The Structural Sources of Verb Meanings
Lila Gleitman, 1990

By Tyler Renslow
I. Intro/Background Info
II. Learning by Observation
III. A New Approach to Verb Acquisition
IV. Conclusions
Introduction

* John Locke: Who’s that guy?
  * An Essay Concerning Human Understanding (1690)
* “Common Knowledge”: Verb meanings acquired by observing the environment
  * Is this really enough?
Outline

I. Intro/Background Info
II. Learning by Observation
III. A New Approach to Verb Acquisition
IV. Conclusions
Locke: “Differences in Experience lead to Differences in Meaning Acquired”

* Blind vs. Sighted Children
* Both distinguished exploratory and achievement verbs, i.e. look and see
* Cows can be green, but not ideas

Contrary to Locke: same semantics must be acquired in differing environments

* Gleitman: Experience is sensory and perceptual
Blind and sighted children understand vision related terms differently. ‘Look’ and ‘see’ either haptic or visual. Perceive in whatever way possible. Color of objects “because we say so”. Hypothesis: look/see = explore nearby object manually. Seems obvious. Look is most reliably used in this context by blind caretakers.
FIGURE 2: A blind child's response to the command "Look up!" (Reproduced from Vandari & Gleitman, 1983, p. 56, with permission of the artist, Robert Thieker.)
<table>
<thead>
<tr>
<th>Verb</th>
<th>In-Hand or Near</th>
<th>For</th>
<th>No Object</th>
<th>Total Cases</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td><em>Perceptual</em></td>
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<tr>
<td>Look</td>
<td>.50</td>
<td>.22</td>
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<tr>
<td>See</td>
<td>.30</td>
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<td>.44</td>
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<td>Watch</td>
<td>.56</td>
<td>.00</td>
<td>.44</td>
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<tr>
<td><em>Nonperceptual</em></td>
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<tr>
<td>Come</td>
<td>.00</td>
<td>.05</td>
<td>.00</td>
<td>.32</td>
</tr>
<tr>
<td>Go</td>
<td>.45</td>
<td>.05</td>
<td>.20</td>
<td>.05</td>
</tr>
<tr>
<td>Give</td>
<td>.97</td>
<td>.00</td>
<td>.03</td>
<td>.00</td>
</tr>
<tr>
<td>Go</td>
<td>.00</td>
<td>.52</td>
<td>.10</td>
<td>.14</td>
</tr>
<tr>
<td>Have</td>
<td>.55</td>
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<td>.33</td>
<td>.14</td>
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<td>Hold</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
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<tr>
<td>Play</td>
<td>.50</td>
<td>.20</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Put</td>
<td>.97</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
</tbody>
</table>


*These total to N = 248, the number of utterances containing common verbs (those occurring 10 or more times in the corpus). The remaining rarer verbs (occurring fewer than 10 times) and 183 instances of be were excluded from the analysis.
- The data don’t support hypothesis
  - ‘Put’, ‘give’, ‘hold’ more likely used in NEAR contexts
  - ‘See’ used more in FAR context
  - ‘Look’ 72% NEAR; not overwhelming evidence
- Table not to be written off!
  - Extralinguistic features can distinguish two semantically similar verbs
  - ‘give’ vs. ‘get’
Word-to-world mapping mechanism more subtle

Infants and children notice *everything*
  - Sources and goals of verbs, for example
  - Proved in past studies
  - Why not use these skills?

New position: children use *all* percepts to encode verb meaning
  - Possible pitfalls?
Restricting Percepts

* Pinker (1987): 8 observables in an event
  * Multi-dimensional hypothetical space
  * Too much to compute
  * Can never be restrictive enough
  * Maybe children are mind readers?
    * Golinkoff (1986): evidence against immediate comprehension between child and mother
Multiple Event Interpretations

- Verbs encode unobservable perspectives of speaker
  - ‘push’ vs. ‘move’ an object
- Compare and contrast with meaning elimination
  - Cannot permanently discard any interpretation
- Opens up avenue for probabilistic model
  - Further confounds meaning extraction
  - begs question: how could we ever be 100% sure of a word’s meaning?
Antonyms

* Paired Verbs
  * ‘flee’ and ‘chase’, ‘buy’ and ‘sell’, ‘give’ and ‘receive’
  * How to distinguish, given highly similar environments?
* Back to idea of perspective
  * Wouldn’t need to converse; just point and grunt
* Learning by Observation looking pretty weak
  * You know nothing, John Locke!
Varying level of specificity employed by speaker
  - How are hypernyms and hyponyms determined?

