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AUTHOR Curtis, Reagan P.
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ABSTRACT

For this experiment, part of a larger study on preschoolers' counting competence, 3-, 4-, and 5-year-olds played a counting game with their peers after becoming familiar with the game during structured interviews with an adult. It was expected that the symmetrical nature of peer interaction would allow children to display quantitative knowledge in ways that differed from an asymmetrical clinical interview. Categories of quantitative term use, judgments of others' counting, display of quantitative knowledge without number words, turn negotiation, and role negotiation were analyzed from video and audio recordings. Age differences in quantitative knowledge displayed were not marked. Findings did indicate that preschool children are able to take what they have learned in interactions with an adult into their peer interactions, and that games and collaborative group activities may provide particularly fertile ground for preschool mathematics education. (Author/EV)

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Preschooler's Counting in Peer Interaction

Reagan P. Curtis

University of California, Santa Barbara

Author Note

Reagan P. Curtis (now at College of Education, Northwestern State University, Natchitoches, LA 71497)

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Abstract

Three, four and five-year-old preschool children played a counting game with their peers. It was expected that the symmetrical nature of peer interaction would allow children to display quantitative knowledge in ways that differed from an asymmetrical clinical interview. Categories of quantitative term use, judgments of others' counting, display of quantitative knowledge without number words, turn negotiation and role negotiation were examined. Differences in quantitative knowledge displayed were not marked. This study did show that preschool children are able to take what they have learned in interactions with an adult into their peer interactions. Games and collaborative group activities provide particularly fertile grounds for preschool mathematics education.

Counting is a basic way that people make sense of the world in quantitative terms. The development of counting proficiency between three and five years of age is of major importance for further learning because counting concepts form the basis of arithmetic and other mathematical systems that children acquire once they enter school. If the counting knowledge that children bring to school is better understood, it may become the basis for teaching strategies that bridge existing and new knowledge. This makes the development of counting proficiency a critical area for the study of children's educational and cognitive development.

Social interaction is an important and often neglected factor in children's educational and cognitive development. Verba's (1994) analysis of peer interaction stated that interaction between peers has particular dynamics that allow learning to emerge in ways that do not occur in less symmetric interactions. The relative equality of peers allows them to share competing opinions and meta-cognitive supports in ways that don't occur in adult-child interactions. The asymmetric nature of many clinical interviews and educational contexts may prevent children from displaying knowledge that they might offer to a peer.

The data reported here are part of a larger study that is a developmental exploration of preschoolers' counting competence across 3 different contexts. The larger study was designed to broaden understanding of the development of counting competence by varying the amount of familiarity with materials and social interaction across contexts. This study followed Scribner's (1976) advise to employ several different methods to create a range of situations from, "the experimental to the naturally occurring". A broad range of children's quantitative knowledge

was thereby displayed. The measure reported here introduced social interaction among peers by having two or more children play a board game without adult supervision. The game situation may provide cognitive supports that allow individuals to display knowledge that might not be brought to the fore in unfamiliar situations. Games add increased motivation to perform in a familiar context for preschool children. This allows them to display knowledge that might not be accessed in unfamiliar or less motivating circumstances. This measure allowed observation of children in a fairly naturalistic situation.

Methods

Participants

The participants for this study were 2 three-year-old boys (M= 41.5 months and SD= 3.5 months), 9 four-year-olds (3 boys and 6 girls with age M= 56.0 months and SD= 2.3 months) and 5 five-year-olds (2 boys and 3 girls with age M= 62.6 months and SD= .55 months). These 16 children were part of a larger study that included 36 participants. Subjects were drawn from two Santa Barbara, CA area preschools that served upper-middle SES families.

Procedure

There were three measures used in the larger study: a structured clinical interview, a contextual clinical interview with a board game and a peer interaction context where the same board game was played between participants. The structured interview included participants counting as high as possible without objects and counting 10 dots. One half of the subjects in each age group began with the structured interview followed by the contextual interview while the other half received the contextual interview first. The first two measures were administered

during one session. All three of these measures were administered in a secluded area of the preschools and videotaped with an audio microphone placed on the table.

The peer interaction measure was always administered after the first two were completed so that the participants were familiar with the game (See Figure 1). Two or more participants were shown the game board. Gender and age were not systematically varied, but some groups were same sex and same age while others were heterogeneous. Children were given two dice and two game pieces and told that they should play the game together in any way that they wanted. Children were encouraged to play the game for at least 10 minutes, but not longer than 20 minutes. The investigator was in an adjoining room during the session. An audio and video record was later transcribed to form the data for subsequent analyses.

