Syntactic bootstrapping mental verbs and perception verbs with limited morphosyntactic cues

Daoxin Li
University of Pennsylvania
BUCLD 46, Nov 4, 2021

Learning word meanings is a hard task

- Many possible meanings, unhelpful visual world;

Learning word meanings is a hard task

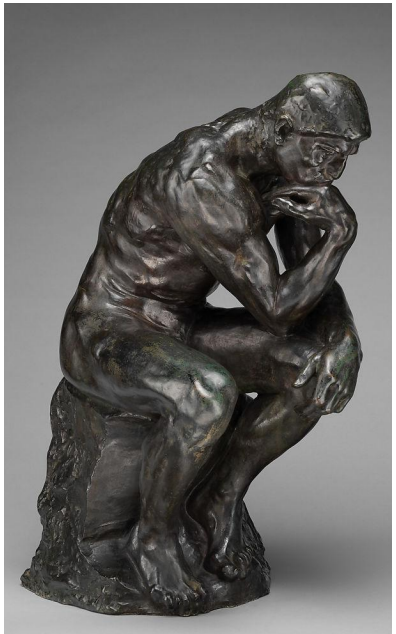
- Many possible meanings, unhelpful visual world;
- Especially hard for words that are abstract and lack reliable correlates in the world (e.g. Gillette et al. 1999, Medina et al. 2010).

Learning word meanings is a hard task

- Many possible meanings, unhelpful visual world;
- Especially hard for words that are abstract and lack reliable correlates in the world (e.g. Gillette et al. 1999, Medina et al. 2010).

  e.g. Mental verbs: *think, know, believe, remember,...*

  Perception verbs: *see, watch, hear, listen,...*



Learning word meanings via syntactic bootstrapping

- A helpful strategy: Syntactic bootstrapping - using syntactic context to restrict possible word meanings (e.g. Gleitman 1990, Fisher et al. 1991, Gleitman et al. 2005).

- e.g. Argument type
  Mental verbs: associated with sentential complements (Papafragou et al., 2007, Harrigan et al., 2019, Harrigan, 2020).

Mental verbs vs. perception verbs

- But what if different classes of verbs overlap in the types of arguments they can take?

- Both mental verbs and perceptions verbs are associated with CP and NP complements cross-linguistically (e.g. Landau & Gleitman 1985, Fisher et al. 1991, Whitt, 2009), but they do differ in their meanings.

(1) a. “John *knew* that it rained.” b. “John *saw* that it rained.”
(2) a. “John *knew* the answer.” b. “John *saw* the answer.”

How do children learn the distinction between mental verbs and perception verbs?

Roadmap

A corpus study on whether there are reliable distributional cues to distinguish belief verbs and perception verbs in children's input, taking Mandarin as a case study.

- Semantics and syntax of mental verbs and perceptions verbs
- Semantics and syntax of mental verbs and perception verbs in Mandarin
- Corpus analyses
- Discussion and conclusion

Semantics and syntax of mental verbs and perception verbs

Semantics and syntax of mental verbs

- Mental verbs: refer to mental states; mainly take CP and NP arguments (e.g. Fisher et al 1991, Papafragou et al. 2007).

- Two main classes:

Type	Semantics	Syntax (English)	Example
Belief verbs	Judgments of truth	Finite CP complement	"She *thinks* it will rain."
Desire verbs	Preferences	Non-finite CP complement	"She *wants* it to rain."

(e.g. Bolinger 1968, Searle & Vanderveken 1985, Villalta 2000, 2008, White et al. 2014)

Semantics and syntax of mental verbs

- Mental verbs: refer to mental states; mainly take CP and NP arguments (e.g. Fisher et al 1991, Papafragou et al. 2007).

- Two main classes:

Type	Semantics	Syntax (English)	Example
Belief verbs	Judgments of truth	Finite CP complement	"She *thinks* it will rain."
Desire verbs	Preferences	Non-finite CP complement	"She *wants* it to rain."

