“Two Children Found Four Caterpillars”

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AAAL/ March 27, 2012
Boston MA
Is that...

Distributively and/or Collectively?

Does it make a difference for children’s math? How?
Collective and Distributive  (Vendler, 1967)

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Image of all flowers in a vase" /></td>
<td><img src="image2" alt="Image of three flowers in a vase" /></td>
</tr>
</tbody>
</table>

All the flowers are in a vase.

Three flowers are in a vase.

Every/ each flower is in a vase.
The semantic, syntactic, and pragmatic properties of quantifiers are not well-fixed for children.

How do they sort them all out?

What happens while they’re figuring them out?
Acknowledgments

- Much of this work was done in conjunction with the DELV Project National Institutes of Health (NIDCD) Contract #N01 DC8-2104 to Harry Seymour, Principal Investigator at the University of Massachusetts Amherst, with Thomas Roeper and Jill de Villiers at UMass and Smith College as co-investigators for the Diagnostic Evaluation of Language Variation-DELV tests (2003, 2005)

- Some of the materials and conceptualization during a stint at the University of Wales, Bangor –

- Margaret Grace (B.A., 2010) helped with the child participants
1. Brief background on implicit semantic properties of words telling about quantities (“how many,” numbers, “some”), especially wrt **collectivity** and **distributivity**

2. The role of specific markers of distributivity (and collectivity): “each” and “together”

3. Developmental trends

4. Impact on some simple math problems

(This is in L1. We’re moving toward cross-linguistic analyses, and have a few comparisons, but we’re not there yet.)
Early experience with the collective & distributive

- Child learns lexical items very early "all gone" (collective)
- They learn 1 to 1 counting (very distributive)
- ?How learn implicit (or possibly context-driven) properties?
“Baselines” or Biases

Before testing the math, explore responses to Neutral, Distributive Bias, & Ambiguous examples
Neutral

How many books do the children have?

On DSLT (Seymour, Roeper & de Villiers, 2000)
Body parts, distributive bias

How many hands do the children have?

Do the boys have two hands or four hands?

i.e. Is that each (distributed) or all together (collective)?
Intentionally ambiguous!

- Every boy has 3 buckets, and these girls have one bucket.

  Is that one bucket for each girl?  Or one in all?
Design

- 2 groups: L1 (English) adults and children

- Adult data from websurvey
  - [link]

- Children (ages 3-10) tested with PPT adaptation of the survey, individually at their schools

<table>
<thead>
<tr>
<th>L1 Adults</th>
<th>L1 children</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>54</td>
</tr>
</tbody>
</table>
Collective or Distributive Responses by Group by Condition

% collective responses

<table>
<thead>
<tr>
<th></th>
<th>L1 adults (n = 33)</th>
<th>L1 children (n = 56)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neutral (books)</strong></td>
<td>80%*</td>
<td>50%</td>
</tr>
<tr>
<td><strong>Distributive bias (hands)</strong></td>
<td>55%</td>
<td>25%</td>
</tr>
<tr>
<td><strong>Ambiguous (buckets)</strong></td>
<td>67%**</td>
<td>50%</td>
</tr>
</tbody>
</table>

*25% give explanations in terms of needing “each” or “together” (6% of children also commented.); **some wanted to be parallel to first part of sentence.
Hands, as expected, more distributive than other objects for both groups.

- Books & buckets: 5:2 said I need “each” to distribute vs. needing “together” for collective.
- (Note: L2 adults required more explicit markers (“each”/ “together”)
- Children 50:50 haven’t established preference (except hands).
Age trend, older children more like adults
“Qualifiers” – by 7 years realize that they can’t assume distributive or collective, and are more likely to say (not assume) “each” than “together”
Ambiguous Buckets

- Cf Adults 67% collective
Explaining is still hard

- “One for everybody” (reason for distributive)
- “these equals all” – one for all (but means each)

- “plural girls equals plural buckets”

- Clearer: “one to share”; “all have their own”
- Collective reasons: “Doesn’t say each.”

(i.e. if you mean to distribute, you have to say each).
Markedness? Bias?

- More people requiring “each” to distribute
- Smaller number who required “in all” not to.

- Sounds like collective is the default (?),
  - but kids need to learn it.

- Might be language-specific
- L₂ close to L₁ English, but were much more likely to require explicit direction to distribute (e.g. 8/8 Asian)
Back to practical interest: 2 children found 4 caterpillars?

How many did each child find?

How many altogether?
Two children found 4 caterpillars.

Two children (together) found four caterpillars (together)

Collective/collective - CC
Two children found 4 caterpillars.

Two children (each) found four caterpillars (each)

Distributive/distributive - DD
Two children found 4 caterpillars.

Two children (each) found four caterpillars (together/ in all)

Distributive/Collective - DC
### Math translation: how many did each child find?

<table>
<thead>
<tr>
<th>CC</th>
<th>(CD??)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(together/together)</td>
<td>Collective children/collective caterpillars</td>
</tr>
<tr>
<td>“Yes” (No operations)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DC</th>
<th>DD</th>
</tr>
</thead>
<tbody>
<tr>
<td>(each/together)</td>
<td>Distributive children/collective caterpillars</td>
</tr>
<tr>
<td>Divide. (=4/2)</td>
<td>Add (or multiply) (=4*2)</td>
</tr>
<tr>
<td>(each/each)</td>
<td>Distributive children/distributive caterpillars</td>
</tr>
</tbody>
</table>
### Results

<table>
<thead>
<tr>
<th>Age</th>
<th>Coll/coll</th>
<th>Dist/Dist</th>
<th>Dist/Coll</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-4 years</td>
<td>67%</td>
<td>8%</td>
<td>8%</td>
<td>17%</td>
</tr>
<tr>
<td>N = 10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-6 years</td>
<td>31%</td>
<td>15%</td>
<td>15%</td>
<td>32%</td>
</tr>
<tr>
<td>N = 12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-8 years</td>
<td>&lt; 5%</td>
<td>14%</td>
<td>64%</td>
<td>10%</td>
</tr>
<tr>
<td>N = 22</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-10 years</td>
<td>&lt; 5%</td>
<td>33%</td>
<td>55%</td>
<td>11%</td>
</tr>
<tr>
<td>N = 10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Textbook answer**

Linguistics/ Communication Disorders
In summary:

How many did each child find? How many altogether?

