Generalisation over semantic cues in child and adult artificial language learning

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May 2014
Artificial language learning in children

The majority of artificial language learning studies are with adults, while studies with children generally use infants (up to around 2 years). Only a handful with school aged children.
Artificial language learning in children

TODAY:

Experiments exploring **generalization over semantic cues** in artificial languages comparing 6 year olds and adults
Language learning and generalization

• learning a language involves generalization

• how do we work out what groups of words pattern together?

• *statistical learning approach:* learners extract generalizations from the input by identifying recurring patterns and using that information to form grammatical generalizations
Language learning and generalization

- **distributional cues**: categorising words according to the linguistic environments in which they occur
- **phonological cues**: categorising words according to sound similarities
- **semantic**: categorising words according to meaning similarities
Semantics based generalization

• long standing tension as to the extent to which language learning is driven by function/form

• e.g. earlier arguments that first grammars are entirely semantic in nature (e.g. Macnarma 1982)

• “semantic bootstrapping” hypothesis, e.g. Pinker (1989); Ambridge (2013) hybrid statistical/semantics approach
Semantics based generalization

**Studies with adult learners**

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- in all of these studies: two classes of nouns which co-occurred with different function words / morphology
- all show that adults pick generalize new nouns in accordance with semantics
Semantics based generalization

• **Studies with child learners**
  
  Saffran & Lany (2010; 2011) - study with two year olds
  
  **animals:** two syllable words, co-occur with “org” and “erg”
  **vehicles:** one syllable words, co-occur with “alt” and “ush”
  
  • evidence that patterns are learned and use in word learning task
  • e.g. know a new 2 syllable words with ong/erg is more likely to refer to an animal than a vehicle
Semantics based generalization

- **Studies with child learners**

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Studies with child learners

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- compared 8 year olds, 12 year olds and adults
  animate-noun + verb+ev
  inanimate-noun + verb+ar
- 12 year olds and adults learned trained pairs and were to generalize new nouns correctly on the basis of animacy
- 8 year olds learned trained pairs but were not able to generalize correctly
- despite up to 15 training sessions for some 8 year olds
Current Experiments

Artificial language paradigm established in Wonnacott (2011)

• 1 novel verb: \textit{glim} (THERE ARE TWO)

• “borrowed” English nouns: e.g. dog, car

• 2 novel “particles”: e.g. kem/ bup (NO SEMANTICS)

CREATE LANGUAGES WHERE SEMANTIC CUES DETERMINE PARTICLE USAGE:

\begin{align*}
\text{vehicle-noun} &+ \text{kem} \\
\text{animal-noun} &+ \text{bup}
\end{align*}
Questions

• Can 6 year olds (and adults) learn and generalize over the semantic cues?

• Is generalization affected by statistics?

**TYPE FREQUENCY MANIPULATION**

- **Low type frequency**: 4 exemplars per class
  
  i.e. 4 animals with kem; 4 vehicles with bup

- **High type frequency**: 8 exemplars per class
  
  i.e. 8 animals with kem; 8 vehicles with bup

High type frequency provides better evidence for generalization.
Questions

• Can 6 year olds (and adults) learn and generalize over the semantic cues?

• Do semantic cues affect both novel nouns and trained items?

• SEMANTICS MANIPULATION
  • Languages with semantic cues
  • Control languages without semantic cues
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<th>Consistent semantic cues: low type frequency</th>
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<td>• 8 animals occur with kem</td>
<td>• 4 animals occur with kem</td>
</tr>
<tr>
<td>• 8 vehicles occur with bup</td>
<td>• 4 vehicles occur with bup</td>
</tr>
<tr>
<td>No semantic cues: high type frequency match</td>
<td>No semantic cues: low type frequency match</td>
</tr>
<tr>
<td>• 4 animals occur with kem</td>
<td>• 2 animals occur with kem</td>
</tr>
<tr>
<td>• 4 animals occur with bup</td>
<td>• 2 animals occur with bup</td>
</tr>
<tr>
<td>• 4 vehicles occur with kem</td>
<td>• 2 vehicles occur with kem</td>
</tr>
<tr>
<td>• 4 vehicles occur with bup</td>
<td>• 2 vehicles occur with bup</td>
</tr>
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**Test:**
- 4 trained animals & 4 trained vehicles
- 4 untrained animals & 4 untrained vehicles
Method

