G Model
EARCHI-1069; No. of Pages 7
ARTICLE IN PRESS
Early Childhood Research Quarterly xxx (2018) xxx–xxx
Contents lists available at ScienceDirect
Early Childhood Research Quarterly

# Number-based sharing: Conversation about quantity in the context of resource distribution

Nadia Chernyak

*Department of Cognitive Sciences, University of California – Irvine, United States*

ARTICLE INFO

*Article history:*
Received 21 November 2017
Received in revised form 25 April 2018
Accepted 20 June 2018
Available online xxx

*Keywords:*
Resource distribution
Number
Quantity
Parent–child conversation

ABSTRACT

Recent work suggests a strong connection between our numeracy skills, and our social behavior – in particular, children's numerical cognition predicts their abilities to understand fairness and to act fairly in their resource distribution behavior. This project investigated how children's early socio-linguistic contexts help to form the link between numerical cognition and resource distribution. This work analyzed existing transcripts in the CHILDES database for instances of talk about resource distribution. Both adults and children were more likely to talk about numbers and quantifiers within resource distribution contexts than outside of them, suggesting that resource distribution is a fruitful context for evoking quantity talk. Not surprisingly, discussion of discrete items promoted talk about number, and continuous items promoted talk about quantifiers. Somewhat surprisingly, however, adults were more likely to use number words with girls than boys in this context. Additionally, compared with statements and questions, adults' directives ("give me those two") and requests ("can you share one with me?") were more likely to contain number words. As children grew older, they were more likely to use quantifiers, and girls were more likely to use quantifiers than boys. Overall, these results suggest that (a) resource distribution contexts may be a particularly fruitful context to promote quantity talk, and (b) adults discuss numbers differently in these contexts than they might outside of them. Results are discussed with reference to recent work on numeracy skills and sharing and in terms of specific features of resource distribution that promote quantity talk.



## 1. Introduction

One of the most important cultural acquisitions is the development of formal numeracy skills. Not surprisingly, one of the most fruitful ways to learn about numeracy is through repeated exposure both at home and school: numeracy-based talk and activity at home have important downstream consequences for children's own acquisition of numerical skills (e.g., Berkowitz et al., 2015; Levine, Suriyakham, Rowe, Huttelocher, & Gunderson, 2010; Ramani, Rowe, Eason, & Leech, 2015). In spite of its importance, the prevalence of informal quantity talk is relatively low (Levine et al., 2010). At least two studies report that even when parents are provided with conversational tools (e.g., storybooks or games explicitly focused on number), they expend less than a quarter of their utterances devoted to numeracy-based talk on average (e.g., Goldstein, Cole, & Cordes, 2016; Ramani et al., 2015), with some parents devoting less than 4% (though see also Mix, Sandhofer, Moore, & Russell, 2012). Contexts that are not explicitly numerical in nature show even lower rates (Levine et al., 2010). More troublingly, parents show gender bias in their numeracy-based talk (Chang, Sandhofer, & Brown, 2011). Given the importance of parental input for children's own numerical skills, it is imperative to identify informal contexts that promote number talk. The research presented here explored one potential fruitful context for numeracy-based talk: sharing.

Sharing resources, defined here as the potential transfer of items between two or more parties, often relies on numerical understanding. First, concepts of equality often rely upon understanding cardinality: in order, for example, to appreciate that the fairest way to divide 6 cookies between 2 children, one must also appreciate that sharing requires splitting 6 cookies into equivalent sets. Although such an understanding does not necessarily rely upon numbers (and may instead, rely on one-to-one correspondence; see Frydman & Bryant, 1988), a more recent work suggests that indeed, children's acquisition of cardinality and counting skills explains their abilities to share resources fairly (Chernyak, Sandham, Harris, & Cordes 2016; Muldoon, Lewis, & Freeman, 2009; Sarnecka & Wright, 2013). Moreover, mathematical concepts of division may be more easily learned, understood, and processed through the

*E-mail address:* nadia.chernyak@uci.edu

https://doi.org/10.1016/j.ecresq.2018.06.011
0885-2006/

Please cite this article in press as: Chernyak, N. Number-based sharing: Conversation about quantity in the context of resource distribution. *Early Childhood Research Quarterly* (2018), https://doi.org/10.1016/j.ecresq.2018.06.011

action schema of sharing (Hamamouche, Chernyak, & Cordes, submitted for publication; Squire & Bryant, 2002a, 2002b, 2003). The culmination of this work suggests that understanding sharing and understanding counting are linked in early development.

Sharing contexts may thus be powerful in at least two respects: First, they provide informal opportunities to discuss numbers with young children, especially in the context of cardinal equivalence. For example, utterances such as "You have two, so he should have two" or "but you already got one so let's give this one to your brother" are not only useful for their references to numerical labels, but also for their ability to draw attention to the need to accomplish one-to-one correspondence between two sets. Even when numbers – or for that matter, equality – are not explicitly referenced, resource distribution and transfer often relies on explicitly denoting relative quantities (e.g., "let's give him some more"). Thus, as with other informal activities that require quantification skills (e.g., cooking with a recipe; Vandermaas-Peeler, Boomgarden, Finn, & Pittard, 2012), sharing contexts may promote numeracy- and quantification-based talk subtly and without explicit cultural implication that it ought to do so (as might be the case with counting storybooks).

