Probing the limits of linguistic experience in our theories of language

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Linguistic experience shapes grammars and language processing

Grammar

Grow up
learn English g

Grow up w
learn Mandarin grammatical rules.

Language processing
(e.g. lexical decision)

frenzy

ecognized slowly
Low frequency

How exactly is experience related to grammars and processing?

An influential idea: Processing and grammatical knowledge can be modeled directly with the statistics of ling experience

Word recognition / Word frequency

belief

Recognized quickly
High frequency

frenzy

Recognized slowly
Low frequency

Sentence processing / frequency of verb frames

*The staff **concluded** nothing was stolen.*

Embedded "*was*" is read quickly.

*The staff **discovered** nothing was stolen.*

Embedded "*was*" is read more slowly.

Discover co-occurs with an embedded clause less often than ***conclude***.

Brysbaert et al. 2017; Garnsey et al. 1997, Pereira 2000; among others

Supported by recent advances in computational modeling

Language models (recurrent neural networks):

Impressive performance in natural language processing domains, e.g. machine translation, auto-completion

Good fit for psycholinguistic / grammatical phenomena:

- Acceptability ratings
- Long-distance subject-verb agreement
- Abstract syntax: negative polarity items, island constraints
  Lau et al. 2017, Gulordova et al. 2018, Linzen et al. 2016, Marvin & Linzen 2018, Wilcox et al. 2018

All by getting exposed to strings of words in a corpus!

but see Ettinger 2020, Chaves et al. 2019, Sprouse et al. 2018 etc.

This talk

Picture so far: we seem to capture a lot of linguistic knowledge and behavior through general algorithms and the statistics of easily-observed linguistic features ("language statistics").

Today: figuring out the limits of this approach.

1. In what cases does the "language statistics" approach run into limits?
2. How should we think about these cases?

Three case studies

1. Center-embedding illusions
2. Long-distance wh-questions
3. Learning verb meanings (especially verbs like *think*, *want*)

→ In particular, case studies 1 and 2 have been cited as support for a language statistics approach.

→ Language statistics play **at best an indirect role (although still an important one)** in these phenomena.

→ These phenomena serve as **a reminder of the importance** of other aspects of language, e.g. parsing mechanisms and learning biases.

Case study 1: Centre-embedding illusions

(Joint work with Colin Phillips)

What is centre-embedding?

Ungrammatical missing VP sentences are surprisingly OK in English (and French, Spanish)

Double centre-embedding	The patient [$_{RC}$ the nurse [$_{RC}$ the clinic hired] saw] called. **Grammatical (but difficult to understand)**
"Missing VP"	The patient [$_{RC}$ the nurse [$_{RC}$ the clinic hired]] called. **Ungrammatical** **but relatively easy to process (grammaticality illusion)** **(rated more highly, read faster)**

Frazier 1985 (citing Janet Fodor); Gibson & Thomas 1999; Frank et al. 2016; Frank & Ernst 2019; Huang & Phillips 2021; Gimenes et al. 2009 (French); Paneda & Lago 2020 (Spanish)

But not in German (or Dutch)

German examples from Vasishth et al. 2010

Double centre-embedding

Der Anwalt, [$_{RC}$ den der Zeuge, [$_{RC}$ den der Spion betrachtete], schnitt], überzeugte den Richter.
the lawyer who the witness who the spy watched avoided convinced the judge

Grammatical (Easier to process)

"Missing VP"

Der Anwalt, [$_{RC}$ den der Zeuge, [$_{RC}$ den der Spion betrachtete],], überzeugte den Richter.
the lawyer who the witness who the spy watched convinced the judge

Ungrammatical

(harder to process; no illusion)

Why this cross-linguistic difference?

Vasishth et al. 2010; Frank et al. 2016; Frank & Ernst 2019; but see Bader 2016, Haeussler & Bader 2015

Features of double centre-embedding sentences

Verb sequences

The patient [$_{RC}$ the nurse [$_{RC}$ the clinic **hired**] **saw**] **called**.

Long dependencies

The patient [$_{RC}$ the nurse [$_{RC}$ the clinic **hired**] **saw**] **called**.

Relative frequency of verb sequences and long dependencies in English vs. German

	English	**German**
Verb sequences	Infrequent	Frequent

English: “They have **met** the man who **loves** Kim.”
(Pseudo-)German: “They have the man who Kim **loves met**.”

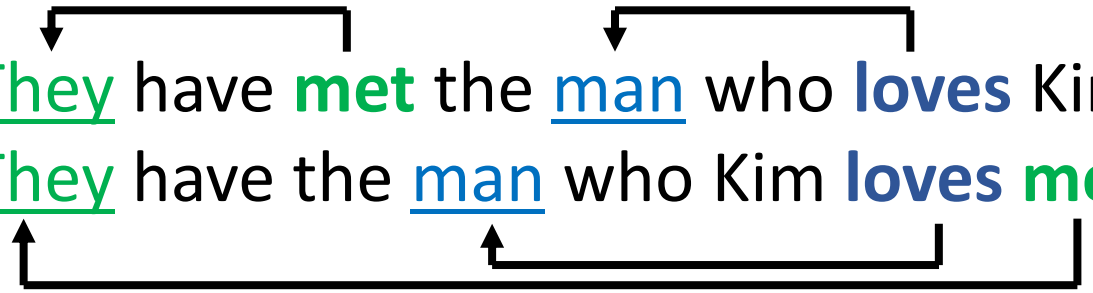
Sequence of 2 verbs

Relative frequency of verb sequences and long dependencies in English vs. German

	English	German
Verb sequences	Infrequent	Frequent
Long dependencies	Infrequent	Frequent

English: “They have **met** the man who **loves** Kim.”

(Pseudo-)German: “They have the man who Kim **loves** **met**.”



Lang. statistics accounts: German speakers are more "prepared" for processing double centre-embedding

	English	German
Verb sequences	Infrequent	Frequent
Long dependencies	Infrequent	Frequent

Verb sequences

The patient [$_{RC}$ the nurse [$_{RC}$ the clinic **hired**] **saw**] **called**.

Long dependencies

The patient [$_{RC}$ the nurse [$_{RC}$ the clinic **hired**] **saw**] **called**.

Vasishth et al. 2010; Frank et al. 2016; Frank & Ernst 2019; but see Bader 2016, Haeussler & Bader 2015

Testing this hypothesis with Mandarin Chinese

Fact 1: SVO language

S	V	O
总理	接见了	部长
Zongli	jiejianle	buzhang.
PM	met	minister

Fact 2: Modifiers of nouns (including relative clauses) always precede nouns

曾	责备过	法官	好几次	的	部长
[$_{RC}$ ceng	zebeiguo	faguan	haojici	de]	[$_{Noun}$ buzhang]
previously	rebuked	judge	a.few.times	DE	minister

“the minister who previously rebuked the judge a few times”

Mandarin double centre-embedding

Double centre-embedding (DCE)

	V		V		V	NP		NP			NP
总理	接见了	曾	责备过	刚	审理	贪污案	不久	的	法官	好几次	的	部长
Zongli	jiejianle	[$_{RC}$ ceng	zebeiguo	[$_{RC}$ gang	shenli	tanwu-an	bujiu	de]	faguan	haojici	de]	buzhang.
PM	met	previously	rebuked	just	hear	corruption-case	recently	DE	judge	a.few.times	DE	minister

“The prime minister met the minister who previously rebuked a few times the judge who just recently exposed the corruption case.”

Ungrammatical Missing NP sentence

	V		V		V	NP				NP
总理	接见了	曾	责备过	刚	审理	贪污案	不久	的		部长
Zongli	jiejianle	[$_{RC}$ ceng	zebeiguo	[$_{RC}$ gang	shenli	tanwu-an	bujiu	de]	]	buzhang.
PM	met	previously	rebuked	just	hear	corruption-case	recently	DE		minister

“*The prime minister met the minister who previously rebuked ___ just recently heard the corruption case.”

Are Mandarin grammatical DCE sentences easier to process than the ungrammatical variant, as in German?

Huang & Phillips, 2021

A language statistics hypothesis predicts Mandarin grammatical DCE should be easier

1. **Modifier-*de*-Noun sequences common.**

总理 接见了 曾 责备过 法官 好几次 的 部长。

Zongli jiejianle [$_{RC}$ ceng zebeiguo faguan haojici de] buzhang.

PM met previously rebuked judge a.few.times DE minister

“The prime minister met the minister who rebuked the judge a few times.”

Mandarin DCE sentences also have these sequences.

的 法官 的 部长

[$_{RC}$ [$_{RC}$ de] faguan de] buzhang.

PM met previously rebuked just hear corruption-case recently DE judge a.few.times DE minister

“The prime minister met the minister who previously rebuked a few times the judge who just recently heard the corruption case.”

A language statistics hypothesis predicts Mandarin grammatical DCE should be easier

2. Mandarin has long **verbal dependencies.**

总理 接见了 曾 责备过 法官 好几次 的 部长。

Zongli **jiejianle** [$_{RC}$ ceng **zebeiguo** faguan haojici de] buzhang.

PM met previously rebuked judge a.few.times DE minister

“The prime minister **met** the minister who **rebuked** the judge a few times.”

Mandarin DCE sentences also have long verbal dependencies.

