Investigating Sources of Change in 5-7-year-olds' Numerical Estimation

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INTRODUCTION

Mental Representations of Number

Many researchers have begun to study children's mental representations of number in order to better understand the exact nature of our internal numerical systems. Once these internal systems are better understood more appropriate educational interventions will be possible, especially with under achieving math students.

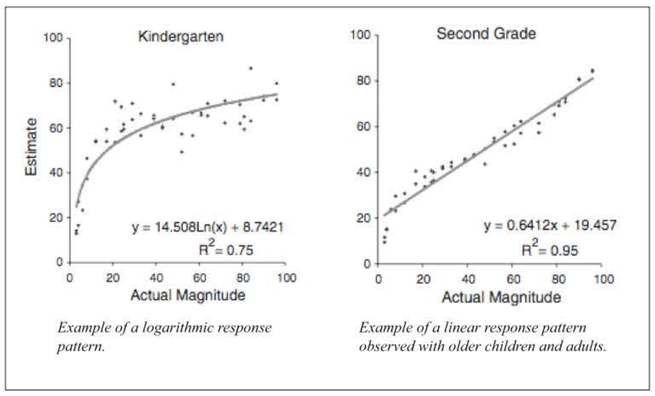
Number Line Estimation Task

In a basic number line task, children are shown a horizontal line with fixed endpoints and are then asked to place a given numeral (e.g. "33") in the proper position on the line.

33

0 _____ 100

The marked positions are then translated into numerical estimates with perfect estimates falling on the line $y=x$. When plotting estimates against actual values, younger children demonstrate a more logarithmically scaled estimation pattern, while older children demonstrate a more linear estimation pattern, similar to that of adults.



Example of a logarithmic response pattern. *Example of a linear response pattern observed with older children and adults.*

Logarithmic-To-Linear Shift

Siegler and colleagues (2003) hypothesize that this shift is due to children's increasing dependence on a more accurate, linear representation of number as they age and gain experience. Siegler and colleagues suggest that number-line data provides evidence of a developmental shift in children's numerical representations (i.e. a *logarithmic-to-linear* shift)

Problems with this Account

1. Patterns of bias (e.g. overestimation and underestimation) are not explained by the log-to-linear shift.

2. Number-line tasks require proportion judgments (Barth & Paladino, 2010).

ACKNOWLEDGEMENTS & REFERENCES

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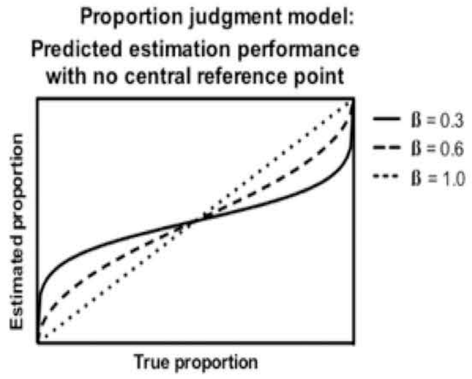
Barth, H. C., & Paladino, A. M. (2010). The Development of Numerical Estimation: Evidence Against a Representational Shift. *Developmental Science, 1-11.*
Lipton, J. S., & Spelke, E. S. (2005). Preschool Children's Mapping of Number Words to Nonsymbolic Numerosities. *Child Development, 76(5),* 978-988.
Siegler, R. S., & Opfer, J. E. (2003). The Development of Numerical Estimation: Evidence for Multiple Representations of Numerical Quantity. *Psychological Science, 14*(3), 237-243.

PROPORTION JUDGMENT ACCOUNT

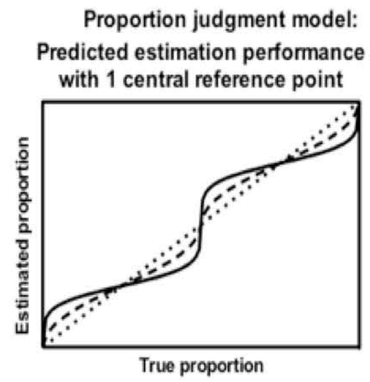
Basic Model of Proportion Judgment

Proportion judgments draw upon biased estimates of two separate magnitudes (a part and a whole).



Cyclical Power Model of Proportion Judgment

Observed if additional reference points are available (e.g. providing a central reference point, "50").



•The exponent β defines the shape of the function. When β=1 the participants' internal representation is perfectly accurate and will take the shape of a straight line. Previous studies have found that values of β tend to be closer to 1 for older children (Barth & Paladino, 2010).

•The W value is the magnitude against which children are comparing the presented numerals to produce their position estimates. W should equal 100 if the child truly understand the magnitudes of the number used in the task.