Second, resource distribution contexts may potentially promote qualitatively different patterns of quantity talk than more formal numerical activities. For example, recent evidence suggests a reversal of traditional gender differences of math-based tasks within sharing contexts: preschool-aged girls tend to outperform boys on sharing tasks. Relative to boys, girls tend to share resources equally at higher rates (Chernyak et al., 2016; Leman, Keller, Takezawa, & Gummerum, 2009), be more likely to endorse the norm of equal sharing (Chernyak, Harris, & Cordes, in press), and be more averse to inequity (McAuliffe, Blake, Kim, Wrangham, & Warneken, 2013). Given that sharing tends to involve numeracy skills, this work suggests that girls may conceptualize sharing in a more numerical way, although further research would be needed to better understand this gender difference. Because the context of resource distribution does not traditionally suffer from the same gender stereotypes as more formal math contexts, parents may not be as susceptible to the same gender biases in their speech to boys and girls. As another example, resource distribution contexts might help provide social motivation to pay attention to quantity.

Using the Child Language Data Exchange System (CHILDES; MacWhinney, 2000), the research here provided a descriptive analysis of how parents and young children talk about quantity in the context of resource distribution through investigating: (a) how frequently parents and children discuss quantity during resource distribution, and (b) the forms of resource distribution contexts that promote such discussion. Each utterance was coded into one of three different dimensions of resource distribution (further details are provided in the methods section). First, utterances were coded for the *type of object* that was being shared/transferred. Because discrete objects (e.g., toys, cookies) more naturally lend themselves to number-talk, and continuous items (e.g., juice, paper) more naturally lend themselves to quantifier talk, analyses looked at quantity talk within discrete and continuous items. Second, given the wealth of research on the usefulness of parents' and children's propensities to ask questions for children's conceptual development (e.g., Hickling & Wellman, 2001; Leech, Salo, Rowe, & Cabrera, 2013; Rowe, Leech, & Cabrera, 2017), conversations were coded for the *type of utterance* (directive, request, statement, or question). In particular, the paper investigated whether questions were more likely to elicit quantity talk than other types of utterances. Although questions are typically a pedagogical tool, it may be the case that resource distribution contexts are ones in which quantity is conveyed through other means (e.g., through directives and requests to produce exact amounts). Third, this work looked at the gender of the child in order to assess potential gender differences in quantity-based talk given the two opposing findings: on the one hand, there are gender biases in parents' discussion of quantity with boys versus girls (Chang et al., 2011), but on the other hand, resource distribution contexts may not be prone to the same biases (as reviewed above). Finally, to assess how each of these dimensions mapped onto the presence of quantity talk, each utterance was coded for the presence of a *number word* ("one", "two", "five"), and *quantifier word* ("both", "half", "some").

## 2. Method

### 2.1. Included transcripts

Given that both the development of numerical cognition and sharing undergo rapid changes between infancy and early childhood, the selection of transcripts focused on transcripts that provided the relevant ages. As such, I included all available transcripts from 9 children that have been extensively analyzed by prior work focusing on early childhood conceptual learning (Bartsch & Wellman, 1995; Wright & Bartsch, 2008): 2 brothers followed in naturalistic settings between when the oldest was 7 months and 8 years: "Ross" and "Mark" (MacWhinney & Snow, 1985, 1990); 3 children of diverse backgrounds followed from the ages of 1.5 to just after 5 years: "Adam", "Eve", and "Sarah" (Brown, 1973); 1 child recorded in the laboratory six times between the ages of 1.5–2.5 years: "Allison" (Bloom 1973), 1 child followed longitudinally between the ages of 1.75 and 3 years: "Peter" (Bloom, 1970); 1 child followed from 1 to 5 years: "Naomi" (Sachs, 1983); one child recorded during book reading sessions and followed between 2.5 and 3.9 years: "Nathaniel" (MacWhinney & Snow, 1990); and 1 child recorded during sessions in the home and followed longitudinally between the ages of 2.3 and just after 4: "Abe" (Kuczaj, 1977). Additionally, because one of the interests of this study was to explore how sharing may be discussed not just among parents, but also among children, I included available transcripts from three additional corpora that included a series of child–child dyads and triads during mealtime and free play (Evans, citation unavailable; Garvey, 1979; Gathercole, 1980). These included conversations from a total of 106 separate target children between the ages of 2 and just over 5.5. Additional details about these corpora are available on the CHILDES Talk Bank website.

