Prediction in bilingual sentence comprehension

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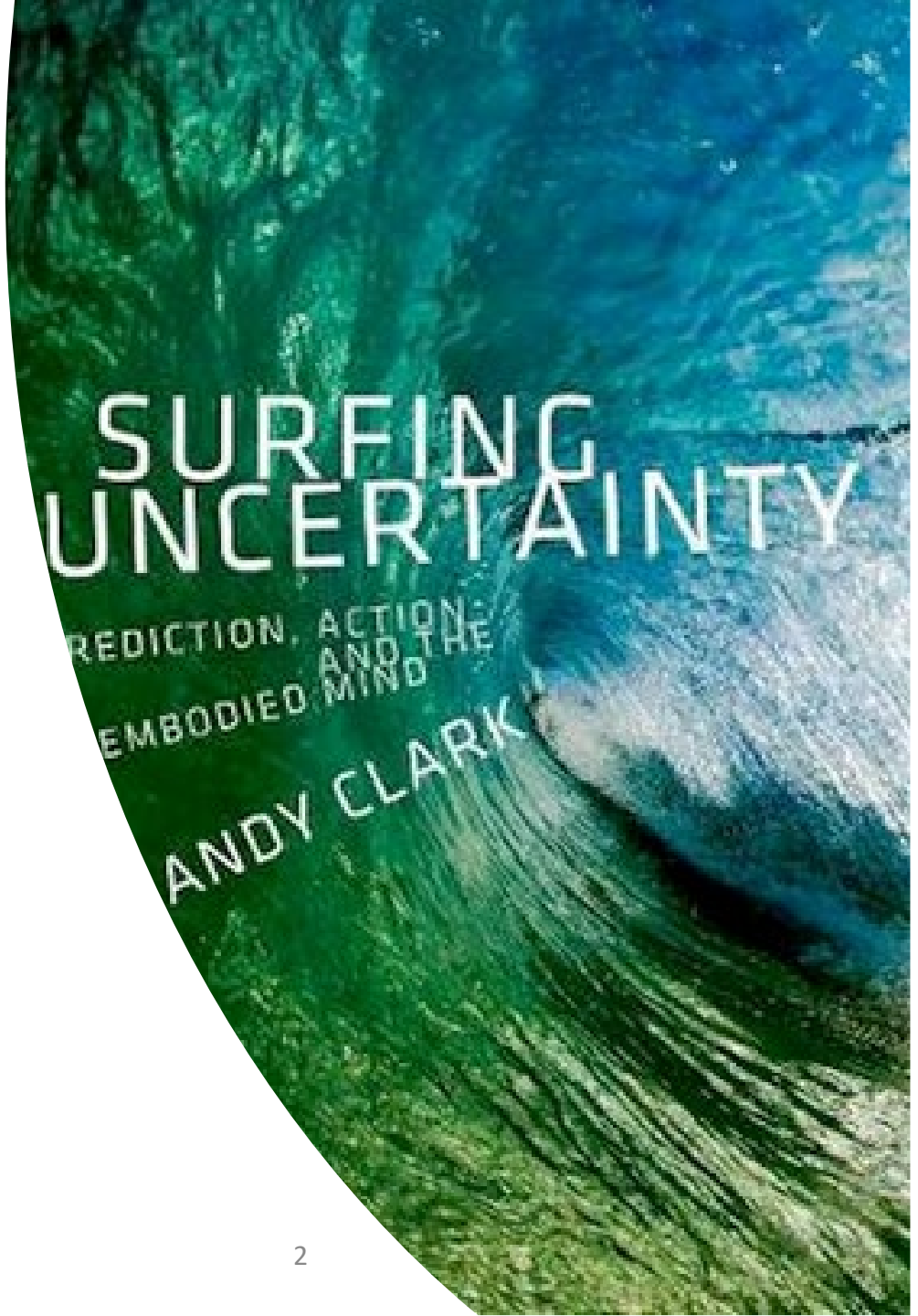
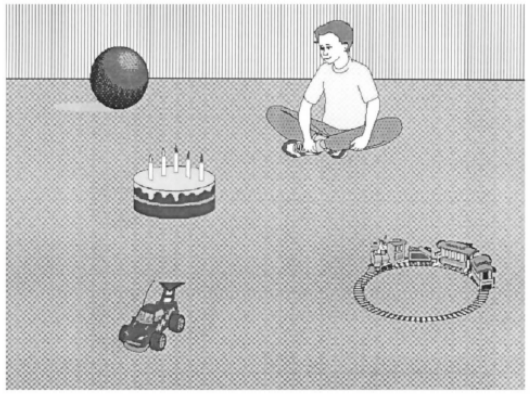
Predictions

- Clark (2015): How do people deal with noisy, uncertain perceptual signals? By trying to stay **slighty ahead** of them, in other words, to make predictions
- Pickering & Gambi (2018): “people are therefore as prepared as they can be for the stimuli that are likely to occur, and the **benefit from getting predictions right most of the time may outweigh any difficulty from occassionally getting them wrong”**
- Ryskin & Nieuwland (2023): “research over the past two decades has **demonstrated the psychological reality of 'linguistic prediction' beyond any reasonable doubt**.”



Prediction: plethora of evidence



The boy will EAT the cake
The boy will MOVE the cake

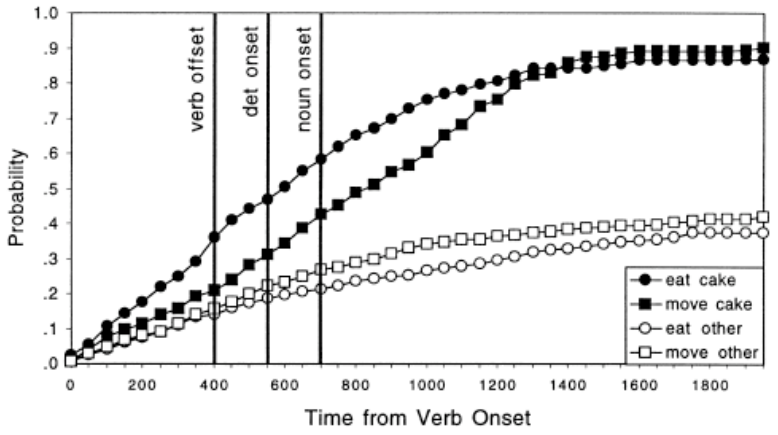


Fig. 2. The cumulative probability of fixating the target object (cake) or a distractor object (other) as a function of condition ('eat' vs. 'move') in Experiment 1 (Section 2). Note: The verb offset, determiner onset, and noun onset are shown, for display purposes, averaged across trials, and are aligned to the 50ms bin within which they fall.

- Many studies using visual-world eye-tracking
- People look at objects they predict to hear mentioned next
- Prediction based on semantics, morphosyntax, etc.
- Also ERP-studies (e.g., testing N400 effects)

Altmann & Kamide (1999)

What about L2? Potential differences

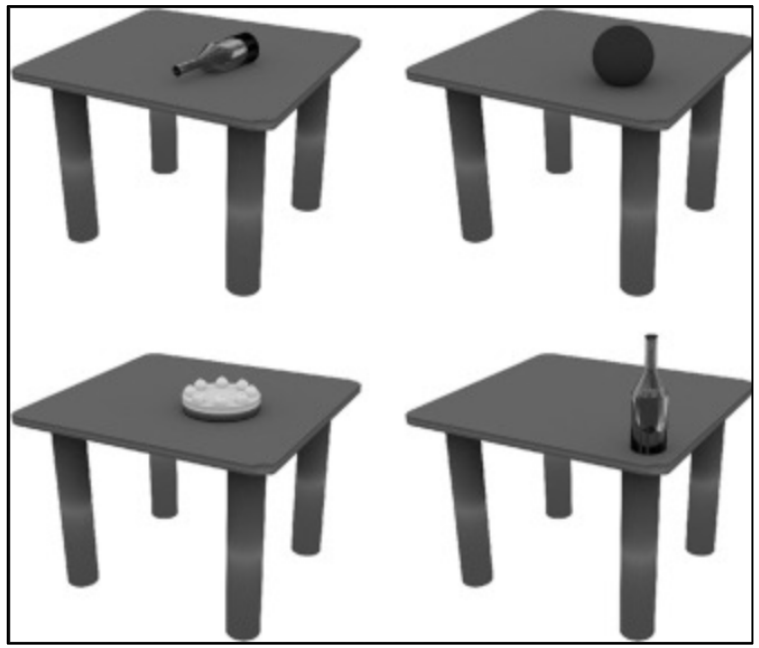
- **Weaker links** (Gollan et al., 2008)
  - L2 words, connections = low-frequency words

- **Cross-language interference** (Odlin, 1989)
  - Positive if L1 and L2 similar features (e.g., gender systems)
  - Negative if they differ

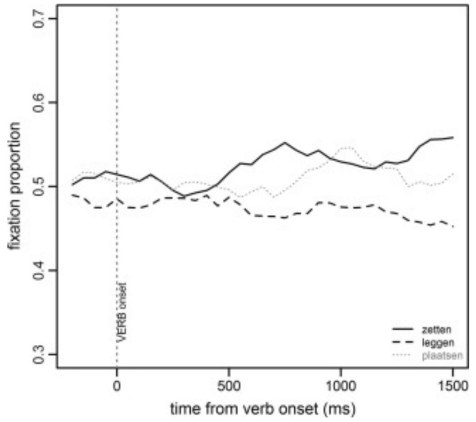
- **Cognitive resources** (Clahsen & Felser, 2006)
  - ”automatic” prediction intact
  - Optional, strategic, resource-intensive prediction reduced

Example different L1 vs. L2 prediction: to *put*

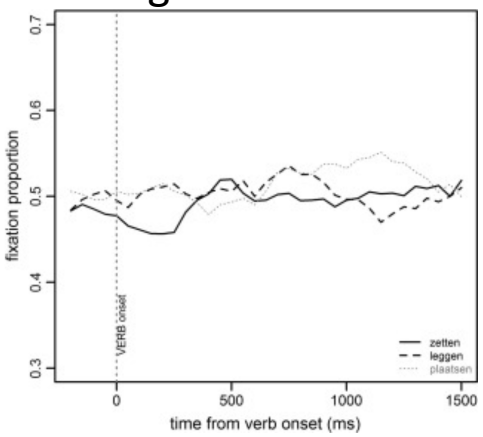
De man **zette** de fles op de tafel
(The man **put_vertical** the bottle on the table)
De man **legde** de fles op de tafel
(The man **put_horizontal** the bottle on the table)