(e.g. Bolinger 1968, Searle & Vanderveken 1985, Villalta 2000, 2008, White et al. 2014)

Semantics of perception verbs

- Perception verbs: convey the experience of physical senses.
- Two major usages:

Type	Semantics	Example
Epistemically neutral	Only refer to the perceptual stimulus	“John saw the rain”
Epistemically non-neutral	Also refer to perceiver’s corresponding mental representation of the stimulus	“John saw that it rained.”

(Bairwise 1981, Higginbotham 1983, Moulton 2009)

Semantics of perception verbs

- Verbs of perceptual exploration vs. achievement (Viberg 1983, Fisher et al. 1991, Levin 1993)

Type	Semantics	Example
Perceptual exploration verbs	An attempt to explore some object or event	“watch”, “listen”
Perceptual achievement verbs	The consequence of the exploration	“see”, “hear”

- In English, perceptual achievement verbs are more likely to be used epistemically non-neutrally (e.g. “Mary saw/*watched that it was raining.”) (Fisher et al. 1991)

Syntax of perception verbs

- Major argument types:
  - Finite CP: “Mary heard he’s getting married.”
  - NP: “Mary heard the music.”
  - Small clause: “Mary heard him [speak]/[speaking]/[spoken to].”

- CP complements are associated with epistemically non-neutral semantics (e.g. Viberg 1983, Fisher et al. 1991, Levin 1993).

Syntax	Semantics	Semantics
CP	Epistemically non-neutral	Perceptual achievement
NP	Epistemically neutral	Perceptual exploration

How to distinguish mental verbs and perception verbs?

- There are some non-overlapping argument types:

Type	Finite clause	Non-finite clause	Small clause	NP
Belief verbs	Yes	No	No	Yes
Desire verbs	No	***Yes***	No	Yes
Perception verbs	Yes	No	***Yes***	Yes

But what about in a language with minimal morpho-syntax cues?

The challenge in Mandarin

- Given its minimal morphology, embedded complements of perception verbs and belief verbs are superficially identical:

(a) wo tingdao ta lai. [perception]
I hear 3s come
'I hear her/him come.'

(b) wo zhidao ta lai. [belief]
I know 3s come
'I know s/he will come.'

Semantics and syntax of mental verbs and perception verbs in Mandarin

Mental verbs in Mandarin

- Mainly take CP and NP complements:
  (a) ta zhidao diqiu rao taiyang zhuan.
  3s know earth around sun revolve
  'S/he knows that Earth goes around the sun.'
  (b) ta zhidao da'an.
  3s know answer
  'S/he knows the answer.'

- Belief vs. desire verbs: no overt finiteness distinction, but

Type	Overt subjects, modal auxiliaries and adverbs, aspect markers
Belief verbs	Allowed in CP complement
Desire verbs	Usually not allowed in CP complement

(e.g. Huang 1982, Li 1990)

Perception verbs in Mandarin

- Same exploration vs. achievement distinction.

- Different from English, the perceptual exploration verb *kan* ‘watch’ rather than the perceptual achievement verb *kandao* ‘see’ is more strongly associated with epistemically non-neutral semantics:

  wo kan/*kandao zhe shi neng cheng.
  I watch/*see this business can succeed
  ‘I think this business will succeed.’

Perception verbs in Mandarin

- Mainly take CP and NP complements:
  (a) ta tingdao wo shuohua.
  3s hear I speak
  'S/he heard me speak.'

  (b) ta tingdao shengyin.
  3s hear sound
  'S/he heard the sound.'

- Minimal morphology - no overt cue for small clauses:
  (c) wo tingdao ta lai. [perception]
  I hear 3s come
  'I hear her/him come.'

  (d) wo zhidao ta lai. [belief]
  I know 3s come
  'I know s/he will come.'

Question

Are there sufficient distributional cues to distinguish between belief verbs and perception verbs in Mandarin input?

Corpus study

Possible cues

- Frequency of CP complements:
  - Only perceptions verbs have epistemally neutral usages.
  - CP complements are usually associated with epistemally non-neutral semantics.
  - Belief verbs are predicted to occur with CP complements more frequently than perception verbs.