The total set of transcripts thus included 115 total children between infancy through the end of early childhood and studied across a wide-variety of settings (at home, in the laboratory, during free play, during mealtime) and interaction types (e.g., parent–child; child–child; parent and 2 children; 3 children).

### 2.2. Selection of utterances

All selected transcripts were initially searched for utterances containing resource distribution terms, which included the words: "fair", "give"; "take", "share", "divide", "split", "equal", and all variants thereof (e.g., "fairness", "gave"). An initial investigation revealed that additional words that could arguably count as resource distribution words (e.g., words denoting ownership such as the word "have" or "my") resulted in too many utterances that were irrelevant to the focal topic and were thus unlikely to contain resource distribution talk.

The initial search resulted in a total of 7366 utterances. We followed approaches used in past studies (e.g., Wright & Bartsch, 2008) of searching through the conversational context in order to determine whether the utterance was related to focal topic. Of these, 2871 utterances were identified as being related to resource distribution. The rest tended to used ownership words either metaphorically (e.g., "are you taking him for a ride?") or discussed

**Table 1**
Coding scheme for each utterance.

| Dimension | Categories | Examples |
|---|---|---|
| Item type | Discrete | Cookies, toys, stickers |
| | Continuous | Milk, juice, water |
| | Both | Money, paper, chicken |
| Utterance type | Directives and requests | "Give me another one"; "Take this"; "Could you please give me that?" |
| | Statement | "That not fair."; "I already gave you two" |
| | Question | "What can we give her?"; "Where's the one I gave you?" |
| Quantity words used[a] | Number | One; two; three; four |
| | Quantifier | Some; all; both; half; whole; few |

[a] Denotes dimensions whose categories were not mutually exclusive (e.g., "take **two** big bites and then take **some more**").

non-distributable items (e.g., "Give me your hand"). The initial identification of resource distribution utterances was done by one coder and then verified by a second coder.

### 2.3. Coding

All of the final selected 2871 utterances were then coded in accordance with the three dimensions (summarized in Table 1).

#### 2.3.1. Item type

First, because different types of items may promote different forms of quantity talk, each utterance was coded for the *type* of item that was being discussed – either continuous (i.e., juice, cookies) or discrete (toys, stickers). These categories were not mutually exclusive: for example, money can be either conceived of a continuous entity (e.g., "some money") or broken up into discretized units (coins, dollars). Similarly, initial analyses showed that conversations tended to shift between conceptualizing some items as discrete and continuous (e.g., paper can either be considered 1 discrete piece or divided continuously). Thus, each coder denoted whether the item was discrete (e.g., toys), continuous (e.g., coffee), or qualified into both categories (e.g., tape).

#### 2.3.2. Utterance type

Next, each utterance was coded into one of four categories: (1) Directives and Requests, which comprised directions provided from one speaker to another (typically, though not exclusively, from the adult to a child); (2) Statements, which were non-directive assertions of fact (e.g., "that's fair"; and (3) Questions, which were included given work showing the benefits of asking children questions more generally. Because a prior work shows that questions that specifically attempt to elicit explanatory responses (e.g., wh-questions; Leech et al., 2013) confer greater benefits in terms of children's linguistic and conceptual development than non-explanatory questions. Requests which comprised questions that typically did not elicit responses but rather did prompt children or adults to action (e.g., "Can you give me that?") were coded under Directives and Requests and not under Questions.

#### 2.3.3. Quantity words

Finally, and critically, each utterance was coded for the presence of (a) a Number Word (any word containing an integer), and/or (b) a Quantifier (words denoting quantity but that do not do note numbers – e.g., "half"; "both"; "some"; e.g., see Sullivan & Barner, 2011). We note that quantity words that were incidentally used in the utterance and were unrelated to source distribution (e.g., a parent mentioning a phone number) were not included.

If a given utterance could not be coded into one of the categories in any dimension, it was coded as uncategorizable and treated as missing data. This occurred rarely (between 0.5% and 3% across the 3 dimensions).

#### 2.3.4. Other measures

Transcripts contained information about each child's age and gender, and the speaker type (mother, father, child, grandmother, investigator). These variables were all included in our analyses. Speaker types were simplified in the analyses and coded as either Children or Adults (e.g., investigators, mothers, fathers, grandmothers). When the speaker was not a child, the adult's "age" was coded with reference to the target child investigated in the original transcript. When multiple children were being investigated (as was the case in several transcripts involving siblings or dyads), adults' ages were coded as the mean age of all children investigated.

### 2.4. Inter-rater reliability

One of two coders (the author and a research assistant) were familiarized with the included transcripts and study aims and coded the 2871 resource distribution utterances according to the dimensions described above. A third coder, unfamiliar with transcripts, context, or study aims then separately coded all resource distribution utterances (inter-coder reliability = 84%). The first coder's codes were used for all reported analyses. Unless otherwise noted, all main model analyses remain consistent when using the second (blind coder's) codes.