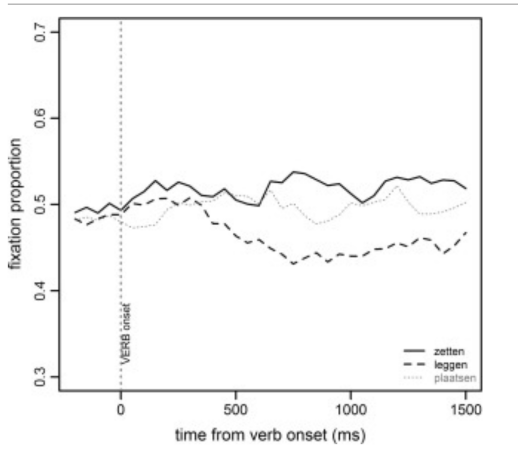
L1 Dutch



L1 English or French



L1 German



Theories of L2 prediction

- Reduced Ability to Generate Expectations (RAGE) hypothesis (Grüter & Rohde, 2013)
  - Several studies showing L2'ers do not use / use less:
    - Morphosyntactic cues (gender, case)
    - Subtle semantic information (Dutch: two verbs for *put*)

- Shared mechanisms hypothesis (Kaan, 2014)
  - Prediction mechanisms are the same in L1 and L2
  - But vary with the same factors: frequency, competing info, …

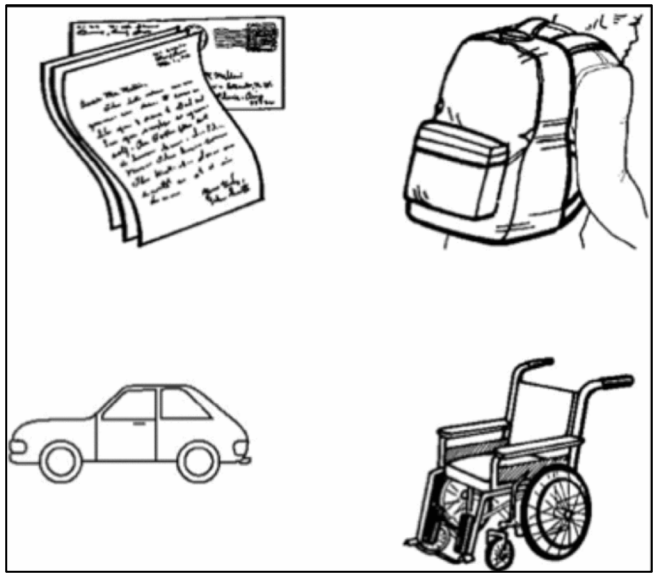
This talk

- Visual-world eye-tracking studies Dutch, English, Chinese as L1 or L2

- Lexical-semantic prediction
- Syntactic prediction (i.e., based on priming)
- Discourse-based prediction

Dijkgraaf et al. (2017): verb semantics

Mary will write the letter
Mary will steal the letter

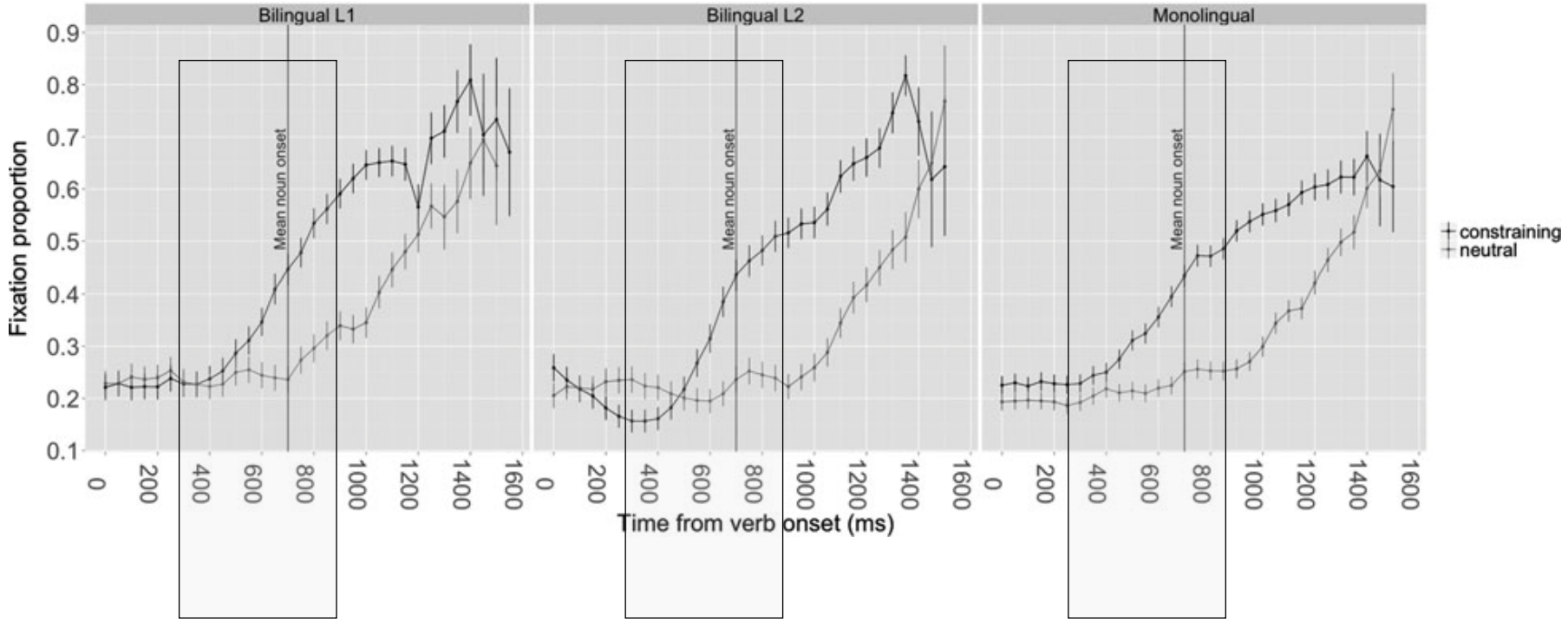


- Tests in Ghent, Belgium (n = 30) and Southampton, England (n = 30)

- Within-participants: L1 Dutch vs. L2 English
- Between-participants: L1 English vs. L2 English

Results Dijkgraaf et al.

Dutch as L1 (Ghent) English as L2 (Ghent) English as L1 (Southampton)



- Prediction effect **similar** in L1 and L2: both in strength and in timing
- Slightly earlier (one time bin) in English monolingual group

(In brackets: moving VWP online…)

Behavior Research Methods (2023) 55:3786–3804
https://doi.org/10.3758/s13428-022-01989-z

Moving visual world experiments online? A web-based replication of Dijkgraaf, Hartsuiker, and Duyck (2017) using PCIbex and WebGazer.js

Mieke Sarah Slim[1] · **Robert J. Hartsuiker**[1]

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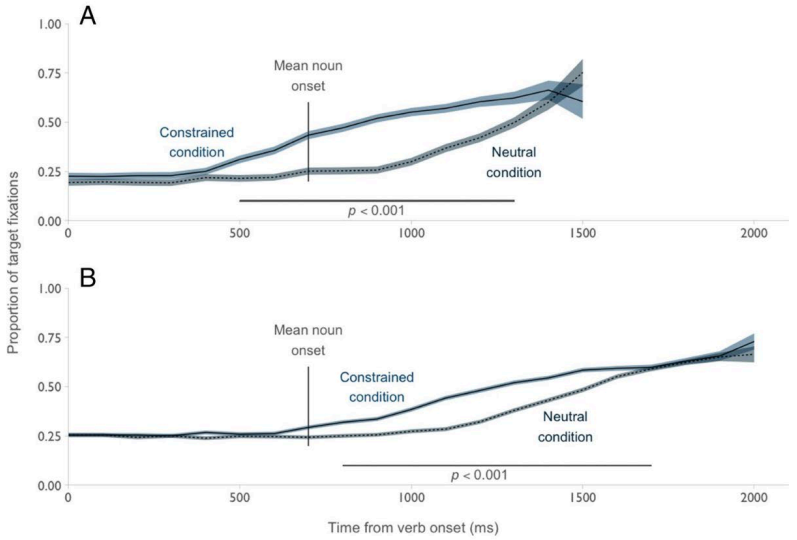
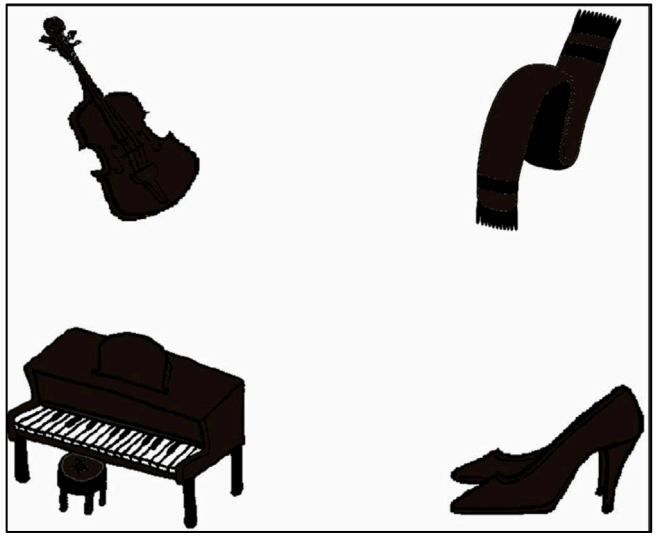


- Replicates Dijkgraaf et al.'s (2017) data *pattern* in a web-based study
- 330 participants recruited, only 90 survived calibration criterion
- Still, a temporal shift in "prediction" effect

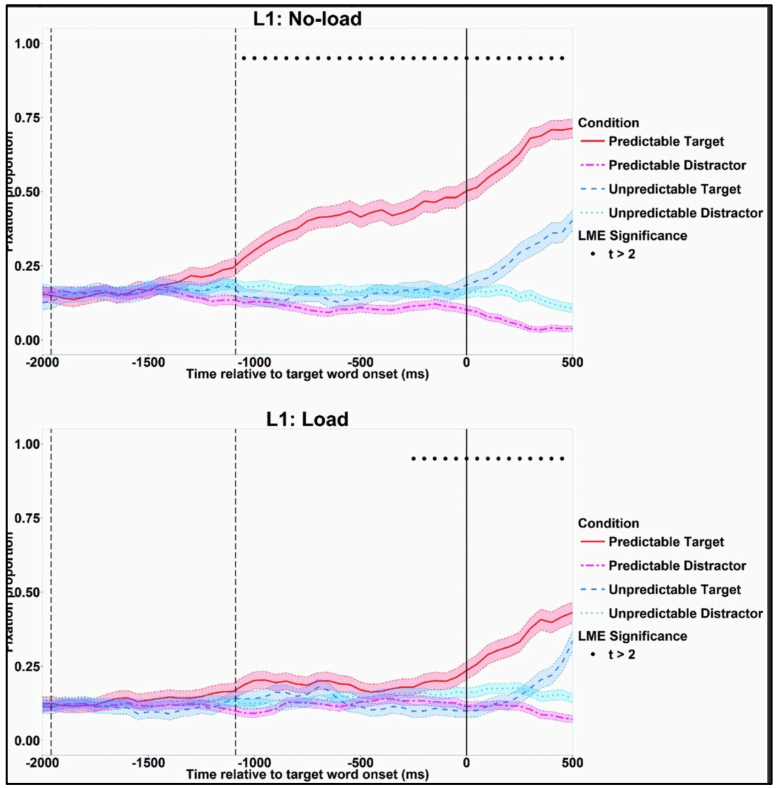
Ito et al. (2018)