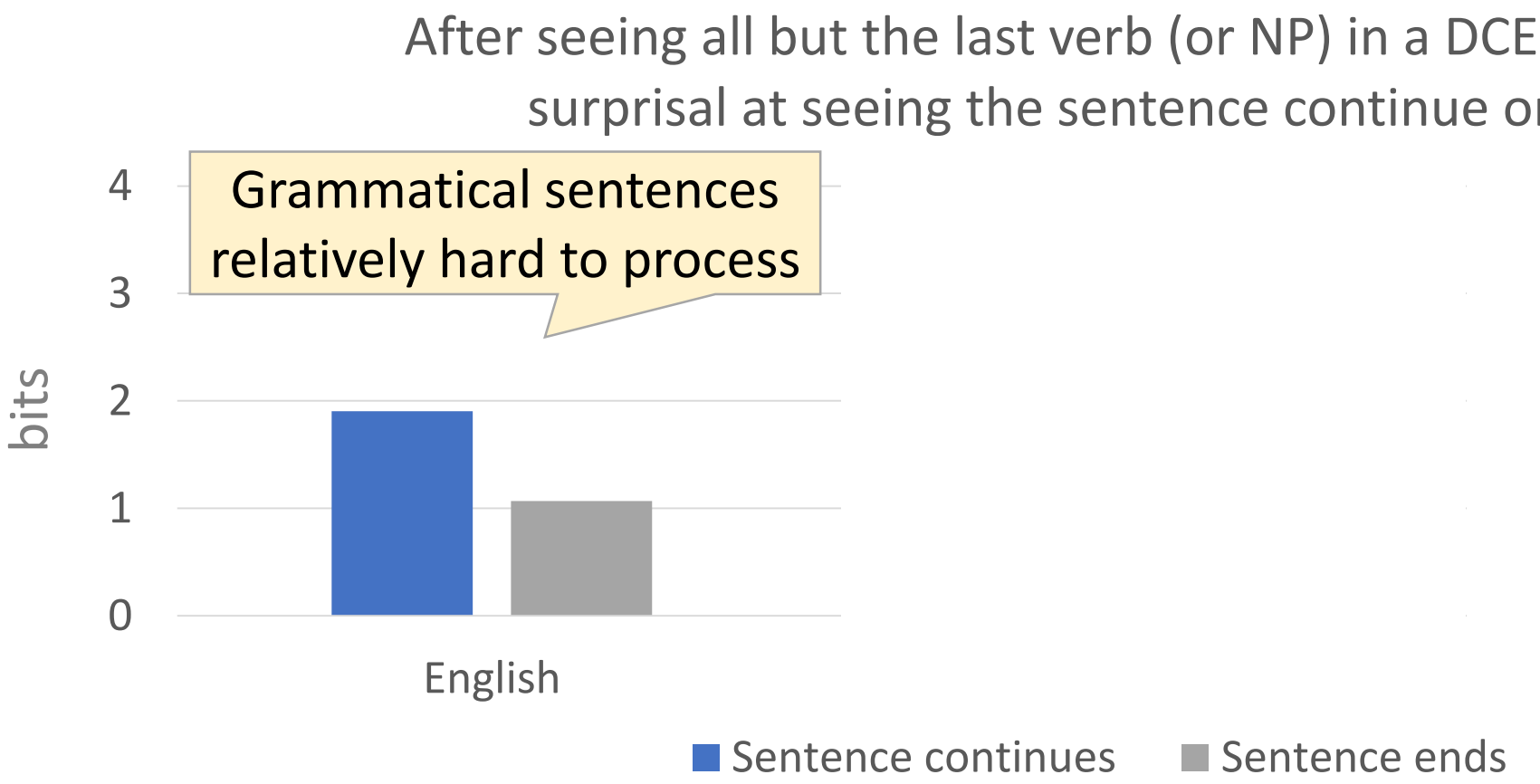
接见了 曾 责备过 刚 审理 贪污案 的 法官 的 部长

Zongli jiejianle [$_{RC}$ ceng zebeiguo [$_{RC}$ gang shenli tanwu-an bujiu de] faguan haojici de] buzhang.

PM met previously rebuked just hear corruption-case recently DE judge a.few.times DE minister

“The prime minister met the minister who previously rebuked a few times the judge who just recently heard the corruption case.”

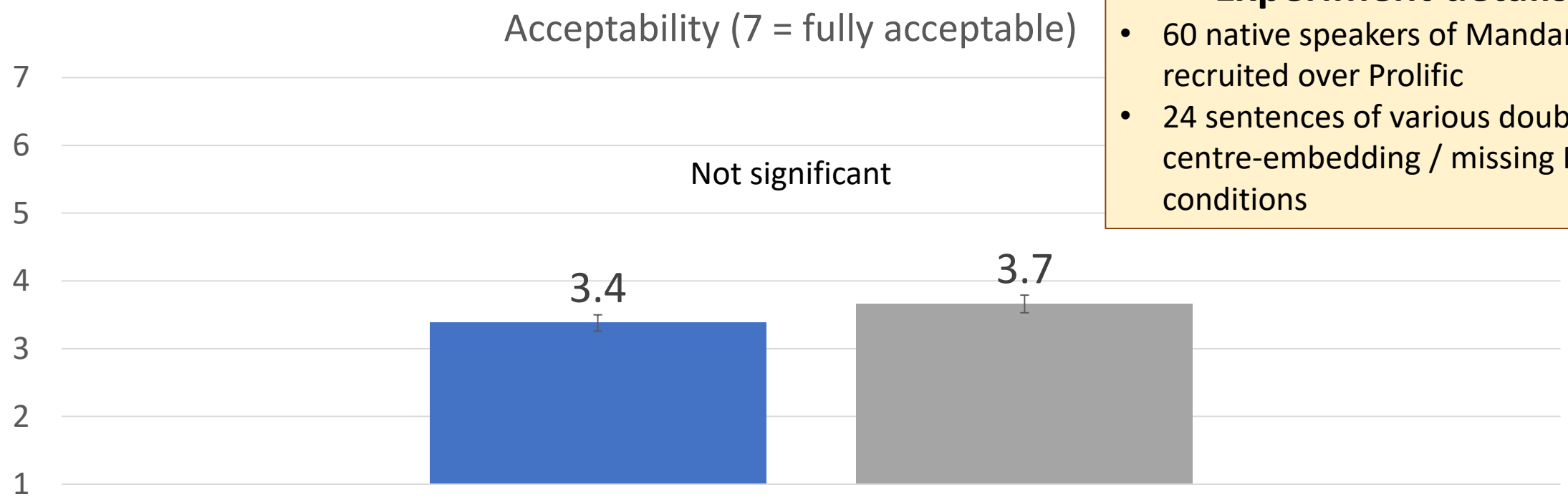
We extended a computational model of the language statistics hypothesis to Mandarin



Huang & Phillips 2021, Exp. 4, also see Futrell et al. 2020, Futrell & Levy 2017

Mandarin grammatical sentences not easier to process

Mandarin patterns with English, not German



Experiment details

- 60 native speakers of Mandarin recruited over Prolific
- 24 sentences of various double centre-embedding / missing NP conditions

Mandarin is a counterexample for language statistics account.

Huang & Phillips 2021, Exp. 1

Our proposal: cross-linguistic difference in illusions reflects syntactic differences and parsing mechanisms

German has a special syntactic position for verbs in main clauses ("**verb-second**").

Not English.
Bader 2016

Our proposal: cross-linguistic difference in illusions reflects syntactic differences and parsing mechanisms

We incorporate this observation about “verb second” word order in a **cue-based retrieval** parsing account.

When parsing sentences, the parser builds a detailed syntactic representation.

Extending the account to Mandarin

In Mandarin, the analogue to the English/German verbs is the NPs.

But Mandarin doesn't syntactically distinguish NPs inside main and relative clauses – **analogous to English**, not German.

							NP			**NP**			**NP**
总理	接见了		曾	责备过		刚	审理	**贪污案**		的	**法官**		的	**部长**
Zongli	jiejianle	[$_{RC}$	ceng	zebeiguo	[$_{RC}$	gang	shenli	**tanwu-an**	bujiu	de]	**faguan**	haojici	de]	**buzhang**.
PM	met		previously	rebuked		just	hear	**corruption-case**	recently	DE	**judge**	a.few.times	DE	**minister**

"The prime minister met the minister who previously rebuked a few times the judge who just recently exposed the corruption case."

NP positions are not structurally distinct →
parsing error more likely, sentence not easier to process

Language statistics approach makes an incorrect prediction for Mandarin.
Syntactic differences + parsing mechanisms offers a more promising account.

Extension

Language statistics hypothesis actually predicts reading times.

Alternative hypothesis:

- Grammatical sentences are easier to process in real time in Mandarin, just like in German.
  → Grammatical sentences are read faster.
- However, Mandarin speakers might find it easier to repair ungrammatical sentences into single centre-embedding sentences.
  → Relatively high acceptability ratings.

Predictions

Double centre-embedding (DCE)

	V		V		V	NP		NP		NP	
总理	接见了	曾	责备过	刚	审理	贪污案	不久	的	法官	好几次	的 部长 …
Zongli	jiejianle	[$_{RC}$ ceng	zebeiguo	[$_{RC}$ gang	shenli	tanwu-an	bujiu	de]	faguan	haojici	de] buzhang.
PM	met	previously	rebuked	just	hear	corruption-case	recently	DE	judge	a.few.times	DE minister

"The prime minister met the minister who previously rebuked a few times the judge who just recently exposed the corruption case."

Ungrammatical Missing NP sentence

	V		V		V	NP			NP
总理	接见了	曾	责备过	刚	审理	贪污案	不久	的	部长 …
Zongli	jiejianle	[$_{RC}$ ceng	zebeiguo	[$_{RC}$ gang	shenli	tanwu-an	bujiu	de]	] buzhang.
PM	met	previously	rebuked	just	hear	corruption-case	recently	DE	minister

"*The prime minister met the minister who previously rebuked ___ just recently heard the corruption case."