PRESENT STUDY

Research Questions:

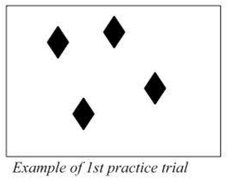
1. Does the proportion judgment model or the representational shift model better account for the observed patterns of children's number line responses?
2. What is the relationship between unrelated estimation tasks and number line performance?
3. Are children's understandings of the magnitude of 100 consistent across tasks?

Task 1: Number-line

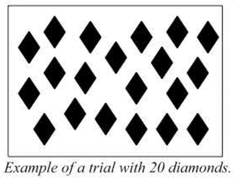
Children ages 5-7-years-old (N=58, Mean Age: 6;4, Range: 5:1-7;11) completed the typical number-line task with endpoints of 0-100. Each testing booklet included 26 numerosities.

Task 2: Set Estimation

Children were shown pictures of varying amounts of diamonds ranging in amount from 20-140 (e.g. 20, 40, 60, 80, 100, 120, 140) with three practice trials showing 4, 6, and 7 diamonds.



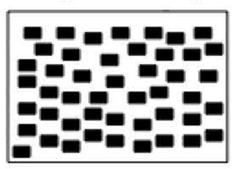
Example of 1st practice trial

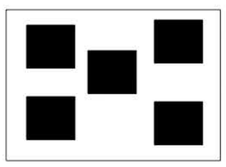


Example of a trial with 20 diamonds.

Task 3: Which One?

Children (N=36, Mean Age: 6;8, Range: 5;2-7;11) were shown 2 pictures at a time and asked to choose which one showed exactly 100 shapes. There were a total of 5 different comparison trials (e.g. 100 vs. 5, 100 vs. 50, 100 vs. 200, 100 vs. 67 and 100 vs. 150), with each trial presented twice (e.g. once with shapes of equal size and once with shapes of equal total area). Task adapted from Lipton & Spelke, 2005.





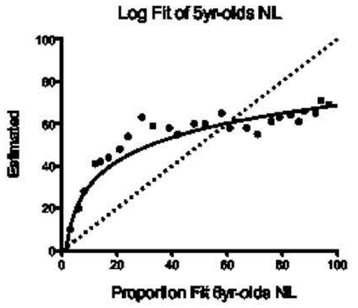
Example of a 100 vs. 5 trial with the shapes on each picture having the same total area

RESULTS & CONCLUSIONS

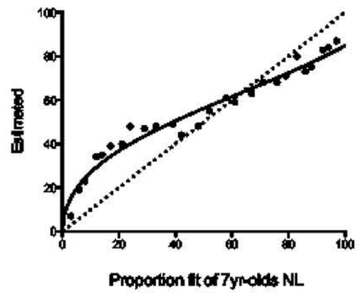
Number Line Results

After fitting the mean and median number line estimates with logarithmic, linear, and proportion models we found that the proportion judgment model provided a significantly better fit than the others (R^2=**0.98**).

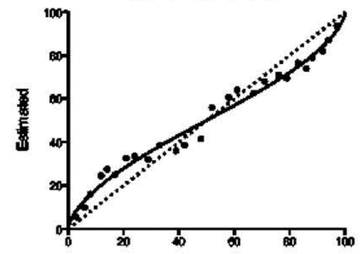
The 5-year-olds median data was better fit by a logarithmic curve (R^2=**0.78**).



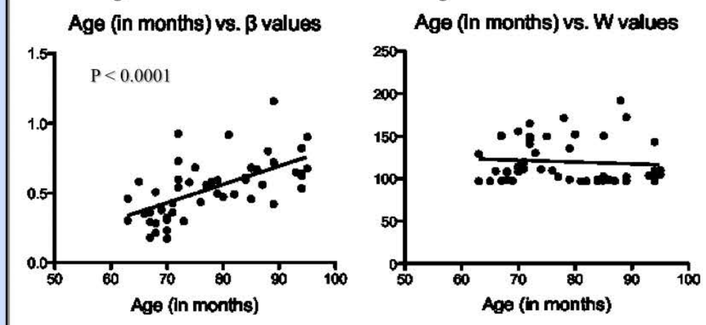
The 6-year-olds median estimates were better fit by a proportion model (R^2=**0.96**)



The 7-year-olds median estimates were better fit by the proportion judgment model (R^2=**0.98**).



Further analysis also showed that age (in months) is significantly correlated with β values, suggesting that with age children produce more accurate estimates (i.e. β approaches 1). There was no significant correlation between age and W values.



Set Estimation Results

Unfortunately, we found no correlation between children's estimates of 100 in the Set Estimation task and their β and W values on the Number Line Task.

Which One? Results

Preliminary analysis suggests that children typically choose the larger set, indicating that they have only a vague conception of the actual mapping between sets of 100 items and the number word 100.

NEXT STEPS

1. Analyze the correlation between overall set estimation accuracy and number line performance
2. Explore correlation between which one results and number line performance.