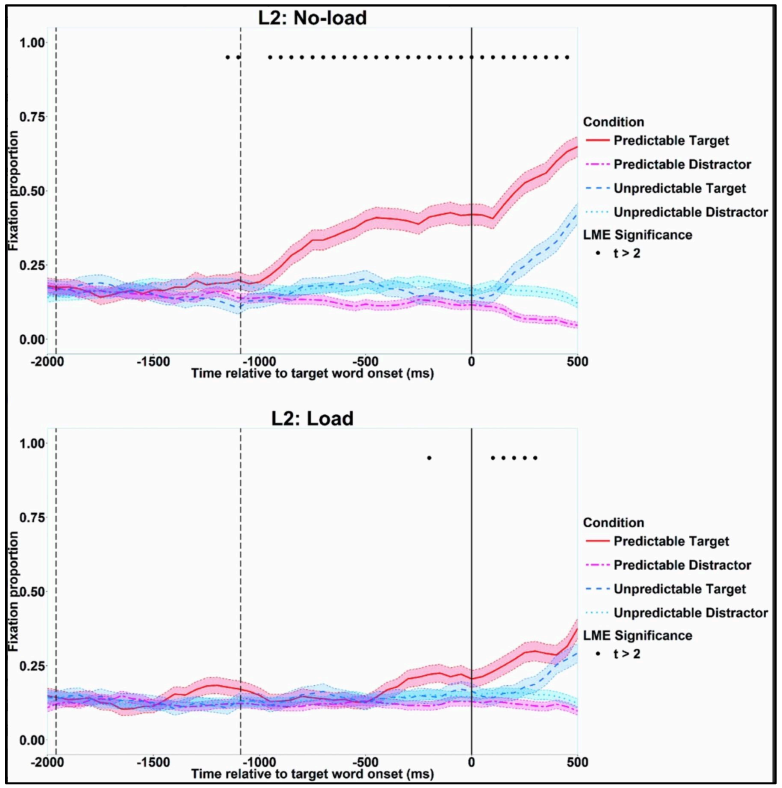
- Similar set-up in L1 and L2 English, but semantic competitor
- L2 English: variety of different L1's
- Half the participants (24 L1, 24 L2): concurrent memory task



The lady will **find** the scarf
The lady will **fold** the scarf

Results Ito et al.



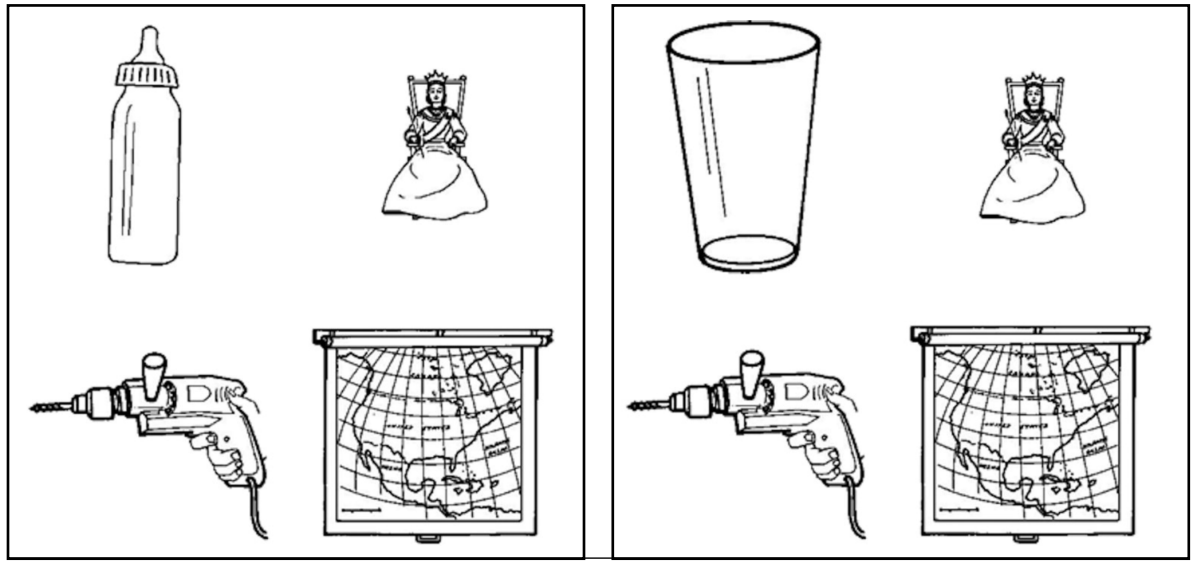


- Similar prediction effect in L1 and L2, with similar time course (top)
- Both in L1 and L2, delayed prediction with load (bottom)
- No spurious looks at semantic competitors (e.g., heels, purple line)

Ito et al. (2018)

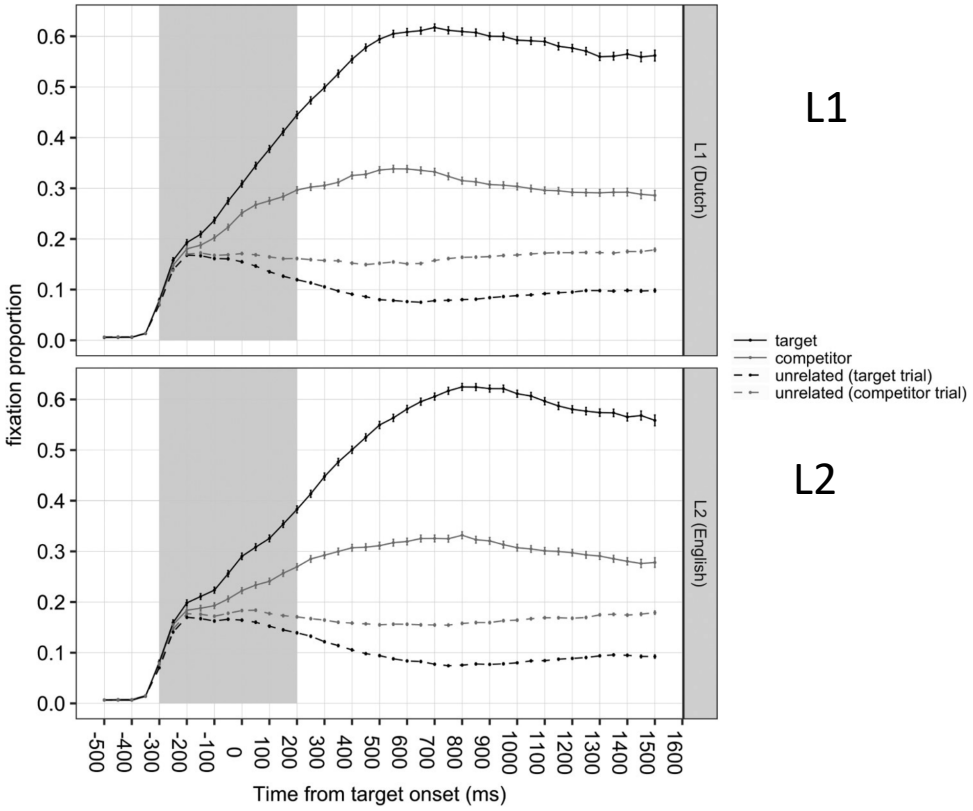
Dijkgraaf et al. (2019)

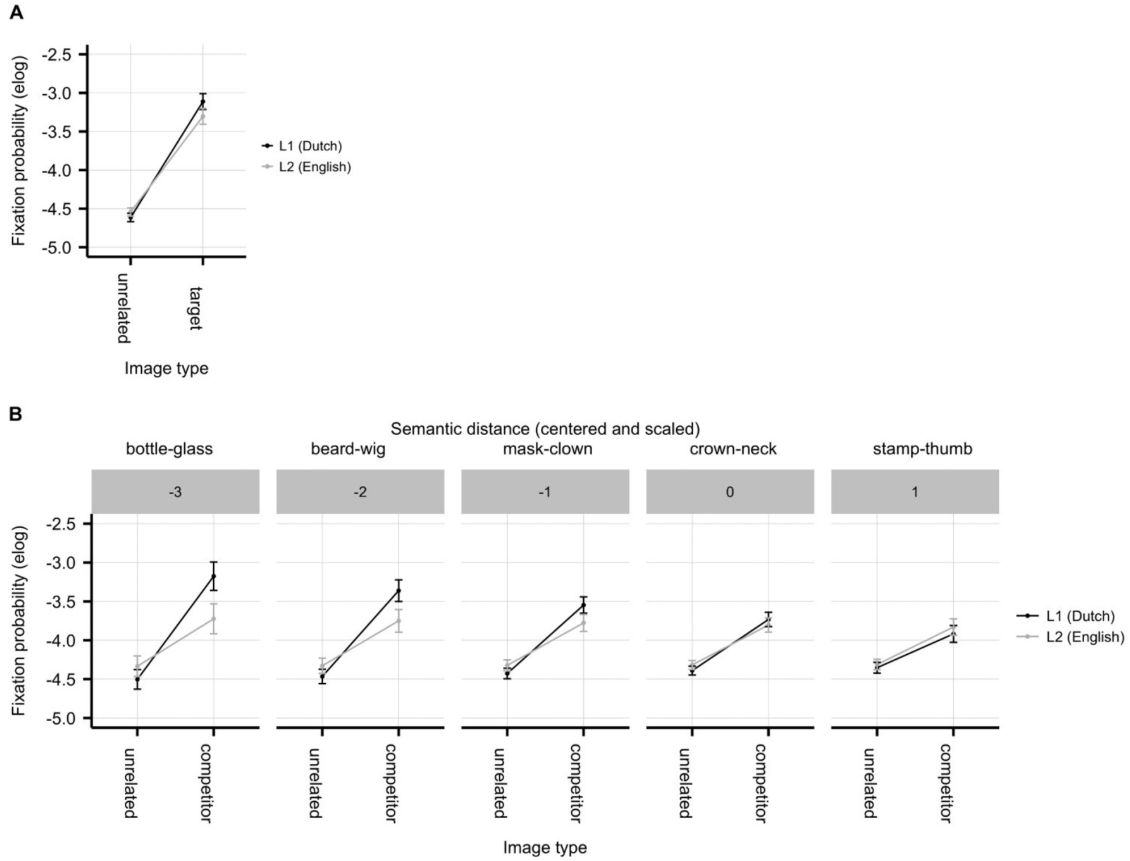
- High-powered study (50 subjects x 362 items)
- L1 Dutch and L2 English (Ghent)
- Reconsidered semantic competition effect: competitors and targets in separate displays



