

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

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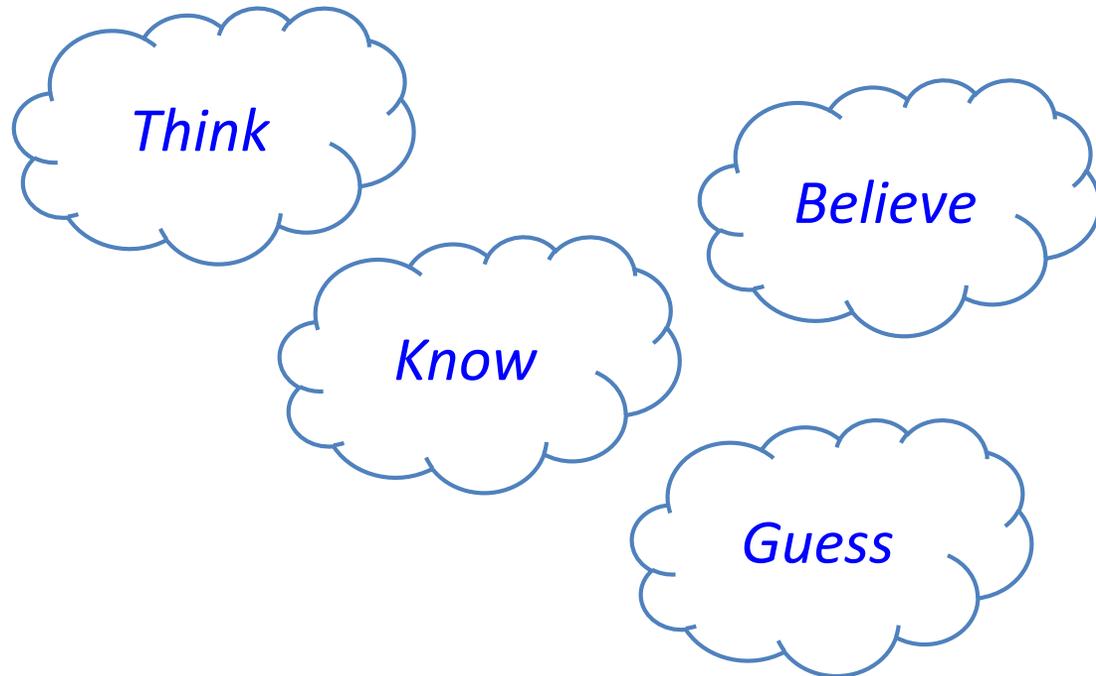
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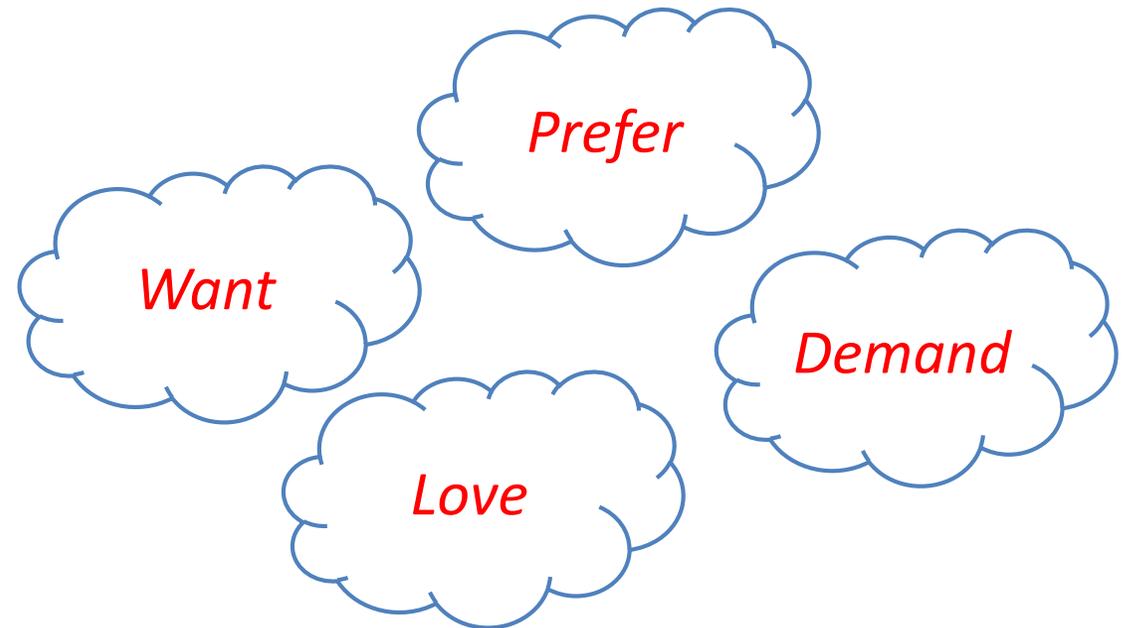


Attitude verbs can be classified into two semantic classes

Belief verbs



Desire verbs



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?



Image source: Jay's Brick Blog

What's the difference between the two situational contexts?

Context #1

"Mary thinks they will leave."



Mary

Context #2

"Mary wants them to leave."



Mary

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?

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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.

I.think that Peter go.PRES.**IND** to the house

Belief verb: 'I think Peter is going to the house.'

ii. **Quiero** que Peter **vaya** a la casa.

I.want that Peter go.PRES.**SBJ** to the house

Desire verb: 'I want Peter to go to the house.'

(Bolinger 1968, Hooper 1975, a.o.)

