# THE RELATIONSHIPS AMONG NUMBER LINE ESTIMATIONS, MATHEMATICS ACHIEVEMENT AND PLACE VALUE CONCEPT

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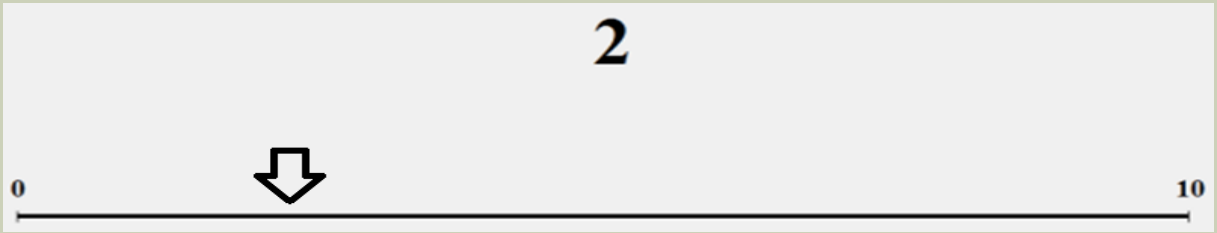
GlobETS: AN INTERNATIONAL CONFERENCE ON EDUCATION, TECHNOLOGY AND SCIENCE 6-9 MAY 2018, Belgrade

# EARLY MEANİNGS OF NUMBERS

- Early meanings of (naturel) numbers are established on quantities,

either;

- continious (measurable) quantity (magnitude), like distance, number line etc...)




Or;

- Discrete (countable) quantity (like sets of objects, sets of dots etc...)
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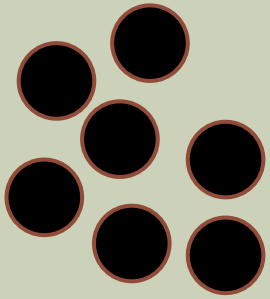

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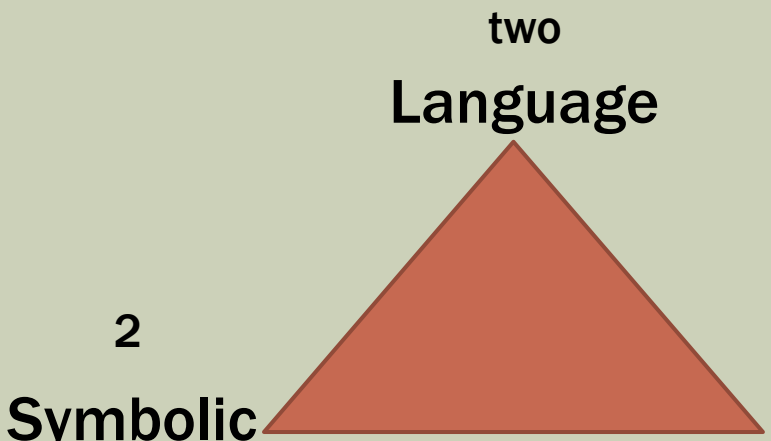
# REPRESENTATIONS OF NUMBERS

- **Triple Coding**

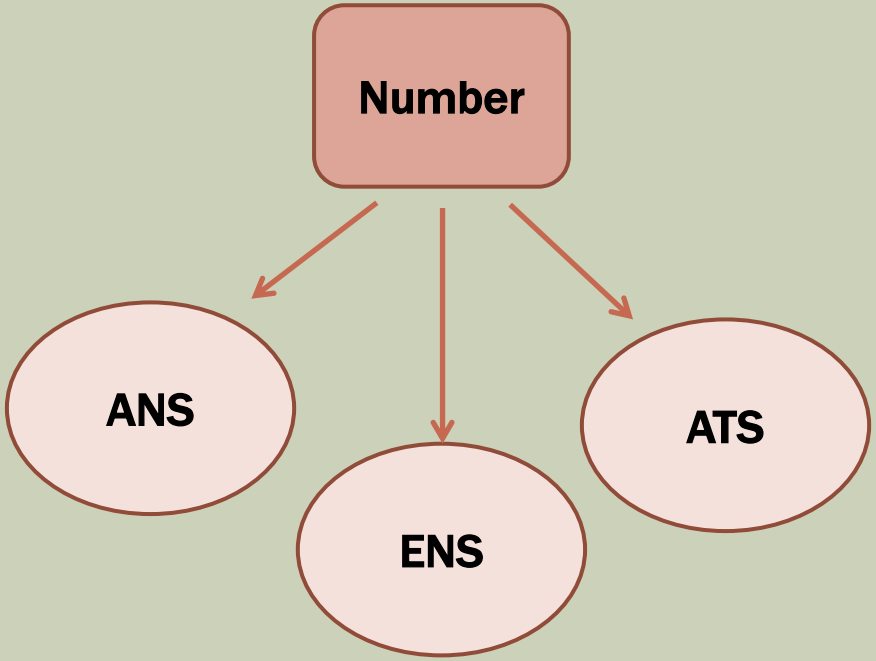



Real events : 2 birds

Concrete manipulatives:

Pictures

# DEALING WITH NUMBERS




ANS: Approximate Number System

ENS: Exact Number System

ATS: Access to Symbols

- The core systems of number has 3 components
- We estimate large numbers but we calculate small numbers
- Each of the ANS acuity, ENS accuity, and ATS (an understanding of number symbols) independently contribute to mathematics achievement
- How do we represent and manipulate (calculate) large numbers?