Her baby doesn't like drinking from a bottle

Results: Dijkgraaf et al. (2019)





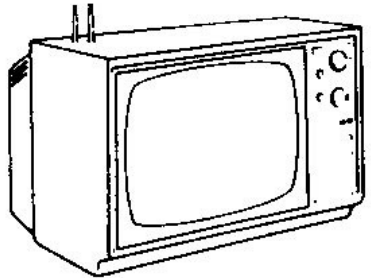
- Prediction slightly weaker in L2 than L1
- Semantic competitor effect interacts with semantic distance and language

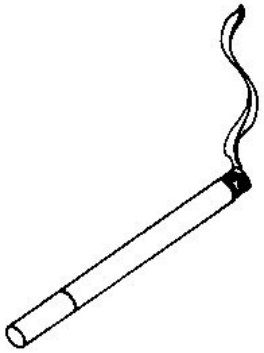
Lexical-semantic prediction in Chinese-English bilinguals

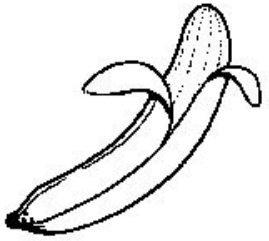
Does bilingual prediction depend on language distance?

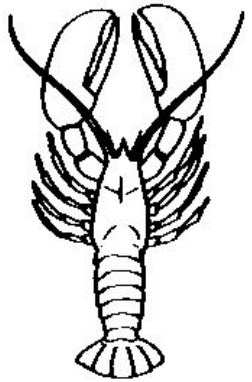
- 32 Chinese-English bilinguals tested in L1 and L2
- 32 Dutch-English bilinguals tested in L1 and L2

Task	Constraint	Sample
Chinese	high	小丽要维修她的电视机。
	low	小丽要购买她的电视机。
English	high	Mary will repair the television.
	low	Mary will buy the television.
Dutch	high	Maria repareert de televisie.
	low	Maria koopt de televisie.

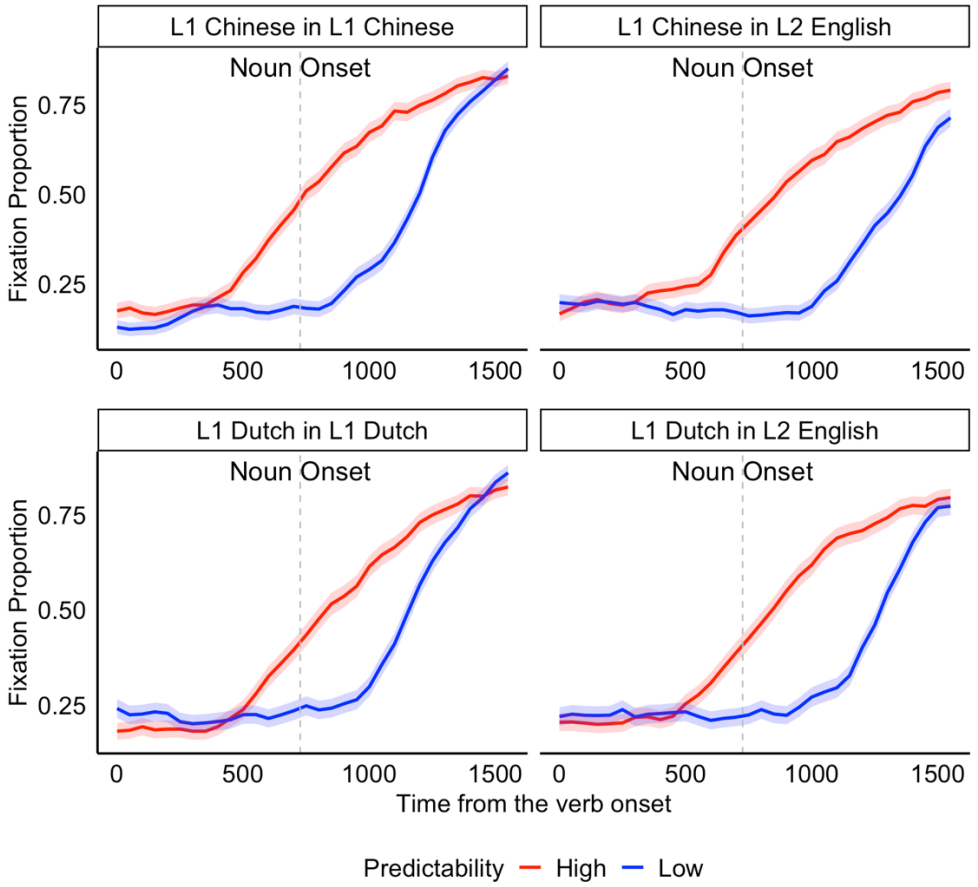








Lu et al. (under revision)



- Similar effect in L1 Dutch and L2 English (cf. Dijkgraaf et al., 2017)
- Similar effect in L2 English for both Dutch and Chinese speakers
- Slightly larger and earlier (1 time bin) effect in L1 Chinese than L2 English or L1 Dutch

Summary: Lexical-semantic prediction

- Overall: very similar prediction in first or second languages

- Subtle differences hinting at stronger prediction in L1
- Slightly earlier onset of prediction in L1
- Cognitive load delays prediction in L1 and L2 alike
- L2 prediction doesn’t seem to depend on which L1

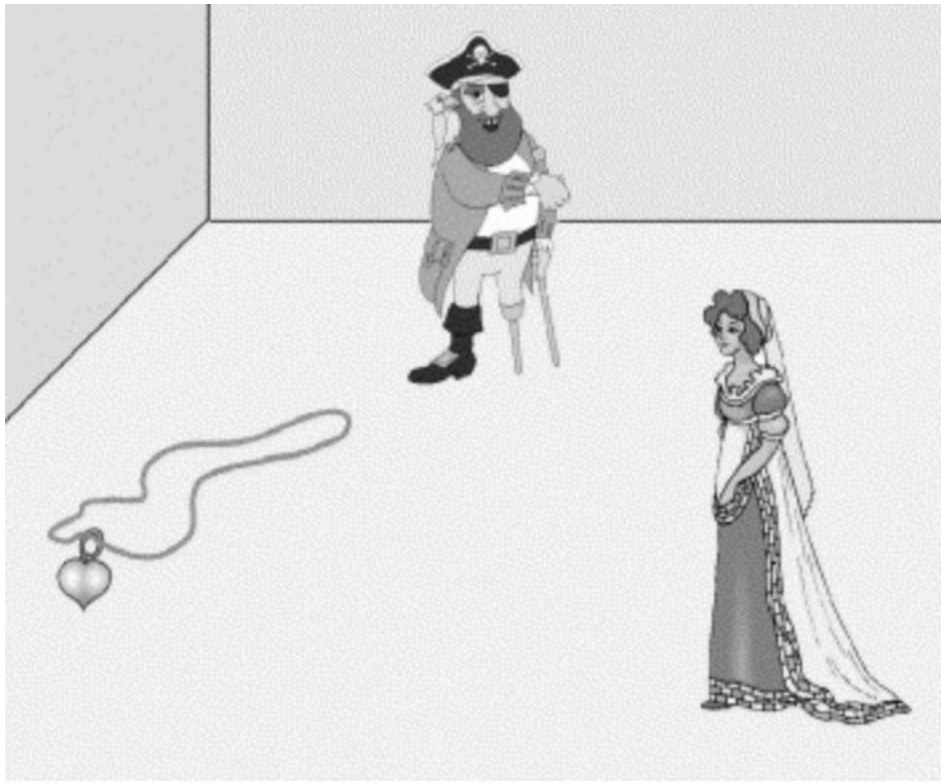
Syntactic prediction (AKA syntactic priming)

- Prediction based on syntactic features:
  - Grammatical gender (Martin et al., 2013)
  - Case (e.g., Hopp, 2015; Mitsugi & MacWhinney 2016)

- Prediction based on **expectation of repetition** (Arai et al., 2007)
  - "Previous sentence was a DO (PO); I expect the next one to be similar"

Double object (DO)	The skier will send the novice the equipment
Prepositional object (PO)	The skier will send the equipment to the novice

Visual world – syntactic prediction



Prime:

DO	The skier will bring/send the novice the equipment
PO	The skier will bring/send the equipment to the novice

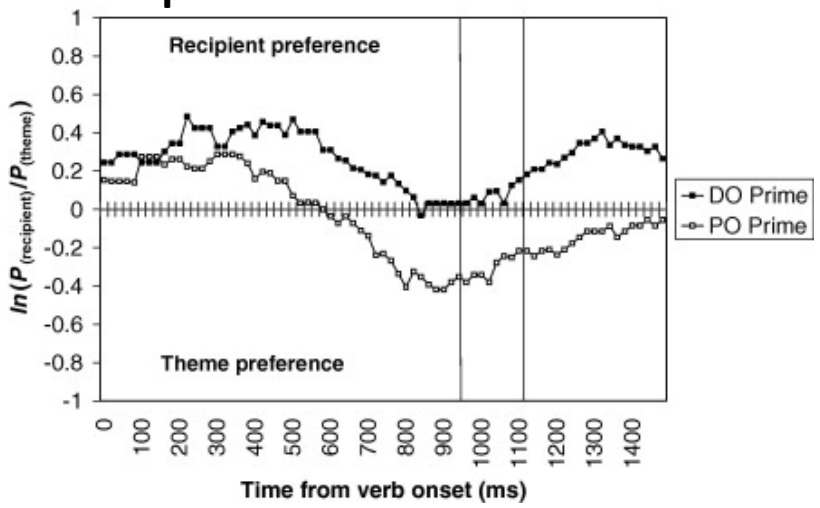
Target: The pirate will **send** ….