## 3. Results

The first question concerned whether resource distribution contexts were overall likely to evoke quantity talk. Overall, number words appeared on 9.9% of the resource distribution utterances, and quantifier words appeared on 15.5%. The frequencies of quantity talk in these resource distribution contexts were significantly higher than the frequency of quantity talk that appeared in the transcripts writ large: of the 389,768 total utterances that appeared in all corpora searched in the initial selection, number words appeared 7.1% of the time and quantifier words appeared 8.3% of the time (Number talk: $\chi^2$ (1, $N$ = 2871) = 33.93, $p$ < .001; Quantifier talk: $\chi^2$ (1, $N$ = 2871) = 195.54, $p$ < .001). Follow-up analyses suggest that these differences held for both adult and child speakers for quantifiers, but only for adults for numbers. Adults referenced numbers on 11.1% and quantifiers on 16.6% of their resource distribution contexts. In contrast, adults referenced numbers 5.9% and quantifiers on 8.8% of utterances across all contexts, which was significantly lower than the proportion of utterances devoted to quantity talk within resource distribution contexts (Number talk: $\chi^2$ (1, $N$ = 1670) = 82.52, $p$ < .001; Quantifier talk: $\chi^2$ (1, $N$ = 1670) = 126.17, $p$ < .001). Children referenced numbers on 8.2% and quantifiers on 14% of their utterances within resource distribution contexts, in contrast to number references on 8.3% and quantifier references on 8.2% of overall utterances (Number talk: $\chi^2$ (1, $N$ = 1201) < 1, $p$ > 0.25; Quantifier talk: $\chi^2$ (1, $N$ = 1201) = 53.46, $p$ < .001). Therefore, adults were more likely to discuss numbers and quantifiers in the context of resource distribution specifically than they were in

Please cite this article in press as: Chernyak, N. Number-based sharing: Conversation about quantity in the context of resource distribution. *Early Childhood Research Quarterly* (2018), https://doi.org/10.1016/j.ecresq.2018.06.011

**Table 2**
Descriptives of adult speech utterances ($N = 1595$).

| Dimension | Proportion of utterances within dimension classified as listed category | Proportion of utterances within category containing a number word | Proportion of utterances within category containing a quantifier |
|---|---|---|---|
| Item type | Discrete (73.2%) | 12.5% | 9.6% |
| | Continuous (16.2%) | 3.9% | 32.8% |
| | Both (10.5%) | 6% | 43.5% |
| Utterance type | Directives and requests (39.3%) | 15% | 19.6% |
| | Statements (41.4%) | 7.1% | 17.9% |
| | Questions (19.2%) | 8.1% | 9.4% |
| Gender | Female (42.3%) | 12.1% | 15.7% |
| | Male (57.7%) | 8.8% | 17.4% |

*Note*: Uncategorizable utterances are excluded from overall frequency counts.

the transcripts as a whole; children were more likely to reference quantity in these contexts as well.

The next question concerned which factors of resource distribution contexts were most conducive to quantity talk. To first analyze the features of adults' talk most likely to contain numbers, I analyzed the utterances spoken by adults. A binary logistic Generalized Estimating Equation[1] using Gender of the target child, Age of the target child, Utterance Type, and Item Type as predictors and whether the utterance contained a number word as a response revealed a significant effect of Item Type, Wald $\chi^2$ (2) = 50.50, $p < .001$, Utterance Type, Wald $\chi^2$ (2) = 6.91, $p = 0.03$, and Gender, $\chi^2$ (1) = 8.02, $p = 0.005$, and no effect of Age, $p > 0.25$. See Table 2 for frequencies of utterances within each category containing number words. Not surprisingly, discrete substances evoked a greater proportion of number talk than either continuous, $\chi^2$ (1, $N = 1427$) = 16.25, $p < 0.001$ or mixed substances, $\chi^2$ (1, $N = 1336$) = 6.11, $p = 0.01$, whereas the latter two did not differ from one another. Somewhat surprisingly (Chang et al., 2011), however, adults were significantly more likely to use numbers when speaking to a female child than a male child, albeit modestly so (8.8% of utterances spoken to boys contained number words compared with 12.1%). Additionally, adults were more likely to use numbers when making directives and requests than when asking questions, $\chi^2$ (1, $N = 934$) = 8.70, $p = 0.003$ and more than when making statements, $\chi^2$ (1, $N = 1288$) = 20.50, $p < 0.001$.

Follow-up analyses investigated the unexpected gender difference by testing whether adults' use of numbers with girls was specific to resource distribution contexts. The full set of corpora revealed a strong gender bias in the expected direction: of the utterances containing numbers, 67.6% were directed towards boys, whereas only 32.4% were directed towards girls. In contrast, in the resource distribution utterances subset, of the utterances containing numbers, 52.5% were devoted to boys, and 47.5% were devoted to girls, representing a much more balanced distribution, and more importantly, a significant deviation from the proportions expected based on the full corpora, $\chi^2$ (1, $N = 181$) = 18.88, $p < .001$. Thus, the gender imbalance present in the full set of transcripts nearly disappeared within resource distribution contexts.