# BACKGROUND

- The understanding of the concept of a positional, or place value system is central to developing number sense and is also the basis for the four fundamental operations on numbers.
- Place-value knowledge is particularly important in understanding regrouping, gaining number sense, and making mental computations.
- Children with good place-value understanding were better than their peers at making accurate number-line placements.

45 → 4 reps 40

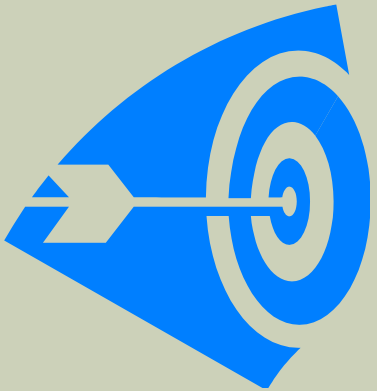
54 → 4 reps 4

16 + 14 = 30

20 + 80 = 100

# PURPOSE

- To investigate the relationships among students' number line estimations, place value understanding and mathematics achievement scores.



# METHODS

- Participants:
  - A total of 355 fourth graders from primary schools in a Mid-Anatolian City

Table 1. Demographics of the participants

| Gender | N | Mean age |
|---|---|---|
| Girls | 171 | 9,3 |
| Boys | 184 | 9,7 |
| Total | 355 | 9,6 |

# METHODS

- **Three tests** were administered to the students.
  - First, students were administered a curriculum based *Mathematics Achievement Test* (**MAT**)
    - It includes numbers, counting, number patterns, four arithmetic operations and fractions.
    - test took one class hour
  - Second, students were administered *Mental Number Line Test* (**MNL**)
    - The test was administered on **Personel Computer (PC)**
    - No timing was recorded for this test.
    - There were 2 sample items before each of the actual test.

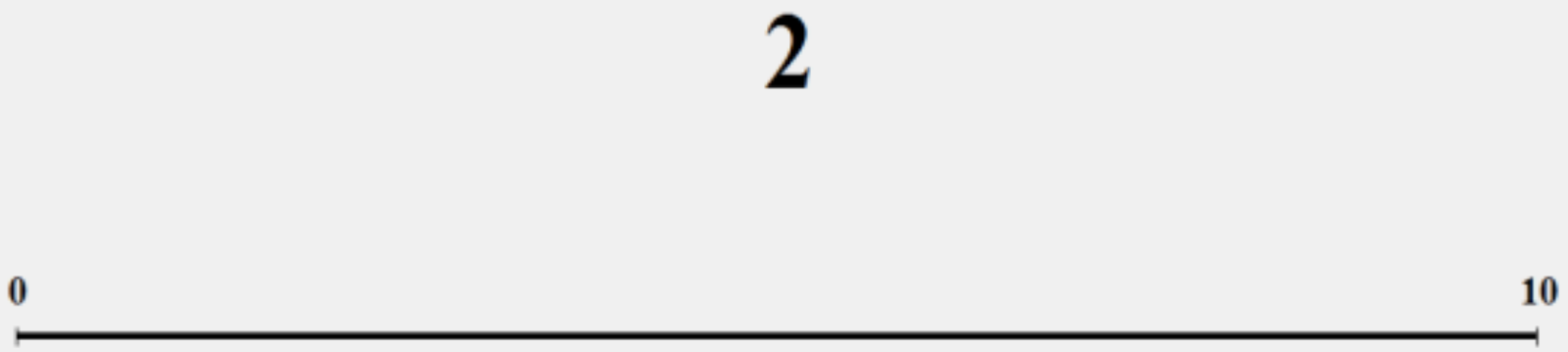
# METHODS

- The third test was the Place Value Test (PVT)
  - Place Value Test were developed by Sari (in press) by considering the relevant acquisitions regarding the concept of place value in 4th grade primary school mathematics curriculum.
  - The administration of the test took one class hour.

# A SAMPLE MNL TASK

SAMPLE

If there is zero on the left end and 10 on the right end, where is 2 on this number line?




