help by retrieving some portion of the dropped stickers with considerable variability in the number of stickers retrieved by each participant. In sum, although there were technically two “correct” helping responses, this is unlikely to account for the present results because neither of these responses were preferred by our participants, nor was number cognition related to either of these response patterns.

A final interpretation, relates to differences in the costs associated with producing the prosocial behavior. In this study, sharing was a zero sum task whereby any stickers shared with the puppet was done so at the expense of the participants’ personal sticker haul; in contrast helping was *not* a zero sum task in that acting prosocially involved no personal sacrifice. If participants were motivated by a desire to minimize their own costs, we can assume they would have exhibited decreased generosity during the costly sharing task, i.e. would have responded by consistently providing fewer stickers when sharing relative to helping. However, this was not the case; rather, participant responses on the tasks were independent of each other. Moreover, previous work also speaks against personal cost alone driving this effect; children share resources equally in both costly, and non-costly sharing tasks, and number cognition relates to precise sharing in both first- and third-person contexts (Chernyak et al., 2016). It is possible, however, that the costly nature of the sharing task in

general motivated children to be more attentive to quantities when sharing, but not helping. That is – regardless of whether it involves balancing concerns for self against concerns for others, or balancing concerns for two unrelated individuals – the nature of both lab-based, and naturalistic sharing, requires consideration of and balancing between two competing demands. Instead of viewing this last alternative as a complication, we view it as an important feature that differentiates helping from sharing tasks and sits at the core of the effect.

Consistent with existing theory, and our results, we propose that numerical cognition is deployed when children are asked to resolve costly tensions between individuals. Notably, while instrumental helping involves behavior that mostly focuses on the needs of the other, equal sharing requires making quantitative comparisons between one's own needs and those of another (in the case of first-party sharing) or the needs of multiple other people (in the case of third-party sharing). If children perceive the needs of these two (or more) people as equivalent, they are then tasked with evaluating and creating equivalent sets of resources for distribution. These complicated quantitative assessments rely heavily on numeracy. Sharing, which always involves quantitative assessments, therefore develops along with children's numerical cognition and tends to emerge at a much later age than instrumental helping. By highlighting the differences in the cognitive underpinnings of both types of prosocial behavior, this work provides experimental support for the theoretical perspective that the development of different prosocial behaviors, in this case sharing and instrumental helping, can best be understood by looking at the unique cognitive substrates that may help children identify opportunities to act prosocially with others, and produce an effective prosocial behavior.

Up to this point, our results are consistent with past research, and existing theoretical proposals. Yet we unexpectedly found an order effect such that participants with lower counting proficiency were less likely to share equally when the helping task was administered first. We believe that this finding might further support our preferred interpretation. Specifically, it is possible that for low proficiency counters in the process of acquiring symbolic counting, the link between their symbolic counting ability and their sharing behavior is still developing. This link is often emphasized when socializing sharing behavior: parents frequently emphasize numbers when teaching sharing in social settings (Chernyak, 2020). Helping, on the other hand, does not recruit number skills even in proficient counters. It is possible that completing a helping task first failed to prime numerical concepts in children with limited counting knowledge resulting in a disengagement from numbers in the familiar sharing context. Highlighting the dissociation between numbers and some prosocial behavior for children with emerging counting ability may result in their decreased attentiveness to numbers when sharing and result in the order effects observed. These results appear to indicate that not only is helping sufficiently removed from number cognition that it fails to recruit numerical skills even in a task requiring them, but also for children with low counting proficiency, completing a helping task before sharing dissociates number cognition so strongly from prosocial behavior that it causes poorer counters to become more approximate in their sharing behavior. We note, of course, that these order effects were unexpected, and require further investigation prior to drawing strong conclusions.

Overall, the results of this study demonstrate the unique relationship between children's numerical cognition and their equal sharing behavior, further emphasizing the distinct socio-cognitive mechanisms that differentially underpin equal sharing and instrumental

helping, resulting in differing developmental timelines. The work provides key experimental evidence supporting the theory that different prosocial behaviors rely on different developmental mechanisms. More generally, as prosocial behavior appears to be an important mediator between social cognition and peer acceptance (e.g., Caputi et al., 2012) a better understanding of the specific mechanisms that support the development of the various prosocial behaviors may highlight concrete avenues for interventions aimed at increasing prosociality in young children.

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## Data Availability Statement

This paper qualifies for Open Science Badges for Preregistration, Open Materials and Open Data at <https://osf.io/jcp2m/> and on AsPredicted at <https://aspredicted.org/blind.php?x=kv5fr9>, via a blind link for review and will be made public upon publication.

## Open scholarship



This article has earned the Center for Open Science badges for Open Data, Open Materials and Preregistered. The data and materials are openly accessible at <https://osf.io/jcp2m/>.

## Declarations of interest

none

## Disclosure statement

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