Possible cues

- Overt embedded subjects
  - “Mary knew *it* rained.” [belief] vs. “Mary saw *it* rain.” [perception]
    subject object
  - Mandarin: old information is more likely to appear at the beginning of a sentence and more likely to be omitted (Li & Thompson 1976).
  - Belief verbs may have fewer overt embedded subjects.

- Note: We do not intend to use this to test whether there are small clauses in Mandarin.

Possible cues

- Type and frequency of aspect markers:
  - According to event property theories, mental verbs and perceptual achievement verbs are “states”, whereas perceptual exploration verbs are “activities”;
  - “Activities” but not “states” can occur with imperfective aspects (e.g. Vendler 1957).
  - Perception verbs, especially perceptual exploration verbs, are predicted to occur with aspect markers more, especially with imperfective aspect markers.

Method

- Eight Mandarin corpora from the CHILDES database (MacWhinney 2000): AcadLang (collected by Zhou), Chang1 (Chang, 1998), Chang2 (Chang 2004), ChangPlay (Chang 2005), TCCM (collected by Cheung & Chang), and Zhou1 (Zhou 2001), Zhou2 (Li & Zhou 2004), Zhou3 (Zhang & Zhou 2009).

- Naturalistic interactions between children and caregivers; children 0;8 - 6 years of age.