German: optional vs. impossible embedded V2

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

	Clausal complement of belief verbs	Clausal complement of desire verbs
English	Finite	Non-finite
Spanish (and other Romance)	Indicative	Subjunctive
German	V2 possible	No V2

A solution around the problem of morphosyntactic variation

	Clausal complement of belief verbs	Clausal complement of desire verbs	Declarative main clause
English	Finite	Non-finite	Finite
Spanish (and other Romance)	Indicative	Subjunctive	Indicative
German	V2 possible	No V2	V2

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 thinks they will leave.”

“Mary wants them to leave.”

Compare clausal complements with declarative main clauses

“Mary thinks **they will** leave.”

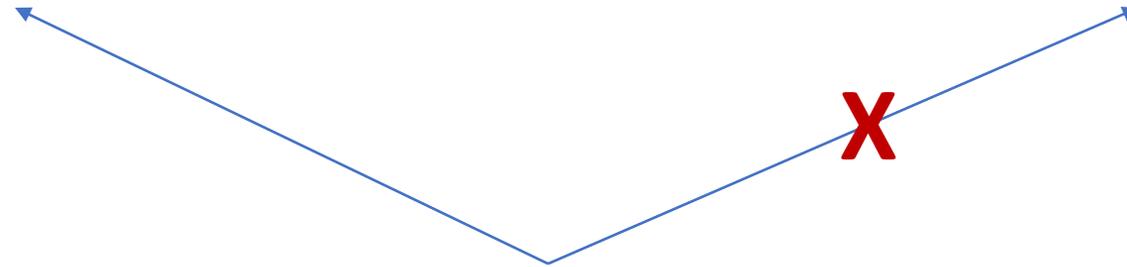
“Mary wants **them to** leave.”

“**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?



...like Chinese?

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

The learning problem for the Mandarin Chinese learner

1. Wo **zhidao** chi shuiguo.

I know eat fruit

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

(subject of “eat” omitted)

Belief semantics

2. Wo **ai** chi shuiguo.

I love eat fruit

“I **love** to eat fruit.”

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 **zhidao** 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.
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Modal

Declarative main clause

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

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Belief verbs

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

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Aspect

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.”

This generalization appear to be fairly robust across attitude verbs...

Verb class (belief / desire / other)	Overt subject	Modal auxiliary/adverb	Aspect markers
(Declarative) main clause	OK	OK	OK
<i>faxian</i> “discover”; <i>huaiyi</i> “doubt”; <i>juede</i> “feel”; <i>renwei</i> “think”; <i>xiang-1</i> “think”; <i>shuo</i> “say”; <i>xiangxin</i> “believe”; <i>zhidao</i> “know”; <i>danxin</i> “worry”; <i>jiang</i> “say”; <i>mingbai</i> “understand”; <i>yiwei</i> “falsely believe”	OK	OK	OK
<i>Xihuan</i> “like”; <i>taoyan</i> “dislike”; <i>yao-1</i> “want/need”	OK	*	*
<i>Ai</i> “love”; <i>xiang-2</i> “want”; <i>gan</i> “dare”; <i>yao-2</i> “FUT”	*	*	*
<i>Dasuan</i> “plan”; <i>zhunbei</i> “get ready to”	Disputed	Only <i>yao</i> “FUT”?	*
<i>Xiwang</i> “hope”	OK	OK	?

... but exceptions exist

Verb class (belief / desire / other)	Overt subject	Modal auxiliary/adverb	Aspect markers
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<i>Xiwang</i> “hope”	OK	OK	?

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 shuiguo.
 past they might eat fruit

“In the past, it might be the case that they ate fruit.”

Belief verbs

ii. Wo **zhidao** tamen keneng chi shuiguo.
 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 **zhidao** tamen chi shuiguo.
 I know they eat fruit
 “I **know** they eat fruit.”

At the individual token level, belief and desire complements might be superficially identical

Belief verbs

i. Wo **zhidao** **chi** **shuiguo.**

I know eat fruit

“I **know** [they] eat fruit.”

Desire verbs

ii. Wo **ai** **chi** **shuiguo.**

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.

