Learning attitude verb meanings in a morphosyntactically-poor language via syntactic bootstrapping

Nick Huang, Chia-Hsuan Liao, Valentine Hacquard, and Jeffrey Lidz
University of Maryland
BUCLD 42, Nov 3, 2017
Attitude verbs can be classified into two semantic classes:

**Belief verbs**
- Think
- Know
- Believe
- Guess

**Desire verbs**
- Want
- Prefer
- Love
- Demand
- Love
- Love
But how does a child learn that these attitude verbs mean different things?

“Mary thinks they will leave.”

“Mary wants them to leave.”
Verb meanings from physical context?

“Tom kicked the ball.”

Image source: Jay's Brick Blog
What’s the difference between the two situational contexts?

**Context #1**
“Mary *thinks* they will leave.”

**Context #2**
“Mary *wants* them to leave.”

Gilette et al. 1999; Gleitman et al. 2005, a.o.
Proposal: syntactic bootstrapping
Gleitman 1990; Gleitman et al. 2005

“Learners use syntactic properties of X to deduce semantics of X.”

1. What might these syntactic properties be, in the case of attitude verbs?
2. Are these properties reliable in the input?
3. Can a child detect these properties?
4. Does the child use these properties to learn semantic differences between attitude verbs?
Proposal: syntactic bootstrapping
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3. Can a child detect these properties?

4. Does the child use these properties to learn semantic differences between attitude verbs?
English: finite vs. non-finite clauses

i. Mary *thinks they will* leave.’  Belief verb

ii. Mary *wants them to* leave.’  Desire verb
Spanish: indicative vs. subjunctive

i. **Creo** que Peter **va** a la casa.
   Belief verb: ‘I think Peter is going to the house.’

ii. **Quiero** que Peter **vaya** a la casa.
    Desire verb: ‘I want Peter to go to the house.’

(Bolinger 1968, Hooper 1975, a.o.)
i. Maria *denkt,* dass Peter *kommt* heute.
   Maria *thinks* that Peter *comes* today
   **Belief verb:** ‘Mary *thinks* Peter is coming today.’

ii. *Maria *will,* dass Peter *kommt* heute.
    Maria *wants* that Peter *comes* today
    **Desire verb:** ‘Mary *wants* Peter to come today.’
    (OK: “... *Peter heute kommt.*”)
    (Scheffler 2008)
A solution around the problem of morphosyntactic variation

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<thead>
<tr>
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Declarative main clause syntax hypothesis

e.g. Hacquard 2014; Harrigan 2015; White et al. 2017; Hacquard & Lidz, to appear

• “Assign belief semantics to verbs whose clausal complements are syntactically similar to declarative main clauses.”

• Declarative main clauses are used for making assertions – to express a judgment of truth, as do these verbs.

• Flexible enough to accommodate morphosyntactic diversity.
How the declarative main clause syntax hypothesis might work

“Mary \textit{thinks} they will leave.”  "Mary \textit{wants} them to leave.”
Compare clausal complements with declarative main clauses

“Mary thinks they will leave.”  “Mary wants them to leave.”

“They will leave.”
(Declarative main clause)
Observe morphosyntactic similarities in one of the complement types

“Mary thinks they will leave.”

“Mary wants them to leave.”

“They will leave.”

(Declarative main clause)
Assign belief / desire semantics to the verb

“Mary *thinks* they *will* leave.”

Belief semantics

“Mary *wants* them *to* leave.”

Desire semantics

“They *will* leave.”

(Declarative main clause)
Proposal: syntactic bootstrapping
Hacquard 2014; Harrigan 2015; White et al. 2017; Hacquard & Lidz, to appear

“Learners use syntactic properties of X to deduce semantics of X.”

1. What might these syntactic properties be, in the case of attitude verbs?
   If verb takes a clausal complement that resembles a declarative main clause, assign belief semantics to the verb. If not, assign desire semantics.

2. Are these properties reliable in the input?
   Yes, at least in the previously-reviewed Indo-European languages...
The hypothesis presupposes that the relevant morphosyntactic differences are observable.

What if your language had...

• No tense morphology
• No case morphology
• No mood morphology
• No clear evidence for verb movement
• No clear finiteness distinction
• And allows null arguments?
The hypothesis presupposes that the relevant morphosyntactic differences are observable

What if your language had...

- No tense morphology
- No case morphology
- No mood morphology
- No clear evidence for verb movement
- No clear finiteness distinction Hu et al. 2001; Grano 2015, a.o.
- And allows null arguments?

