ABSTRACT

Cardinal meanings of number words are particularly difficult for children to learn. Although most children recognize numbers as a distinct class of words by age two (Fuson, 1988; Gelman & Gallistel, 1978; Shatz & Backsheider, 2001; Schatz, 2005), they typically take another year or two to learn the cardinal values of these words. The present study looks at children’s learning of two separate aspects of number-word meaning. First, children must distinguish number words (and other quantifiers) from adjectives. Secondly, children must pick out numerosity as the relevant property of the set and to disregard irrelevant properties such as the summed area or summed contour length of set members.

English monolingual children 2 ½ to 4 ½ years old were shown a sample picture and asked to choose from one of two response pictures that matched the sample picture in some way. Trials asking children to match according to number controlled for total area or contour length. Results were analyzed according to how many number words the child understands, which was determined by the Give-N task (Wynn, 1990; 1992).

Results show that children begin to connect high number words to numerosity by the time they are able to use counting to determine the number of items in a set (i.e. by the time they understand the Cardinality Principle). They match pictures on number rather than on properties of individuals (color or mood) or properties of sets (total area or total contour length). Children who do not yet understand the Cardinality Principle, on the other hand, fail to match on number. They seem to be particularly distracted by adjective variables. Follow-up experiments, now underway, will provide a more detailed picture of how children apply number words in the earliest stages of their acquisition.
When do children connect number words to numerosity?

PARTICIPANTS

- 71 English-speaking monolingual children
- Ages range from 2 ½ years to 4 ½ years (mean ≈ 3 ½ years)

GIVE-N DIAGNOSTIC TASK

BACKGROUND

Children acquire number words in a piecemeal fashion. They learn the number words in order (“one” then “two” then “three”, etc.) and can be assigned to ‘levels’ of number knowledge by their performance on the Give-N task.

METHOD

Children are asked to give a stuffed animal a certain number of objects (1 to 6 objects).

KNOWER-LEVELS

Cardinal Principle (CP)-Knowers: Children who can use counting to create a set of any number of items within their count list (thus, succeed on all trial types).

Subset-Knowers: Children who demonstrate knowledge of some number words but not others (e.g. can create sets of one, two or three objects but fail when asked for five or six items).

Pre-Knowers: Children who cannot accurately create sets of any number.
When do children connect number words to numerosity?

**MATCH to SAMPLE TASK**

**BACKGROUND**

- **Number Words vs. Adjectives**: Both appear in the same position on the noun phrase but adjectives refer to properties of individuals whereas number words refer to a property of sets. (see Bloom & Wynn, 1997 for analysis of children’s naturalistic speech)

- **Number Words vs. Quantifiers**: Two studies have claimed that children connect number words to numerosity by the time they understand one or two number-word meanings but neither study systematically controlled for other properties of the set, so a child who thought that number words referred to total area or total volume would still succeed on these tasks. (Wynn, 1992; Sarnecka & Gelman, 2004)

- The Match to Sample task investigates when children understand that number words refer to numerosity rather than adjectival properties or total spatial extent.

**STIMULI**

- Sets of pictures that vary across three dimensions: (Adjectives, Spatial Extent, and Number)

Each stimuli set differs in number by a 1:2 ratio. Children are asked to match pictures according to the following number words: four, eight, five, ten.
**PROCEDURE**

Step 1
Experimenter places SAMPLE picture in front of child.
PROMPT: “This picture has eight turtles.”

Step 2
Experimenter places two RESPONSE pictures to the right and left of the SAMPLE picture.
PROMPT: “Pick up another picture with eight turtles and put it on the dot.”

Step 3
Child chooses picture and experimenter records response.
Experimenter repeats prompt and discourage counting when necessary.
Matching on Adjectives

“This picture has **ORANGE** turtles.
Pick up another picture with **ORANGE** turtles and place it on the dot.”

**EXAMPLE OF TRIAL TYPE**

Sample Picture  |  Response Pictures
--- | ---

When prompted to match according to an **ADJECTIVE** variable (i.e. color or mood), Subset and CP-Knowers choose the correct response picture.

Pre-Knowers are performing at chance.
Matching on Number

“This picture has **EIGHT** turtles.
Pick up another picture with **EIGHT** turtles and place it on the dot.”

When prompted to match according to NUMBER, CP-Knowers choose the correct response picture.

Subset and Pre-Knowers are performing at chance.

**EXAMPLE OF TRIAL TYPE**

**RESULTS**

When prompted to match according to NUMBER, CP-Knowers choose the correct response picture.

Subset and Pre-Knowers are performing at chance.
Matching on Number with an Adjective Distracter

“This picture has **EIGHT** turtles.
Pick up another picture with **EIGHT** turtles and place it on the dot.”

**EXAMPLE OF TRIAL TYPE**

When prompted to match according to NUMBER, CP-Knowers choose the correct response picture, even if they have to ignore an alternative match on an adjective variable (i.e. color or mood).

Subset and Pre-Knowers are performing *below* chance, indicating that they are choosing the response picture that matches on an adjective variable (i.e. color or mood).
RESULTS

CP-Knowers:
- Correctly match pictures according to color, mood, and number.
- Correctly match pictures according to number even if the alternative response picture matches the sample picture’s color, mood, and/or total spatial extent.

Subset-Knowers:
- Correctly match pictures according to color or mood.
- Do not correctly match pictures according to number.
- When given the option, are more likely to match pictures according to color or mood when prompted to match on number.
- When given the option, are NOT likely to match pictures according to total spatial extent (t=-0.92, p=0.47).

Pre-Knowers:
- Do not correctly match pictures according to color, mood, or number.

General Notes:
- No significant differences were found in performance between Subset Knower-Levels (i.e. between One-Knowers, Two-Knowers, Three-Knowers, and Four-Knowers).
- Children (in all Knower-Levels) do not systematically respond differently to controls for summed contour length versus area.
- Although age and Knower Level are significantly correlated, effects of Knower- Level are present when controlling for age.
CONCLUSIONS

Children understand that number words refer to numerosity (rather than adjectival properties or total spatial extent) by the time they make the Cardinal Principle Induction. Prior to this point, children fail to connect number words to number when stimuli control for total spatial extent. Furthermore, when the option is available, they are more likely to match pictures according to adjectival properties even when prompted to match according to the number of items in a picture.

REFERENCES