- After DO prime: looks at princess (recipient)
- After PO prime: looks at necklace (theme)

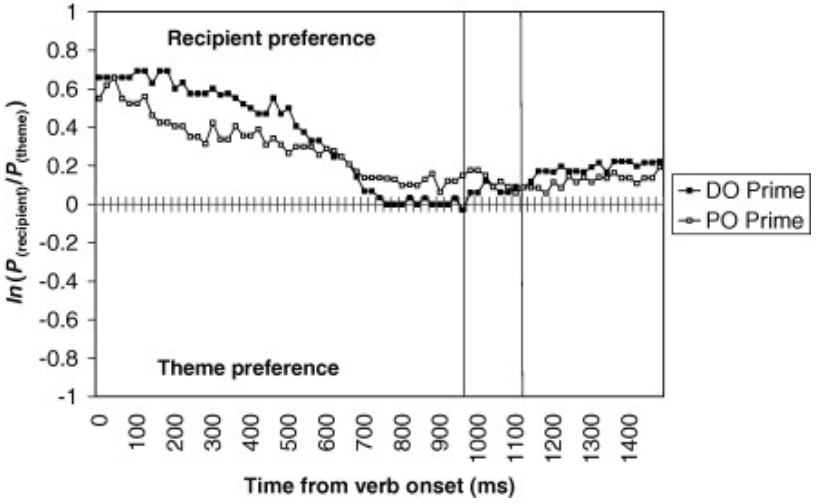
Arai et al. (2007)

Visual world – syntactic prediction

repeated verb



different verb



Prime:

DO The skier will bring/send the novice the equipment

PO The skier will bring/send the equipment to the novice

Target: The pirate will **send** ….

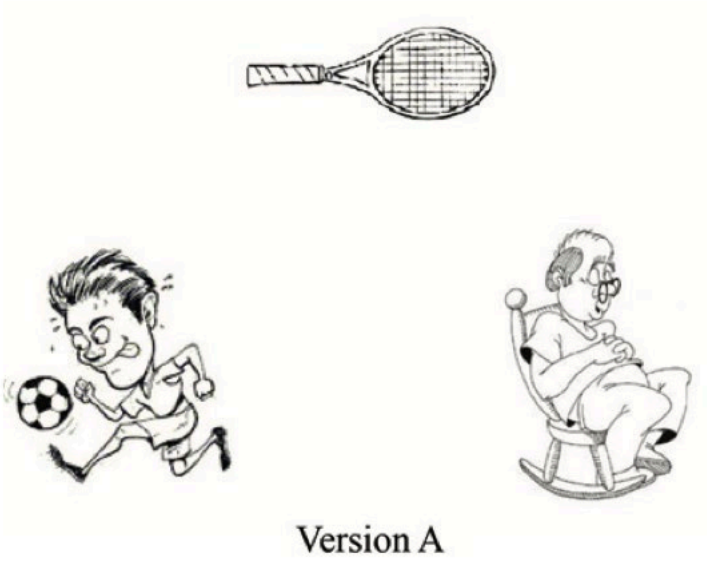
- After DO prime: looks at princess (recipient)
- After PO prime: looks at necklace (theme)

But only prediction/ priming effect when verb repeated!

Arai et al. (2007)

What about Chinese?

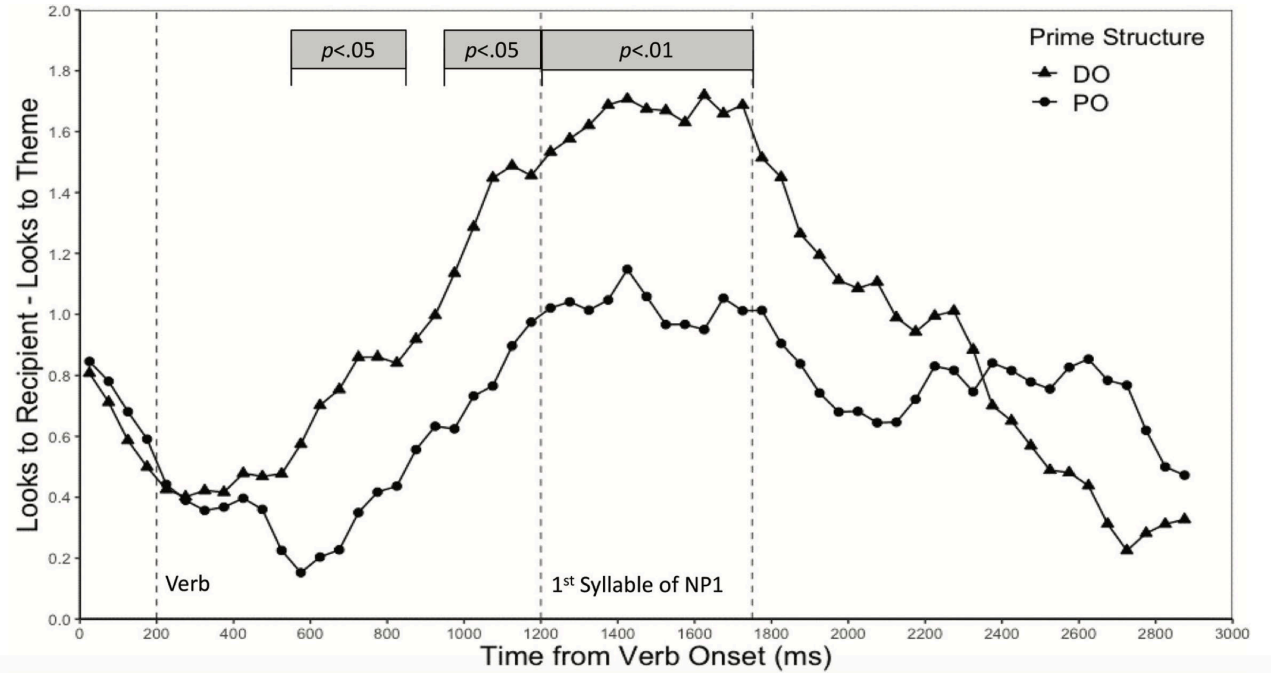
- Chen et al. (2022):
  - Verb-independent structure prediction in Chinese?



Version A

Condition	Example
Prime sentences	
a. DO-biased DO	*Wujing song Tegong yiba Shouqiang*.The policeman gives the spy a gun.
b. DO-biased PO	*Wujing song Shouqiang gei Tegong*.The policeman gives a gun to the spy.
c. PO-biased DO	*Wujing diu Tegong yiba Shouqiang*.The policeman throws the spy a gun.
d. PO-biased PO	*Wujing diu Shouqiang gei Tegong*.The policeman throws a gun to the spy.
Target sentences	
DO	*Yeye huan Qiuyuan yifu Qiupai.*The grandpa returns the football player a racket.
PO	*Yeye huan Qiupai gei Qiuyuan,*The grandpa returns a racket to the football player.

Chen et al. (2022): results



- Clearly a verb-independent prediction effect, beginning in the verb window

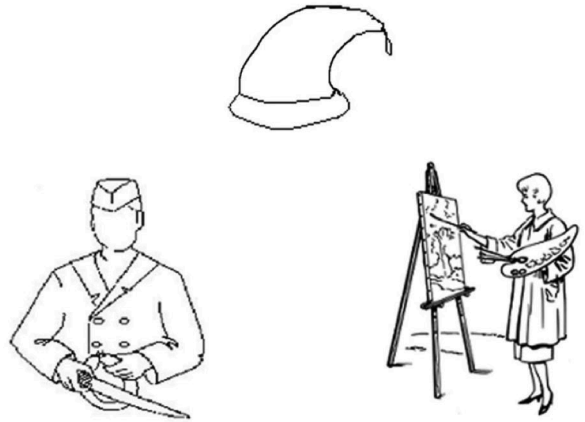
What about Dutch?

- Chen and Hartsuiker (2023):
  - Lack of abstract priming in Arai et al.– property of English?
  - Four studies in Dutch, differing in speech rate, lexical overlap, predictability

Table 2
Example of One Set Materials in Experiment 1

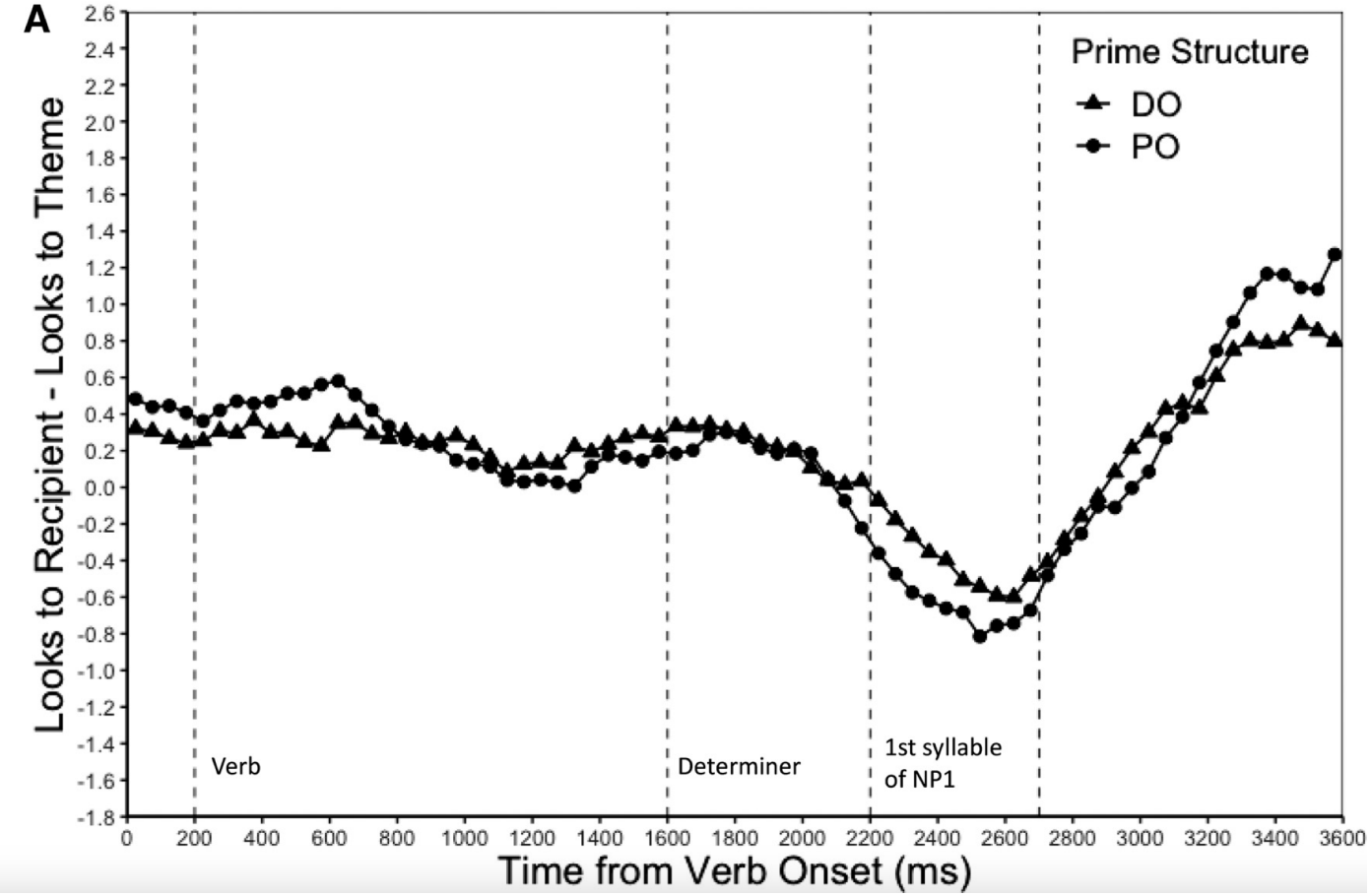
Conditions	Example
Prime sentences	
a. DO-biased DO	*De verpleegster bezorgt een advocaat een koekje.* The nurse delivers a lawyer a biscuit.
b. DO-biased PO	*De verpleegster bezorgt een koekje aan een advocaat.* The nurse delivers a biscuit to a lawyer.
c. PO-biased DO	*De verpleegster verstuurt een advocaat een koekje.* The nurse sends a lawyer a biscuit.
d. PO-biased PO	*De verpleegster verstuurt een koekje naar een advocaat.* The nurse sends a biscuit to a lawyer.
Target sentences	
DO	*De schilder overhandigt een **sla**ger een **slaa**pmuts.* The painter hands a butcher a nightcap.
PO	*De schilder overhandigt een **slaa**pmuts aan een **sla**ger.* The painter hands a nightcap to a butcher.