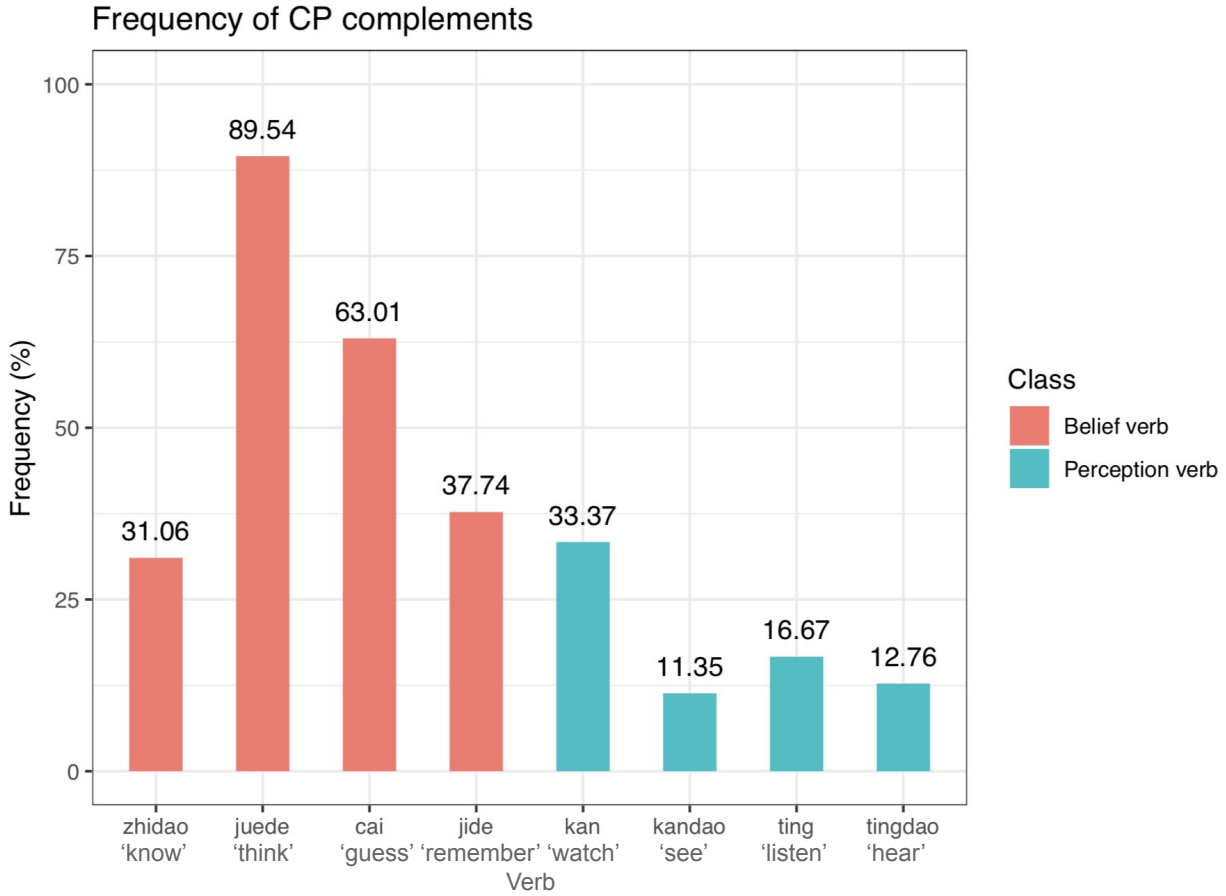
Method

- Extracted all caregivers' utterances that contain the belief or perception verbs in the table below.
- Coded for each token the syntactic category of the verb complement (null, NP, VP, NP+VP) and the aspect marker in the matrix clause.