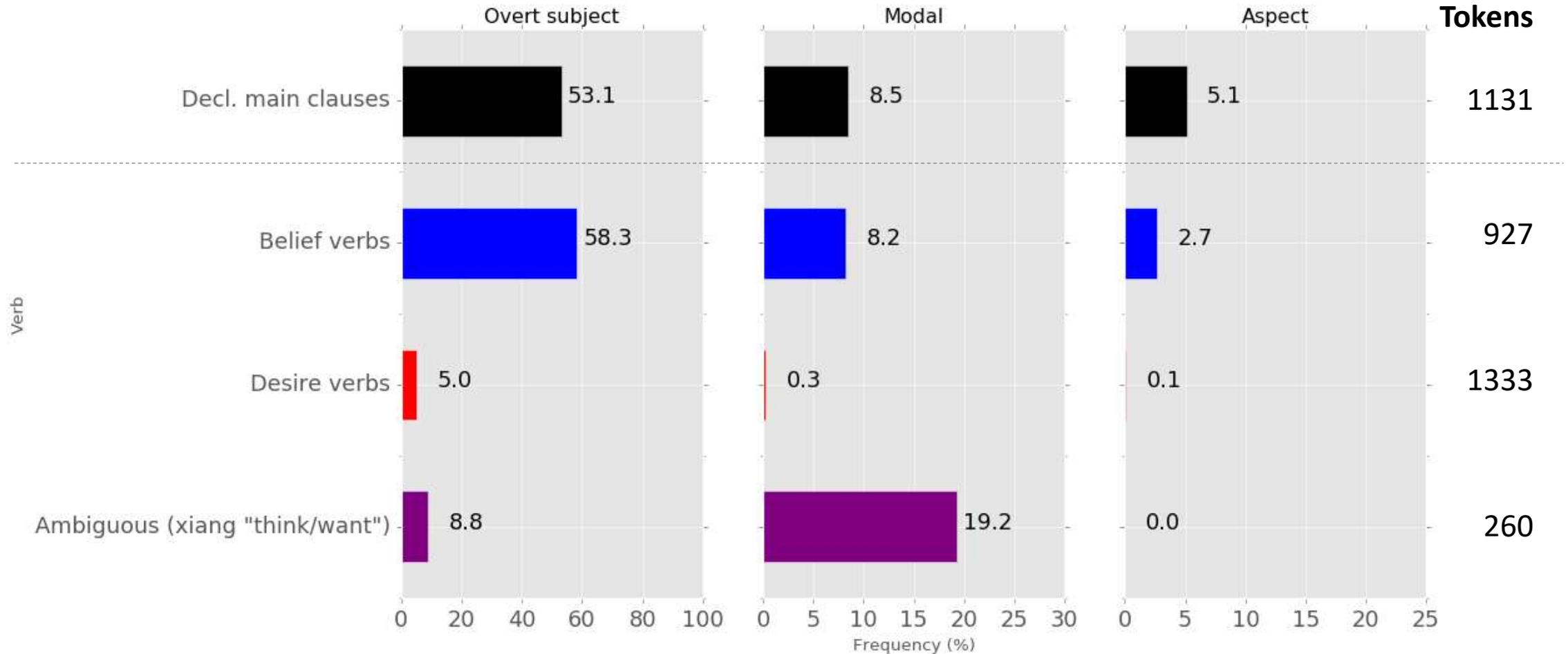
CHILDES corpora properties

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

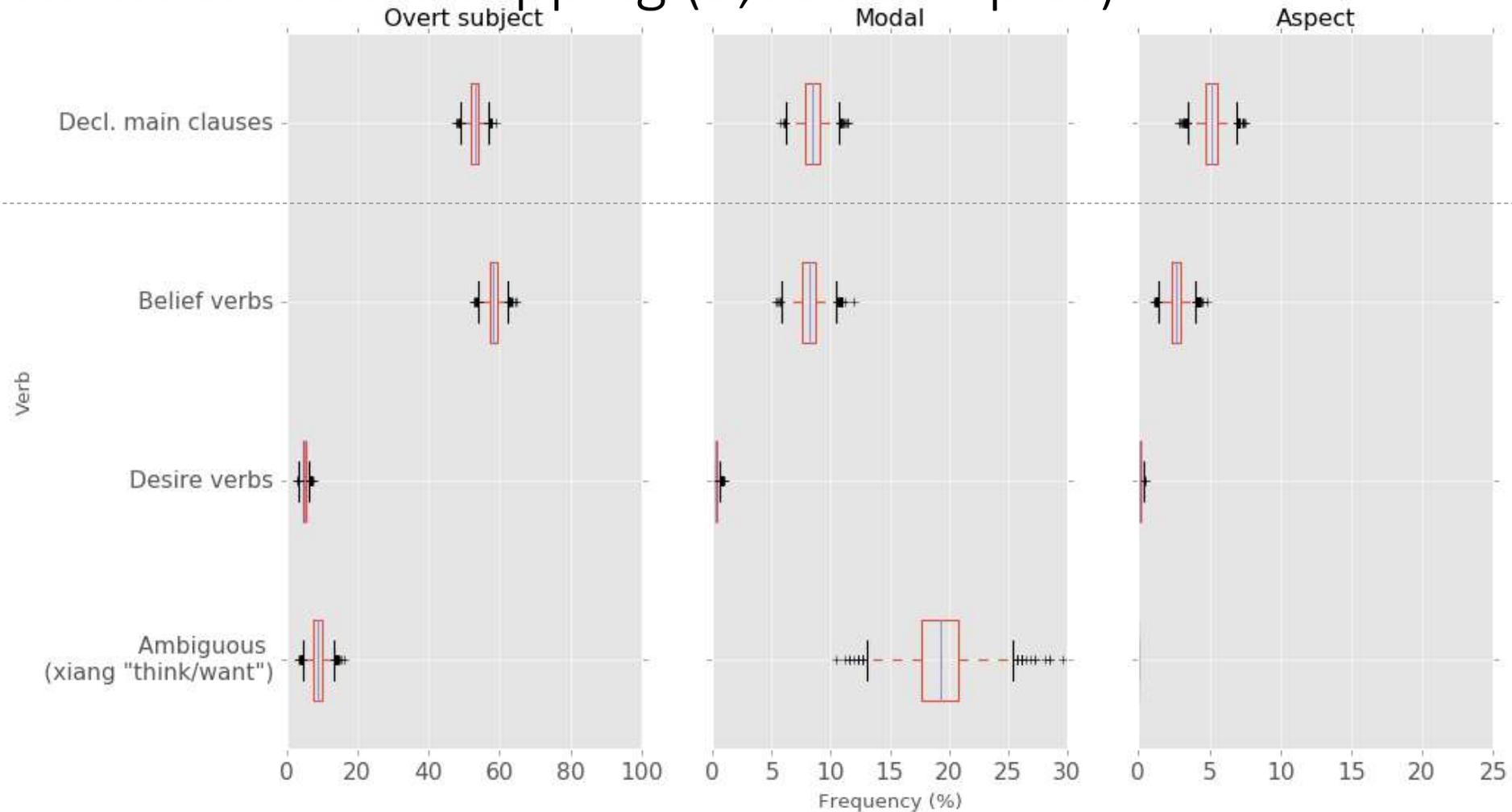
Methodology

	Attitude verbs	Main clauses
Sample	All child-ambient utterances containing relevant attitude predicates	5% random sample of child-ambient utterances
Number of tokens	~6,000	~6,100
What was coded	Attitude verb's complement: clause, VP, NP, etc. Within the complement: <ul style="list-style-type: none">• Overt subject• Modal auxiliary/adverb• Aspect• Etc.	