MIND, BRAIN, AND EDUCATION

Promoting Math Talk in Adult–Child Interactions Through Grocery Store Signs

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ABSTRACT— Young children have better math abilities when their parents engage in more math-related conversations with them. Yet, previous studies have found that math talk occurs only very infrequently in everyday interactions. In the present study, we sought to promote adult–child conversations about math in a naturalistic context using minimal instructions. We observed 179 adult–child dyads while they shopped in grocery stores with signs prompting them to engage in math-related conversations (math condition), signs prompting them to talk about other topics (general language condition), or without any signs (baseline condition). In the math condition, more adults talked about math compared to the general language or the baseline condition, and this finding could not be explained by demographic characteristics of the dyad or the overall amount of conversations. This study demonstrates that cost-effective signs placed in everyday contexts can promote math-related conversations and potentially provide math learning opportunities for children.

Some academic skills, like math, develop through talk and play with caregivers before formal schooling begins (Elliott & Bachman, 2018; Huntsinger, Jose, & Luo, 2016; Lefevre et al., 2009; Niklas & Schneider, 2014; Ramani, Rowe, Eason, & Leech, 2015; Zippert & Ramani, 2017). In one of the first longitudinal studies examining parental talk about numbers in the home, Levine, Suriyakham, Rowe, Huttenlocher, and Gunderson (2010) video-recorded naturally occurring parent–child interactions for 90 min every 4 months when the children were between 14 and 30 months of age. They found marked variability in parents' use of number words during these interactions; while one of the parents only produced four number words over the course of the 7.5 h of observation, another parent produced 257 number words (mean = 90.8 number words). Importantly, parents who used more number words when children were between 14 and 30 months of age had children who had a better understanding of the cardinal meaning of number words at 46 months. Other recent work found that children exposed to more conversations about math broadly (i.e., math talk) tend to score higher on a standardized test of mathematical ability one year later (Susperreguy & Davis-Kean, 2016). In addition, parental labeling of quantities (i.e., talking about cardinality) when children are 3 years old is a better predictor of math achievement in preschool and first grade than parental identification of numerals or counting (Casey et al., 2018). Finally, previous work has separated parental elicitations of math talk (e.g., "How many pennies are there?") and statements about math (e.g., "You have three pennies."), but neither seem to separately predict children's later math abilities (Casey et al., 2018). Thus, these studies highlight the importance of parental math talk for young children's math abilities, though the overall frequency of parental math talk in everyday contexts is fairly low and there might be differences between different aspects of math talk.

To determine whether certain types of activities may increase parents' math talk, a few studies have examined math talk within the context of specific activities. For example, Vandermaas-Peeler et al. (2009) compared parental math talk during book reading and during free play with a set of toys related to the story. Math talk occurred more frequently during free play compared to book reading, suggesting that certain contexts more readily lend themselves to eliciting math-related learning opportunities than others. Similarly, Anderson (1997) found a wide range of

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math talk between parents and children, depending on the task they were completing. Even when parent–child dyads read the same books together or play the same board game, parents differ dramatically in their amount of math talk (Anderson, Anderson, & Shapiro, 2004; Bjorklund, Hubertz & Reubens, 2004).

This individual variability demonstrates that simply providing parents with materials that lend themselves to math talk may not be sufficient to elicit frequent use of it. Instead, it may be necessary to specifically ask parents to incorporate math-related content into their interactions. To this end, Vandermaas-Peeler, Ferretti, and Loving (2012) gave parent–child dyads a board game to play. In addition to the game, half of the parents were also given a list of numeracy activities to incorporate into the game at their own discretion. Parents who received these math-related suggestions incorporated almost twice as much math talk into the game play compared to parents who only received the game. These findings suggest that implementing activities occurring in children's daily lives can be used to enhance children's exposure to math talk, but parents may need explicit guidance on how to do so. Another study used a similar structure in the context of cooking (Vandermaas-Peeler, Boomgarden, Finn, & Pittard, 2012). Parents were assigned to either the control condition in which they completed the cooking activity with no specific guidance or the math condition in which they received a list of instructions on how to incorporate math concepts into the cooking activity. Unlike the previous study, the cooking task had more naturally occurring opportunities for math talk because of the need to talk about units of measurement and quantities of ingredients. Nonetheless, most parents did not spontaneously provide extensive or advanced math-related input without a list of instructions (Vandermaas-Peeler, Boomgarden, et al., 2012). Finally, Berkowitz et al. (2015) used a tablet-based application to engage parents and children in math-related discussions within the context of a story. Even when parents and children interacted with the application as little as once a week, children still showed an increase in their math ability by the end of the school year. Thus, providing parents with explicit guidance on how to talk about math with their children during typical home-based activities led to increased parental math talk and potentially more opportunities for children to learn math.