- Older kids, a significant minority (1/3) added (Dist/dist) instead of dividing (Distrib/Collect). Get a different answer

- Younger kids especially gave collective/collective (kids together found 4)

  - How can they ignore “each” in the question? (What if “each” means “all”, as one child said? Or see Roeper et al. 2011, “each” not strongly distributive at the younger ages)
All the flowers are in a vase.
Every flower is in a vase
Each flower is in a vase.
## Each versus Every—with flowers

<table>
<thead>
<tr>
<th></th>
<th>All OK</th>
<th>A best</th>
<th>B best</th>
<th>C best</th>
<th>Reject B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Every</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1 Adults</td>
<td>94%</td>
<td>21%</td>
<td>36%</td>
<td>18%</td>
<td>0</td>
</tr>
<tr>
<td>LI children</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
<td>60%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>All OK</th>
<th>A best</th>
<th>B best (1-1)</th>
<th>C best</th>
<th>Reject B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Each</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1 Adults</td>
<td>17%</td>
<td>90%</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>LI children</td>
<td>2%</td>
<td>24%</td>
<td>26%</td>
<td>32%</td>
<td>62%</td>
</tr>
</tbody>
</table>

For large percentage of children, it was not about flowers—it was about VASES.
Each and every elicited same kinds of explanations

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td></td>
</tr>
</tbody>
</table>

“[C], it’s the only one with flowers in every vase.” (9;4)
- “all vases are full” (8)
- * “not A or B, no flowers in those two vases” (6;2) (7;8)
- “No, they don’t have flowers in all vases.” (9)
- Key fact for children seemed to be exhaustivity, not individuation.
Pragmatics?? More real-world knowledge

- Decisions about whether to distribute or not based on the object involved:

Four people bought a dozen cookies for $12.  
*Did each person spend $12?*

Four people bought a dozen roses for $3.  
*Did each person spend $3.*
Same grammar, different decisions

<table>
<thead>
<tr>
<th></th>
<th>Split cookies?</th>
<th>Split flowers?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>All</td>
<td>14</td>
<td>40</td>
</tr>
<tr>
<td>Non-native</td>
<td>3</td>
<td>12</td>
</tr>
</tbody>
</table>

Only one person didn’t split the cookies but split the flowers. Twice as many people would not split the cookies but would split the flowers. Gave reasons based on normal cost of the objects.
What does it tell us?

Semantic (and possibly pragmatic principles in addition to math facts, must be learned (or taught) to help children arrive at the textbook response.

For L1 speakers. Even more perhaps for L2, or English-language learners.
Are these unusual questions?

Are children likely to encounter them in class, in tests, in real life?
Jim gets paid 5 cents for delivering newspapers. He delivers 9 newspapers. How much money does he make?
“Give me a number that goes in each of the spaces in the diagram.”

We asked, “how many numbers are being asked for?”

(How many spaces? Same or different? makes a difference in how hard it is to answer)
Liu is separating the figures below according to their properties. So far, he has made two different groups. List at least 3 figures that could go into each group. Explain what all the figures in each group have in common.

Among the ambiguities in the item is the instruction that [some] figures “could go into each group.” Is that one group per figure, or a single figure that could go into either group? Do all the figures have something in common regardless of group, or only by group?
Another wrinkle

Distributivity interaction with syntax

Distributivity of subject allowed (but not required) in simple sentence, but is Blocked from entering embedded clause.
Example 1 – Different constraints under embedding

- *In our hospital, a nurse cares for every patient.*

- (say there are 100 patients)

- How many nurses are there? (you can give a number or a range)
Embedding example – con’t

- In our hospital, a nurse wants to care for every patient.

- (say there are 100 patients)

- How many nurses are there? (you can give a number or a range)

- Say why.
Native speaker pattern (adults)

People didn’t like the idea of one nurse for 100, but typically said
a) could be any number of nurses, but
b) had to be just one

25 of 33 (76%) restricted distributivity when embedded
Non-native speakers, > half, no clue

16 of 31 (51%) got the distinction

9 made no distinction between the sentences
3 said “it doesn’t say”
3 said “at least one” for the last sentence.
(What does “at least one” mean--when the answer is 1?) to me, could be more, but not less—but I’ve learned not to assume it means for others what I think it means
QUANTIFIERS – are a real challenge

Each vs all together
Every vs each
Where do they fit in sentences?
  ▪ How do they derive or change meaning according to the syntax of the sentence or pragmatics of the situation.

▪ How do we learn them?
▪ (or “unlearn” them)?
Lots more questions

- Lots more phenomena
- Lots more language groups.
- Do the survey (especially non-native English speakers).
Stop here?
Questions??

Please send example problems to
bpearson@research.umass.edu
(Roeper@linguist.umass.edu)
References

References 2

- Roeper, Thomas & Matthei, Ed. (1975). On the acquisition of *some* and *all*. In *Papers and reports on child language development*, Stanford University (pp. 63-74).
References 3