Learning the meanings of large number words

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Introduction

Adults know that number words can refer to approximate numerical magnitudes: "ninety-five" can mean "about 100"). How do children first map large number words to approximate magnitudes? Some researchers propose that mastery of the verbal count sequence must precede, and may guide, the formation of this mapping [1], because only highly skilled counters show any evidence of such a mapping in a simple estimation task. Others suggest that children do have some sense of the relation between number words and approximate magnitudes before they become skilled counters [2], based on the finding that young children will generate increasingly larger estimates for larger sets even for numbers outside their productive counting range [1]. In the present study, a modified rapid estimation task was administered to children who had not yet become skilled counters, in order to gain a clearer picture of the relationship between counting skill level and comprehension of the later = greater principle (the fact that words that occur later in the verbal count sequence refer to larger numerosities).

Previous Research

Lipton & Spelke (2005):

- 5-year-old children were shown cards displaying differing numbers of pink diamonds. Children were asked to produce estimates ("guesses") of how many shapes they thought were on each card.
- Participants were binned into two categories, "Skilled" vs. "Unskilled", via a counting assessment, and the two groups' mean estimates were analyzed.

- ***Results:***
  - "Skilled" counters and adults produced accurate, linearly increasing estimates, while "Unskilled" counters *did not* for sets outside of their counting range.
  - Lipton & Spelke argue that approximate representations of number become linked to large number words at about the time that children become able to count those words reliably.

Ballinger & Barth (2007):

- Administered a similar estimation task but included a new group of participants: Children were included who had not yet reached the skill levels of the children tested in Lipton & Spelke (2005).

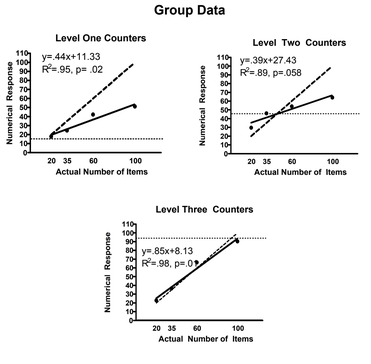
- New Categories:
  - Level 1 = Could count to 35 or less. Unique to this study.
  - Level 2 = Could count above 35 but less than 60. Equivalent to Lipton & Spelke's "Unskilled" counters.
  - Level 3 = Could count past 60. Equivalent to Lipton & Spelke's "Skilled" counters.

- ***Results:*** Level 3 counters produced accurate, linearly increasing estimates, while Level 2 counters did not, for numbers outside their counting range (replicating previous findings). Surprisingly, Level 1 counters did generate increasing estimates, for sets within and outside their verbal counting range (inconsistent with previous conclusions).

- These authors argue that children are able to map large number words to large numerosities before they can consistently count to those words, based upon group level analyses.

Barth, Ballinger, & Sullivan (in preparation):

- Presented a similar rapid estimation task but obtained more data per participant, which allowed for both group and individual analysis.
- ***Results:***
  - Level 3 counters produced accurate, linearly increasing estimates, while Level 2 counters failed to do so outside of their counting range.
  - Level 1 counters again produced linearly increasing estimates even for numerosities outside of their counting range, at both **group** and **individual** levels of analysis: Children apparently *can* produce larger estimates for larger sets before becoming skilled counters.



Aims of Current Study

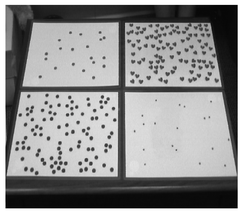
- Previous findings with Level 1 and Level 2 counters were based on small samples, because these children are rarer than Level 3 counters within our target age range. Here we aim to collect more extensive data from these groups by administering a counting assessment prior to the estimation task to filter out the Level 3 counters.
- To present children with a modified version of the rapid estimation task, preventing children's attempts to count and making it clear that guessing, not counting, is the goal.

Participants

- 11 Children, mean age 4 yrs 7 mos., age range 3 yr 6 mos. to 5 yr 7 mos.
- One Level 1 participant was excluded for extreme use of sequential guesses.
- Final N = 10
  - L1: N= 6, mean age 4 yrs 7 mos., age range 3 yrs 7 mos. to 5 yrs 7 mos.
  - L2: N= 4, mean age 5 yrs. 0 mos., age range 4 yr 10 mos. to 5 yr 1 mo.

Stimuli

Stimuli consisted of 2 example cards containing 1 or 200 blue stickers and 56 test cards containing between 6 and 100 stickers. There were 8 trials of numerosities less than 20 to maintain participants' attention, and there were 12 trials each containing 20, 35, 60, and 100 stickers. Stickers were a variety of colors, shapes, and sizes between trials, but were identical within trials.