Children's exposure to math talk in home settings is extremely important, but children also learn from their parents in other environments. Braham, Libertus, and McCrink (2018) examined the malleability of math-related parent–child interactions in a children's museum. Half of the parents were asked to play in the pretend-grocery store exhibit of the museum and shop for a healthy meal that included items from each food group, while the other half of the parents were asked to shop for a meal on a $20 budget. As expected, parents who pretended to shop on a budget used significantly more number words while talking to their children than parents who pretended to shop for a healthy meal. Interestingly, children who shopped with their parents on a budget showed significantly greater spontaneous focus on numerical information on a subsequent task compared to children who shopped for a healthy meal. Such spontaneous focus on number has previously been linked to children's math abilities (Hannula, Lepola, & Lehtinen, 2010), suggesting that creating learning situations that incorporate number into play may help with children's later mathematical abilities.

One issue with previous studies aimed at increasing math talk is that they require guidance and instructions from a researcher, and in some instances, like the tablet-based application, access to expensive materials. In addition, activities such as playing a board game often do not take place as part of families' daily routines and thus require setting aside time to engage in these activities. Ridge, Weisberg, Ilgaz, Hirsh-Pasek, and Golinkoff (2015) tried to overcome similar issues while attempting to increase adult–child conversations generally to boost young children's language skills. They displayed signs around grocery stores that encouraged adults to talk about a variety of topics with their children. When signs were placed in grocery stores in low socioeconomic status (SES) neighborhoods, the amount of adult–child conversations significantly increased compared to when no signs were displayed. Importantly, the quantity and quality of the interactions were around the same level as those observed in mid- to high-SES grocery stores with and without signs. The authors argue that this low-cost intervention promotes increases in conversations between adults and children and in turn may provide children with important opportunities to improve their language skills.

Following the study design by Ridge et al. (2015), we sought to determine whether posting grocery store signs specifically encouraging conversations about math might get more adults and children to talk about math. Thus, the present study consisted of three different conditions: a baseline condition in which no signs were displayed, a math-sign condition in which math-specific prompts were displayed on various signs throughout the store, and a general language sign condition in which general prompts were displayed. We observed adult shoppers with young children and coded the occurrence of different types of math and non-math talk. Following previous work, we separated statements of math-related concepts from elicitations and separated cardinality, counting, and calculations (Casey et al., 2018). The general language sign condition was included to ensure that any observed differences in math talk were a result of math-related prompts and not merely a result of posting any signs. We hypothesized that both sign conditions would yield greater occurrences of adult–child conversations, but that

Table 1
Observed Demographics of the Groups of Shoppers, $N = 179$

Variable	N	*Math signs*	*General language signs*	*Baseline*
Group structure				
One adult and one child	106	29	41	36
One adult and multiple children	30	7	9	14
Multiple adults and one child	37	21	10	6
Multiple adults and multiple children	6	2	0	4
Target child gender				
Male	71	26	24	21
Female	108	33	36	39
Target child age				
Two	35	8	12	15
Three	34	13	9	12
Four	48	18	15	15
Five	62	20	24	18
Target child race/ethnicity				
Asian	7	2	0	5
Black	81	25	29	27
White	88	32	30	26
Hispanic/Latino	3	0	1	2
Target adult gender				
Male	52	24	12	16
Female	127	35	48	44
Target adult race/ethnicity				
Asian	5	2	0	3
Black	80	25	29	26
White	92	32	30	30
Hispanic/Latino	2	0	1	1

Note. All demographic variables were judged from visual appearance by the observers. No information was collected from any of the participating shoppers.

the math-sign condition would specifically promote more shoppers to talk about math.