Figure 3
Example Target Picture in Experiment 1

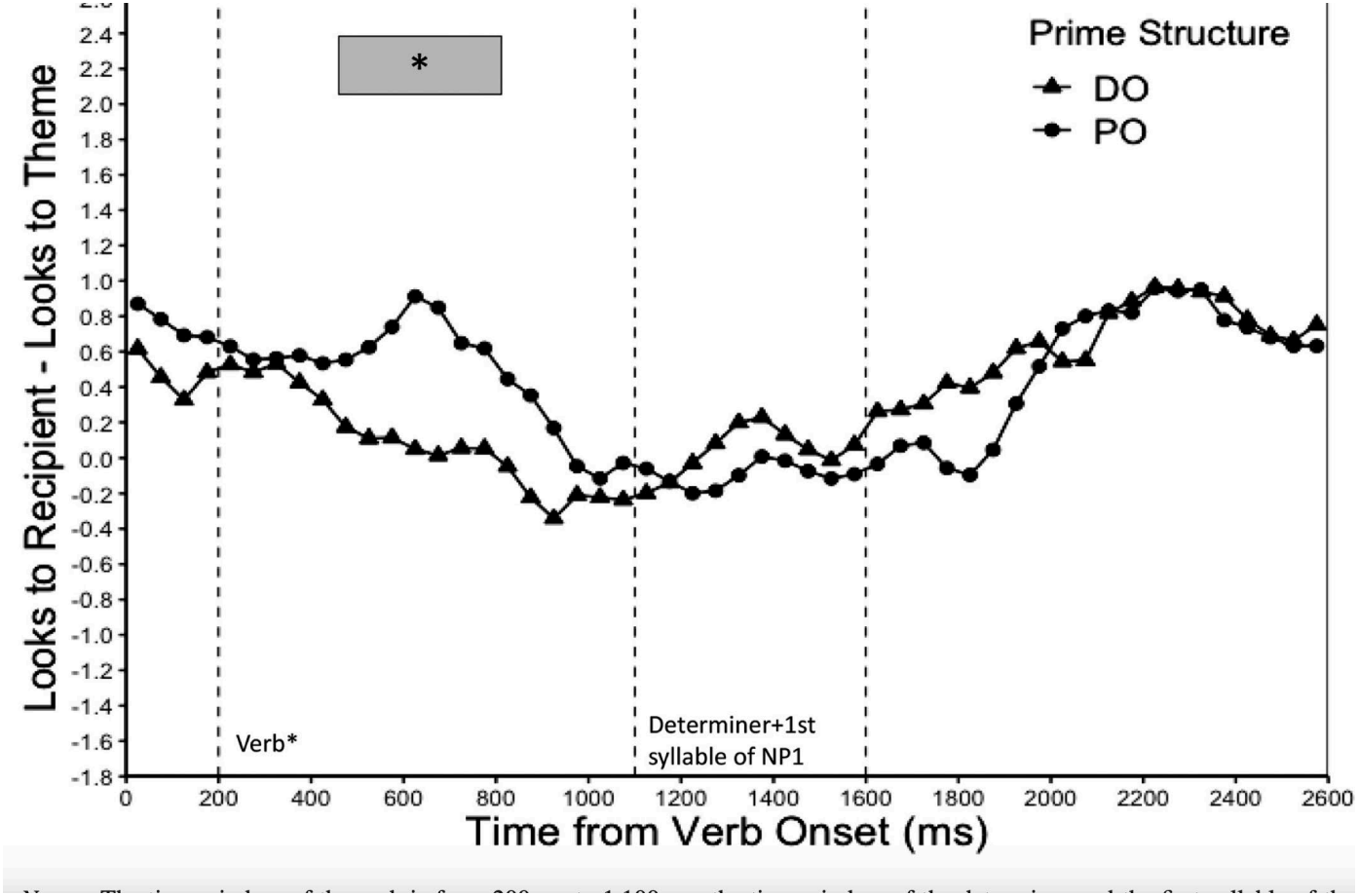


Note. Participants heard DO or PO target sentences (see Table 1) while they saw the corresponding target picture.