Berwick (1982): learners select most restrictive interpretation of language
  - The less inclusive an interpretation, the less possible it is to falsify within the word-to-world framework

Sometimes specific words are more “primitive”
  - ‘lettuce’ vs. ‘vegetable’ and ‘tree’ vs ‘oak’
Verbs which don’t refer to the observable world

- Locke: Those using abstract verbs don’t really understand their meaning

How do we acquire the meaning of ‘think’ or ‘hope’?

- *The Thinker* isn’t always around to refer to!
- Maybe 2- and 3-year olds can’t, but older children can

In how many cases do verbs *actually* match up with environment?

- Metaphor, sarcasm, etc.
If children learn by comparing and contrasting, they must be tolerant of counterexamples

Beckwith, Tinker and Bloom (1989): 67.5% of time ‘open’ uttered with appropriate context

- Other way around: we wouldn’t say “I’m opening the door” when we enter a room
- More likely to greet occupants

No plausible evidence for reducing database of contexts

Maybe we’re looking at verb acquisition the wrong way!
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“They have another source of information”

- Landau and Gleitman (1985): syntax is source
- Sentence-to-world instead of word-to-world
  - All verbs dictate syntax
  - Transitivity, subject must represent semantic content
Syntactic environments

Typical environments for ‘look’ and ‘see’ quite different from other verbs

“Let’s see if...”, “You look like...”, etc.

Here caretaker doesn’t mean ‘explore haptically’

Gleitman: “Syntactic distinction may be available to learner”

Novel term: **Syntactic Bootstrapping**

As opposed to **Semantic Bootstrapping**: Pinker (1984/1987)
<table>
<thead>
<tr>
<th></th>
<th>Perception Verbs</th>
<th>Transfer Verbs</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>look/see-only</td>
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</tr>
<tr>
<td>V2</td>
<td>8</td>
<td></td>
<td></td>
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<tr>
<td>V2</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>V1, S</td>
<td>10</td>
<td>3</td>
<td></td>
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<tr>
<td>V2, S</td>
<td>3</td>
<td></td>
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<tr>
<td>V how S</td>
<td>2&lt;sup&gt;i&lt;/sup&gt;</td>
<td></td>
<td></td>
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<tr>
<td>V S</td>
<td>5</td>
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<td>V like NP</td>
<td>5</td>
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<td>some V NP</td>
<td>3</td>
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<td>Exclude</td>
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<tr>
<td>look/see</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>V NP PP&lt;sub&gt;loc&lt;/sub&gt;</td>
<td>5</td>
<td>31</td>
<td>2</td>
</tr>
<tr>
<td>V NP D&lt;sub&gt;loc&lt;/sub&gt; PP</td>
<td></td>
<td>2</td>
<td></td>
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<td>V NP D&lt;sub&gt;loc&lt;/sub&gt;</td>
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<td>2</td>
<td>6</td>
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<tr>
<td>V D&lt;sub&gt;loc&lt;/sub&gt; NP</td>
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<td></td>
</tr>
<tr>
<td>V NP NP</td>
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<td>2</td>
<td></td>
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<tr>
<td>V NP where S</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>V PP</td>
<td></td>
<td></td>
<td>1&lt;sup&gt;P&lt;/sup&gt;</td>
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<td>Overlap</td>
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<td>look/see</td>
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<tr>
<td>V PP&lt;sub&gt;loc&lt;/sub&gt;</td>
<td>3</td>
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<td>2</td>
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<td></td>
<td>10</td>
</tr>
<tr>
<td>V s</td>
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<td>3</td>
<td></td>
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<td>V NP</td>
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<td>11</td>
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<tr>
<td>V AP</td>
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<td></td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>18</td>
<td>21</td>
</tr>
</tbody>
</table>

Note. Adapted from Landau and Gleitman, 1985, p. 112, with permission of the publisher, Harvard University Press.

