Connecting Early Number Word Knowledge and Approximate Number System Acuity

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Background
Children typically undergo great leaps in verbal number development between 3 and 5 years of age. During this time, a nonverbal system for representing numerical quantities – the Approximate Number System – also undergoes dramatic change as numerical acuity sharply increases. Symbolic number knowledge is correlated with ANS acuity throughout the lifespan.

The Present Study
Is growth in verbal number knowledge tightly linked with change in ANS acuity? In a 6-month longitudinal study, children were tested monthly on verbal number knowledge and non-verbal ANS acuity.

Number Word Assessments
Give-a-Number Task
(Wynn, 1992, 1999)
Children are asked to give 1 to 8 objects. Assigned a ‘Knower Level’ based on highest number with systematic correct responses.

Subtask Knowers:
Demonstrate knowledge of some number words but not others (e.g., create sets of one, two or three objects, but fail when asked for five or six items).

Cardinal Principle (CP-Knowers):
Can see counting to create a set of any number of items within their count list.

Fast Cards Task
(LeCorre & Carey, 2007)
Children estimate sets of 1-15 items, rapidly displayed (5s) on a computer. Assigned a ‘Mapper Level’ based on estimates for larger sets (estimates for 10 are larger than estimates for 5).

Non-Mappers:
Have not mapped large number words to approximate numerosities (fail to give higher numbers for larger sets).

Mapper:
Symbolically give higher estimates for larger sets.

ANS Acuity
Who Has More? Task
(Adapted from Halberda & Feigenson, 2008)
Children compared two sets of dots and said which set has ‘more’. Set sizes varied from 4-15 dots. Sets differed by ratios between 1:2 and 6:1. For half the trials, summed area was anti-correlated with the number of dots.

Cross-Sectional Analysis
Is there a correlation between Level and numerical acuity?

W-score systematically decreases with Knower Level. ANS Acuity increases with Verbal Number Knowledge.

Longitudinal Analysis
Do jumps in Level correspond to increases in numerical acuity?

ANs undergoes the greatest change for children jumping from a Subset- to CP-Knower Level.

Conclusions
Nonverbal Number Development
Our longitudinal data support Halberda & Feigenson (2008), showing rapid increases in ANS acuity during the preschool years.

Verbal Number Development
Replicating Wynn (1992), Knower Level transitions are highly stable.

• This supports claims that Knower Levels reflect meaningful conceptual states.

Mapper transitions are unstable: there were as many drops from Mapper to Non-Mapper as increases from Non-Mapper to Mapper.

• The hypothesized Non-Mapper to Mapper transition may not represent a rapid, robust conceptual shift (cf. LeCorre & Carey, 2007).

Connecting Verbal and Nonverbal Number
Strong correlation between non-verbal numerical acuity and Knower Level in preschoolers.

Jumps from Subset to Cardinality Knower Levels are coincident with large increase in ANS acuity.

Because changes in verbal and non-verbal performance occurred within a single interval, the temporal order of events is not clear.

• Maturation of the ANS may precede and support verbal number development.

• Number language may precede and support developmental change in numerical acuity.

These findings highlight an intimate relationship between nonverbal and symbolic number systems in the earliest stages of number learning.

Acknowledgements
We thank Sarah Edelman and Barry Finfer for data collection, Jessica Sullivan and Ryan Ly for assistance with piloting, recruiting schools, and programming, and children and teachers at the participating preschools. This project was funded by a Wesleyan Project Grant to A.S. and an NSF CAREER (DBI-0848564) to A.S.