Slowdown after the final NP, as sentence is incomplete

Conditions

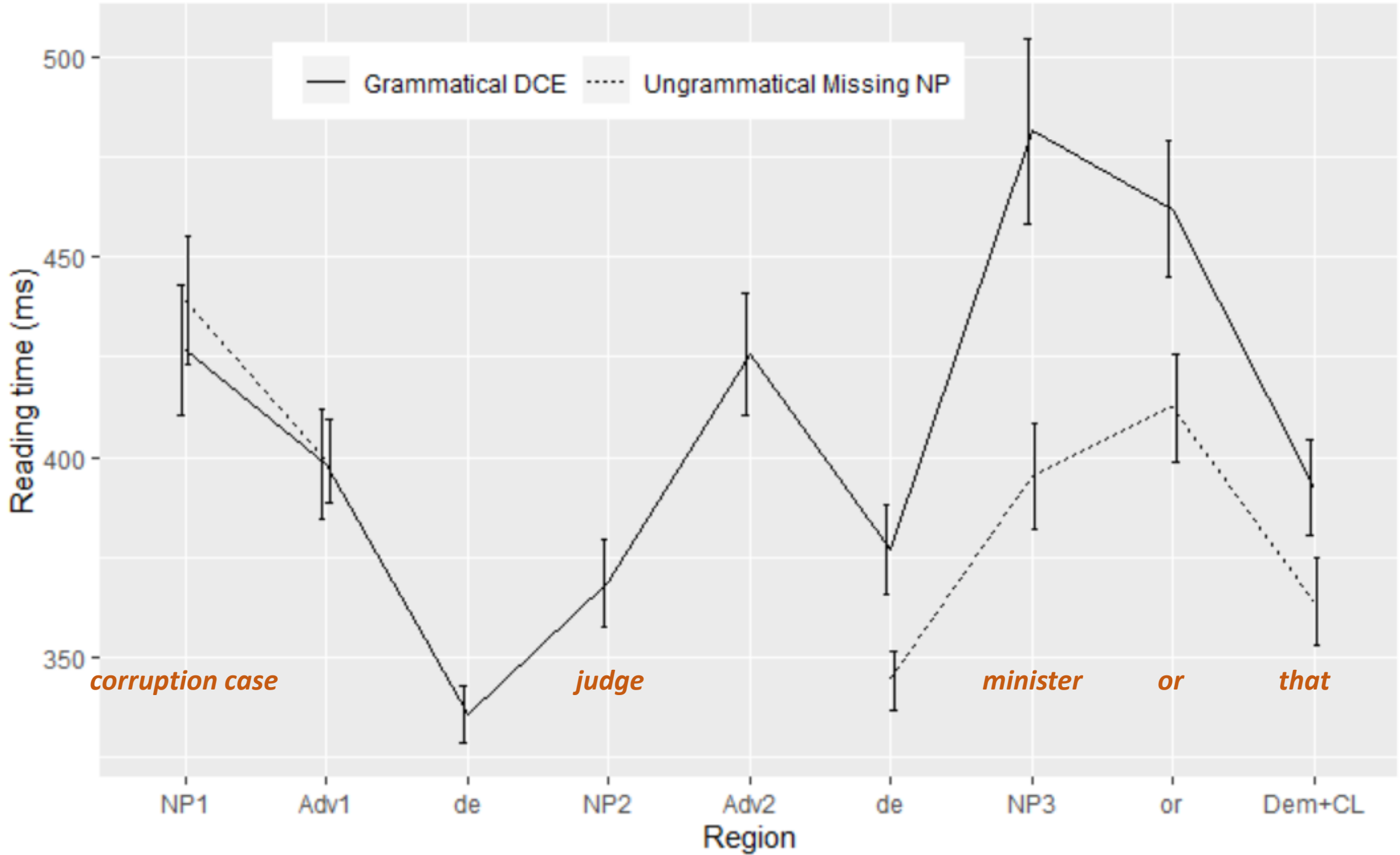
PM *daodi* V1 V2 V3 NP1 (NP2) NP3 *haishi* Dem NP?

“Did the prime minister actually meet the … or that actor?”

haishi Dem NP: spillover region.

Daodi – emphasis, along the lines of “actually”.

- Optional, but if used, is only found in questions.
- Used here to facilitate the processing of *haishi*.


Grammatical DCE
Ungrammatical Missing NP
Reading time (ms)
500
450
400
350
corruption case
judge
minister
or
that
NP1
Adv1
de
NP2
Adv2
de
NP3
or
Dem+CL
Region

pants

ɔn

Case study 2: Long-distance wh-questions

(joint work with Diogo Almeida and Jon Sprouse)

Case study 2: Within-language variability in acceptability of “long-distance” wh-questions

Kim said that Jo saw someone.

Kim grumbled that Jo saw someone.

A number of recent accounts attribute the difference between *say* and *grumble* (and other verbs) to **processing difficulties**, which in turn reflect certain statistics of **linguistic experience**.

- In other words, both questions are grammatical.
- But the *say* question is easier to process than the *grumble* question.

Huang, Almeida, Sprouse, 2021 ms.

Kothari 2008; Dąbrowska 2008, 2013; Liu et al. 2019; see also Richter & Chaves 2020; Erteschik-Shir 1973; Ambridge & Goldberg 2008

Two hypotheses based on language statistics

Who did Kim say that Jo saw?

??Who did Kim grumble that Jo saw?

Say + clause: very frequent

Grumble + clause: less frequent

Hypothesis 1: Frequency could **directly** affect how we process these questions.

Kothari 2008, Liu et al. 2019

Hypothesis 2: Sentence processing relies on lexically-specific "templates", based on the most **frequent** sentence types we observe.

- For long-distance questions, we have templates that feature the verbs *say* and *think*, but not *grumble*.
- We can use the templates to easily process the *say* question, but not the *grumble* question.

Dąbrowska 2008, 2013; Ambridge & Goldberg 2008

depict elect suppose suggest profess endorse spot smell emphasize prefer dislike find proclaim approve disce
guarantee implore request deplore investigate hate deem ordain pretend presuppose advise swear say demand cha
praise criticize illustrate dread intercept assess stress attest pronounce wish specify recommend showcase make out
out warrant postulate believe decree exclaim fear yelp envisage admire philosophize generalize recollect desp
estimate murmur preach deduce feel claim anticipate hope counsel sense decide announce hint reckon confirm obse
detect re er indica
expect d e explica
tout und ion dicta
observe nk decla
highlight fer suspe
boast ide ffirm agr
compreh e simula
broadcas elabora
rediscove e fantas
resolve log gath
ascertain ate mou
presume disappro
answer r whimp
testify let slip justify figure jest shout out clarify articulate trumpet predict disclose forgive report flaunt reason
propose vote communicate submit moan gabble gesture cheer croon tell recite desire insist quip fuss judge comme
convince take for granted consent bark recount cry rave ramble twitter grieve sign urge teach notice burst out rese
conceal screech uncover put out brag beg reply find out stammer love doubt relish fume blubber speculate narrate pie

Data quality concern

English has hundreds of verbs that appear with clauses.

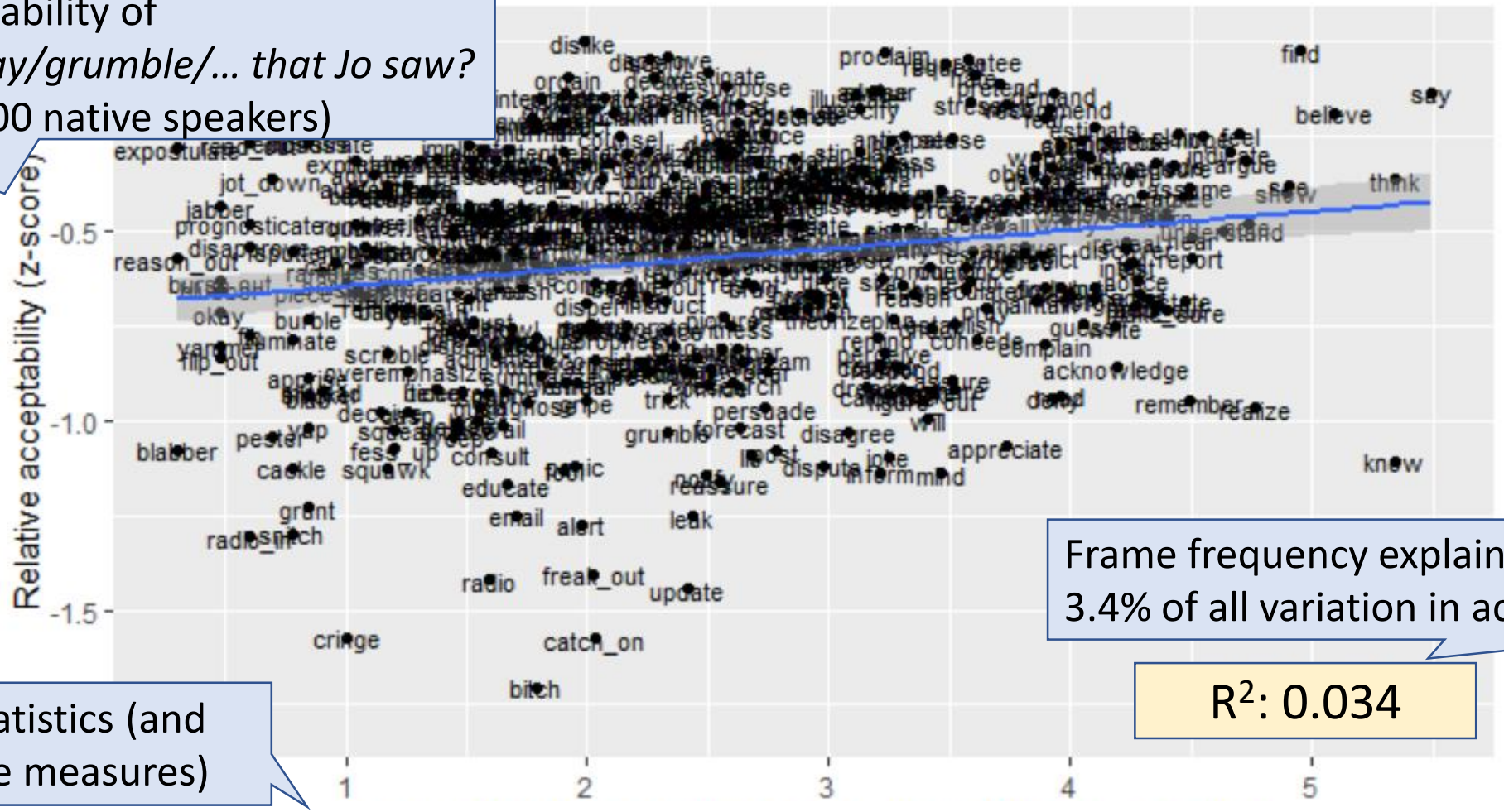
Current generalizations / experiments have small samples (~12-75 verbs).