*E.g., "Look how I'm doing it."*<sup>17</sup> *Let's have Barbara babysit" (causative).*<sup>17</sup> *Hold the N up to me.*<sup>17</sup> *Put it where it belongs.*<sup>17</sup> *Play with the reciprocal preposition with, for example, "You're not gonna play with the triangle, so forget it!"*
<table>
<thead>
<tr>
<th>Contextual instance</th>
<th>NEAR</th>
<th>FAR</th>
<th>NO OBJECT</th>
<th>&quot;NEAR PROPORTION&quot;</th>
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<tr>
<td><strong>Cognitive Salience</strong></td>
<td></td>
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<tr>
<td>Frame and declarative functions</td>
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<tr>
<td>Look at NP</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1.00</td>
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<tr>
<td>Look to</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Look?</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Look! This is NP</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td></td>
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<tr>
<td>Say NP</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Say?</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
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<tr>
<td>Say? This is NP</td>
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<td>0</td>
<td>0</td>
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<td><strong>Motion auxiliary</strong></td>
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<td>Come see NP</td>
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<tr>
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<tr>
<td>Look AP</td>
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<td>1</td>
<td></td>
</tr>
<tr>
<td>Look like NP</td>
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<td>0</td>
<td>5</td>
<td>0.18</td>
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<td>Look how S</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Look S</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>See S</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>See S</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0.25</td>
</tr>
<tr>
<td><strong>Total (all environments)</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Look</td>
<td>25</td>
<td>7</td>
<td>9</td>
<td>0.73</td>
</tr>
<tr>
<td>See</td>
<td>7</td>
<td>10</td>
<td>1</td>
<td>0.39</td>
</tr>
</tbody>
</table>

*Note: Reproduced from Landau and Cillemann, 1985, p. 115, with permission of the publisher, Harvard University Press.*
Verbal structure a function of meaning
  * For example: ‘give’ always takes three noun phrases
  * Syntax and Semantics always working in tandem
  * Semantic Bootstrapping: verbs with similar meaning dictate similar sentence structure
    * Children predict structure based on meaning understood: Bowerman (1974, 1982)
  * Gleitman: still insufficient for acquiring meaning
**Bootstrapping Compared**

- Inherent quality of language: verbs determine certain clauses
- The syntactic structure is included in a verb’s dictionary entry
- Only a limited number of syntactic structures
  - How can this be enough to determine meaning?
- Gleitman: two bootstrapping processes complement each other
Counters Addressed

* Explains blind children’s acquisition of visual verbs
* Picks up where observation falls short
* Simplifies compare and contrast process
* Eliminates probabilistic approach
* Serves to define point at which learner has acquired a language
* Disambiguates events with multiple interpretations
Problem Solved...?

- To which degree does relation between bootstrapping methods support acquisition?
  - Syntactic B.: main idea of verb
  - Semantic B.: allows for determining specificity
- Cross-linguistically applicable?
  - Fisher et al. (in press at time): claim is strong across English and Italian
  - Primitive enough for children to apply
Can infants parse?

- Evidence for sensitivity to physical properties of signal
- Infants preserve phrasal info when listening to maternal speech; sufficient for full partitioning

Prelinguistic knowledge of meaning of phrasal structures?

- Experimentally shown that children recognize order of phrases
- Verbs can change transitivity
- Certain phrases exclude certain expressions
Naigles (in press at the time):

* Rabbit and duck scene, each animal making circles in air with one arm, rabbit pushing duck down
* “The rabbit is gorping the duck.” vs. “The rabbit and duck are gorping.”

Children gleaned new meaning of word based on primer sentence
* Further evidence against observation being sufficient
Investigation of Syntactic Bootstrapping

* Fisher et al. (1989): studying 3- and 4 year olds to see if method continues to be employed
* Given scene with multiple plausible interpretations and accompanying sentence
* Number of arguments
* Position of agent and patient
* Prepositional markers
<table>
<thead>
<tr>
<th>Scenario</th>
<th>Sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (a) Rabbit caring.</td>
<td>The rabbit moos.</td>
</tr>
<tr>
<td>(b) Elephant feeding rabbit.</td>
<td>The elephant moos the rabbit.</td>
</tr>
<tr>
<td>2. (a) Monkey pushing elephant.</td>
<td>The monkey pushes the elephant.</td>
</tr>
<tr>
<td>(b) Elephant falling.</td>
<td>The elephant punes the elephant.</td>
</tr>
<tr>
<td>3. (a) Monkey riding elephant.</td>
<td>The monkey gonos the elephant.</td>
</tr>
<tr>
<td>(b) Elephant carrying monkey.</td>
<td>The elephant gonos the monkey.</td>
</tr>
<tr>
<td>4. (a) Rabbit fleeing skunk.</td>
<td>The rabbit razs the skunk.</td>
</tr>
<tr>
<td>(b) Skunk chasing rabbit.</td>
<td>The skunk zarps the rabbit.</td>
</tr>
<tr>
<td>5. (a) Rabbit giving a ball to elephant.</td>
<td>The rabbit ziffs a ball to the elephant.</td>
</tr>
<tr>
<td>(b) Elephant taking a ball from rabbit.</td>
<td>The elephant ziffs a ball from the rabbit.</td>
</tr>
<tr>
<td>6. (a) Skunk putting blanket on monkey.</td>
<td>The skunk is hitting a blanket on the monkey.</td>
</tr>
<tr>
<td>(b) Skunk covering monkey with a blanket.</td>
<td>The skunk is hitting the monkey with a blanket.</td>
</tr>
</tbody>
</table>