Analytic Procedure

A coding system for quantitative term use by preschool children engaged in free play was developed by Amaiwa (1997). Transcripts were obtained from a study of the development of gendered language in preschoolers (Kyratzis, personal communication) to develop a coding system for children's use of quantitative terms during the peer interaction measure. The Amaiwa (1997) coding system was translated and modified to include fewer categories that reflected only relevant numerically different usage. Three categories involved using the count sequence. The most sophisticated of these were Counting Objects and Counting Actions. These categories required applying the count string to either objects or events. Number Word Sequence was a less sophisticated usage of the count sequence without applying it to objects or events. Four categories involved using a quantitative term without invoking the count sequence. Quantity Evaluation was the use of a count term to signify the cardinality of some set. This included exact quantities and estimated quantities. Estimated Quantity Evaluation was use of a large

quantitative term to mean something like, "a lot". Measurement included quantitative terms that signified length, height, weight or age and Time included quantitative terms for days, time of day, months and years. The final numerical usage for count terms was Order where children used a quantitative term to indicate sequencing. The last category was Non-numerical Usage and included use of quantitative terms without invoking their quantitative dimension as in, "I want that one."

After all quantitative terms were identified and coded, participants' statements were broken up into turns. One turn consisted of one speaker's utterances and continued until a second speaker interjected. Turns were coded as to whether they fell into one of four categories: (a) judgments of others' counting, (b) display of quantitative knowledge without using quantitative terms, (c) turn negotiation and (d) role negotiation. Judgments of other's counting included any instances where one participant told another that their count was correct or incorrect. Displaying quantitative knowledge without using quantitative terms would include a participant telling another where to move without using number words. Turn negotiation included discussion of whose turn it was, who would go first and who would go next. Role negotiation included discussion of who would be which game piece, who would use which pen colors and who would be the winner or the loser.

The author coded the first group's transcript for quantitative term use, judgments of other's counting, displaying quantitative knowledge without using quantitative terms, turn negotiation and role negotiation. This coded transcript was then used to train another rater. Both raters independently coded the remaining seven groups. After agreement was reached, the codes were tallied and categorized as to the gender and age of the participants involved.

Results and Discussion

This section begins by discussing preexisting differences in counting knowledge between three, four and five-year-olds. Results of the coding of quantitative term use are then followed by judgments of others' counting and displaying quantitative knowledge without using quantitative terms. Finally, results relevant to turn and then role negotiation are presented. Instances of each coding category are given for groups separated according to both age and gender.

Preexisting differences in counting skills between the three age groups were assessed by testing participants' ability to count both with and without objects. Two four-year-olds and 2 five-year-olds did not provide data for these measures. As expected, the trend revealed that five-year-olds were better counters than three-year-olds. Counting without objects, three-year-olds reached the number 10 on average, four-year-olds reached 13 and five-year-olds reached 27. Only one of the two three-year-olds counted 10 dots accurately while all of the four and five-year-olds were correct. Two Kruskal-Wallis one-way ANOVAs were computed with age as the independent variable for counting 10 dots [χ^2 (2, $\underline{N}$ = 12) = 5.00, $\underline{p}$ = .08] and counting without objects [χ^2 (2, $\underline{N}$ = 12) = 1.16, $\underline{p}$ = .56]. Differences between age groups when counting 10 dots approached significance.

There were eight separate peer interaction games played by these 16 preschoolers. Participants agreed to come and play the game with peers of their own choosing. Gender and age makeup varied, as did the number of participants, for each group. The eight groups consisted of the following:

(1) 2 four-year-old boys and 1 three-year-old boy,

(2) 3 four-year-old girls and 1 five-year-old boy,

(3) 2 four-year-old girls,

(4) 1 four-year-old girl and 1 five-year-old girl,

(5) 1 five-year-old girl and 1 five-year-old boy,

(6) 1 four-year-old boy and 1 four-year-old girl,

(7) 1 three-year-old boy, 1 four-year-old boy and 1 five-year-old boy, and

(8) 1 five-year-old girl and 1 four-year-old boy.

The last three, groups 6, 7 and 8, each involved a participant who had been in an earlier group.