The same model was then run predicting quantifier talk and thus using whether the utterance contained a quantifier was a predictor. There was a significant effect of Item Type, Wald $\chi^2$ (2) = 41.23, $p < .001$, Utterance Type, Wald $\chi^2$ (2) = 159.50, $p < 0.001$, and no effect of Gender or Age ($p$'s > 0.10). Follow-up analyses showed that adults were more likely to use quantifiers when speaking about continuous items than discrete items, $\chi^2$ (1, $N = 1426$) = 95.99, $p < 0.001$, and when speaking about mixed items than discrete items, $\chi^2$ (1, $N = 1335$) = 141.01, $p < 0.001$. Continuous and mixed items did not differ from one another in proportion of quantifier talk ($p > 0.10$). Finally, questions were less likely to contain quantifiers than directives and requests, $\chi^2$ (1, $N = 934$) = 15.65, $p < 0.001$, and also less likely than statements, $\chi^2$ (1, $N = 967$) = 11.56, $p < 0.001$, though the latter two did not differ from one another ($p > 0.10$).

Therefore, overall, discrete items provoked number talk and continuous and mixed items provoked quantifier talk. Generally, directives and requests were the most likely to promote both number and quantifier talk and questions the least likely.

The next set of analyses then focused on children's utterances. The same models were re-run on the set of utterances produced by children. Table 3 shows the raw proportions. For number talk, there was a significant effect of Item Type, Wald $\chi^2$ (1) = 30.24, $p < 0.001$, and no other significant effects (all $p$'s > 0.25). Follow-up analyses showed that discrete items were more likely to contain number words than continuous items, $\chi^2$ (1, $N = 1{,}016$) = 6.65, $p = 0.01$ though no other categories differed from one another (all $p$'s > 0.05).

Finally, the model predicting quantifier talk among children showed a significant effect of Gender, Wald $\chi^2$ (1) = 4.74, $p = 0.03$, a significant effect of Age, Wald $\chi^2$ (1) = 10.17, $p = 0.001$, a significant effect of Item Type, Wald $\chi^2$ (2) = 47.40, $p < 0.001$, and no effect of Utterance Type ($p > 0.25$). Children were more likely to reference quantifiers as they grew older. Girls were also more likely to reference quantifiers than boys, and children were more likely to reference quantifiers when discussing continuous substances than discrete substances, $\chi^2$ (1, $N = 1{,}016$) = 93.96, $p < 0.001$, and when discussing mixed substances than discrete substances, $\chi^2$ (1, $N = 980$) = 60.29, $p < 0.001$. Mixed and continuous substances did not differ from one another ($p > 0.25$).[2]

The final analysis explored whether the finding that girls were more likely to reference quantifiers than boys was specific to resource distribution contexts. The full set of corpora revealed a

[1] All GEE models were run assuming a robust estimator and independent correlation structure. To account for potential inter-correlations among utterances coming from the same transcript and the same child, Corpus (i.e., study from which the data originated) was entered as a subject variable and Transcript ID (i.e., unique identifier for each separate conversational recording) and Utterance ID (i.e., line number within each transcript) as within-subject variables.

[2] Age and gender effects for this model did not hold when using the second coder's codes. Therefore, these effects should be interpreted with some caution (e.g., paper; tape; a cake).

Please cite this article in press as: Chernyak, N. Number-based sharing: Conversation about quantity in the context of resource distribution. *Early Childhood Research Quarterly* (2018), https://doi.org/10.1016/j.ecresq.2018.06.011

**Table 3**
Descriptives of children's speech utterances ($N$ = 1129).

| Dimension | Proportion of utterances within dimension classified as listed category | Proportion of utterances within category containing a number word | Proportion of utterances within category containing a quantifier |
|---|---|---|---|
| Item type | Discrete (75.2%) | 7.9% | 8.2% |
| | Continuous (14.0%) | 1.9% | 35.8% |
| | Both (10.8%) | 7.3% | 37.7% |
| Utterance type | Directives and Requests (43.4%) | 7.7% | 15.4% |
| | Statements (51.4%) | 6.2% | 14.0% |
| | Questions (5.3%) | 10.0% | 13.3% |
| Gender | Female (36.6%) | 7.0% | 12.8% |
| | Male (63.4%) | 7.1% | 17.9% |

*Note*: Uncategorizable utterances are excluded from overall frequency counts.

strong gender bias in the expected direction: of the utterances containing quantifiers, 70.2% were spoken by boys, whereas only 29.8% were spoken by girls. In contrast, in the resource distribution utterances subset, of the utterances containing quantifiers, 55.4% were spoken by boys, and 44.6% were spoken by girls, representing a much more balanced distribution, and more importantly, a significant deviation from the full corpora, $\chi^2$ (1, $N$ = 166) = 17.33, $p$ < .001. Thus, the gender imbalance present in the full set of transcripts nearly disappeared within resource distribution contexts.