Clause type: declarative, interrogative, ... Within the main clause: <ul style="list-style-type: none">• Overt subject• Modal auxiliary/adverb• Aspect• etc.
What was analyzed	~2,500 clause-like complements <ul style="list-style-type: none">• NP and other complements excluded	1,131 declarative main clauses <ul style="list-style-type: none">• Disfluencies, interrogatives and imperatives etc. excluded

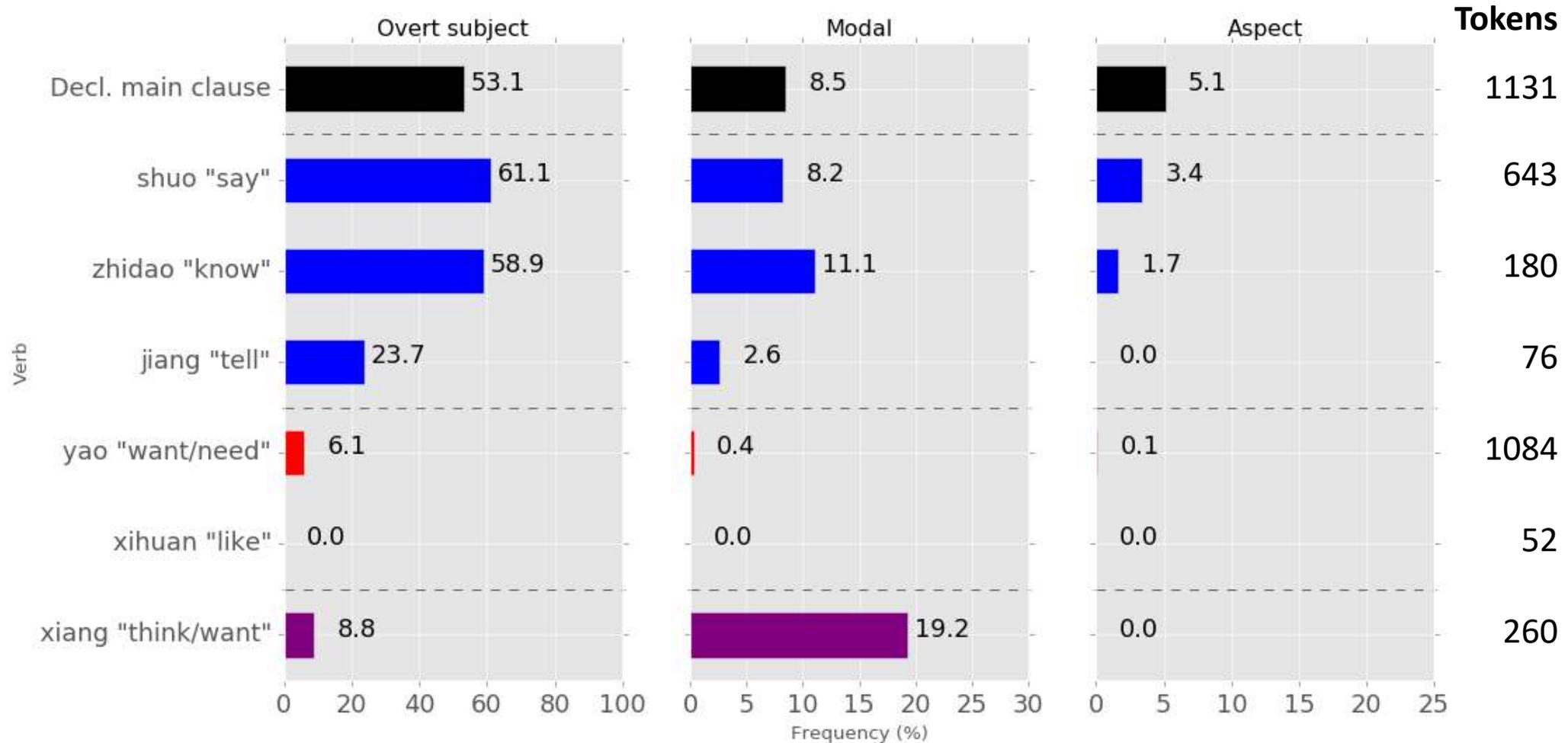
CHILDES corpus study: results by verb class