We reevaluated existing claims using an exhaustive approach, surveying 640 verbs in English.

Huang, Almeida, & Sprouse, 2021 ms.

Does acceptability depend on how frequently a verb appears with a clause?

Relative acceptability of
Who did Kim say/grumble/… that Jo saw?
(Total N = ~4,800 native speakers)

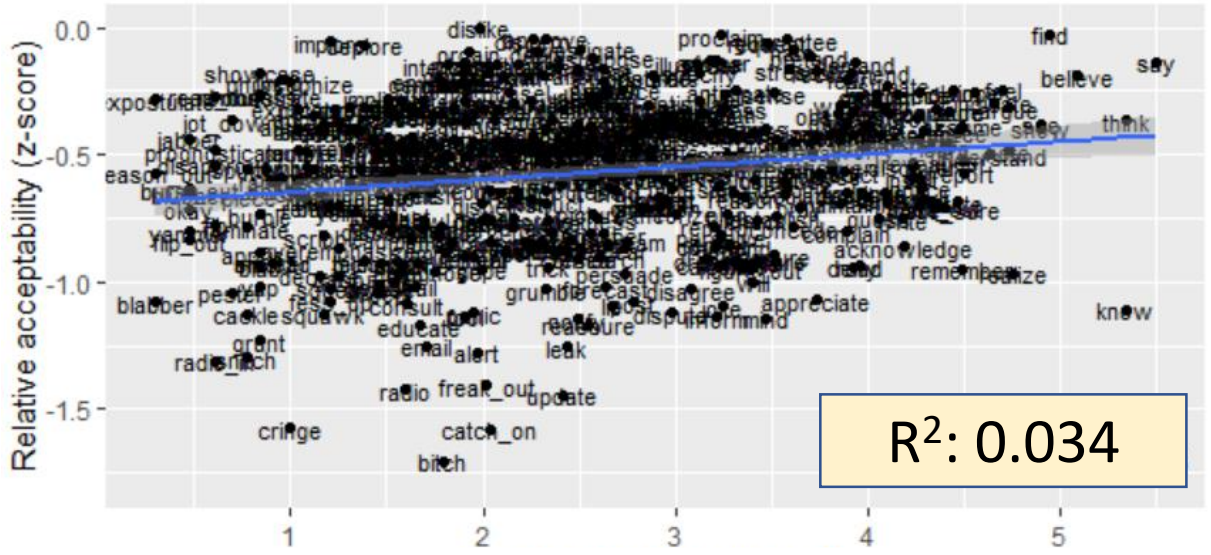


Frame frequency explains only 3.4% of all variation in acceptability

R^2: 0.034

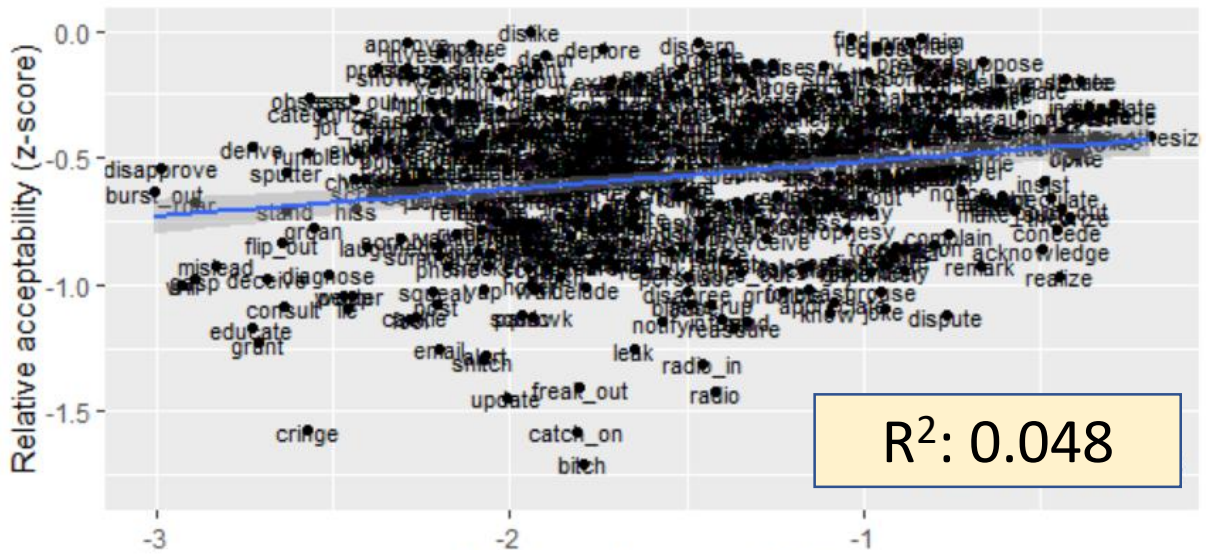
Frequency statistics (and other suitable measures)

Frame frequency model 1



Number of times ver

Frame frequency model 2



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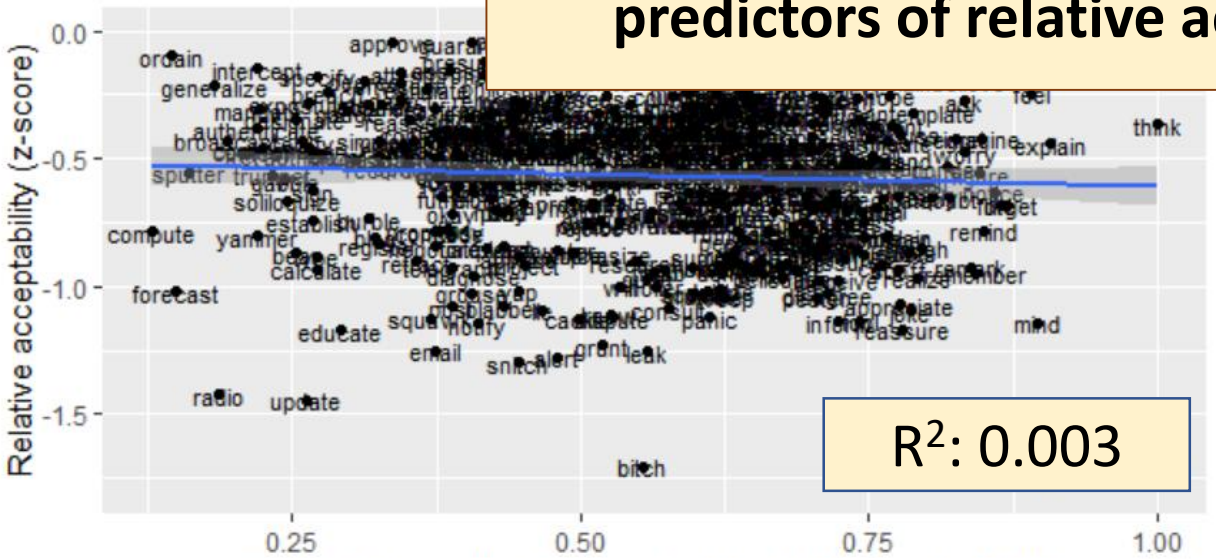
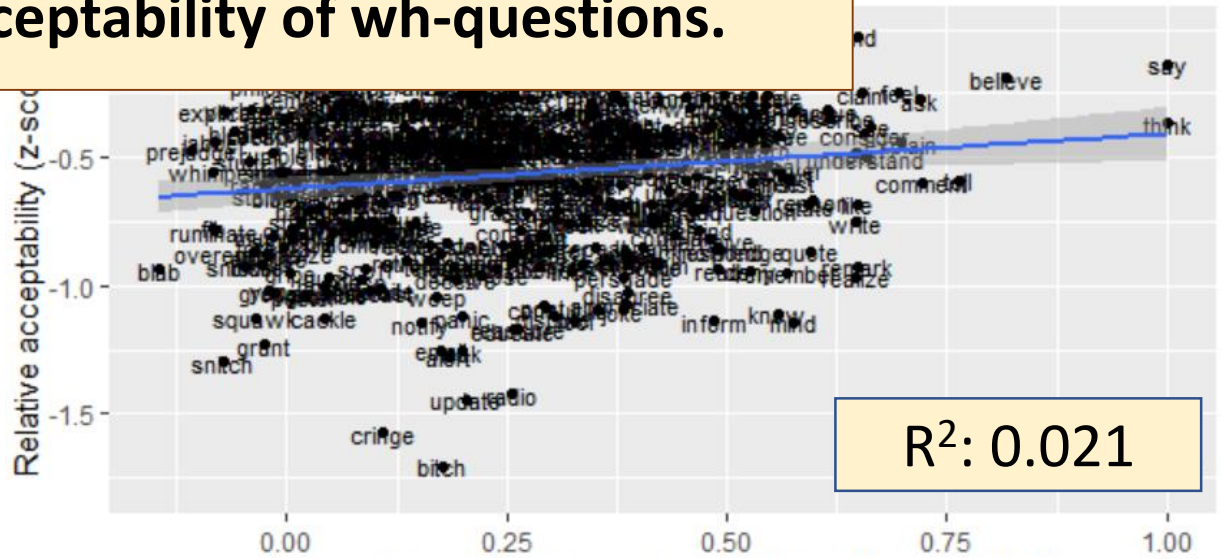
Takeaway: Accounts based on language statistics are poor predictors of relative acceptability of wh-questions.

