Understanding of Numerical Magnitude: Preparation for Future Learning in Mathematics

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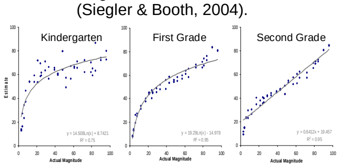
Background:

- Preparation for Future Learning
  - Individuals transfer previous knowledge and experience into situations to help them learn (Bransford & Schwartz, 1999; Schwartz, Sears, & Bransford, in press).
- Understanding of Numerical Magnitudes
  - Young children do not make accurate judgments of numerical magnitudes between 0 and 100. (Siegler & Booth, 2004).



  - Knowledge of numerical magnitudes affects children's ability to complete measurement, numerosity, and computational estimation tasks (Booth & Siegler, 2006)
  - Having an accurate understanding of numerical magnitudes is related to higher math achievement (Siegler & Booth, 2004; Booth & Siegler, 2006)

Purposes:

1. Determine if having an accurate understanding of numerical magnitudes prepares students to learn addition facts
2. Determine whether providing students with magnitude information during the learning process facilitates learning

Hypotheses:

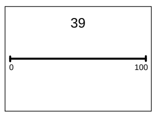
1. A strong understanding of numerical magnitudes will predict learning beyond other predictors (e.g., math achievement, working memory, addition knowledge)
2. Students who are given magnitude information will learn more addition facts and improve their magnitude knowledge

Participants

- 105 first grade students recruited from four schools in a middle-income district

Tasks

- Number Line Estimation
  - 26 numbers between 0-100



- Math Achievement
  - Math section of the WRAT-Expanded (2001)
- Working Memory
  - Forward Digit Span from the WISC-IV (2002)
- Addition Facts
  - 13 Facts with sums between 0-100
  - 4 facts used for training

Procedure

- Four individual sessions with the experimenter
  - Three 10-15 minute sessions within a week's time
  - One 5 minute follow-up two weeks later
- Session 1:
  - Number Line Pretest,
  - Working Memory Pretest
  - Addition
    - Pretest
    - Training
    - Addition Test
- Session 2
  - Addition
    - Pretest
    - Training
    - Addition Test
  - Number line test
  - WRAT (Math section)
- Session 3
  - Addition
    - Pretest
    - Training
    - Addition Test
  - Number Line Posttest
- Follow up
  - Addition fact retention test

Design

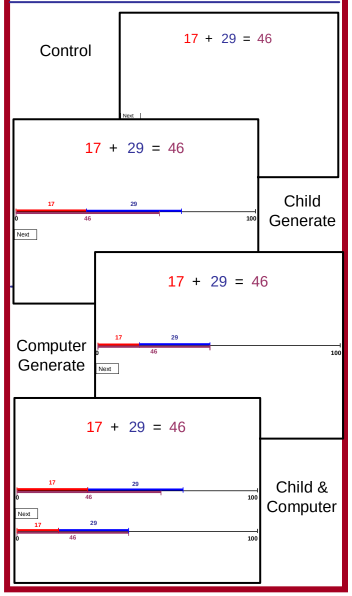
- 2 x 2 Factorial

Computer Placement	Child Placement: No	Child Placement: Yes
No	Control	Child Generate
Yes	Computer Generate	Child & Computer Generate

Addition Fact Training

- Computer screen showed fact and (in certain conditions) number line
- Over the course of each training session, students heard each fact once and repeated it 3 times
- One practice trial was given before each training session to demonstrate (or remind students of) the procedure and ensure that they understood all facets of the representation

Example Summary Screens



Predictors of Addition Fact Learning

- Pretest Magnitude Knowledge, Math Achievement, and prior Addition Knowledge all predict learning (pretest performance is controlled for)
- Magnitude knowledge is an independent predictgor
  - Accounts for additional variance after all other predictors are entered

Relations Among Pretest Measures

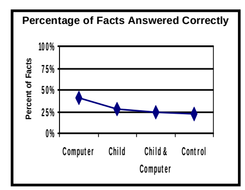
- All measures were significantly correlated, with the exception of number line and working memory measures

	Addition (Error)	Math Achieve-ment	Working Memory
Magnitude Knowledge (R^2_{Lin})	-.41***	.57***	.07
Working Memory	-.21**	.21**	
Math Achieve-ment	-.48***		

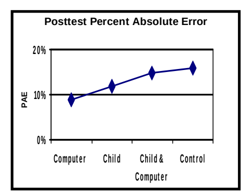
df = 103; **p<.05, ***p<.01

Instructional Conditions: Addition Facts

- Computer Generate group learned significantly more facts than the other groups ($t(103)=2.74$, $p < .01$)

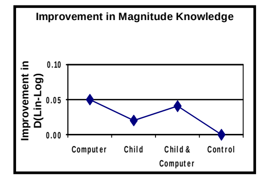


- Computer Generate group produced less error in answers to addition fact posttest than the other groups ($t(103)=2.13$, $p < .05$)



Instructional Conditions: Magnitude Knowledge

- Trend toward Computer Generate group gaining more magnitude knowledge than other groups ($t(102)=1.88$, $p < .10$)



Summary of Results

1. Knowledge of numerical magnitudes predicts learning and retention of addition facts (beyond that predicted by math achievement and prior knowledge of addition)
2. Providing magnitude information during instruction can both improve learning of arithmetic facts and increase magnitude knowledge

Implications

- Knowledge of numerical magnitudes is important for learning in mathematics
- An important goal of early mathematics education should be to provide students with a strong foundation of knowledge of numerical magnitudes
- One way for educators to accomplish this would be to include a concrete representation of magnitude while teaching everyday mathematics lessons

Future Questions:

- How does understanding numerical magnitudes affect learning in other tasks and other ranges of numbers?
- How immediate are the effects of improved magnitude knowledge? Would such improvements transfer to even better prepare students for learning in mathematics?

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