• Participants
  • 5-6 year olds (mean: 5y 7m; range 5y;2m : 6y;1m)
  • adults (Warwick undergraduates)

<table>
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<tr>
<th></th>
<th>5-6 yrs</th>
<th>adults</th>
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<tr>
<td>consistent-high</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>consistent-low</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>inconsistent-high</td>
<td>6</td>
<td>10</td>
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planned sample n=15 per condition (preliminary results)
Method

- Procedure
  - Day 1
    - noun practice
  - exposure: (8* each noun)
  - production test: (trained + untrained)

- Day 2: noun practice + exposure
- Day 3: noun practice + exposure + production test

Example:
- e.g. see "car"
- hear "glim car bup"
- COMPLETE SENTENCE: noun practice + exposure + production test

Data from first and final day
Results

• trials coded as correct/incorrect

• correct = produce noun + correct particle

• incorrect trials include
  • using the alternative particle
  • producing a different word in place of the particle (i.e. not one of the two in the input)
  • producing noun and no particle
  • refusing to produce anything
  • something else (e.g. “glim rabbit likes carrots”)

• analysed using logistical LME
Results: Children, trained nouns

- reliable effect of day ($p<0.001$)
- all groups performance > 50% on day4
- no reliable main effect of semantic cues ($p=0.15$)
- interaction semantics * type frequency ($p<0.05$)
  - **high type frequency**
    - semantic cues > no semantic cues ($p<0.005$)
  - **low type frequency**
    - no reliable difference ($p>0.4$)
  - **semantic cues**
    - high type frequency > low type frequency ($p<0.005$)
  - **no semantic cues**
    - no reliable difference ($p>0.1$)
Results: Children, untrained nouns

- “correct” production = using the particle in line with semantic class
- effect of day ($p < .001$) and type frequency ($p < 0.001$)

![Semantic cues conditions](Day 1)

![Semantic cues conditions](Day 4)
Results: Children, trained nouns

- reliable effect of day ($p < 0.001$)
- all groups performance > 50% on day4
- no reliable main effect of semantic cues ($p = 0.15$)
- interaction semantics * type frequency ($p < 0.05$)

**High type frequency**
- semantic cues > no semantic cues ($p < 0.005$)

**Low type frequency**
- no reliable difference ($p > 0.4$)

**Semantic cues**
- high type frequency > low type frequency ($p < 0.005$)

**No semantic cues**
- no reliable difference ($p > 0.1$)
Results: Adults, trained nouns

• reliable effect of day ($p<.0001$)
• all groups performance > 50% on both days
• reliable main effect of semantic cues ($p<.005$)
• no reliable semantics * type frequency interaction ($p<0.1$)
Results: Adults, untrained nouns

• “correct” production = using the particle in line with semantic class

• no effect of day (p=0.2) or type frequency (p=0.4)
Summary

MAIN TAKE HOME
➢ children generalize noun behaviour on the basis of a semantic cue (animals/vehicle)
➢ however generalization is determined by input statistics
  • need multiple exposure sessions
  • need to witness multiple exemplars: 4 per category isn’t sufficient

fits with a rational statistical learning perspective: don’t generalize without good evidence

➢ adults in this experiment – generalize quickly on the basis of 4 examples per category
Summary

OTHER FINDINGS

• both children and adults can learn arbitrary associations between nouns and particles

• where semantic cues are used with novel nouns (adults: both conditions, children high type frequency) these also boost performance at the item level

• adult performance is also stronger at the level of reproducing item level associations
Conclusions for human language acquisition

• children are able generalize over semantic cues and use this to determine the behaviour of novel nouns (rule like behaviour)

however their may be constraints on the usage of semantic cues - usage may depend on sufficient exposure and reliability of cue in the input
Ongoing questions

• Can children pick up on cues when they are only partially correlated with semantic usage?

• Ongoing experiment

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• Are there constraints on the types of cues that children will generalize over?