METHOD

Participants

One of two trained research assistants observed 179 groups of shoppers that included at least one child between the ages of 2–5 years, based on the observers' estimate, and any accompanying adults or other children. Data were originally collected from 180 observations, but one observation was excluded from analyses due to missing data from observer error. When the group of shoppers included more than one child in the appropriate age range, the observer chose one child as the target child. Additionally, the adult who talked to the target child the most was designated as the target adult. Older children were never chosen as the target adult. Other adults in the group and older children who were over the target age range were included in the coding of conversational turns, but were not included in the coding of any other variables. Demographic information for our sample is shown in Table 1.

Procedure

In all conditions, a sign stating, "Talking to your child is important for preparing them for school!" was placed at all entrances of each of the stores (Figure 1). In the baseline condition, no additional signs were placed in the store. In the math sign and general language sign conditions, additional signs were placed in areas of the store where common foods are purchased (i.e., milk, eggs, and bread). The math signs encouraged conversation about topics involving numbers and math, while the general language signs encouraged conversation about topics other than math (Figure 1). On each sign, we included two types of prompts that differed according to the level of abstraction, or complexity, of the question (Blank, Rose, & Berlin, 1978; Uscianowski, Almeda, & Ginsburg, 2018). The first prompt in each of the signs was a lower-level question that was designed to elicit more basic conversations (i.e., questions that could be answered with a single word or one sentence), while the second prompt was a higher-level question that was designed to elicit more complex conversations (i.e., a longer explanation). The rationale for including these two types of prompts was that we expected the first prompt to be more appropriate for younger children in our age range while the second prompt would be more appropriate for older children.