"Templates" (p



Similarity to say/think (SEMILAR LSA/Wikipedia dataset)

ts) model 2



Similarity to say/think (NLPL GloVe/Wikipedia dataset)

Results call for better theories

Our inspection of our results suggest that **verb classes** matter: there are **constraints** on which verb classes can appear with long-distance wh-questions (contrary to language statistics accounts).

- e.g. “verbs of predicative complements” e.g. *think*, *expect*, *believe* (Levin 1993).

Issues under investigation:

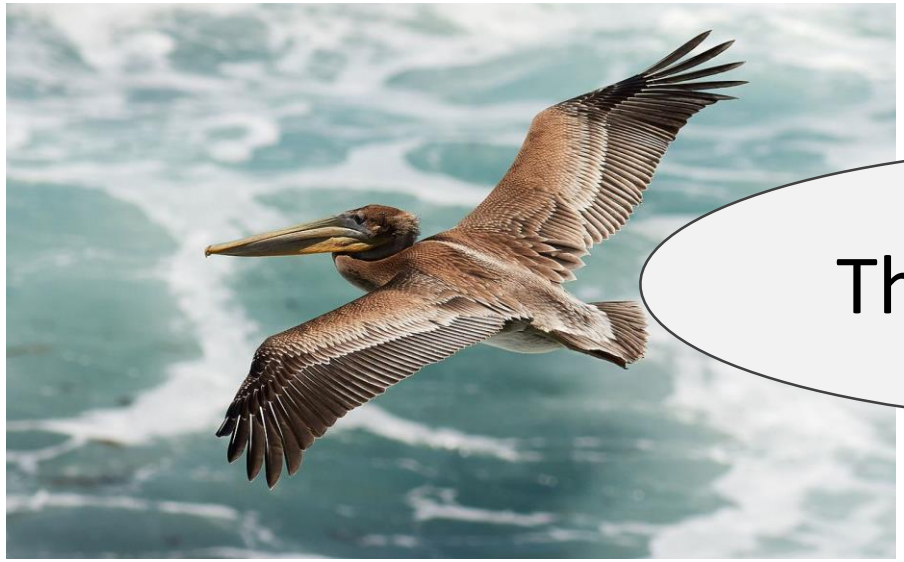
1. Is this constraint due to verb **semantics**, **pragmatics**, or even **syntax**?
2. **Learning**: Some languages lack long-distance wh-questions (e.g. Polish, some German varieties), i.e. the constraint varies across languages and has to be learned from linguistic experience.

See also prior discussion by Erteschik-Shir 1973; Ambridge & Goldberg 2008; Fodor 1992

Case study 3. Learning meanings of (attitude) verbs

(Joint work with Chia-Hsuan Liao, Aaron Steven White, Valentine Hacquard, and Jeffrey Lidz)

What does the verb *fly* mean?



The bird is **flying**!

© Frank Schulenburg, Wikipedia

But not all verbs are like *fly*

Attitude verbs: describe abstract mental states

"Belief" verbs

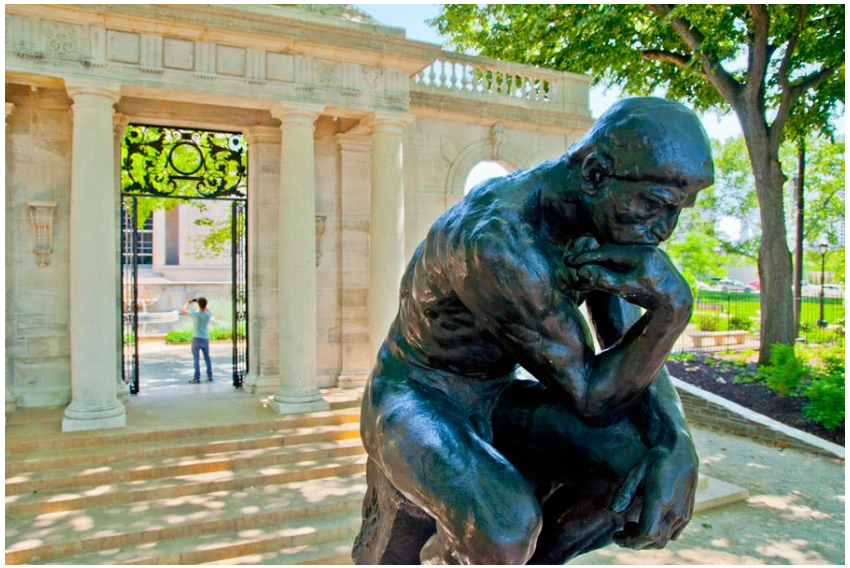
think

know

believe

guess

say



"Desire" verbs

want

prefer

love

like

*Dora **thinks** Kim went to bed.*

Express commitment to truth of "Kim went to bed"

*Dora **wants** Kim to go to bed.*

Express preference for "Kim goes to bed"

How might a child figure out the meanings of *think* and *want*?

Via Elmhurst College

Why is Dora so happy?

"Dora **thinks** Kim went to bed.
She **wanted** Kim to go to bed."

Gleitman 1990; Gillette et al. 1999

Belief and desire verbs are differentiated morphosyntactically

Belief and desire verbs are differentiated morphosyntactically

*Dora **pense** que Kim **est** au lit.*

"Dora thinks that Kim is.IND in bed."

*Dora **veut** que Kim **soit** au lit.*

"Dora wants Kim be.SUBJ in bed."

	Embedded clause of belief verbs	**Embedded clause of desire verbs**
English	Finite	Non-finite
French (and Romance)	Indicative	Subjunctive

Hacquard & Lidz 2018, Bolinger 1968, Hooper 1975, a.o.

Belief clauses resemble declarative sentences

	Declaratives
*Dora **thinks** Kim went to bed.*	*Kim went to bed.*
*Dora **pense** que Kim est au lit.*	*Kim est au lit.*
"Dora thinks that Kim is.IND in bed."	"Kim is.IND in bed."

	Embedded clause of belief verbs	**Embedded clause of desire verbs**	**Declarative sentences**
English	Finite	Non-finite	Finite
French (and Romance)	Indicative	Subjunctive	Indicative

Hacquard & Lidz 2018, Bolinger 1968, Hooper 1975, a.o.

Syntactic bootstrapping: learning semantics from syntax

Specifically: **learn verb semantics from clausal syntax**.

- But resemblance to declarative sentences itself is not helpful: it doesn't tell learners anything about verb meanings.

Proposal

If a verb has an embedded clause that looks like a declarative sentence, that verb is a belief verb.

If not, it is a desire verb.

Huang, White, Liao, Hacquard, Lidz, to appear; Huang, Liao, Hacquard, & Lidz 2018; Hacquard & Lidz, 2019; Harrigan 2015; Papafragou et al., 2007; Lee & Naigles 2005; Gleitman 1990

Why? A role for pragmatics

“Dora thinks Kim went to bed.”

“Dora wants Kim to go to bed.”

“Kim went to bed.”

Direct assertion

Huang, White, Liao, Hacquard, Lidz, to appear; Huang, Liao, Hacquard, & Lidz 2018; Hacquard & Lidz, 2019

Why? A role for pragmatics

"Dora thinks Kim went to bed."

Indirect assertion of "Kim went to bed"

"Dora wants Kim to go to bed."

"Kim went to bed."

Huang, White, Liao, Hacquard, Lidz, to appear; Huang, Liao, Hacquard, & Lidz 2018; Hacquard & Lidz, 2019

Why? A role for pragmatics

*"Dora **thinks** Kim went to bed."*

"Dora wants Kim to go to bed."

Indirect assertion of "Kim went to bed"

→ *Think* expresses truth judgments

"Kim went to bed."

Huang, White, Liao, Hacquard, Lidz, to appear; Huang, Liao, Hacquard, & Lidz 2018; Hacquard & Lidz, 2019

A syntactic bootstrapping account requires belief and desire clauses to look distinct

Proposal

- If a verb has an embedded clause that looks like a declarative sentence, that verb is a belief verb.
- If not, it is a desire verb.

The requirement is easily satisfied in languages with finiteness and mood morphology.

But what about a language that lacks such morphology, like Mandarin?