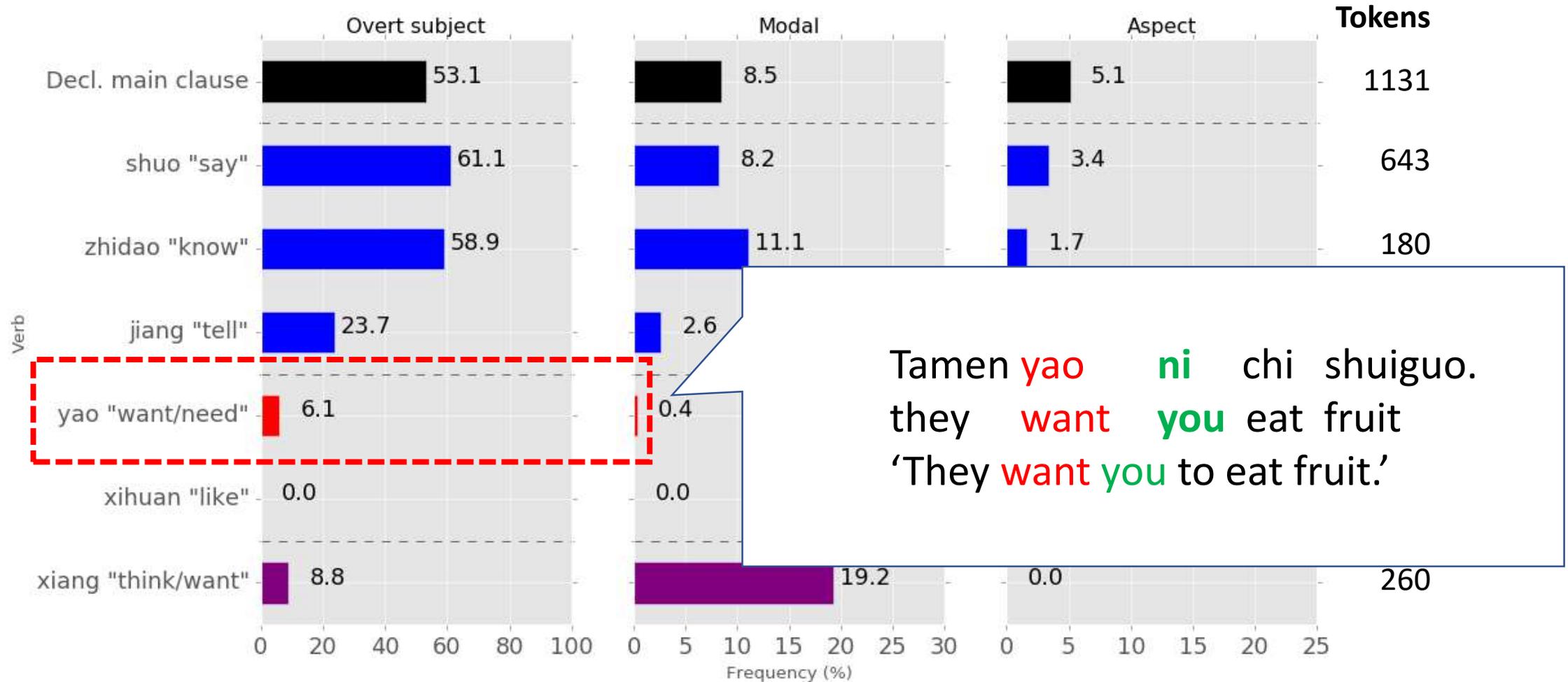
Confidence intervals: results by verb class via statistical bootstrapping (5,000 samples)