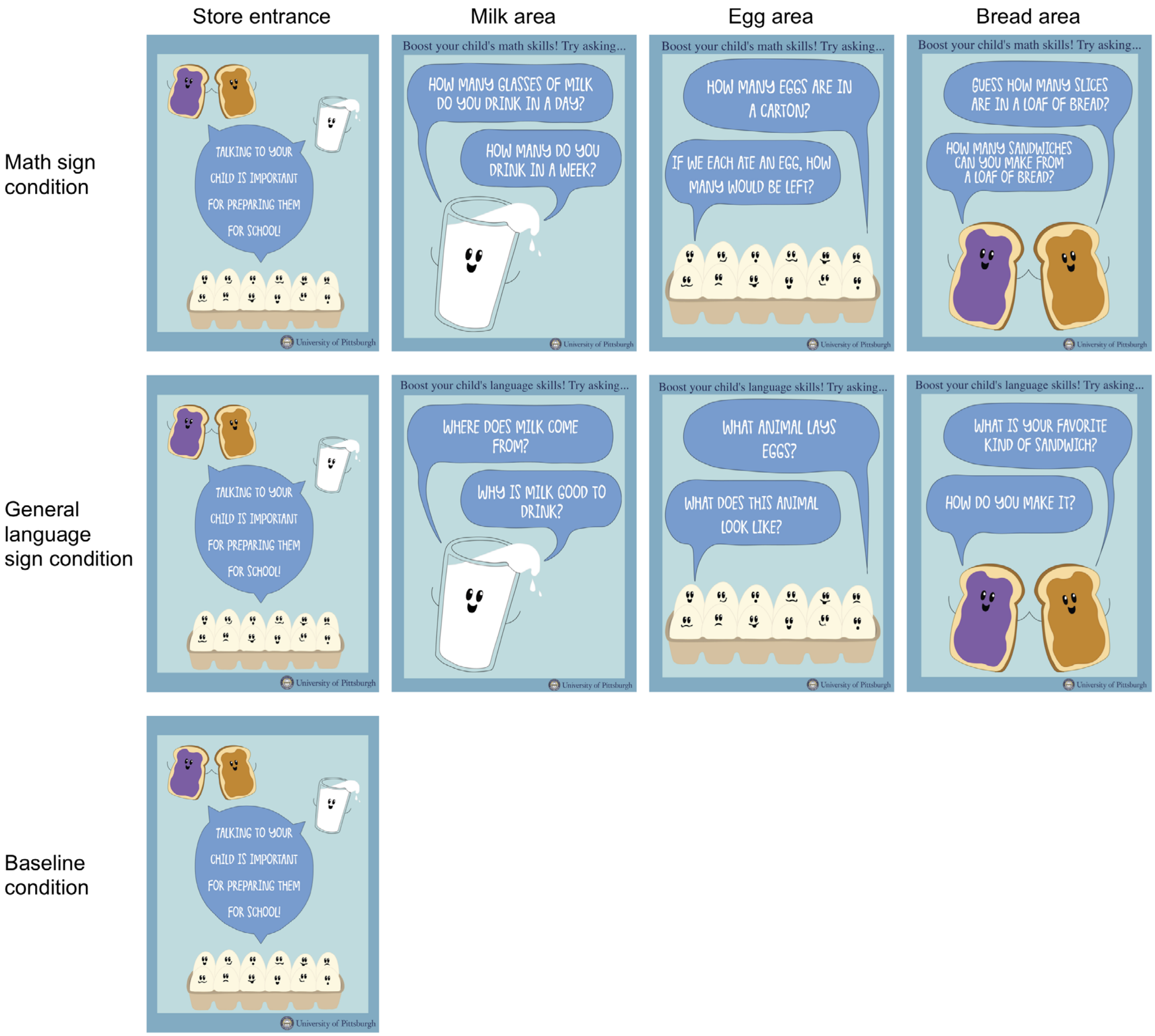

Fig. 1. Images of the signs placed in each area of the stores for each condition.

All observations were conducted on weekend days at one of two store locations. The two stores were located in different neighborhoods in Philadelphia, PA, USA. Time of day, sign condition, area (i.e., milk, eggs, or bread), and store were counterbalanced across observations. Ten groups of shoppers were observed in each area for each condition in each store. Amount of time spent observing the shoppers in each condition at each store greatly differed by location and day, but generally ranged between 1 and 4 hr. Observations took place at only one area of the store per day in order to avoid coding the same group of shoppers more than once. In each area, observers started coding the interaction when the shoppers entered the aisle and were able to be both seen and heard. Any shopper with at least one child in the desired age range was observed. Observers stopped coding once the shoppers left the aisle. The observers acted as though they were customers shopping in the store and accessed a coding sheet on Qualtrics, an online survey system, using smart phones. The accessibility of coding on a phone allowed for natural observer behavior. Shoppers' conversations were not recorded.

The two observers simultaneously observed and coded 27 of the 179 groups of shoppers in order to establish reliability. The groups were observed across two conditions (math sign and general language sign), two store locations, and the three different store areas. The coders had 100% agreement on all coded variables included in the analyses, including child age, gender, race/ethnicity, as well as math talk and price-, product-, and sign-related coding.

Table 2
Descriptions and Examples of Types of Math Talk Between Adults and Children

Type	*Eliciting math talk description*	*Eliciting math talk example*	*Using math talk description*	*Using math talk example*
Cardinality	Prompting or asking for a number word or number of items in a set.	"How many gallons of milk do we have in our cart?"	Stating any number word or number of items in a set.	"We have two gallons of milk in our cart."
Counting	Prompting or asking to count.	"Let's count together how many pieces of bread there are!"	Reciting counting words, counting objects in a set.	"In this bag, there are 1, 2, 3, 4 … 12 slices of bread."
Calculation	Prompting or asking for performance of calculations like addition, subtraction, multiplication, or division.	"How many eggs would we have left?"	Verbally performing calculations like addition, subtraction, multiplication, or division.	"There are twelve eggs in a carton and if I ate one and you ate one there would be 10 eggs left!"