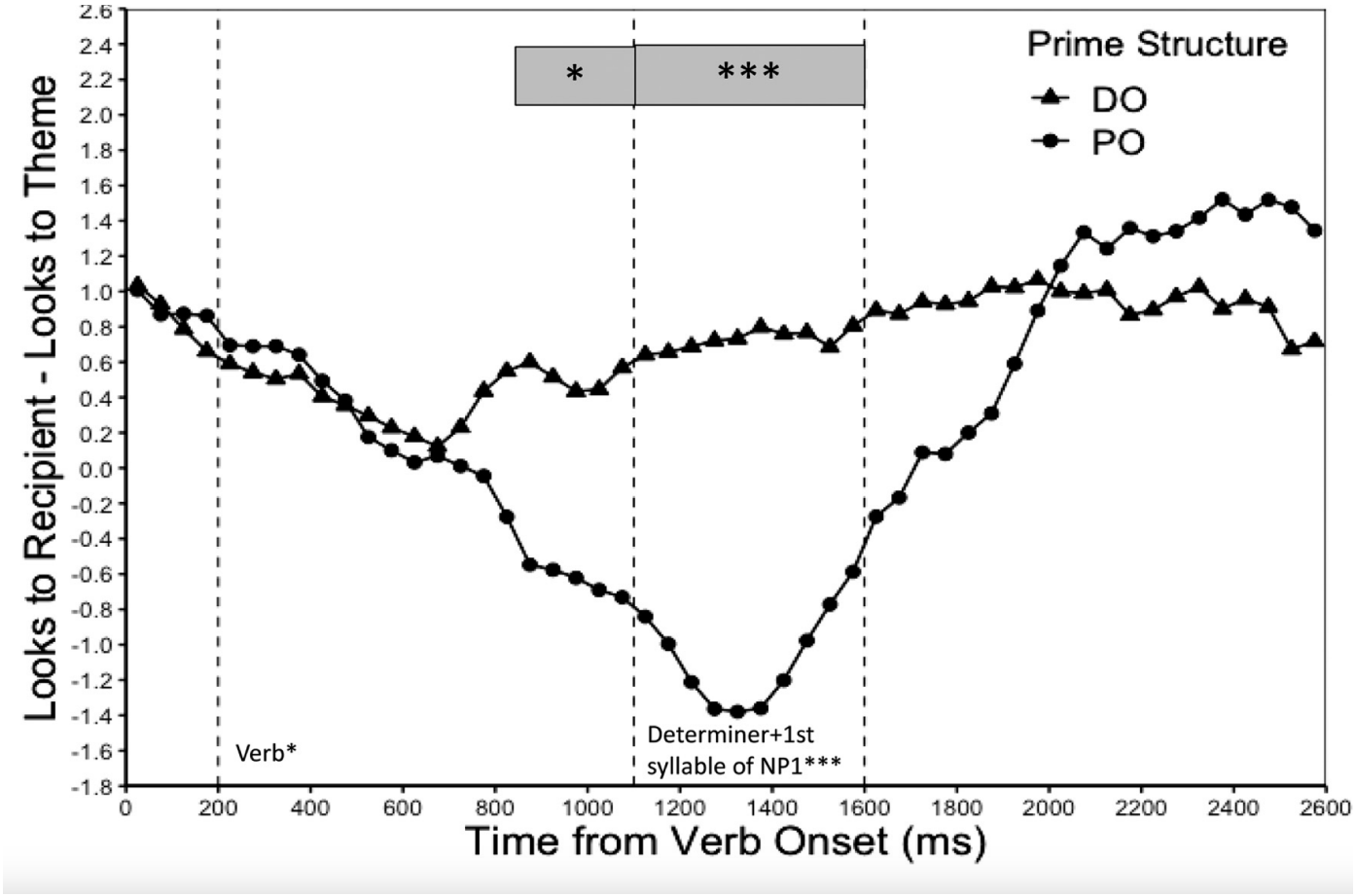
Chen & Hartsuiker (2023): Expt 1



Chen & Hartsuiker (2023): Expt 2 fast speech



Chen & Hartsuiker (2023): Expt 3 verb overlap



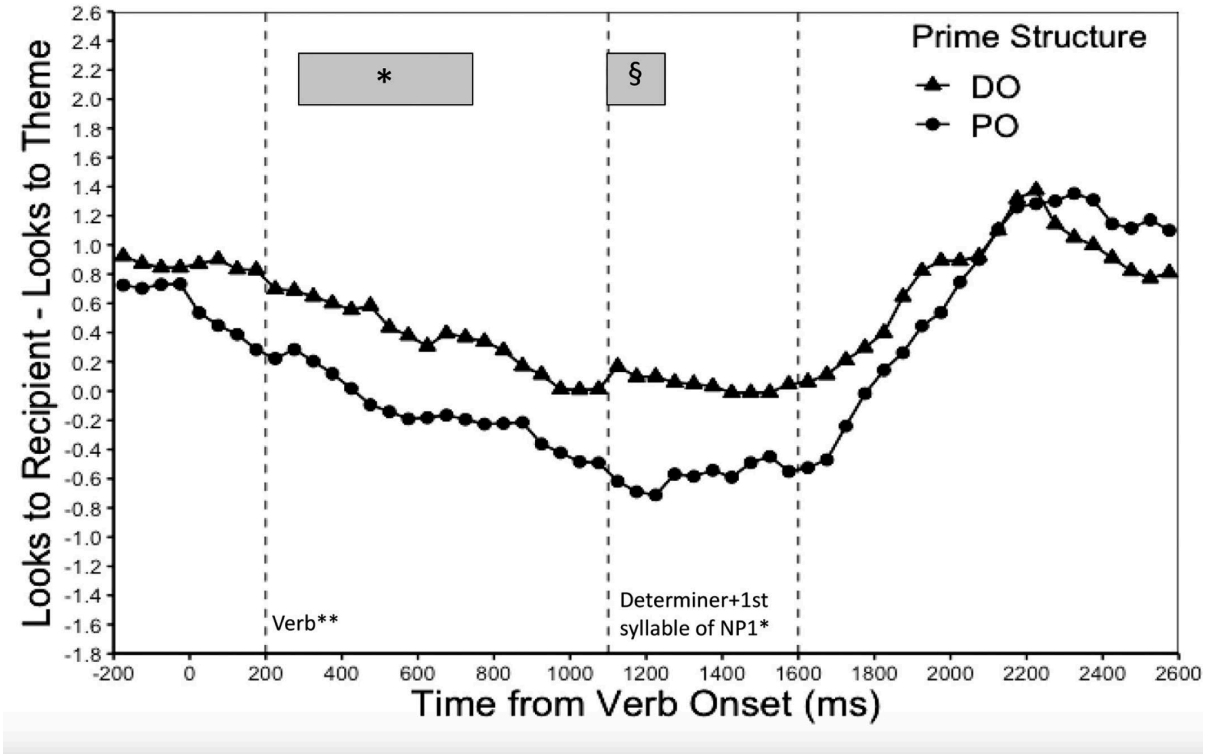
Chen & Hartsuiker (2023)

- Dutch, like English (Arai et al., 2007): only prediction effect with lexical overlap
- But in Chinese, clear abstract priming

- One possibility: more syntactic options in Chinese
  - Dutch, English: the painter gives – either DO or PO
  - Chinese: other options (the nightcap the painter gave belongs to the butcher) – also used as fillers in Chen et al.
  - More prediction in an unpredictable situation?

Chen & Hartsuiker (2023): Expt 4 diverse fillers

in Experiment 4



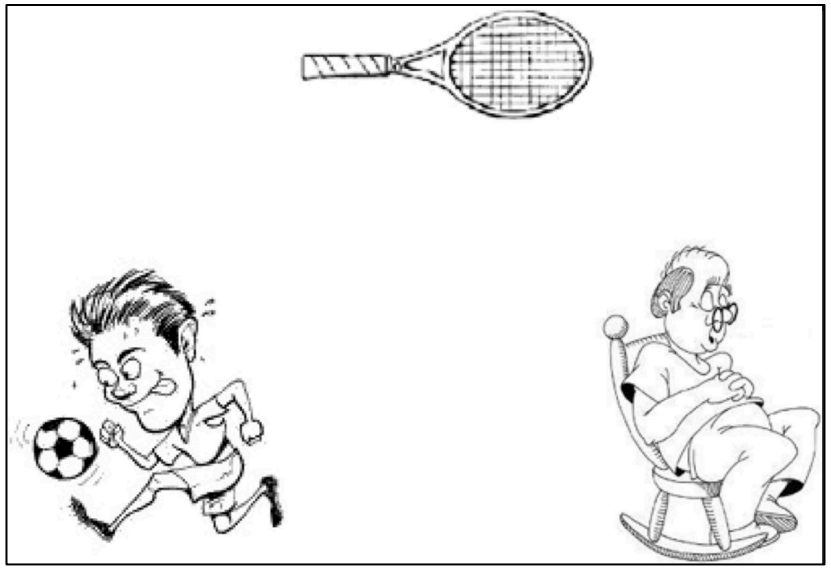
Fillers now included:

- Shifted datives (the painter gives to the butcher the nightcap)
- Verb final structures (the professor has the boxer a magazine delivered)

- Prediction effect now appears! (although much weaker than Expt 3)

Do we predict structure across languages?

- Chen, Wang & Hartsuiker (2023): Cantonese-Mandarin-English trilinguals
- Primes were in Cantonese, Mandarin or English
- Targets in L2 Mandarin – verbs same/translation vs. different



Prime Condition	Example
a. DO-English	The parent left the babysitter a key.
b. PO-English	The parent left a key to the babysitter.
c. DO-Mandarin	父母留保姆一把钥匙。 *(Fumu liu Baomu yiba Yaoshi.)* *Lit. Parent Left Babysitter A Key.*
d. PO-Mandarin	父母留钥匙给保姆。 *(Fumu liu Yaoshi gei Baomu.)* *Lit. Parent Left Key To Babysitter.*
e. DO-Cantonese	父母留保姆一把钥匙。 *(Fumou lau Boumou jatbaa Joeksi.)* *Lit. Parent Left Babysitter A Key.*
f. PO-Cantonese	父母留钥匙给保姆。 *(Fumou lau Joeksi kap Boumou.)* *Lit. Parent Left Key To Babysitter.*

Results Chen et al. (2023)

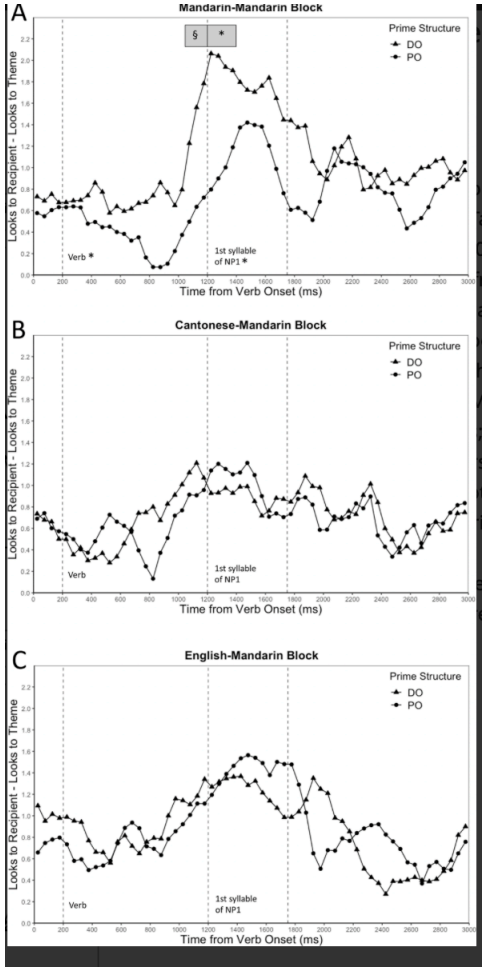
Prime language

Mandarin

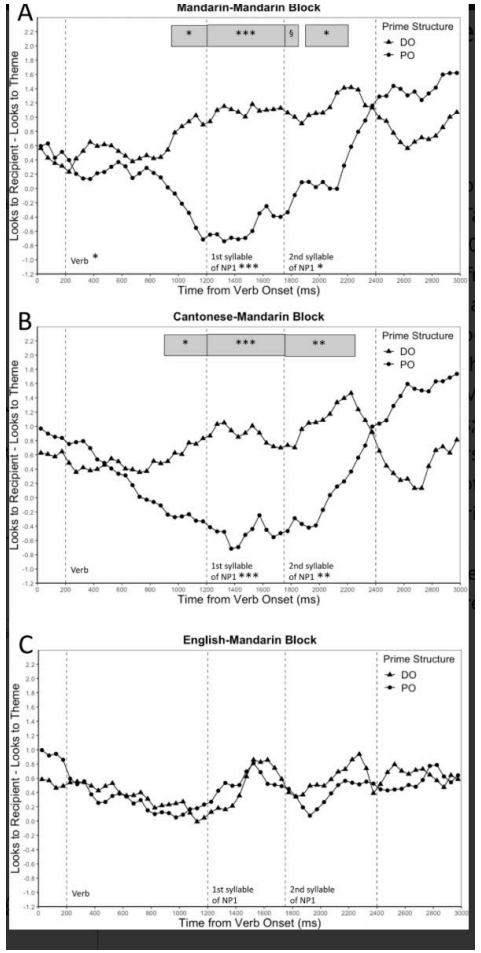
Cantonese

English

Different Verb



Same Verb



Abstract prediction effect: only within-language (Mandarin – Mandarin)

X-language with closely related language (same verb)
(Cantonese – Mandarin)

No prediction with unrelated languages
(English – Mandarin)

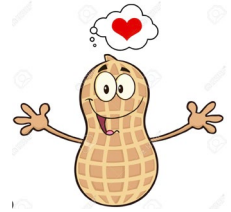
Interim summary: syntactic prediction

- Monolingually: depends on …
  - presence of verb overlap
  - language
  - composition filler materials
  - task (Thothathiri & Snedeker: abstract effect in English in acting-out task)

- Bilinguals:
  - Verb overlap
  - Language relatedness (possibly cognate status)

Discourse as cue for prediction

- Usually investigated using ERPs (e.g. Brothers et al., 2020; Metusalem et al., 2012; Nieuwland & Van Berkum, 2006)
  - Event knowledge affects prediction
  - Global context can even overrule lexical-semantic constraints



(1) *A huge blizzard ripped through town last night. My kids ended up getting the day off from school. They spent the whole day outside building a big* ***snowman*** *in the front yard.*

Snowman
Jacket
Towel

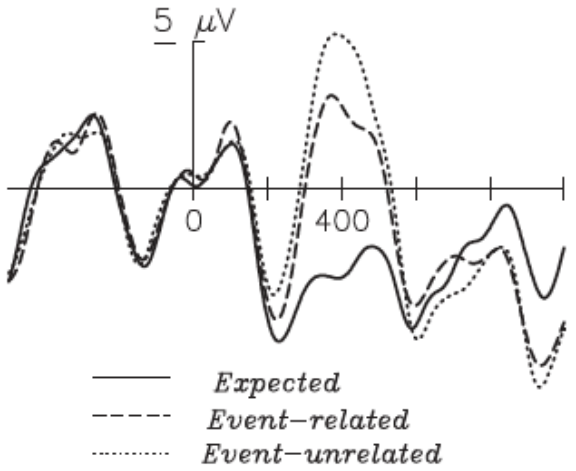


Fig. 3. Grand average ERPs at the midline parietal electrode (MiPa) in Experiment 1.