Huang, White, Liao, Hacquard, Lidz, to appear; Huang, Liao, Hacquard, & Lidz 2018

Hallmarks of Mandarin declarative sentences and belief clauses vs. desire clauses

	Declarative sentences	**Embedded clause of belief verbs**
Overt subjects	Optional	Optional
Modals	Optional	Optional
Aspect markers	Optional	Optional

Problem: overt subjects, modals, and aspect markers are all optional – they can be omitted in the right context.

N. Huang 2018, Grano 2015, Li 1990, C.-T. J. Huang 1982

Mandarin Chinese

我	**觉得**	他们	可能	吃过	水果
Wo	**juede**	tamen	keneng	chi-guo	shuiguo.
I	feel/think	they	might	eat-EXP	fruit

“I **think** they might have eaten fruit.” (Belief)

Mandarin Chinese

		Subject	Modal	Aspect					
我	**觉得**	他们	可能	吃过	水果	我	**喜欢**	吃	水果
Wo	**juede**	tamen	keneng	chi-guo	shuiguo.	Wo	**xihuan**	chi	shuiguo.
I	feel/think	they	might	eat-EXP	fruit	I	like	eat	fruit

"I **think** they might have eaten fruit." (Belief)

"I **like** to eat fruit." (Desire)

他们	可能	吃过	水果
Tamen	keneng	chi-guo	shuiguo.
they	might	eat-EXP	fruit

"They might have eaten fruit." **(Declarative)**

Mandarin Chinese

我	**觉得**	吃	水果
Wo	**juede**	chi	shuiguo.
I	feel/think	eat	fruit

“I **think** [they] eat fruit.”

我	**喜欢**	吃	水果
Wo	**xihuan**	chi	shuiguo.
I	like	eat	fruit

“I **like** to eat fruit.”

A solution

Learners can track the **overall distribution** of various morphosyntactic features.

Perhaps belief clauses and desire clauses **look different in aggregation**.

1. Is this the case?
2. If there is differentiation between belief and desire clauses, are the differences enough for the learner?

Q1: Are the clauses differentiated in the input?

我 **觉得** 他们 可能 吃过 水果 我 **喜欢** 吃 水果

Wo **juede** shuiguo.

I feel/thin fruit

5 child-directed speech corpora in CHILDES
(Beijing, Chang1, Context, Zhou1, Zhou2)

~4,200 attitude verbs with embedded clauses
~1,600 declarative sentences

Tamen keneng chi-guo shuiguo.

they might eat-EXP fruit

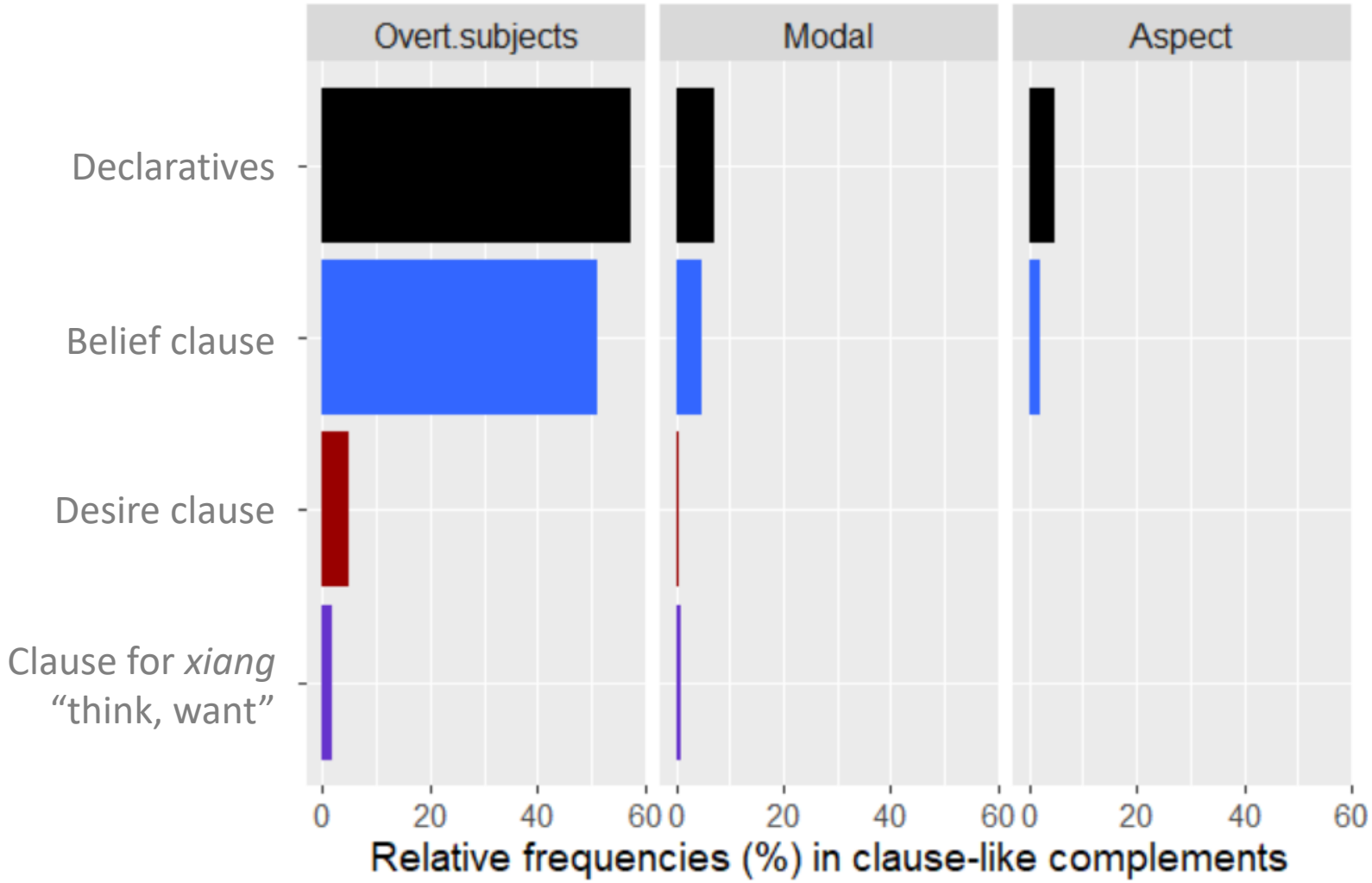
If the clauses are differentiated in the input, syntactic bootstrapping is feasible

我	觉得	他们	可能	吃过	水果	我	喜欢	吃	水果
Wo	**juede**	tamen	keneng	chi-guo	shuiguo.	Wo	**xihuan**	chi	shuiguo.
I	feel/think	they	might	eat-EXP	fruit	I	like	eat	fruit

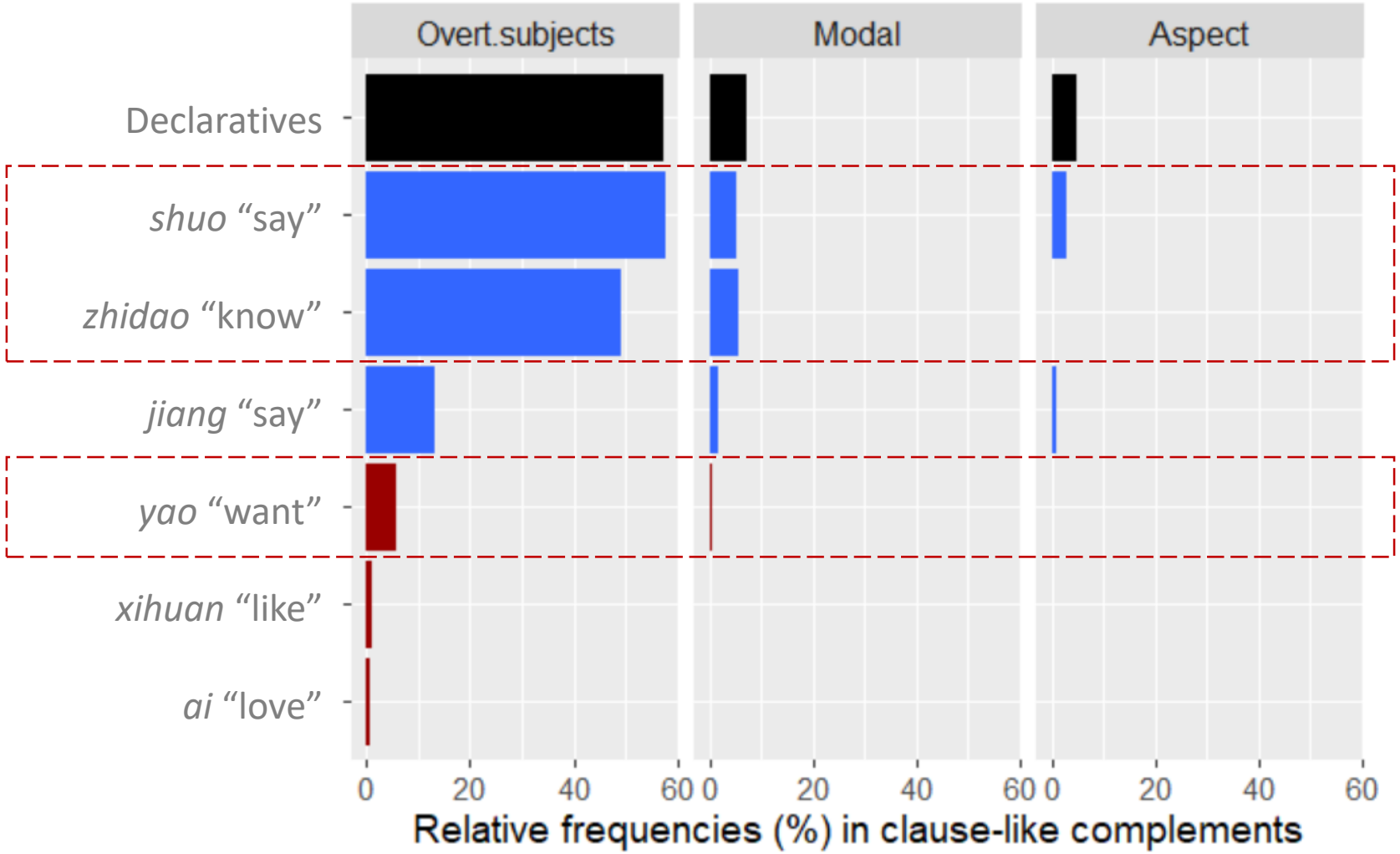
Each token coded for presence of
overt subject, modal, aspect markers