Overall, for both children and adults, discrete items evoked number talk and continuous and mixed substances evoked talk about quantifiers. Additionally, adults' directives and requests were the most likely to contain number words. Finally, girls showed some advantages with quantity talk: adults spoke more about numbers when speaking to girls during resource distribution, and girls were more likely to use quantifiers in the context of resource distribution.

## 4. Discussion

Recent work has taken an interest in the types of social contexts that promote quantity and number talk (Goldstein et al., 2016; Mix et al., 2012) given the important contribution that such a talk plays in the development of children's number concepts (e.g., Levine et al., 2010; Ramani et al., 2015). This work points to resource distribution as one potential context that may be exploited in future work. Overall, both parents and children referenced numbers in the context of resource distribution more often than they did overall, suggesting that discussion about distributing items generally lend themselves to quantification. Of course, quantity talk was nonetheless modest, especially when compared to the amount of talk used in educational activities. However, resource distribution contexts may nonetheless confer several benefits including providing additional social motivation to attend to number. In fact, several utterances may in fact have reflected adults' attempts to teach children about numbers through using social means (e.g., "Give Ernie 5"; "(what) if I give you ten dollars?"; "I gave him three dollars and he didn't even want to give me my seventy-five cents"). Yet other utterances appear to reflect purely social motivations ("generous people give two to another boy"; "I take two vitamins everyday; right, Dad?"; "so we have two so we don't have to share") but nonetheless contained number and quantifier talk. Both cases suggest that the social domain may be an important way in which to scaffold young children's quantity knowledge (see also Hamamouche et al., under review). Overall, this paper joins recent attempts to better understand how and when quantity-based concepts are transmitted in parent–child conversation (see Willits, Jones, & Landy, 2016).

This work also identified several key features of resource distribution contexts that may be particularly conducive to quantity talk, and ways in which resource distribution contexts differ qualitatively from other contexts. First, adults were more likely to reference numbers when speaking with girls, and girls were more likely to use quantifiers in their resource distribution speech than boys. Both of these results, but the former especially, are surprising in light of work showing traditional gender biases in parents' number talk (Chang et al., 2011), spatial talk (Pruden & Levine, 2017), and explanatory science talk (Crowley, Callanan, Tenenbaum, & Allen, 2001). However, these findings are not as surprising in light of several datasets finding that girls are better adept at both sharing resources equally and at understanding norms of equal sharing than boys (Chernyak et al., 2016; under review; Leman et al., 2009). Gender differences of this sort generally ought to be interpreted carefully given other potential cultural confounds and future work is needed to better understand the motivations behind parents' talk about number. Moreover, given the limited sample size and historical timing of the CHILDES sample, it will be important to extended these investigations to present-day settings prior to drawing strong conclusions. It will also be important for future work to identify other potential search terms that may contain resource distribution utterances within CHILDES, as well as to investigate whether number concepts obtained during resource distribution transfer to more formalized mathematical setting.

Directives and requests were particularly fruitful for promoting both number and quantifier talk from parents. Prior work has generally shown the benefits of question-asking (e.g., Leech et al., 2013; Rowe et al., 2017; Tamis-LeMonda, Baumwell, & Cristofaro, 2012; Yu, Bonawitz, & Shafto, 2017) for young children's conceptual and linguistic development. Many of the questions that adults asked of children in the context of the present study were pedagogical in nature and therefore likely beneficial in ways that are not related to children's learning of numeracy skills. However, questions were not particularly helpful with respect to referencing quantity – instead, directives and requests were the most likely to contain such talk, likely because number-based resource distribution often involves parents prompting children to undertake actions (e.g., even out quantities; hand over or take a specific set of resources). Such directives and requests may thus reflect adults specifying how resource distribution ought to be done.

Not surprisingly, continuous substances were more likely to evoke quantifier talk and discrete items were more likely to evoke number talk. Thus, both adults and children modulated their speech according to the item being shared or discussed. Quantifier talk was overall more prevalent than number talk, and continuous and mixed substances were overall more likely to elicit quantity talk in the context of resource distribution. One possibility for this may be that our early concepts of resource distribution are built out of considering continuous extent (e.g., sharing juice, splitting a cookie), rather than exact equality. Such a possibility would be consistent with recent findings showing an early-developing focus on fairness (e.g., Geraci & Surian, 2011; Schmidt & Sommerville, 2011), which, like, notions of approximate quantity, may develop during infancy (Feigenson, Carey, & Hauser, 2002; see also vanMarle & Wynn, 2011), in light of our relatively later-developing notions of behavioral equality, which may rely on exact, symbolic understanding of number (Chernyak et al., 2016; see also Blake, McAuliffe, & Warneken, 2014; Sheskin, Chevallier, Lambert, & Baumard, 2014).