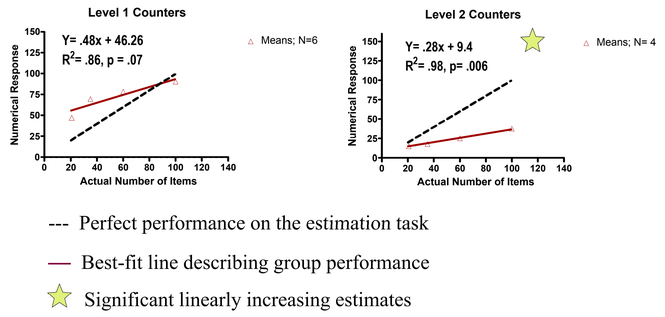


Stimuli were presented one at a time for an approximate duration of 1-2 seconds.

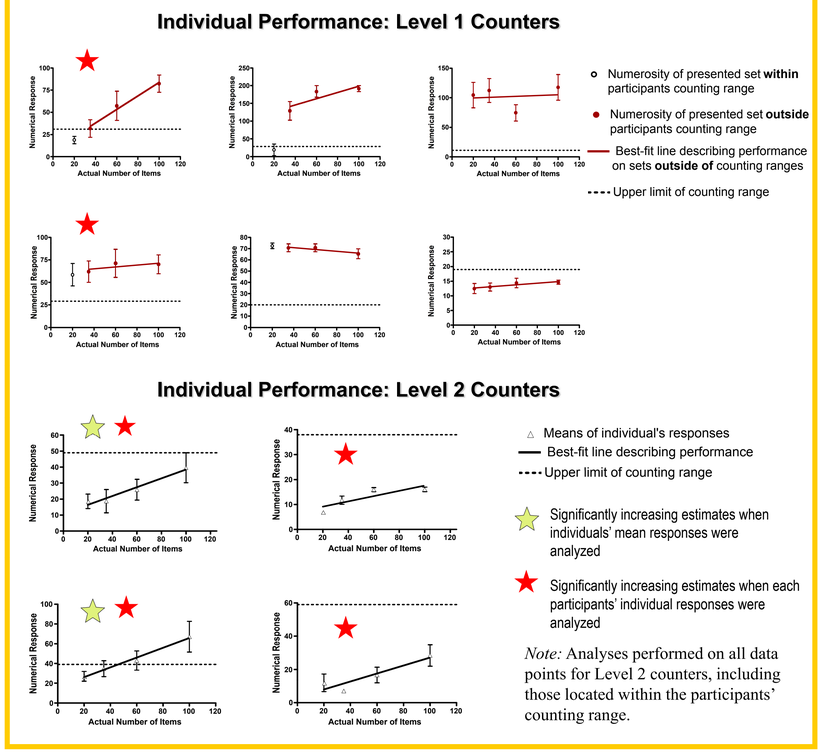
Methods

- Participants' counting levels were assessed prior to the estimation task. This allowed the experimenter to obtain data from the less common Level 1 and Level 2 counters only.
- In a key change, the display cards were flashed for an approximate duration of 1-2 seconds, and were then removed from the child's sight. This served the dual purpose of eliminating the option to count, while reminding the children that this was a guessing game, not a counting game.
- Participants were shown 56 cards and asked to guess how many stickers they saw on each card.
- Participants who produced imaginary responses or guesses outside of the 1-200 range were reminded that all of the cards had fewer than 200 stickers and were asked to make a new guess.

Group Results



Individual Results



Note: Analyses performed on all data points for Level 2 counters, including those located within the participants' counting range.

Conclusions

- At the group level, Level 1 counters did not produce linearly increasing estimates, while Level 2 counters did.
- At the individual level, when the data are analyzed using individual responses, all of the Level 2 and two out of six Level 1 counters produced increasing estimates.
- When the mean responses were analyzed (as in previous studies) two of the Level 2 counters produced linearly increasing estimates, while none of the Level 1 counters did.
- Seven out of ten participants produced overall estimates from outside their counting ranges. This suggests a familiarity with large number words before they can be reliably reached in a count sequence.
- Although the group data show a lack of linearly increasing estimates, individual data from both Level 1 and 2 counters demonstrate that children who produce increasing estimates prior to mastery of the verbal count list do exist. This suggests that a high level of verbal counting skill is not *necessary* for children to demonstrate some understanding of the "later is greater" principle.
- Additional data from Level 1 and Level 2 counters are necessary to determine whether real differences exist between these two categories, and whether children in each group do reliably tend (on average) to produce larger estimates for larger sets. With the help of further data from these less-skilled counters, we hope to understand children's acquisition of the mappings between large number words and numerical magnitudes.

Acknowledgements

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References

1. Ballinger, A., & Barth, H. (2007). Counting, estimation, and approximate nonverbal arithmetic in young children. Conference abstract, Annual Meeting of the Society for Research in Child Development (SRCD).
2. Lipton, J., & Spelke, E. (2005). Preschool children's mapping of number words onto nonsymbolic numerosities. *Child Development, 76,* 978-988.
3. Barth, H., Ballinger, A., Sullivan, J. (In preparation). Mapping large number words to numerosities: General principles precede children's counting skills.