他们	可能	吃过	水果
Tamen	keneng	chi-guo	shuiguo.
they	might	eat-EXP	fruit

Corpus study: results by verb class



Corpus study: results by verb class



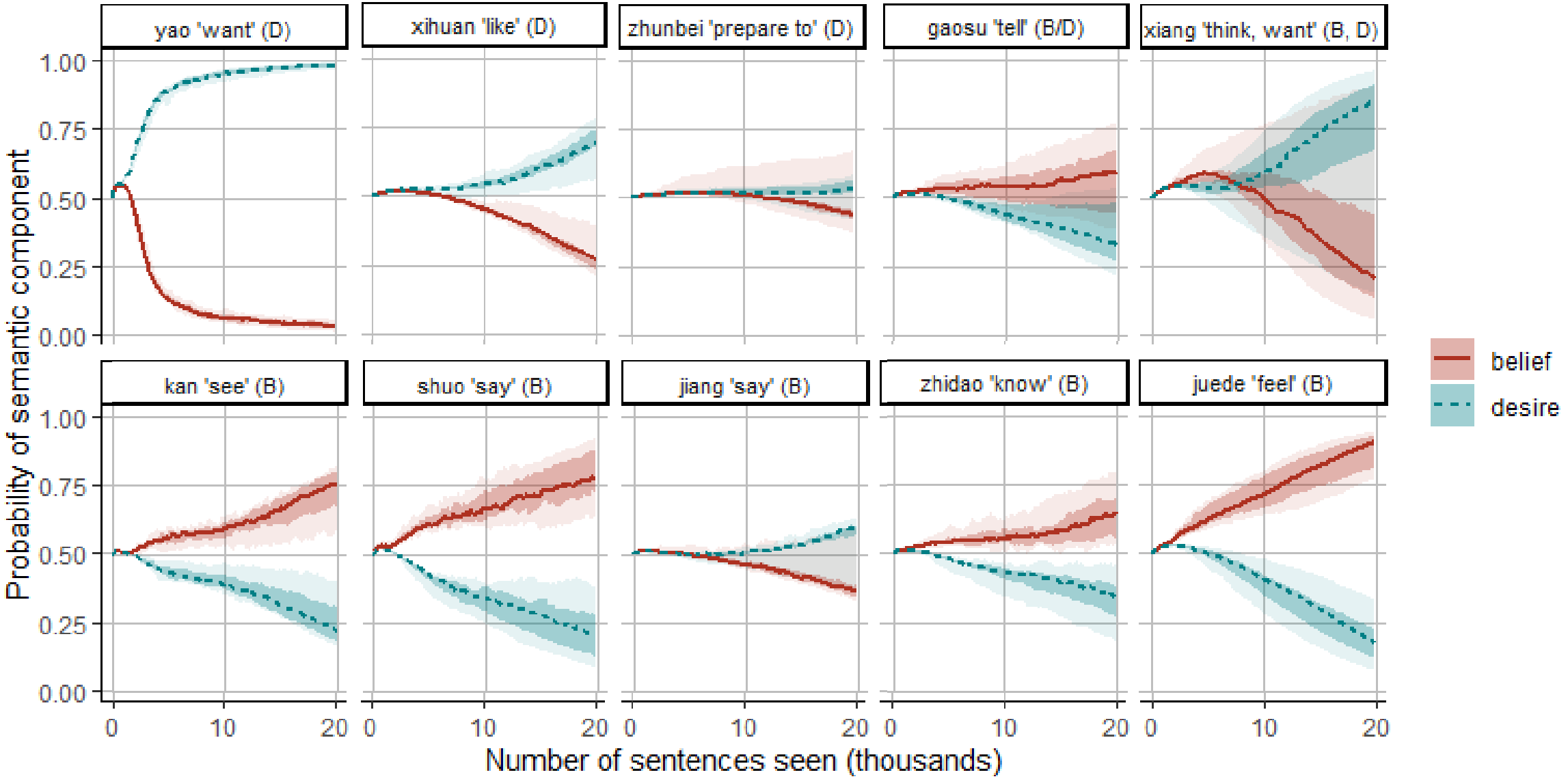
Q2: Do distributional differences guarantee successful learning of verb semantics?

Simulate a learner.

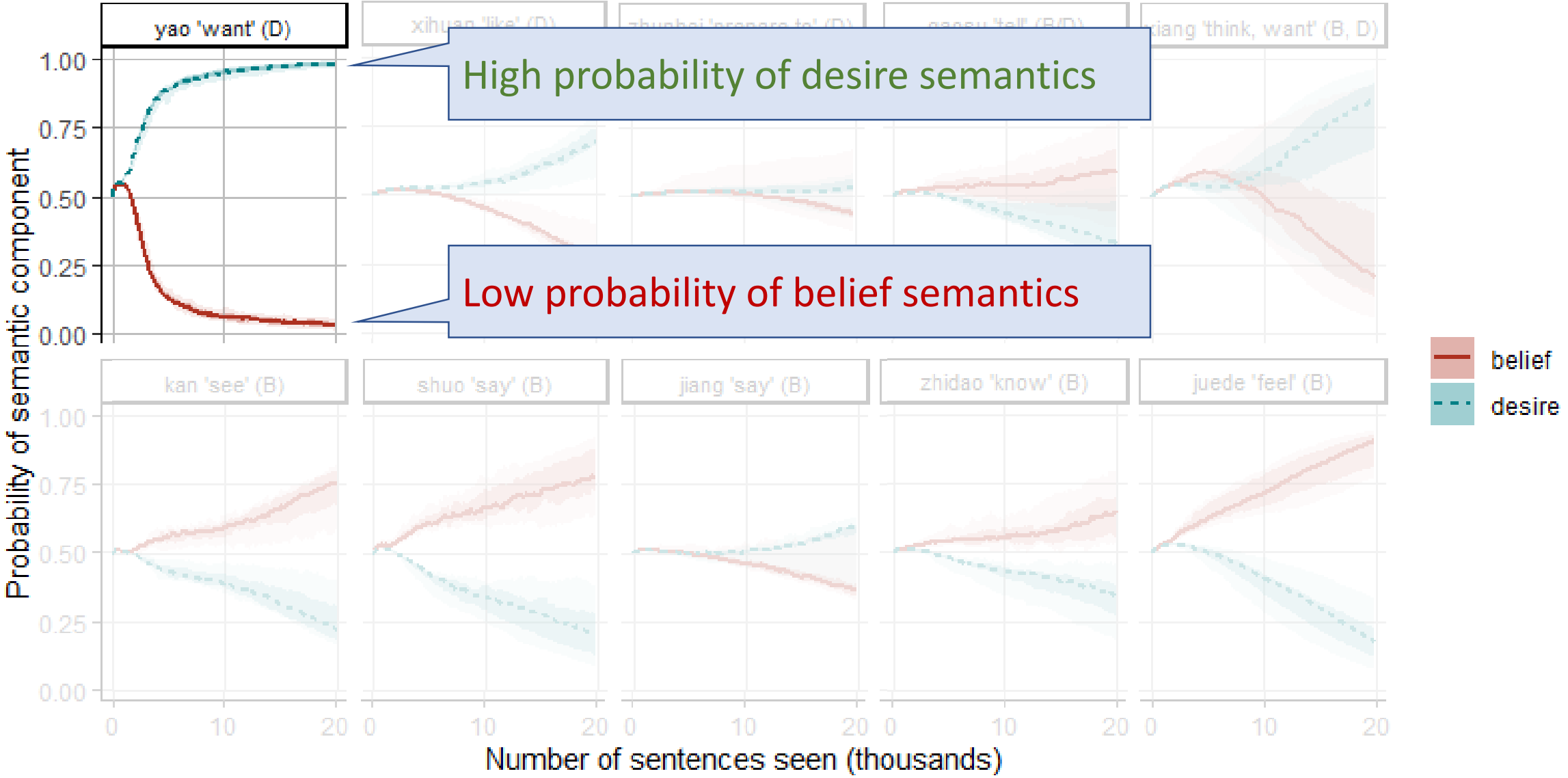
- Adapt a **computational model of syntactic bootstrapping** by White et al. 2018.
- Shown to model acquisition of English attitude verbs, using English child-directed speech data.

Does this “learner” succeed with Mandarin attitude verbs?