Substances that could be *either* discretized or thought of continuously (e.g., paper) evoked both number and quantifier talk at relatively high rates, suggesting either that adults purposely used such substances in order to talk about quantity, or that such substances inherently lent themselves to more quantity-based talk. Given that the items discussed tended to be typical household items (e.g., paper, tape, and a cake), the latter possibility appears more likely. Future work may also investigate whether such items are particularly helpful in appreciating the connection between discrete and continuous quantities because they may naturally lend themselves to discrete-continuous transformations (e.g., 1 continuous cake can be divided into 8 discrete pieces; a bowl of noodles represents both a continuous mass of spaghetti and discrete units of individual spaghettis).

These findings also have theoretical implications for recent work finding that young children's numeracy abilities and social skills may be intrinsically linked in early childhood (Chernyak et al., 2016; Muldoon et al., 2009; Sarnecka & Wright, 2013) and suggest that children's early social contexts may be one important way that promotes this link. Given the great importance of quantity input in young children's numeracy skills, it is important to identify contexts that spontaneously promote it. Although a recent work has looked at discussion of number in more formal math-based activities (e.g., Ramani et al., 2015) little work has been devoted the types of spontaneous, everyday contexts that are evoke quantity talk. The activity of resource distribution promoted spontaneous talk about quantity across multiple naturalistic settings, for both children and adults, and across a wide variety of conversational exchanges (e.g., between children, between adults). Future work may focus on the types and forms of number talk that resource distribution is likely to produce as well as whether resource distribution contexts may be a fruitful means of introducing and scaffolding more formal mathematical concepts (e.g., counting; arithmetic) in more formal settings.

## Acknowledgements

I would like to acknowledge Kristin Danyluk, Celine Lim, Jonathan Miksis, and Jenna Moscarelli for assistance with data handling and coding; Raychel Gordon for research support; and Sara Cordes for kindly lending resources and support to conduct this project. This work was funded by Grant #56348 from the John Templeton Foundation.

## References

Bartsch, K., & Wellman, H. M. (1995). *Children talk about the mind*. New York, NY: Oxford University Press.

Berkowitz, T., Schaeffer, M. W., Maloney, E. A., Peterson, L., Gregor, C., Levine, S. C., & Beilock, S. L. (2015). Math at home adds up to achievement in school. *Science*, *350*, 196–198.

Blake, P. R., McAuliffe, K., & Warneken, F. (2014). The developmental origins of fairness: The knowledge–behavior gap. *Trends in Cognitive Sciences*, *18*, 559–561.

Bloom, L. (1970). *Language development: Form and function in emerging grammars*. Cambridge, MA: MIT Press.

Bloom, L. (1973). *One word at a time: The use of single-word utterances before syntax*. The Hague: Mouton.

Brown, R. (1973). *A first language: The early stages*. Cambridge, MA: Harvard University Press.

Chang, A., Sandhofer, C. M., & Brown, C. S. (2011). Gender biases in early number exposure to preschool-aged children. *Journal of Language and Social Psychology*, *30*(4), 440–450.

Chernyak N., Harris P.L., & Cordes S. (in press). Explaining early moral hypocrisy: Numerical cognition promotes equal sharing behavior in preschool-aged children. Developmental Science.

Chernyak, N., Sandham, B., Harris, P. L., & Cordes, S. (2016). Numerical cognition explains age-related changes in third-party fairness. *Developmental Psychology*, *52*, 1555–1562.

Crowley, K., Callanan, M. A., Tenenbaum, H. R., & Allen, E. (2001). Parents explain more often to boys than to girls during shared scientific thinking. *Psychological Science*, *12*, 258–261.

Feigenson, L., Carey, S., & Hauser, M. (2002). The representations underlying infants' choice of more: Object files versus analog magnitudes. *Psychological Science*, *13*, 150–156.

Frydman, O., & Bryant, P. (1988). Sharing and the understanding of number equivalence by young children. *Cognitive Development*, *3*, 323–339.

Garvey, C. (1979). An approach to the study of children's role play. *The Quarterly News-letter of the Laboratory of Comparative Human Cognition*.

Gathercole, V. (1980). *Birdies like birdseed the bester than buns: A study of relational comparatives and their acquisition*. University of Kansas (Unpublished doctoral dissertation).

Geraci, A., & Surian, L. (2011). The developmental roots of fairness: Infants' reactions to equal and unequal distributions of resources. *Developmental Science*, *14*, 1012–1020.

Goldstein, A., Cole, T., & Cordes, S. (2016). How parents read counting books and non-numerical books to their preverbal infants: An observational study. *Frontiers in Psychology*, *7*, 1100.

Hamamouche, K.A., Chernyak, N., & Cordes S. (submitted for publication). Sharing scenarios facilitate division performance in preschool-aged children.

Hickling, A. K., & Wellman, H. M. (2001). The emergence of children's causal explanations and theories: Evidence from everyday conversation. *Developmental Psychology*, *37*, 668–683.

Kuczaj, S. (1977). The acquisition of regular and irregular past tense forms. *Journal of Verbal Learning and Verbal Behavior*, *16*, 589–600.