Quantitative Terms Use

The first group's transcript was coded for quantitative terms by the author and then used to train another rater. The remaining seven groups were coded independently by the first author and this rater. The results of comparing these two sets of codes indicated that 678 out of 698 codes agreed yielding a 97% rate of agreement between raters. The author made the final decision regarding any discrepancies.

There were a total of 873 quantitative terms used by participants: 354 by boys and 519 by girls. Amaiwa (1997) studied preschoolers' quantitative term use in naturalistic preschool settings without any intervention. The difficulty with her study was that the incidence of quantitative term use was very low, on the order of 1 term for each hour of videotape. The present study has shown that introducing children to a counting game and later asking them to play this game with their peers can be very successful in eliciting counting and quantitative term use in a fairly naturalistic setting.

Three-year-olds generated the fewest quantitative terms averaging 15 quantitative terms each. Five-year-olds averaged 35 terms apiece and four-year-olds generated the most, averaging 74 quantitative terms each. There may well be real differences in the amount of number words used across age groups, but small numbers of participants in each age group makes the reliability

of this finding suspect. A small difference in average number of quantitative terms used by gender was also present. Boys averaged 51 terms each and girls averaged 58.

The most frequent category of quantitative term use was Counting Objects which accounted for 75% (656 out of 873) of all quantitative terms. This finding was not surprising because the game required rolling dice and counting how many spaces to move. The percentage of quantitative terms that were used for counting objects by boys and girls were very similar with boys using this category somewhat more frequently. Boys used quantitative terms for counting objects 81% (287 out of 354) of the time while girls used them in this fashion 71% (369 out of 519) of the time.

There were few differences across age groups in the proportion of quantitative terms used for counting objects although the number of terms did differ. All of the three-year-old boys' quantitative terms were used for counting objects (30 out of 30), while four and five-year-old boys used quantitative terms for counting objects 82% (215 out of 263) and 85% (42 out of 61) of the time, respectively. Four and five-year-old girls used quantitative terms for counting objects 71% (286 out of 403) and 72% (83 out of 116) of the time, respectively. Three-year-olds may not have used other categories of quantitative terms because they focused only on the counting aspect of the game. In particular, three-year-olds may not have used Exact Quantity Evaluation because they had not yet connected counting and count term with cardinality or the size of a set (Curtis, 1999; Wynn, 1990). The following turn illustrated a three-year-old counting and then apparently being unable to label the set with the result of his count:

1 Three-year-old boy rolls 6 "I got 1, 2, 3, 4, 5, 6" as counts with finger "Uh look how many I got"

The second most frequent category was Exact Quantity Evaluation accounting for 19% (170 out of 873) of the quantitative terms. While boys used Counting Objects more frequently, girls used Exact Quantity Evaluation more frequently. Boys used Exact Quantity Evaluation 16% (55 out of 354) of the time while girls used it 22% (115 out of 519) of the time.

Older children used Exact Quantity Evaluation more frequently than younger children. As mentioned above, three-year-olds never used quantitative terms in this fashion. Four and five-year-old boys used this category 15% (39 out of 263) and 26% (16 out of 61) of the time, respectively. Four and five-year-old girls used exact quantity evaluation 21% (86 out of 403) and 25% (29 out of 116) of the time, respectively. Exact quantity evaluation, particularly when it occurs directly after a count, is evidence that children have developed some understanding of cardinality. It may be that they view the size of a set as simply being the last word of a count. Here is an example of a four-year-old girl counting a set of objects and then supplying the last count term as the size of the set:

1 Four-year-old girl "I roll it" "1, 2, 3, 4, 5" points with pen to all dots while counting "I got 5"

Four and five-year-old boys used quantitative terms to indicate Order 2% (6 out of 263 and 1 out of 61, respectively) of the time. Four and five-year-old girls indicated order with quantitative terms 5% (19 out of 403) and 1% (1 out of 116) of the time. Four-year-old girls were the only group to use quantitative terms to indicate Measurement, doing so on 2% (7 out of 403) of their counts. The only instance of a quantitative term being used to indicate Time was by a five-year-old boy. It seems reasonable that other types of numerical games could be devised to elicit more of these categories of quantitative terms in future studies. It would be interesting to see how this changes the dynamics of children's interactions and use of number words.