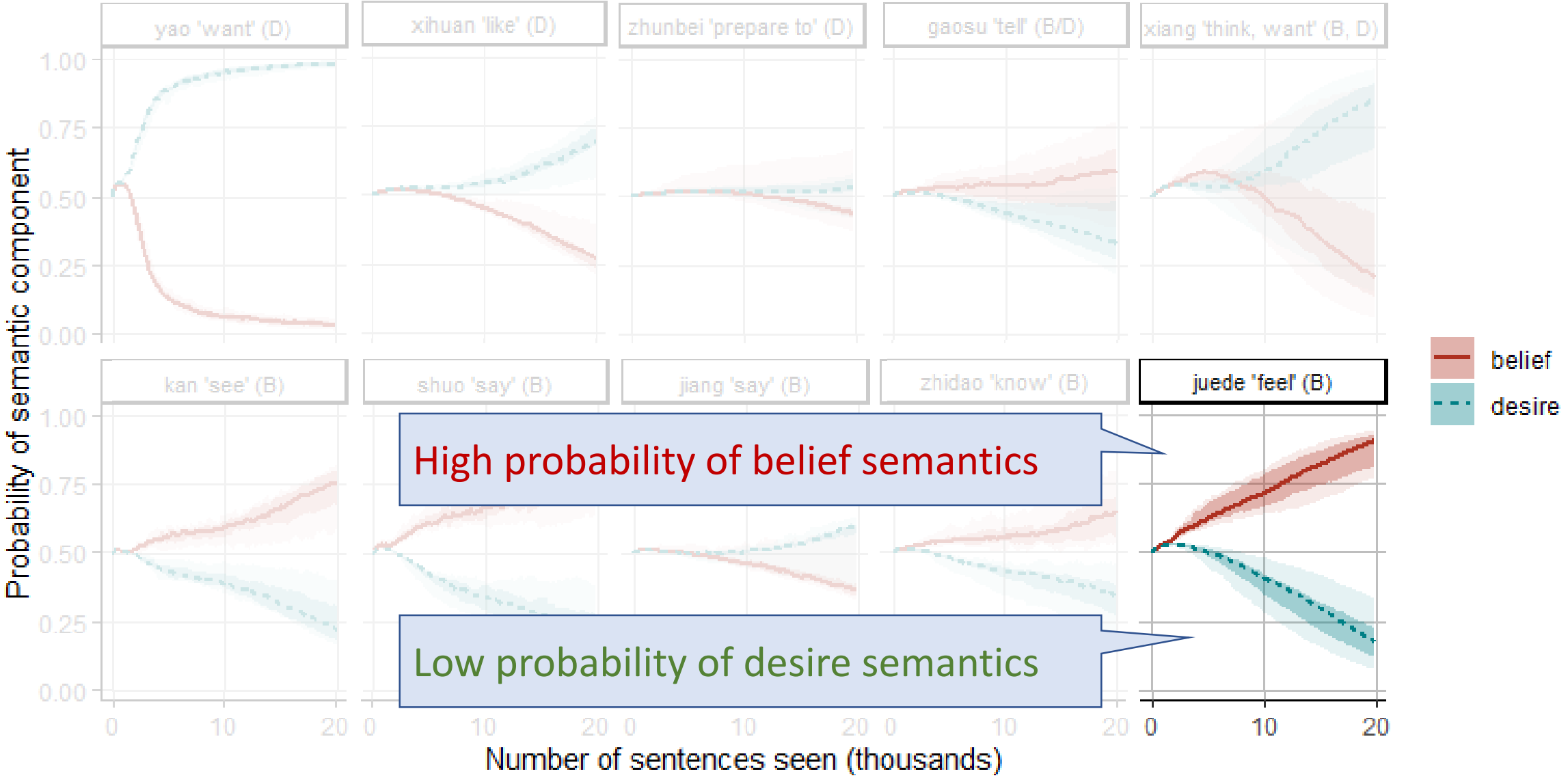
Mandarin results (10 CHILDES corpora)



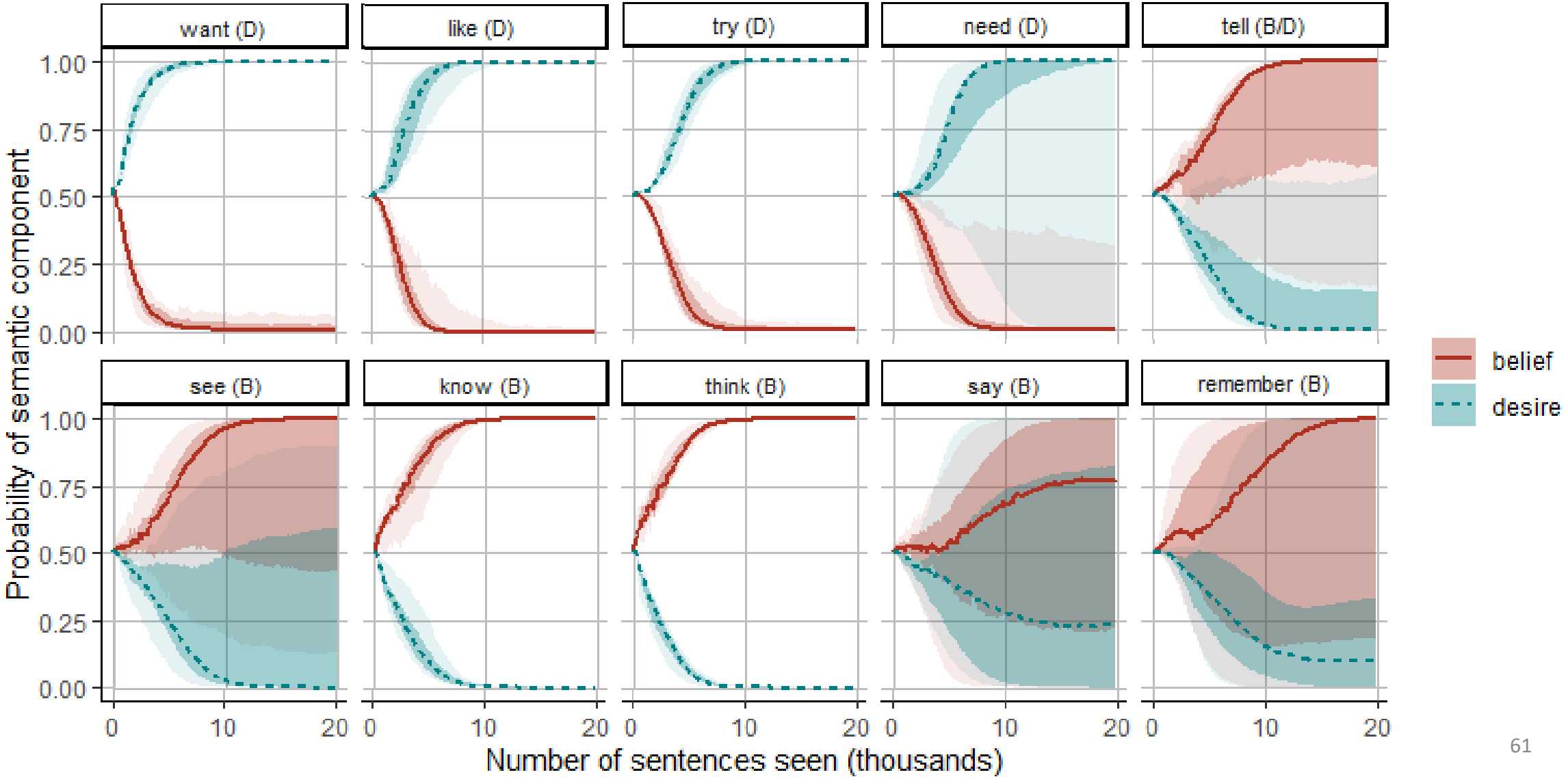
Mandarin results (10 CHILDES corpora)



Mandarin results (10 CHILDES corpora)



English results (replicating White et al. 2018)



Takeaways

Attitude verbs present a learning challenge, due to their abstract semantics.

Syntactic bootstrapping provides a solution to this challenge: learners might infer the semantics of these verbs using **their linguistic experience and a suitable learning algorithm**.

Mandarin's morphosyntax poses a potential problem for syntactic bootstrapping.

- Corpus analysis + Computational model suggests that this is not as serious a problem as one might expect.
- In fact, our Mandarin and English results suggest that this strategy is **cross-linguistic viable**.

Conclusion

Three case studies

1. Centre-embedding
2. Wh-questions
3. Attitude verbs

Lesson #1: Value of good samples

1. Centre-embedding
2. **Wh-questions** **Verb samples**
3. Attitude verbs

Existing proposals based on small samples of clause-embedding verbs.

- A study of a full set of verbs reveals weaknesses in theories.

Lesson #1: Value of good samples

1. **Centre-embedding** **Language samples**
2. Wh-questions
3. **Attitude verbs** **Language samples**

Expanded the sample of languages to include Mandarin, which has several interesting morphosyntactic properties.

Mandarin provides a useful test case for **evaluating proposals**:
the value of cross-linguistic research!

Lesson 2: The limits of linguistic experience

1. **Centre-embedding**
2. **Wh-questions**
3. Attitude verbs

Both phenomena previously argued as evidence for a language statistics approach.

However, experimental evidence suggests alternative approaches more promising.

Lesson 2: The limits of linguistic experience

1. Centre-embedding
2. **Wh-questions** **Cross-linguistic differences: learning implicated?**
3. **Attitude verbs** **Learning biases (syntactic bootstrapping)**

Attitude verbs case study: learners might track the statistics of morphosyntactic features.

- But these statistics in themselves cannot tell learners much about verb meanings.
- Learning biases also necessary to help learners acquire semantics.

Conclusion

A classic question: How does linguistic experience shape the way we learn and process language?

Findings from the case studies: Limitations of an approach that relies only on statistics in our linguistic experience (despite empirical successes elsewhere).

Value of theories that better delineate the roles of statistics, learning biases, and processing mechanisms.

- An integrated approach to build a more nuanced, richer understanding of human language.

Thank you

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