(see also Lee & Naigles 2005 re: general feasibility of syntactic bootstrapping in Mandarin)

...like Chinese?
The learning problem for the Mandarin Chinese learner

1. Wo **zhidao** chi shuiguo.  
   I ?? eat fruit
2. Wo **ai** chi shuiguo.  
   I ??? eat fruit
The learning problem for the Mandarin Chinese learner

1. Wo zhidao chi shuiguo. 2. Wo ai chi shuiguo.

   I know eat fruit I love eat fruit

   “I know [I/(s)he/it/we/you/they] eat fruit.”
   (subject of “eat” omitted)

Belief semantics Desire semantics
Outline

• Syntactic hallmarks:
  • Mandarin declarative main clauses
  • Complements of belief and desire verbs

• Corpus studies: how feasible is syntactic bootstrapping with the declarative main clause hypothesis in Mandarin?

• Next steps and conclusion
Hallmarks of Mandarin declarative main clauses

While Mandarin has minimal verbal morphology and null arguments, there are some syntactic properties associated with declarative main clauses:

• Overt subjects possible
• Modal auxiliaries and adverbs possible
• Aspect markers possible

The same syntactic properties also generally distinguish the complements of belief verbs from the complements of desire verbs, but exceptions exist.

e.g. C.-T. J. Huang 1982; Li 1990; pace Hu et al. 2001
Examples

**Declarative main clause**

i. Yiqian tamen keneng chi-guo shuiguo.
   past they might eat-EXP fruit
   “In the past, they might have eaten fruit.”

**Belief verbs**

ii. Wo zhidaoyi tamen keneng chi-guo shuiguo.
    I know they might eat-EXP fruit
    “I know they might have eaten fruit.”
Overt subject

**Declarative main clause**

i. Yiqian [tamen] keneng chi-guo shuiguo.
   past they might eat-EXP fruit
   “In the past, they might have eaten fruit.”

**Belief verbs**

ii. Wo [zhidao] [tamen] keneng chi-guo shuiguo.
    I know they might eat-EXP fruit
    “I know they might have eaten fruit.”
Modal

Declarative main clause

i. Yiqian tamen *keneng* chi-guo shuiguo.
   past they might eat-EXP fruit
   “In the past, they might have eaten fruit.”

Belief verbs

ii. Wo *zhidao* tamen *keneng* chi-guo shuiguo.
   I know they might eat-EXP fruit
   “I *know* they might have eaten fruit.”
Aspect

**Declarative main clause**

i. Yiqian tamen keneng chi-\textit{guo} shuiguo.
   past they might eat-EXP fruit
   “In the past, they might have eaten fruit.”

**Belief verbs**

ii. Wo zhidao tamen keneng chi-\textit{guo} shuiguo.
    I know they might eat-EXP fruit
    “I know they might have eaten fruit.”
This generalization appear to be fairly robust across attitude verbs...

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<tr>
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<th>Overt subject</th>
<th>Modal auxiliary/adverb</th>
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<td>(Declarative) main clause</td>
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<td>*</td>
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<tr>
<td><em>Ai “love”; xiang-2 “want”; gan “dare”; yao-2 “FUT”</em></td>
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<td>*</td>
<td>*</td>
</tr>
<tr>
<td><em>Dasuan “plan”; zhunbei “get ready to”</em></td>
<td>Disputed</td>
<td>Only yao “FUT”?</td>
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... but exceptions exist

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Further, these properties are all optional

**Declarative main clause**

i. Yiqian tamen keneng chi-guo shuiguo.
   past they might eat-EXP fruit

   “In the past, they might have eaten fruit.”

**Belief verbs**

ii. Wo zhidao tamen keneng chi-guo shuiguo.
    I know they might eat-EXP fruit

   “I **know** they might have eaten fruit.”
Further, these properties are all optional

Declarative main clause

i. Yiqian tamen keneng chi shuiguuo.
   past they might eat fruit
   “In the past, it might be the case that they ate fruit.”

Belief verbs

ii. Wo zhidaao tamen keneng chi shuiguuo.
    I know they might eat fruit
    “I know they might have eaten fruit.”
Further, these properties are all optional

**Declarative main clause**

i. Yiqian tamen chi shuiguo.
   past they eat fruit
   “In the past, they ate fruit.”

**Belief verbs**

ii. Wo zhidaotamen chi shuiguo.
    I know they eat fruit
    “I know they eat fruit.”
Further, these properties are all optional

**Declarative main clause**

i.  Yiqian
    past

    "In the past, [they] ate fruit."

**Belief verbs**

ii. Wo  zhidao
    I

    "I know [they] eat fruit."
At the individual token level, belief and desire complements might be superficially identical

**Belief verbs**

i. Wo  zhidao  chi  shuiguuo.

I  know  eat  fruit

“I know [they] eat fruit.”

**Desire verbs**

ii. Wo  ai  chi  shuiguuo.

I  love  eat  fruit

“I love to eat fruit.”
An empirical question

Complements of belief verbs are *in principle* more similar to declarative main clauses than to the complements of desire verbs.