Quantitative terms were used Non-numerically by four and five-year-old boys 1% (3 out of 263) and 2% (1 out of 61) of the time. Non-numerical usage by four and five-year-old girls occurred 1% (5 out of 404) and 3% (3 out of 116) of the time. When the word "one" is used in this way it is not quantitative term at all, but only serves to point out a particular object.

Judgments of Others' Counting

The first groups' transcript was coded by the author for judgments of others' counting, display of quantitative knowledge without using quantitative terms, turn negotiation and role negotiation. This transcript was then used to train another rater. Each line of the transcripts from the remaining 7 groups were then independently coded. The results of comparing these codes showed that 841 out of 928 lines were coded identically yielding 91% agreement.

The transcripts were then segmented into a total of 622 turns. A turn consisted of one participant's continuous statements until another participant interjected. Thirteen of these turns were coded as judgments of others' counting. Four-year-old boys accounted for 8 of these judgments. Four and five-year-old girls made 2 judgments each. Here is an example of a segment with 3 judgment turns:

1 four-year-old boy takes pen top off to mark 4 dots "1, 2, 3, 4" moves girl 1 space back "Your supposed to be here"

2 five-year-old girl "no I should be right here" moves it back

3 four-year-old boy "This is 4" points to space "Let me count.... 1, 2, 3, 4" points to each space while counting "See, that space makes 5" moves her back one space, "that's four."

Judgments were of particular interest in the larger study connected with this measure. The results of that study (Curtis, 1999) showed that children displayed counting knowledge in their own

behaviors before being able to use that knowledge to judge others counting. As no judgment was specifically asked for in this measure, it was not surprising that there were very few. Judgments that did occur involved children who were particularly competent counters. For instance, the two four-year-olds in the example above were both able to correctly judge a puppet's unusual and incorrect counts in a clinical interview context with an adult (Curtis, 1999).

Displaying Quantitative Knowledge without using Quantitative Terms

Out of a total of 622 turns, 9 turns were coded as displaying quantitative knowledge without numerical terms. Six of these were by four-year-old boys, one was by a five-year-old boy, one was by a five-year-old girl and one was by a preschooler who did not participate in the study. Here is a segment including 2 turns coded in this way:

1 four-year-old boy on right "You do that, that, that" pointing to spaces in succession

four-year-old boy on left "Ok, I'll do it"

2 four-year-old boy on right "See where mine is" points to spaces

The boy on the right is indicating the correct way to count without using counting words. He also indicated where the game piece should be after moving three spaces. This category was particularly rare because children were much more likely to used number words when displaying quantitative knowledge. The few instances of this category that did occur point out that numerical understanding can be displayed in a wide variety of ways.

Role Negotiation

Of the total 622 turns, 140 were coded as involving role negotiation. Boys used role negotiation more frequently than girls did. Twelve role negotiation turns were by a three-year-old boy, 46 were by a four-year-old boy and 24 were by a five-year-old boy. Twenty-five turns

involving role negotiation were by four-year-old girls and 18 were by five-year-old girls. Fifteen instances of role negotiation codes involved children who played the game without participating in the study. There were differences in the ways that roles were negotiated, as well as in how much role negotiation was done by boys and girls. Boys often negotiated roles of winner and loser in a relatively adversarial fashion as in the following excerpt:

1 Five-year-old boy "NO, I win, we got to this end , so we won"

2 Three-year-old boy "I win too"

3 Five-year-old boy "NO"

4 Three-year-old boy "YES I did"

5 Five-year-old boy "We go up the tree, we win up the tree, we win up the three, we win up the tree... We WON"

6 Three-year-old boy "I Win"

7 Five-year-old boy "We was here first and we was racing and you was taking a nap so we won"

8 Three-year-old boy "And you didn't cause there's no room

Girls also negotiated the roles of winner and loser, but did so in a more collaborative fashion. Here is an example from the transcripts

1 Four-year-old girl "know what, I know you gonna win... I really know it... I know you are gonna win in this game, you always always win"

2 Three-year-old girl "no, maybe we play again and you gonna win"

3 Four-year-old girl "play this again"

4 Three-year-old girl "yeah"

5 Four-year-old girl "maybe we can play again"

6 Three-year-old girl "Yeah... we can take turns winning"

These examples display dominant trends in boys and girls interactions, but are not meant to indicate that girls are always collaborative or that boys are always adversarial.