Discourse prediction in L2?

- Can people make discourse-based predictions in L2?
- Do they predict to the same extent as in L1?
- Does it matter what the L1 is – e.g., how similar L1/L2?

- Lu et al.: Visual-world discourse-based prediction study in L1 English, Dutch, Chinese and L2 English

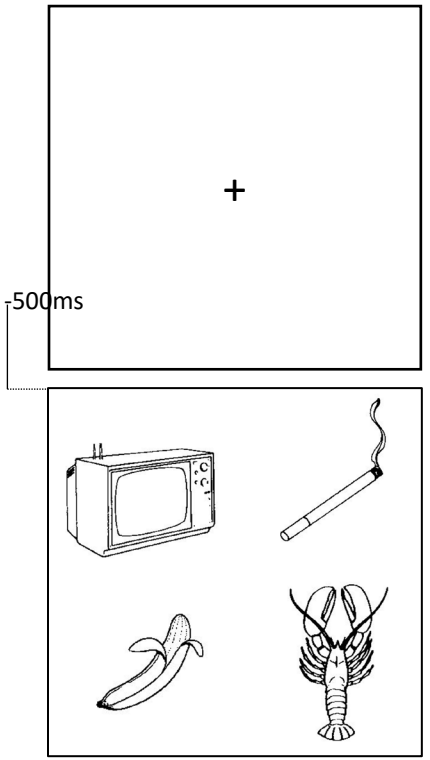
Lu et al. (in prep): Discourse prediction in L2

Mary is … decorating her new house / … preparing for a party

She feels happy

There is one other thing she needs

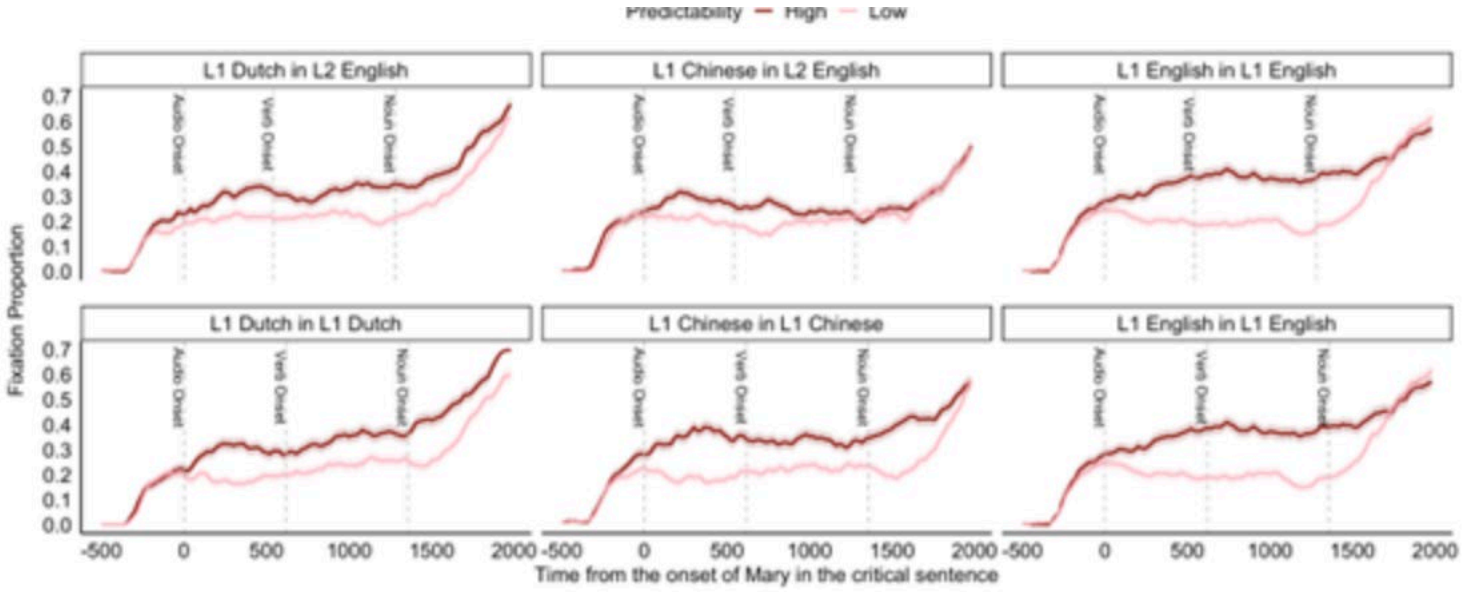
Mary <u>buys</u> the television



- Global vs. no constraint
- Neutral verb semantics
- 500 ms preview time

- Dutch – English
- Mandarin – English
- English monolinguals

Lu et al. (in prep) results



- Prediction from the start
- Similar in L1 tasks (bottom row)

- English task (top row)
  - Time window 1
    - Comparable
  - Time window 2
    - **Stronger** in English than Dutch group
    - **Weaker** in Chinese than Dutch group

Discourse study

- Overall, **similar** prediction patterns in L1 and L2 for both groups of bilinguals (and for L1 of monolinguals)

- But differences in Time Window 2 b/ween L1 and L2s: weaker prediction in L2, especially in the Chinese-English group

- Is Chinese-English group more likely to use **local** constraint (verb semantics), neutralising prediction?

Discussion: Putting it together

- Verb-semantics studies
  - Slightly stronger and earlier prediction in L1
  - Language relatedness does not seem to matter

- Syntax study
  - Prediction in L2 affected by same factors as L1 (e.g., verb overlap)
  - Language relatedness matters

- Discourse study
  - Weaker in L2 in time window after verb onset
  - Language relatedness matters

Theories of L2 prediction

- Overall, plenty of evidence for strong prediction effects in L2
  - Does not fit RAGE-theory well

- Some evidence for weaker prediction, but may be related to same factors affecting L1 (Kaan, 2014):
  - Syntactic prediction – affected by language and verb overlap
  - Lexical-semantic – possibly affected by weaker links

Theories of L2 processing

- **Weaker links**
  - Some support (e.g. Dijkgraaf et al. 2019)

- **Resource hypothesis**
  - No support (e.g., Ito et al., 2018)
  - Optional (syntactic) prediction reduced in L2 (Chen et al., 2023)

- **Cross-language interference**
  - No support, but not really tested here
  - Some evidence that language relatedness matters

What comes next?

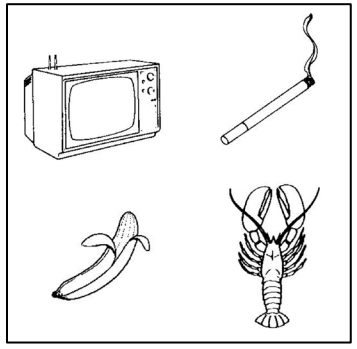
- Discourse study: weaker prediction after verb onset in L2 English for L1 Chinese
  - More inclined to use verb cue (neutralising prediction)?
  - Replication needed (and planned)
  - Study pitting verb cue and discourse against each other:

Mary is decorating her new house

She feels happy

There is one other thing she needs

Mary <u>smokes</u> the cigarette

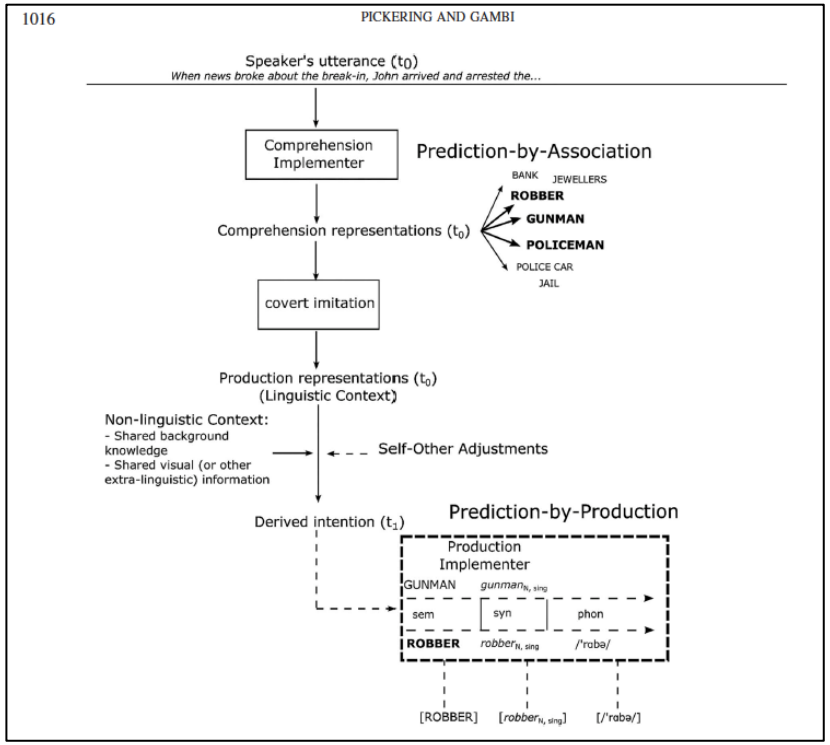


Discussion – is prediction mandatory?

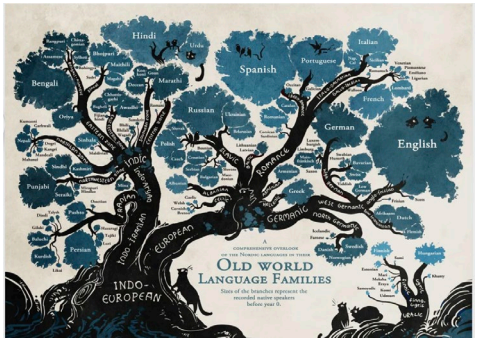
- Findings do no fit **mandatory** prediction account

- Especially **syntactic** prediction studies
  - Not based on a linguistic constraint
  - But rather on an expectation of syntactic parallelism
  - Not: error-driven learning

- Compatible with accounts that have multiple prediction mechanisms, some mandatory, some optional (e.g., Gambi & Pickering, 2018)



Discussion - Language similarity



- Some evidence similarity L1 and L2 plays a role in L2 prediction
  - Very clear for features like grammatical gender, case, *put*-verbs ,…
  - Less so for other properties tested here

- Some outstanding questions
  - Do languages differ in processing strategies? Weights on prediction cues?
  - Any L1-L2 differences in prediction: result of **general** differences in language similarity / relatedness / distance?
    - If so, what metric is most relevant?

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