Leech, K. A., Salo, V. C., Rowe, M. L., & Cabrera, N. J. (2013). Father input and child vocabulary development: The importance of wh questions and clarification requests. *Seminars in Speech and Language*, *34*(November), 249–259.

Leman, P. J., Keller, M., Takezawa, M., & Gummerum, M. (2009). Children's and adolescents' decisions about sharing money with others. *Social Development*, *18*, 711–727.

Levine, S. C., Suriyakham, L. W., Rowe, M. L., Huttenlocher, J., & Gunderson, E. A. (2010). What counts in the development of young children's number knowledge? *Developmental Psychology*, *46*, 1309–1319.

MacWhinney, B. (2000). . *The CHILDES project: The database* (Vol. 2) Psychology Press.

MacWhinney, B., & Snow, C. (1985). The child language data exchange system. *Journal of Child Language*, *12*, 271–295.

MacWhinney, B., & Snow, C. (1990). The child language data exchange system: An update. *Journal of Child Language*, *17*, 457–472.

McAuliffe, K., Blake, P. R., Kim, G., Wrangham, R. W., & Warneken, F. (2013). Social influences on inequity aversion in children. *PLOS ONE*, *8*(12), e80966.

Mix, K. S., Sandhofer, C. M., Moore, J. A., & Russell, C. (2012). Acquisition of the cardinal word principle: The role of input. *Early Childhood Research Quarterly*, *27*(2), 274–283.

Muldoon, K., Lewis, C., & Freeman, N. (2009). Why set-comparison is vital in early number learning. *Trends in Cognitive Sciences*, *13*, 203–208.

Pruden, S. M., & Levine, S. C. (2017). Parents' spatial language mediates a sex difference in preschoolers' spatial language use. *Psychological Science*.

Ramani, G. B., Rowe, M. L., Eason, S. H., & Leech, K. A. (2015). Math talk during informal learning activities in Head Start families. *Cognitive Development*, *35*, 15–33.

Rowe, M. L., Leech, K. A., & Cabrera, N. (2017). Going beyond input quantity: Wh-questions matter for toddlers' language and cognitive development. *Cognitive Science*, *41*, 162–179.

Sachs, J. (1983). Talking about the there and then: The emergence of displaced reference in parent–child discourse. In K. E. Nelson (Ed.), *Children's language* (Vol. 4). Hillsdale, NJ: Lawrence Erlbaum Associates.

Sarnecka, B. W., & Wright, C. E. (2013). The idea of an exact number: Children's understanding of cardinality and equinumerosity. *Cognitive Science*, *37*, 1493–1506.

Schmidt, M. F., & Sommerville, J. A. (2011). Fairness expectations and altruistic sharing in 15-month-old human infants. *PLoS ONE*, *6*, e23223.

Sheskin, M., Chevallier, C., Lambert, S., & Baumard, N. (2014). Life-history theory explains childhood moral development. *Trends in Cognitive Sciences*, *18*, 613–615.

Please cite this article in press as: Chernyak, N. Number-based sharing: Conversation about quantity in the context of resource distribution. *Early Childhood Research Quarterly* (2018), https://doi.org/10.1016/j.ecresq.2018.06.011

Squire, S., & Bryant, P. (2002a). The influence of sharing on children's initial concept of division. *Journal of Experimental Child Psychology*, *81*, 1–43.

Squire, S., & Bryant, P. (2002b). From sharing to dividing: young children's understanding of division. *Developmental Science*, *5*, 452–466.

Sullivan, J., & Barner, D. (2011). Number words, quantifiers, and principles of word learning. *Wiley Interdisciplinary Reviews: Cognitive Science*, *2*, 639–645.

Tamis-LeMonda, C. S., Baumwell, L., & Cristofaro, T. (2012). Parent–child conversations during play. *First Language*, *32*(4), 413–438.

Vandermaas-Peeler, M., Boomgarden, E., Finn, L., & Pittard, C. (2012). Parental support of numeracy during a cooking activity with four-year-olds. *International Journal of Early Years Education*, *20*, 78–93.

Willits, J. A., Jones, M. N., & Landy, D. (2016). Learning that numbers are the same, while learning that they are different. *Proceedings of the 37th annual conference of the cognitive science society*.

Wright, J. C., & Bartsch, K. (2008). Portraits of early moral sensibility in two children's everyday conversations. *Merrill-Palmer Quarterly*, *54*, 56–85.

Yu, Y., Bonawitz, E., & Shafto, P. (2017). Pedagogical questions in parent–child conversations. *Child Development.*

vanMarle, K., & Wynn, K. (2011). Tracking and quantifying objects and non-cohesive substances. *Developmental Science*, *14*, 502–515.

Please cite this article in press as: Chernyak, N. Number-based sharing: Conversation about quantity in the context of resource distribution. *Early Childhood Research Quarterly* (2018), https://doi.org/10.1016/j.ecresq.2018.06.011