In the input, do complements of belief verbs resemble declarative main clauses more than complements of desire verbs?

If yes:

• Syntactic bootstrapping / the declarative main clause syntax hypothesis is viable

... even in a language like Mandarin, where the cues are not always available.
### CHILDES corpora properties

<table>
<thead>
<tr>
<th>Corpus</th>
<th>Age</th>
<th>Number of children</th>
<th>Description</th>
<th>Total utterances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>1;9.3-2;2.7</td>
<td>10</td>
<td>Longitudinal study in naturalistic settings Tardif 1993, 1996</td>
<td>91,288</td>
</tr>
<tr>
<td>Context</td>
<td>2</td>
<td>25</td>
<td>Cross-sectional study with single observations of 25 Mandarin-speaking children Tardif, Gelman, and Xu 1999</td>
<td>24,007</td>
</tr>
<tr>
<td>Chang</td>
<td>3-6</td>
<td>24</td>
<td>Toy play and narratives Chang 1998</td>
<td>5,798</td>
</tr>
<tr>
<td>Zhou1</td>
<td>3-6</td>
<td>15</td>
<td>Play sessions with mother</td>
<td>11,694</td>
</tr>
</tbody>
</table>
## Methodology

<table>
<thead>
<tr>
<th></th>
<th>Attitude verbs</th>
<th>Main clauses</th>
</tr>
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<tbody>
<tr>
<td><strong>Sample</strong></td>
<td>All child-ambient utterances containing relevant attitude predicates</td>
<td>5% random sample of child-ambient utterances</td>
</tr>
<tr>
<td><strong>Number of tokens</strong></td>
<td>~6,000</td>
<td>~6,100</td>
</tr>
<tr>
<td><strong>What was coded</strong></td>
<td>Attitude verb’s complement: clause, VP, NP, etc.</td>
<td>Clause type: declarative, interrogative, ...</td>
</tr>
<tr>
<td></td>
<td>Within the complement:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Overt subject</td>
<td>Within the main clause:</td>
</tr>
<tr>
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<td>• Aspect</td>
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<tr>
<td></td>
<td>• Etc.</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>• etc.</td>
</tr>
<tr>
<td><strong>What was analyzed</strong></td>
<td>~2,500 clause-like complements</td>
<td>1,131 declarative main clauses</td>
</tr>
<tr>
<td></td>
<td>• NP and other complements excluded</td>
<td>• Disfluencies, interrogatives and imperatives etc. excluded</td>
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CHILDES corpus study: results by verb class

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<td>Decl. main clauses</td>
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<td>8.5</td>
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<td>58.3</td>
<td>8.2</td>
<td>2.7</td>
<td>927</td>
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<tr>
<td>Desire verbs</td>
<td>5.0</td>
<td>0.3</td>
<td>0.1</td>
<td>1333</td>
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<tr>
<td>Ambiguous (xiang “think/want”)</td>
<td>8.8</td>
<td></td>
<td>0.0</td>
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Confidence intervals: results by verb class via statistical bootstrapping (5,000 samples)
CHILDES corpus study: results by verb

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<td>643</td>
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<td>zhidao &quot;know&quot;</td>
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<td>1.7</td>
<td>180</td>
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<tr>
<td>jiang &quot;tell&quot;</td>
<td>23.7</td>
<td>2.6</td>
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<td>76</td>
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<tr>
<td>yao &quot;want/need&quot;</td>
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<td>0.4</td>
<td>0.1</td>
<td>1084</td>
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<td>xihuan &quot;like&quot;</td>
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<tr>
<td>xiang &quot;think/want&quot;</td>
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Tamen yao ni chi shuiguo. they want you eat fruit ‘They want you to eat fruit.’
Confidence intervals: results by verb via statistical bootstrapping (5,000 samples)

Baseline

Belief verbs

Desire verbs

Ambiguous
How representative are our results?

Perhaps the resemblance between complements of belief verbs and declarative main clauses is accidental, e.g. an artifact of ...

- ... the choice of corpora / data collection
- ... the choice of annotation standards

Solution: look at another corpus that was independently annotated.
The Chinese Penn Treebank
(v7.0, Xue et al. 2010)

Fully-bracketed corpus of 51,447 sentences of Mandarin Chinese.
• Note that a sentence can be formed by conjoining multiple clauses.

Bias toward written and/or formal registers: newswire, magazines, broadcast news and conversations, newsgroup and blogs.