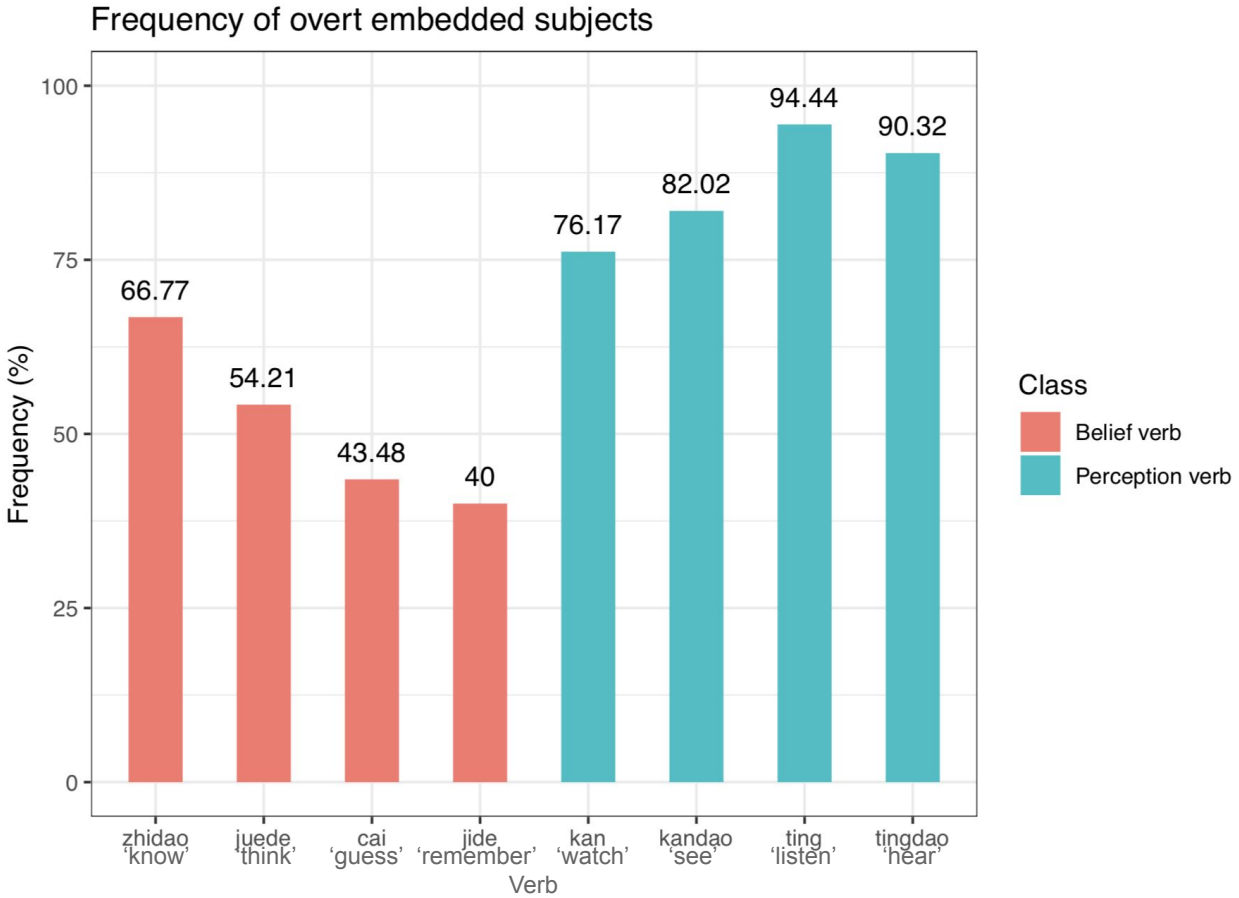
CP

Class	Verb	Count
Belief verb	*zhidao* 'know'	998
	juede 'think'	239
	cai 'guess'	73
	jide 'remember'	53
Perception verb	*kan* 'look, watch'	5961
	kandao 'see'	784
	ting 'listen'	432
	tingdao 'hear'	243