Coding

General Information

Observers estimated the age, gender, and ethnicity of the target child and adult. In addition, observers coded who initiated the conversation and the valence of the overall adult–child interaction on a 5-point scale (1 = *very negative*; 5 = *very positive*) based on verbal and non-verbal emotional expressions. The observers also estimated the number of conversational turns, which was defined as the number of times the adults and children in the group took turns speaking. Every utterance from the target child counted as a single conversational turn. An utterance could be a single word, a sentence, or a few sentences that were not interrupted or broken by another speaker. If an adult or older child in the group said something directed toward the target child, it was counted as a conversational turn. If the adults or older children in the group were only conversing among themselves and did not include the target child, these interactions were not coded as conversational turns. Non-verbal gestures, like responsive head nods or shakes, were also included as conversational turns. The overall number of conversational turns was coded in ranges, that is, 0, 1, 2–5, 6–9, 10+ because pilot testing revealed that exact coding of the number of conversational turns was too difficult given the other codes that needed to be observed. Note that unlike conversational turns, all of the other codes described below were coded in a binary fashion (i.e., code present or absent) and were recorded separately for the target adult and target child.

Product-Related Coding

We coded for several ways that target adult and child may have interacted with the products mentioned in the signs (i.e., eggs, milk, or bread). Specifically, we coded whether they put the product in their cart as well as whether they conversed about the product. If either the target child or adult said the product name or did simple gestures like pointing to or picking up the product, the presence of product-related interaction was recorded (i.e., "simple product interaction"). If the conversation included further information about the product such as a description of its physical or non-physical features or follow-up questions about the product were asked, those were coded as well (i.e., "product description"). We included these codes because we wanted to see whether there were differences between sign conditions, for example in the frequency with which shoppers purchased the product displayed on our signs.

Price-Related Coding

We also coded for the presence of interactions about the price. If the target adult or child said the price of the product, pointed to the price tag, or discussed the price it was coded as presence of price-related interaction. The price of the product was separated from math talk because it was considered to be related to the product, not the signs promoting specific conversations and we wanted to ensure that the use of math talk was prompted by our signs.

Sign-Related Coding

In the math-sign condition and general language sign condition, we also coded the extent to which the shoppers discussed the characters on the sign, pointed to the sign, read the questions on the sign, answered the questions posed on the sign, or elaborated and explained the questions further. Presence of "sign-related interaction" was coded if the target adult or child engaged in any of these behaviors.

Math Talk

Since math talk was our primary measure of interest, the occurrence of a variety of different math talk categories was coded. Descriptions and examples of each type of math talk are provided in Table 2. We distinguished between elicitations of math talk and uses of math talk as well as conversations about cardinality (i.e., statements with a single number word in the absence of counting), counting, and calculation.

Analysis Plan

We first compared shoppers' interactions between the three different conditions. In order to assess whether the conditions varied in valence, we ran an analysis of variance (ANOVA) with valence of the interaction as the dependent measure. To test whether the conditions elicited different amounts of conversational turns or different amounts of interaction about the product, price, or sign, we ran a series of chi-squared analyses. We collapsed across store areas (i.e., eggs, bread, and milk) for all analyses because preliminary chi-squared analyses revealed no differences in any of our variables.