CHILDES corpus study: results by verb

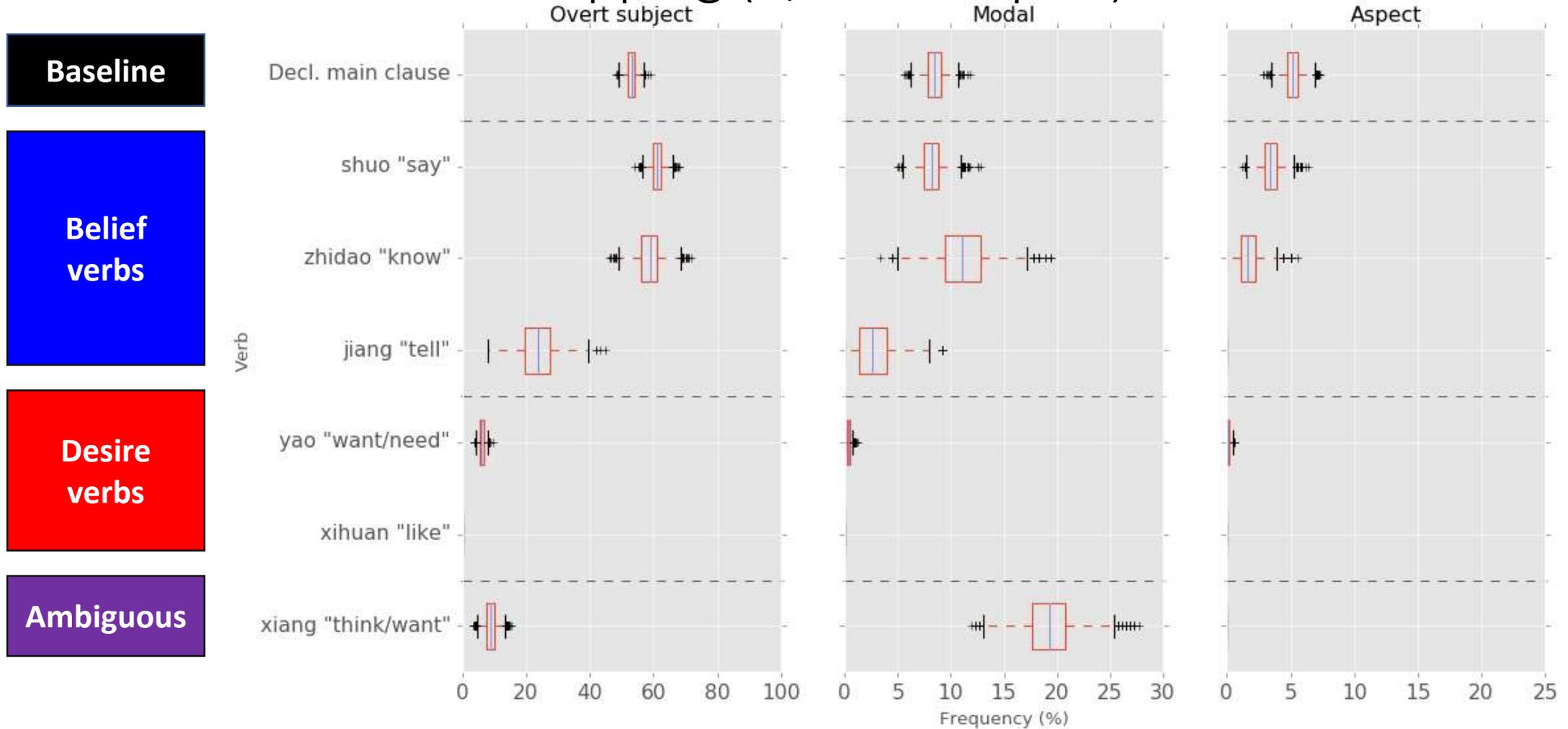


CHILDES corpus study: results by verb



Confidence intervals: results by verb

via statistical bootstrapping (5,000 samples)



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)

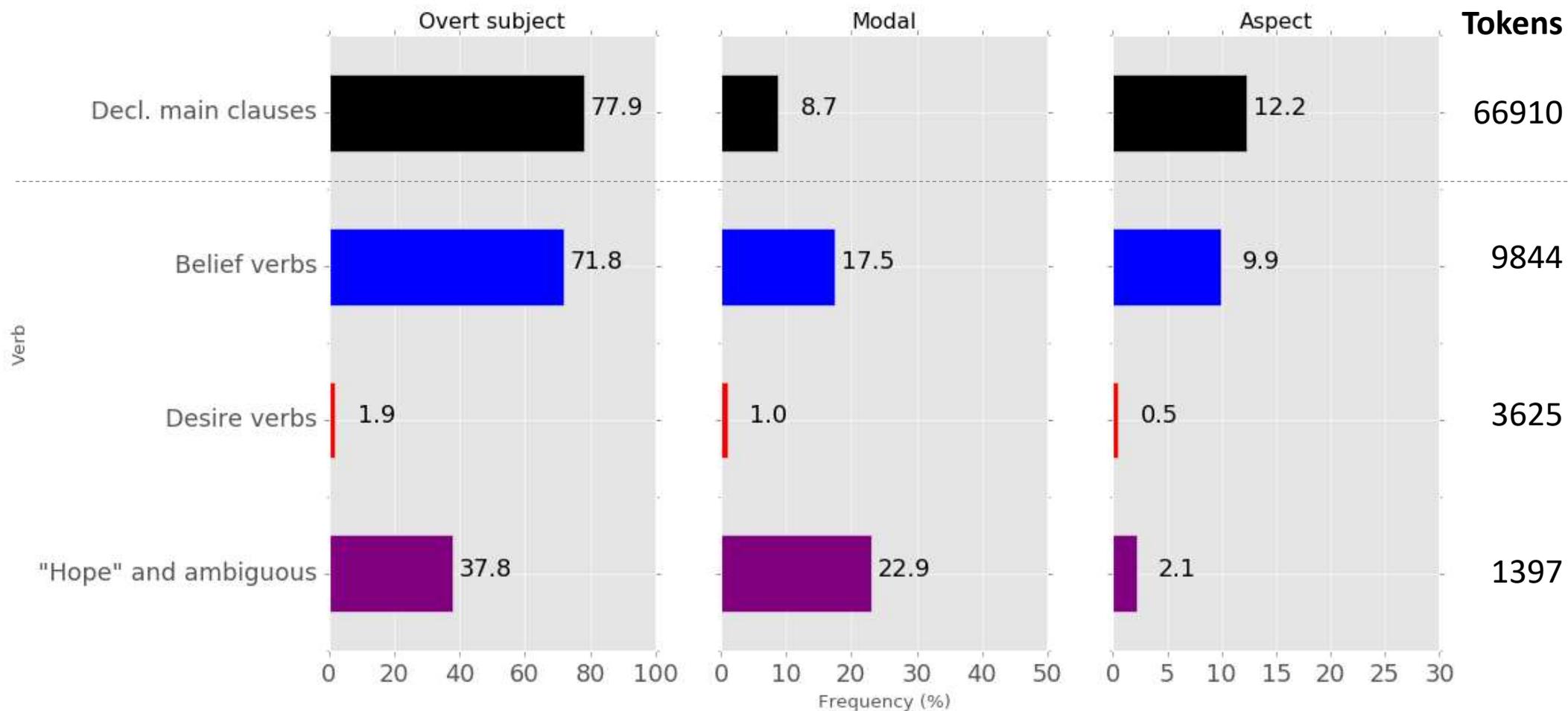
Fully-bracketed corpus of 51,447 sentences of Mandarin Chinese.

- Note that a sentence can be formed by conjoining multiple clauses.