Turn Negotiation

Of the total 622 turns, 124 were coded as involving turn negotiation. There was very little difference between boys and girls in the amount of turn negotiation that went on. There were 3 examples of turn negotiation by three-year-old boys, 37 by four-year-old boys and 19 by five-year-old boys. There 48 were instances of turn negotiation by four-year-old girls and 10 by five-year-old girls. Seven turns by non-participants were coded as turn negotiation. While there was little difference in the amount of turn negotiation by boys and girls there was again a difference in the type of negotiation. Here is an example of two four-year-old girls involved in fairly collaborative turn negotiation:

1 First four-year-old girl "um you go, oh we both go first" and picks up 1 of the dice

2 Second four-year-old girl "uh, how 'bout I go first because uh ... I played it before"

3 First four-year-old girl "I played it before too"

4 Second four-year-old girl while rolling the dice "Well can I go first"

Here is a second example of two boys involved in decidedly more adversarial turn negotiation:

5 Four-year-old boy on left "My turn" drops die (5), rerolls die (2) "I got"

6 Four-year-old boy on right rolls other die (4) "I got one[1], two[1]..."

7 Four-year-old boy on left "No I do, I go for,..."

8 Four-year-old boy on right..."three[1], four[1]. I got four[4a]" marks spaces

9 Four-year-old boy on left..."I do I for for, I go next after you, ok Griffin?"

10 Four-year-old boy on right continues marking spaces "One[1], two[1], three[1], "

11 Four-year-old boy on left "I go next after you! Remember!" clenches hand and pumps arms up and down

12 Four-year-old boy on right "Ok, Gabriel. I didn't do it right"

Conclusions

A consistent feature of all of the transcripts was that children seemed to have taken on the script for playing the game from the contextual interview. They roll the dice, count the spaces and take turns. This shows that games may be a very promising area where preschool children can learn concepts from adults and then take them into interactions with their peers. More detailed analyses of the relations between asymmetrical interactions and subsequent symmetrical interactions appear promising. Pre-Kindergarten educators can benefit from an understanding of how what they do with children may be taken into those children's play with their peers. Understanding how knowledge that is acquired through interaction with an adult resurfaces and is reshaped through peer interaction is a promising area for further study.

Mathematical reasoning with peers is not beyond even three-year-old preschool children. Children showed a considerable amount of sophistication in playing this counting game with each other. This is a promising area for the development of mathematical curricula that take advantage of group activities even in preschool. Initial familiarization with materials is likely to be more crucial with preschool children than with older age groups. Group collaborative activities have been lauded as beneficial with older age groups, but this study shows that they can be successful when implemented with preschool children.

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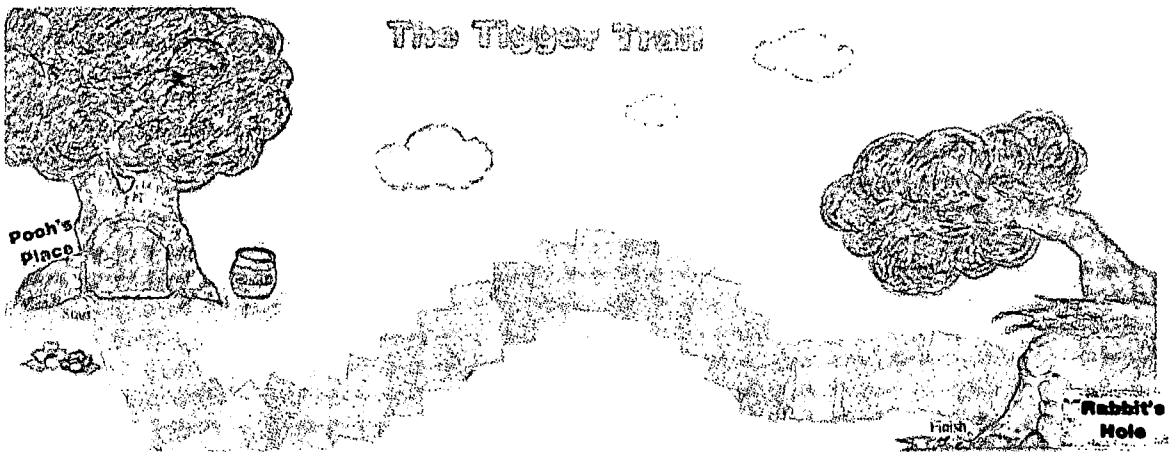
Figure 1. The Tigger Trail Game Board.



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