To address our main research question, we conducted a series of analyses to test whether math signs led more adults to use math talk. Initially we looked at the difference between the different types of math talk as shown in Table 2. Given the relative infrequency of some of the specific types of math talk and the consistent patterns across conditions (such that all forms of math talk were more frequent in the math-sign condition), a single variable indicating whether any math talk occurred was used in all further analyses. To this end, we first collapsed across all types of math talk and ran a series of chi-squared tests comparing the percentages of adults who used math talk across the three conditions. To account for other factors that may have affected the interactions, such as the store location, age, gender, and race of the adult and child, we conducted a series of follow-up logistic regression models including a set of covariates to predict the odds of adults' use of math talk based on condition (math signs, general language signs, or baseline, with math signs as the reference group). Specifically, models included adult gender and race/ethnicity (White, Black, or other, with White as the reference group), child gender and estimated age (0 = two or three years old, 1 = four or five years old), as well as dummy codes to reflect store location. Importantly, we also included the rated valence of the interaction, the number of conversational turns (1, 2–5, 6–9, or 10 or more, with 1 as the reference group as there were no shoppers with zero conversational turns), and whether the adult interacted with the product (either as "simple product interaction" or product description), put the product in their cart, discussed the price of the product, or interacted with the sign as covariates. These variables were treated as dichotomous indicators (0 = no, 1 = yes) to control for the general valence and length of the interaction. Note that we focused only on adults for these analyses and could not split cardinality, counting, and calculation because some of these types of math talk occurred too infrequently in some of the conditions and were even more infrequent in children (Table 3).

Table 3
Observed Frequencies of Each Type of Math Talk for Target Adults and Children Across Conditions

Adult math talk	*Math signs*	*General language signs*	*Baseline*
Cardinality statement	44%	20%	20%
Cardinality elicitation	31%	2%	2%
Counting statement	17%	2%	2%
Counting elicitation	17%	0%	0%
Calculation statement	14%	0%	0%
Calculation elicitation	7%	0%	0%
Child math talk	*Math signs*	*General language signs*	*Baseline*
Cardinality statement	34%	2%	8%
Cardinality elicitation	2%	0%	2%
Counting statement	19%	0%	2%
Counting elicitation	2%	0%	0%
Calculation statement	3%	0%	0%
Calculation elicitation	2%	0%	0%

RESULTS

First, we examined whether conversational valence and the number of conversational turns varied between the three conditions. A one-way ANOVA revealed no differences in the valence of interactions observed across conditions, $F(2, 176) = 2.45$, $p = .090$. However, there were significant differences in the number of conversational turns between conditions, $\chi^2(6) = 14.13$, $p = .028$. Only 10% of observations in the math-sign condition included a single conversational turn compared to 15% and 27% in the general language sign and baseline conditions, whereas 40% of observations in the math-sign condition included 10 or more turns compared to 25% and 17% in the general language sign and baseline conditions, respectively. Similarly, differences were seen in how adults interacted with the products, $\chi^2(2) = 8.91$, $p = .012$, with more simple product interactions observed in the general language sign condition (60%) compared to the math sign (42%) and baseline (33%) conditions. No differences were observed in whether adults provided more complex descriptions of the products, $\chi^2(2) = 4.98$, $p = .083$, put the products in their cart, $\chi^2(2) = 1.57$, $p = .457$, or discussed the price of the product, $\chi^2(2) = 4.17$, $p = .125$, across the three conditions. However, adults were significantly more likely to interact with the signs in the math-sign condition (46%) compared to the general language sign condition (27%), $\chi^2(1) = 4.70$, $p = .030$.

The number of adults who used math talk varied significantly across conditions, $\chi^2(2) = 15.27$, $p < .001$, as 53% of adults used math talk when math signs were displayed compared to 23% of adults when general language signs or no signs were displayed (Figure 2). To test whether the

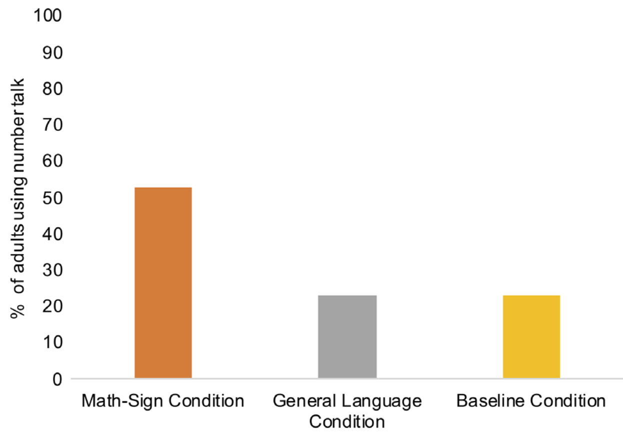

Fig. 2. Percentages of parents using math talk by sign condition.