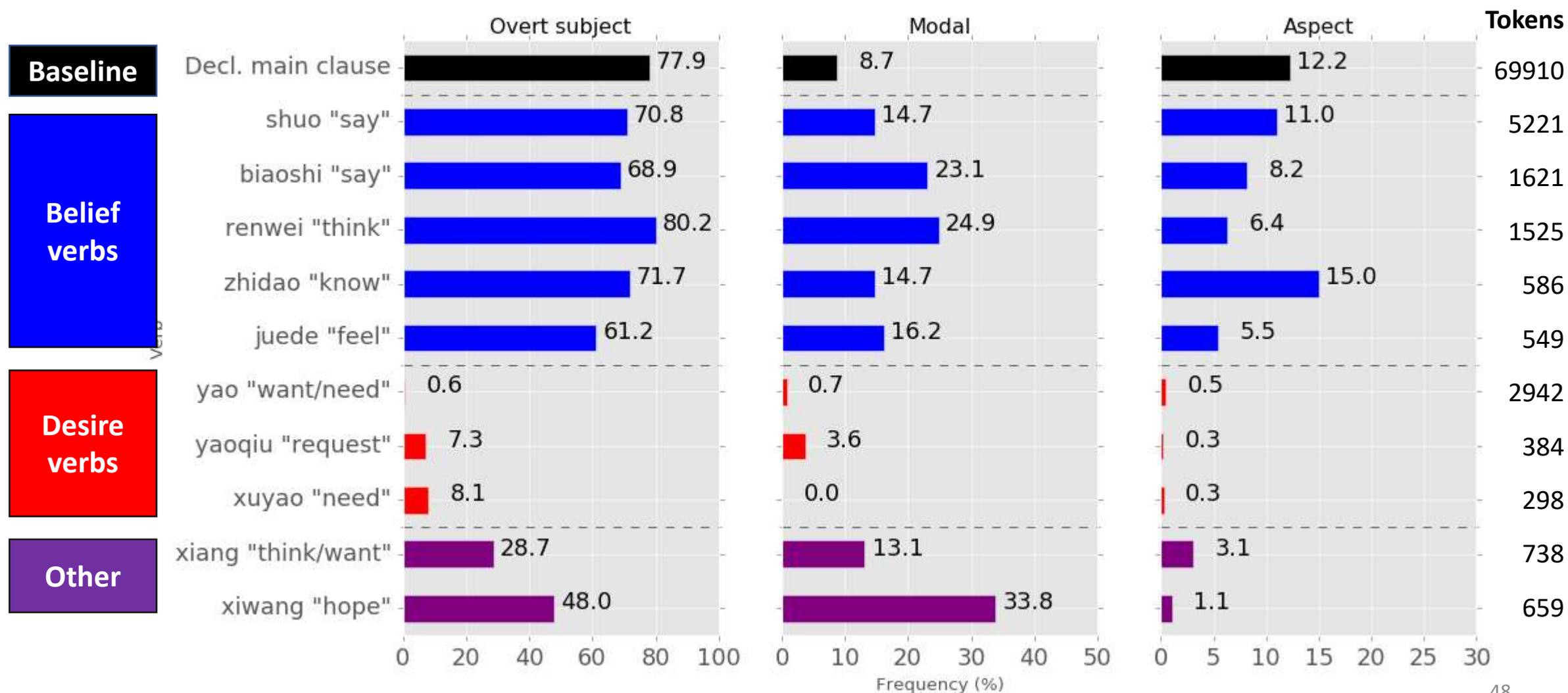
Bias toward written and/or formal registers: newswire, magazines, broadcast news and conversations, newsgroup and blogs.

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



Chinese Penn Treebank: results by verb



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?

- Building on Harrigan 2015, Harrigan et al. 2016, 2017, Lidz et al. 2016 on English.

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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- We also gratefully acknowledge the support of NSF grants #1551628 and #1449815.