We wrote a script to read the annotations to determine if a clause has declarative force or not, and if it contains an overt subject, modal, or aspect marker.
Chinese Penn Treebank: results by verb class

- Decl. main clauses
  - Overt subject: 77.9 tokens
  - Modal: 8.7 tokens
  - Aspect: 12.2 tokens

- Belief verbs
  - Overt subject: 71.8 tokens
  - Modal: 17.5 tokens
  - Aspect: 9.9 tokens

- Desire verbs
  - Overt subject: 1.9 tokens
  - Modal: 1.0 tokens
  - Aspect: 0.5 tokens

- "Hope" and ambiguous
  - Overt subject: 37.8 tokens
  - Modal: 22.9 tokens
  - Aspect: 2.1 tokens

Tokens: 66910 (Decl. main clauses), 9844 (Belief verbs), 3625 (Desire verbs), 1397 ("Hope" and ambiguous)
## Chinese Penn Treebank: results by verb

<table>
<thead>
<tr>
<th>Verb</th>
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<td>70.8</td>
<td>14.7</td>
<td>11.0</td>
<td>69910</td>
</tr>
<tr>
<td>biaoshi &quot;say&quot;</td>
<td>68.9</td>
<td>23.1</td>
<td>8.2</td>
<td>5221</td>
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<tr>
<td>renwei &quot;think&quot;</td>
<td>80.2</td>
<td>24.9</td>
<td>6.4</td>
<td>1621</td>
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<tr>
<td>zhidao &quot;know&quot;</td>
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<td>15.0</td>
<td>1525</td>
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<td>0.7</td>
<td>0.5</td>
<td>549</td>
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<td>yaoqiu &quot;request&quot;</td>
<td>7.3</td>
<td>3.6</td>
<td>0.3</td>
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<td>xuyao &quot;need&quot;</td>
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<td>0.0</td>
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<td>xiang &quot;think/want&quot;</td>
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<td>13.1</td>
<td>3.1</td>
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<tr>
<td>xiwang &quot;hope&quot;</td>
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**Baseline**

**Desire verbs**

**Other**
Syntactic bootstrapping for attitude verbs

“Learners use syntactic properties of X to deduce semantics of X.”

1. What might these syntactic properties be, in the case of attitude verbs?
   If verb takes a clausal complement that resembles a declarative main clause, assign belief semantics to the verb. If not, assign desire semantics.

2. Are these properties reliable in the input?
   Yes, at least in the previously-reviewed Indo-European languages... and Mandarin Chinese
Open questions

3. Are these properties detectable by the child? Can we test the hypothesis with an actual model of syntactic bootstrapping?
   • We are in the process of modeling the acquisition process with the Mandarin datasets, building on White et al. 2017 for English.

4. Do Mandarin-learning children actually use these syntactic cues to learn semantic differences between belief and desire verbs?
Conclusion

Syntactic bootstrapping provides a way to learn semantic differences within attitude verbs.

Although Mandarin has minimal verbal morphology and null arguments...
• ... belief and desire verbs have clausal complements with distinct syntactic profiles, in principle and in aggregation in the input.
• The profile of belief complements resemble the profile of declarative main clauses.

If Mandarin learners are sensitive to the overall profile of these clausal complements:
• Syntactic bootstrapping – the declarative main clause syntax hypothesis – can help them learn a semantic distinction within attitude verbs and assign semantics correctly.
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Backups
Imperatives

• Imperatives can take overt 2\textsuperscript{nd} person and universally-quantified subjects. Chen-Main 2005, Li and Thompson 1981

• Declaratives and imperatives can appear without overt subjects.

• Can be difficult to distinguish in transcripts, even with context.
  • Our diagnostics: force of utterance (from context / judgment) and/or presence of prohibitive \textit{bie}.

(1) Ni zuo nali.
  
  you sit there
  ‘[You] sit there!’ (imperative) / ‘You sit there’ (declarative)

(2) Ni bu yao zuo nali.
  
  you NEG want sit there
  ‘Don’t [you] sit there!’ (imperative) / ‘You don’t want to sit there’ (declarative)
CHILDES corpus excluding 2nd person subjects and orders: results by verb class
CHILDES corpus excluding 2\textsuperscript{nd} person subjects and orders: results by verb

![Graph showing frequency of words and their usage patterns in CHILDES corpus.](image-url)
The problem of polysemy

- *Xiang* and *yao* have multiple readings.
  - *Xiang*: think, want, miss (someone/something)
  - *Yao*: want, need, future

- How do children learn all these?
  - For *yao*: since future *yao* is a raising predicate (LaBarge 2016, van Dooren et al. 2017), perhaps children attend to animacy properties of the subject?
Data excluded from the main analysis: a sample

- Main clauses judged to have exhortative, imperative, or promissive force
- Questions
- “Affirmatives” ("good", "correct", "not correct"...)
- Formulaic utterances ("thank you", "sorry")
- Any incomplete utterance: fragments, interruptions, trailoffs
- Any utterances that we could not parse
- Utterances that repeat the target child’s
Selected references