Note. All children were exposed to the same six scenes (each scene has two plausible interpretations, called (a) and (b) in the left-hand column). Along with these scenes, half of the children heard (a) stimulus sentences and half heard (b) stimulus sentences (with appropriate counterbalancing across children and stimuli).
Results

* Children’s guesses greatly dependent on syntax
* Statistically significant outcome
* Maybe children simply paraphrased based on previous knowledge?
  * Doesn’t seriously detract from results
  * Counter to Pinker: Syntactic structures understood without prior knowledge of verb meanings (parental claim)
* Is Input rich enough?
  * Gleitman (1989): mothers provide highly diversified syntax
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Recap

* Locke’s view / Word-to-world
* Observation falls short
* New idea: Syntactic Bootstrapping
* Don’t discount Semantic Bootstrapping!
* Multiple experiments supporting new idea
* Conclusion: Language learners use knowledge of syntactic structures to deduce meaning where observation comes up short
That’s great! But...

- Cannot quantify the process
  - How much information provided?
  - How much is burden of learning reduced?
- Data with respect to syntactic variety scarce
- Not generalizable to all languages yet
- Idioms, figurative language, etc.
- Where do linking rules originate?
- When errors present: how to recover?
- Warrants further investigation
Action-based language: A theory of language acquisition, comprehension, and production

Glenberg and Gallese (2012)
Changing Gears

* Paper much more theoretical than previous
* Most points made with no proprietary experimental support
  * Conclusions of past papers synthesized to support argument
* More neurophysiologically detailed
* A theory on *Action-based Language* (ABL)
A Few Terms

- MOSAIC/HMOSAIC: (hierarchical) modular selection and identification for control
- Mirror neurons (MMs)
- Hebbian learning: learning by repetition
- Gain control: inhibition
Introduction

- Meaning is outcome of interaction
- Adapt the MOSAIC/HMOSAIC (old idea) to action-based language (novel concept)
- Not all language accommodated by action framework
Glenberg and Robertson (1999): Sentences are understood by simulating underlying actions
  * Called *Indexical Hypothesis*
  * Gestures correspond to movement of action

Zwaan and Taylor (2006): Movement contrary to sentence slows reading times
Neurophysiology Connection

- Mirror neurons
  - Discharged when performing goal-related acts
  - Gain control is suppression of discharge
- Broca’s Area: studies show it contributes to speech as well as hand movements
- Hierarchical in nature
  - High level: intentions
  - Lower levels: components of motor actions
MOSAIC/HMOSAIC Theories

- Two models
  - Controller: computes context-related movements
  - Predictor: computes outcomes for these movements
- MOSAIC model has multiple pairs working together for each verb (referred to as modules)
Predictors

Lift

Controllers
500 grams? 350 grams? 100 grams?

Sensory Feedback
Gain
Integrate

Social Environment

Bodily Actions & Perceptions

Physical Environment

Forces applied to lift 350 grams.
Adaptation to ABL Model

- Motor repertoire for eyes, arms, etc.
  - Includes entries for their movement abilities
- Creating contextually-appropriate utterances also applies to motor control
- Challenges:
  - Constraints on meaning must reflect constraints on movement
  - How hierarchical language organization comes from hierarchical motor control
- All made possible by mirror neurons
  - “Do what we say, say what we do”
Learning Linguistic Constructions

- Nouns: eyes move toward objects mentioned
- Verbs: mirror neurons activated, Hebbian process strengthen association of verb and action
- Nouns learned quicker
- Verbs acquired within $i+1$ framework
- ‘Give’ requires many modules/components
  - Finding object, extending arm, finding recipient, etc.
- Glenberg: comprehension = fitting together actions suggested by linguistic symbols to accomplish goal
Controller and Predictor activate according to entities in utterance heard, predicated on syntax

- Gestures occurring synchronously; even for blind people
- Gestures aid in comprehension and understanding
  - F2 higher when accompanied by related gesture
- Gestures “leftovers” after gain control
  - Cannot inhibit all motion since mouth needs to move
Compare/Contrast

- Probability
- Mimicking
- Action
- Approach
Thank you!