Table 4
Logistic Regression Results Predicting Use of Math Talk Across Sign Conditions, $N = 179$

Predictor	*Math talk*
Sign condition	
General language	0.26^{**} (0.12)
Baseline	0.25^{**} (0.13)
Store dummy code	2.77^{*} (1.13)
Target child is female	0.63 (0.25)
Target adult is female	0.93 (0.43)
Target adult race	
Black/African American	0.38^{*} (0.17)
Other	2.70 (2.63)
Target child is four or five years old	0.72 (0.31)
Conversational valence	1.07 (0.25)
Conversational turns	
2–5	$0.34^{\dagger}$ (0.22)
6–9	0.40 (0.30)
10+	0.65 (0.50)
Target adult interacts with product	1.17 (0.52)
Target adult describes product	$2.38^{\dagger}$ (1.12)
Target adult puts product in cart	$0.48^{\dagger}$ (0.20)
Target adult discusses price	2.07 (1.08)
Target adult interacts with sign	1.62 (0.88)
Intercept	2.14 (2.21)

Note. Values in each cell are odds ratios and their standard errors. The reference group in these analyses is observations from the math-sign condition with one conversational turn in which both the target adult and child were male, adults were White, and target children were two or three years old.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

differences in the numbers of adults who used math talk across conditions persisted when controlling for other factors in these interactions, logistic regression models were estimated predicting overall math talk (Table 4). Consistent with the chi-squared analyses, the logistic regression models indicated that significantly more adults used math talk when math signs were displayed compared to the other conditions. Controlling for the set of covariates (i.e., store location, child and adult gender, adult race, child age, conversational valence, number of conversational turns, adult interactions with and conversations about the product, price, or sign), adults who saw the math signs had 3.92 times higher odds of using math talk than adults who saw the general language signs and 3.96 times higher odds than the adults in the baseline condition. For interpretation, these odds ratios imply that the predicted probability of using math talk when the math signs were displayed for shoppers in the reference group (i.e., a White male adult shopping with a male two- or three-year-old, who did not interact with the product or sign at all, etc.) was 68%, whereas the predicted probability of a comparable shopper using math talk was 35% when the general language signs or no signs were displayed. Importantly, these condition effects were detected when controlling for conversational turns and therefore reflect increases in math talk, instead of mere increases in conversation.

DISCUSSION

The main goal of this study was to test the efficacy of a cost-effective intervention to promote the occurrence of math-related conversations between adults and children during everyday activities in a naturalistic context. Specifically, we found that putting up signs in a grocery store that prompt adult–child conversations about math increased the number of adults who used math talk with their child compared to no signs or signs that prompted conversations about non-math-related topics. Importantly, these findings could not be explained by an overall increase in conversational turns, increased interactions with the product or sign, merely talking about the price of the product, or any demographic factors associated with the shoppers.

Our study demonstrates that by simply posting signs with math-related prompts in grocery stores, more adults use math talk with their children. In general, parental math talk occurs infrequently in everyday contexts (Levine et al., 2010), but previous studies demonstrate that parents can increase their math talk when given instructions and explicit suggestions for math activities to do with their children (Berkowitz et al., 2015; Braham et al., 2018; Vandermaas-Peeler, Boomgarden, et al., 2012; Vandermaas-Peeler, Ferretti, & Loving, 2012; Vandermaas-Peeler & Pittard, 2014). In children's museums, signs help caregivers recognize what and how children learn through playing in exhibits (Song et al., 2017). Here, we used signs to promote math talk in the context of a grocery store that does not require adults to set aside the extra time that may be needed for playing a board game or visiting a children's museum. Importantly, we were able to promote math talk without explicit instructions and the presence of a researcher.