- We had two types of numberlines: 0-10 and 0-100
- 18 tasks for 0-10 type, 40 tasks for 0-100 type

# ANALYSIS

- We have determined the row score of students in MAT and PVT.
- Total Absolute Errors (TAE) were calculated for MNL 0-10, MNL 0-100 and MNL 0-1000 estimations (Siegler & Booth, 2004)
  - TAE = (Estimations – to be estimated number) / scale

# ANALYSIS

- We looked at the correlations among the tests.
- To estimate the explanatory power of mathematics achievement, and arithmetic tests on Number Line Estimations, we run **regression analysis**.
- We also compared males and female students' scores in **MAT**, **MNL** and **PVT** through **Independent-Samples T-tests**

# RESULTS

Table 1: Correlations among the tests used in the study

| Tests | PVT | MAT | MNL1 | MNL2 | MNL3 |
|---|---|---|---|---|---|
| PVT | - | .836** | -.519** | -.517** | -.599** |
| MAT | | - | -.496** | -.544** | -.597** |
| MNL1 | | | - | .576** | .565** |
| MNL2 | | | | - | .824** |
| MNL3 | | | | | - |

**PVT:** Place Value Test, **MAT:** Mathematics Achievement Test, **MNL1:** Mental Number Line 0-10, **MNL2:** Mental Number Line 0-100, **MNL3:** Mental Number Line 0-1000.

- As you see from Table 1, we found statistically significant correlations among all the tests used for the study.
- The highest correlation was calculated between PVT and MAT scores.
- Also PVT have stronger correlations with MNL3.
- MAT have correlations with Mental Number Estimations, stronger with MNL3

# RESULTS

Table 2: Summary of regression results for MNL1, MNL2, and MNL3 with PVT

| Model | Variables | R | $R^2$ | F | β | t | p |
|---|---|---|---|---|---|---|---|
| 1 | MNL1<br>MNL2<br>MNL3 | .637 | .406 | 80.06 | -.465 | -6.21 | .000 |

a Predictors: (Constant), MNL1 (Mental Number Line 0-10), MNL2 (Mental Number Line 0-100), MNL3 (Mental Number Line 0-1000)

The results also showed that;

- When MNL1, MNL2, and MNL3 were entered in the regression we saw that all of the tests have significant explanatory power on place value test (PVT).
- MNL1, MNL2, and MNL3 together have explained 41% of the variance in PVT.
- MNL3 alone has accounted for 36% of the variance in the PVT.

# RESULTS

Table 3: Summary of regression results for MNL1, MNL2, and MNL3 with MAT

| Model | Variables | R | $R^2$ | F | β | t | p |
|---|---|---|---|---|---|---|---|
| 1 | MNL1<br>MNL2<br>MNL3 | .629 | .396 | 76.62 | -.465 | -6.21 | .000 |

a Predictors: (Constant), MNL1 (Mental Number Line 0-10), MNL2 (Mental Number Line 0-100), MNL3 (Mental Number Line 0-1000)

The results showed;

- MNL1, MNL2, and MNL3 together have explained 40% of the variance in MAT.
- MNL3 alone accounted for 36% of the variance in the MAT.
- On the other hand, MNL 0-1000 (large numbers) contributed more to mathematics achievement.

# RESULTS

Table 4: T-test results of lower and upper groups' PVT and MAT Scores

| Variables | Groups | N | Mean | Sd | df | t | p |
|---|---|---|---|---|---|---|---|
| PVT | Lower-group | 42 | 3.30 | 2.56 | 79 | -14.822 | .000* |
| | Upper group | 39 | 11.20 | 2.20 | | | |
| MAT | Lower-group | 42 | 3.66 | 2.66 | 79 | -14.999 | .000* |
| | Upper group | 39 | 12.87 | 2.85 | | | |

# RESULTS

Also;

- In order to see if **PVT scores** have any effect on **MAT**, a linear regression analysis was run.
- Results showed that **PVT** ($R = .836$, $R2 = .698$) **explained 70%** of the variance ($F_{(1\text{-}353)} = 817.53$, $p < .01$) **in MAT**.
- On the other hand, **PVT contributed more than MNL to mathematics achievement.**

# RESULTS

Table 5: Gender differences

| | N | PVT Mean | MAT Mean | MNL1 TAE | MNL2 TAE | MNL3 TAE |
|---|---|---|---|---|---|---|
| Boys | 184 | 7.95 | 8.73 | 29.44 | 199.6 | 2533.8 |
| Girls | 171 | 7.85 | 9.27 | 31.16 | 218.3 | 2944.7 |
| | p | (.789) | (.263) | (.368) | (.237) | (.014)* |

- Gender analysis showed that there were no statistically significant differences between boys and girls in PVT, MAT, MNL1 and MNL2.
- There are gender differences only in the MNL3 favoring boys.

# CONCLUSIONS

- The analysis showed six main results:

- First, Place Value (PVT) understanding has strong correlations with both Mathematics Achievement scores and Number Line estimations (0-1000).
- Second, boys generally did better, (made) more accurate number line estimations (0-1000) than girls.
- Third, number line estimation skill is a strong predictor of place value understanding, with MNL (0-1000) being the strongest,

# CONCLUSIONS

- Fourth, number line estimation skill is a strong predictor of mathematics achievement, with MNL (0-1000) being the strongest.
- Fifth, there are huge differences between the worse number line estimators (bottom 27%) and better number line estimators (top 27%) in terms of both math achievement and place value understandings
- Sixth, place value understanding explains a significant portion of math achievement.

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