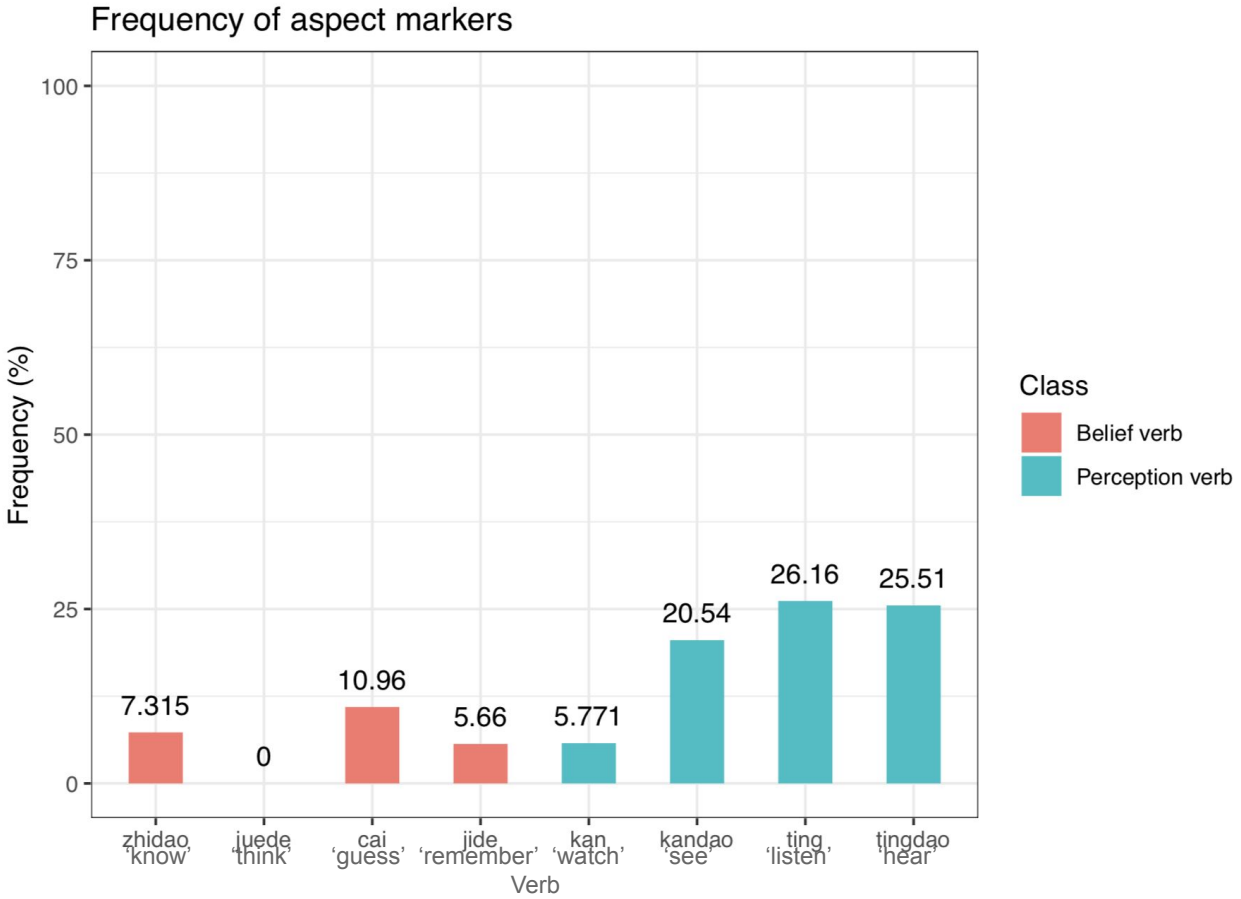
Results


Frequency of CP complements
Frequency (%)
100
75
50
25
0
89.54
63.01
37.74
33.37
31.06
11.35
16.67
12.76
zhidao 'know'
juede 'think'
cai 'guess'
jide 'remember'
kan 'watch'
kandao 'see'
ting 'listen'
tingdao 'hear'
Verb
Class
Belief verb
Perception verb