Previous research has shown that the amount of parental math talk that children are exposed to is related to children's math abilities (Benavides-Varela et al., 2016; Elliott, Braham, & Libertus, 2017; Gunderson & Levine, 2011; Levine et al., 2010; Ramani et al., 2015; Susperreguy & Davis-Kean, 2016). These studies found that when parents used more math talk during everyday interactions, the children had better math skills. Thus, our findings open up the possibility that promoting adult–child conversations around math concepts while shopping is one way to increase children's opportunities to learn math. However, the current study did not investigate the mathematical abilities of the children, leaving it unresolved whether an increase in math talk was related to increased mathematical ability. This might only occur in some but not all children and this possibility needs to be explored in future studies.

Regardless of the content of the observed adult–child conversations, we found significant differences in the number of conversational turns across all conditions. Replicating Ridge et al. (2015), we observed more conversational turns in the general language sign condition compared to baseline. In general, adult–child conversations have been linked to better language skills in children (Topping, Dekhinet, & Zeedyk, 2013; Zimmerman et al., 2009), suggesting that prompting adults to engage in conversations with children while shopping may provide children with opportunities to acquire language skills. In addition, the math-sign condition elicited conversations with more turn taking between adults and children compared to the general language condition. One possible reason for these differences is that math conversations may have been more complex and required more back-and-forth between adults and children. However, since we did not code the exact content of the conversational turns, we cannot test this hypothesis in the present study.

We also observed that adults were more likely to interact with the signs in the math condition than in the other two conditions. In contrast, we found more simple product interactions in the general language sign condition. It is possible that the prompts on the math signs led more adults to point to the signs while the prompts on the general language signs led more adults to point to or pick up the product. Since multiple behaviors were coded for both the sign-related codes and product-related codes, we cannot clearly differentiate what led to these significant differences. Importantly, these differences in sign- and product-related interactions could not explain differences in the number of adults who engaged in math talk in the three conditions.

Several limitations need to be acknowledged. Due to the constraints of our naturalistic observations, observers could not be blind to the conditions. Observations were also only conducted in two store locations in neighborhoods where families likely had high levels of income or parental education, and so future studies should examine how these signs operate in a wider variety of stores, particularly stores serving low-SES families. Ridge et al. (2015) found that general language signs only led to more conversational turns in low-SES neighborhood stores, suggesting that adults shopping in high-SES neighborhood stores may already be talking to their children frequently. Interestingly, we found that our math signs led to more conversational turns than the general language signs suggesting that there is still room to increase adult–child conversations even among presumably middle- to high-SES families. Another limitation of our study is its purely observational nature. This method of data collection severely limited the amount of demographic information available as well as the overall level of detail in any of our variables of interest. This method also limited our knowledge of continual influence on math talk in adult–child interactions after leaving the grocery store. Although we have shown how math signs prompted more adults to engage in math talk while shopping, it is unclear whether or not these interactions have a positive influence on the children's overall mathematical ability and to what extent children's existing math abilities and interest in math affected adults' behaviors. We also could not ask parents whether or not they noticed the signs. In one study in a children's museum, only 55% of parents reported noticing the signs posted in an exhibit (Song et al., 2017). Future studies in grocery stores could include follow-up analyses in which observations are combined with additional information obtained afterwards if shoppers agree to provide it.

Several open questions remain regarding the effectiveness of these signs. For example, if signs similar to the ones used in our study were posted around grocery stores permanently, would adult–child conversations return to baseline after shoppers had already seen the signs on previous shopping trips? Or, would these signs continue to elicit adult–child conversations because they act as a reminder to adults to engage in meaningful conversations with children? And if so, could these conversations extend to contexts beyond the grocery store and help children in other contexts?

In sum, we found that significantly more adults used math talk while interacting with their child when math-related prompts were displayed on signs around grocery stores compared to signs encouraging adults to talk about non-math topics with their children or no signs. Our findings suggest that it is possible to implement low-cost interventions in naturalistic settings to support math talk in the hopes to increase children's opportunities to acquire math skills. Future research should broaden the types of data collected to determine if and how the initial exposure to math-related prompts in the grocery stores affects interactions over time and elsewhere.

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