Backups

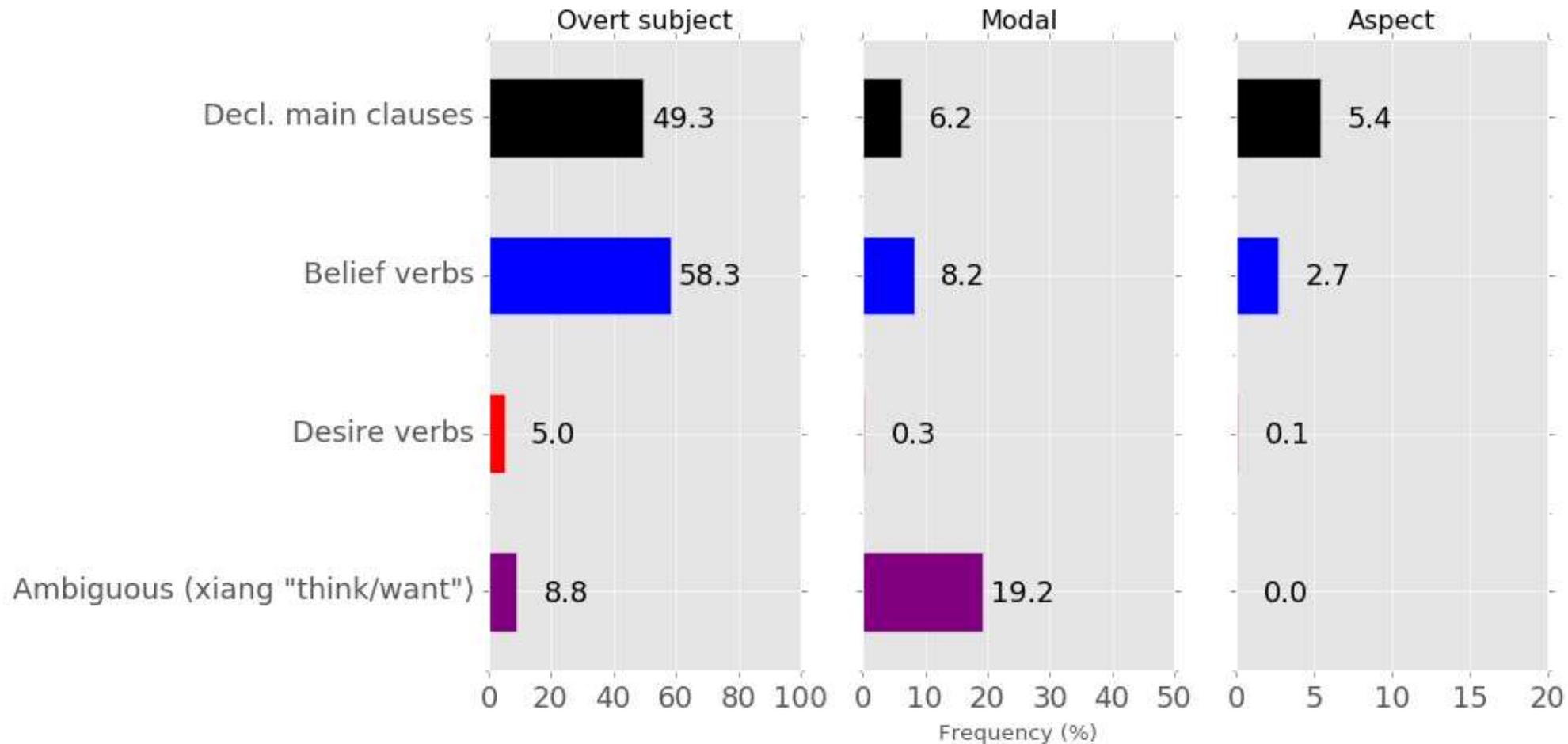
Imperatives

- Imperatives can take overt 2nd 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 *bie*.

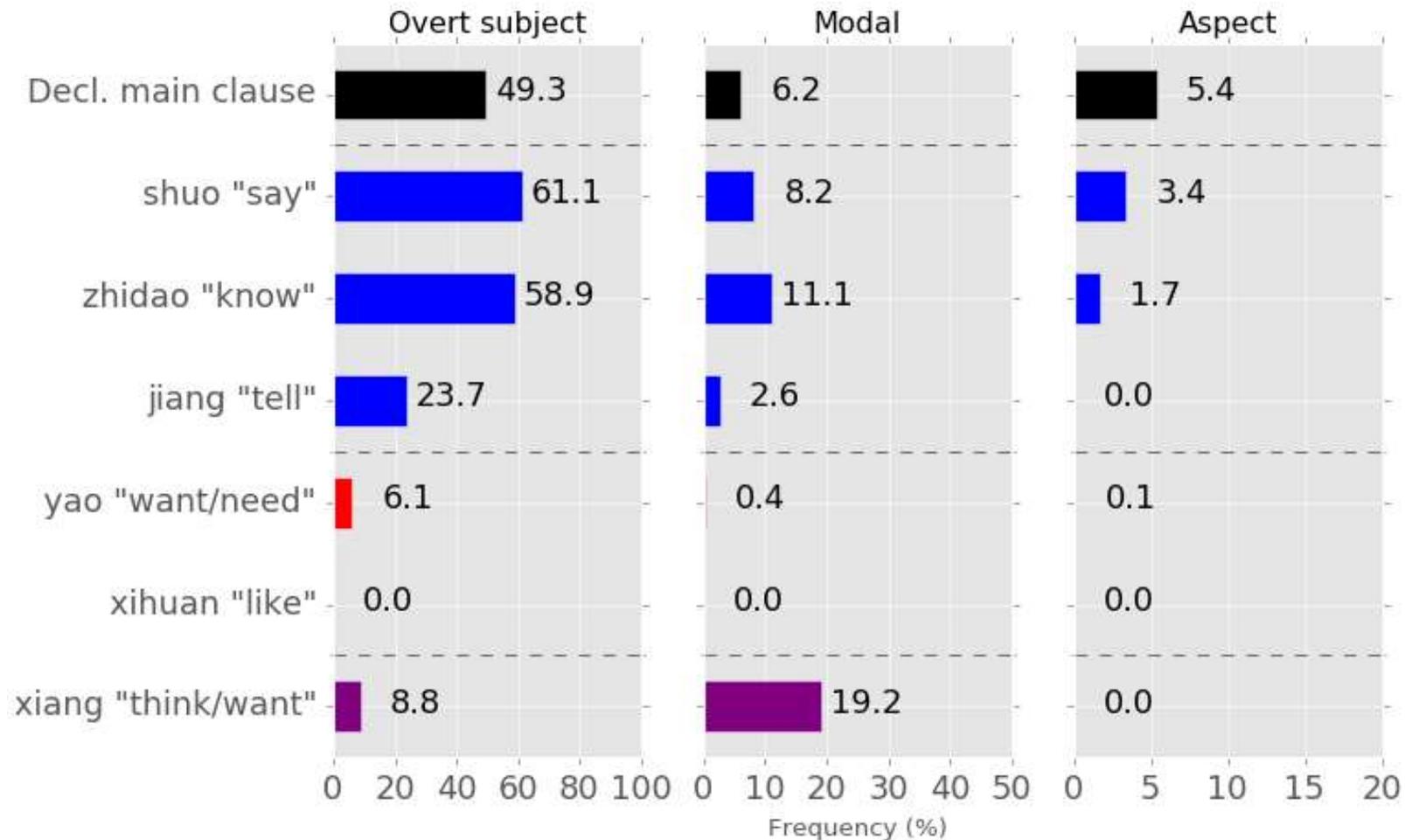
(1) Ni zuo nali.
you sit there
'[You] sit there!' (imperative) / 'You sit there' (declarative)

(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 2nd person subjects and orders: results by verb



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

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