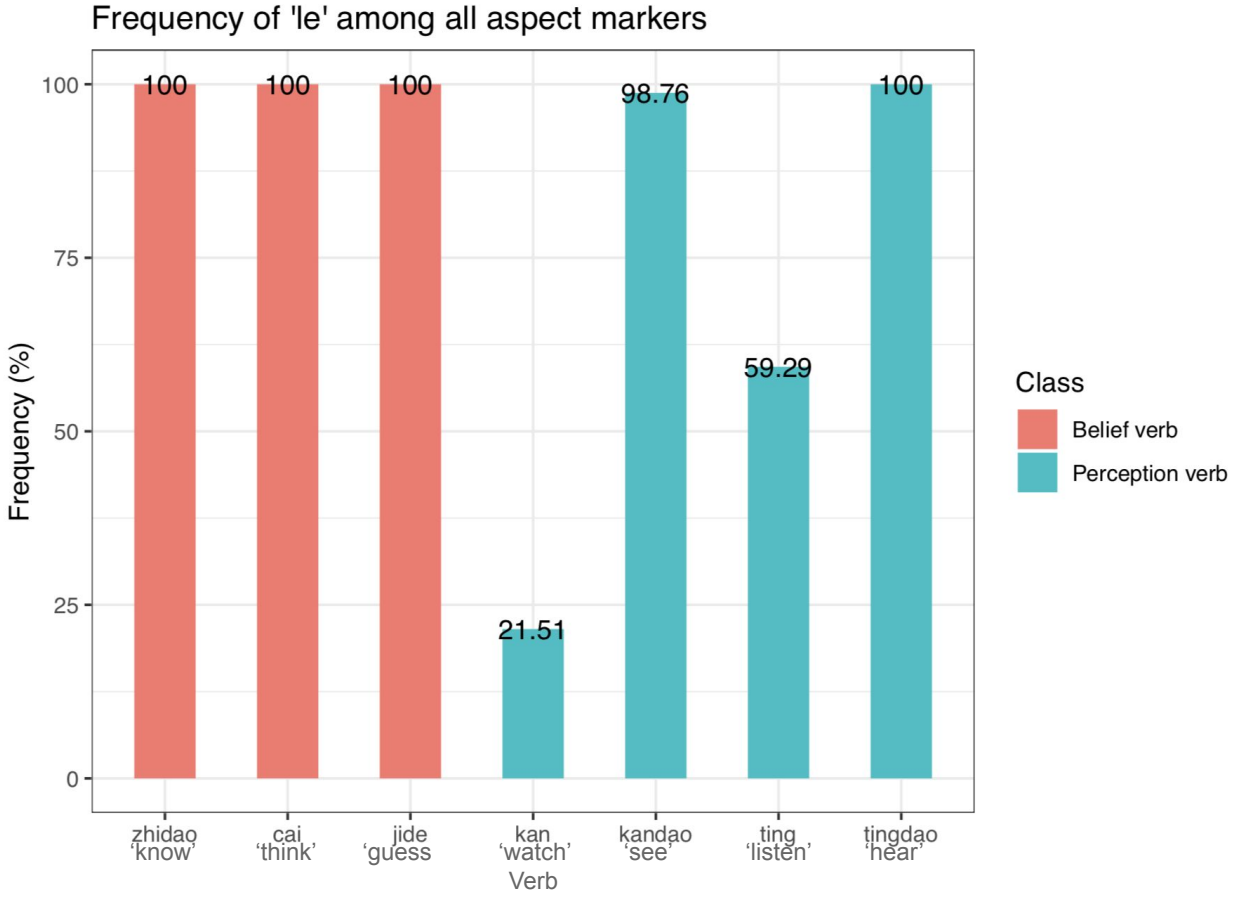
Results


Frequency of overt embedded subjects
Frequency (%)
100
75
50
25
0
66.77
54.21
43.48
40
76.17
82.02
94.44
90.32
zhidao 'know'
juede 'think'
cai 'guess'
jide 'remember'
kan 'watch'
kandao 'see'
ting 'listen'
tingdao 'hear'
Verb
Class
Belief verb
Perception verb

Results


Frequency of aspect markers
Frequency (%)
100
75
50
25
0
7.315
0
10.96
5.66
5.771
20.54
26.16
25.51
zhidao 'know'
juede 'think'
cai 'guess'
jide 'remember'
kan 'watch'
kandao 'see'
ting 'listen'
tingdao 'hear'
Verb
Class
Belief verb
Perception verb

Results


Frequency of 'le' among all aspect markers
Frequency (%)
100
75
50
25
0
100
100
100
21.51
98.76
59.29
100
zhidao
'know'
cai
'think'
jide
'guess
kan
'watch'
kandao
'see'
ting
'listen'
tingdao
'hear'
Verb
Class
Belief verb
Perception verb

Summary

- At both individual verb level and verb class level, perception verbs are significantly more likely than belief verbs to take non-clausal complements, to have overt embedded subjects, and to co-occur with aspect markers, particularly aspect markers other than the perfective marker *le*.

- *kan* ‘watch’ often patterns with belief verbs, which is not surprising given its epistemally non-neutral use in Mandarin.

- The distributional learning mechanism needs to be flexible enough to allow this cross-linguistic difference (e.g. Yang 2016).

Conclusion

- Although mental verbs and belief verbs in Mandarin take the same types of arguments, there is still reliable distributional information in the input to distinguish them.

- Syntactic bootstrapping could be a universal learning strategy, as it is feasible even in a language with impoverished morphosyntax.

Remaining questions

- We still don’t have a complete learning story:
  - Can children actually detect such morphosyntactic cues?
  - Can children actually use such morphosyntactic cues to learn the distinction between belief and perception verbs?
  - How do children integrate distributional information and other types of information during word learning?

Thank you!

Thanks to Charles Yang, and members of the Child Language Lab and the Language and Cognition Lab at University of Pennsylvania for comments and discussion!

Selected references

- Fisher, Cynthia, Henry Gleitman, and Lila R. Gleitman. 1991. On the Semantic content of subcategorization frames. *Cognitive Psychology 23*: 331-392.
- Gillette, Jane, Henry Gleitman, Lila R. Gleitman, and Anne Lederer. 1999. Human simulations of vocabulary learning. *Cognition 73*:135–176.
- Gleitman, Lila. 1990. The structural sources of verb meanings. *Language Acquisition 1*:3–55.
- Gleitman, Lila, Kimberly Cassidy, Rebecca Nappa, Anna Papafragou, and John C Trueswell. 2005. Hard words. *Language Learning and Development 1*:23–64.
- Medina, Tamara Nicol, Jesse Snedeker, John C. Trueswell, and Lila R. Gleitman. 2011. How words can and cannot be learned by observation. *PNAS 108 (22)*: 9014-9019.
- Papafragou, Anna, Kimberly Cassidy, and Lila Gleitman. 2007. When we think about thinking: The acquisition of belief verbs. *Cognition 105*:125–165.
- Viberg, Åke. 1983. The verbs of perception: A typological study. *Linguistics 21*: 123–162.
- Whitt, Richard. 2009. *Evidentiality and perception verbs in English and German.* Bern: Peter Lang.

Questions?