
Modeling the interplay of rational production and comprehension of discourse connectives

Frances Yung , Jana Jungbluth & Vera Demberg



Universität des Saarlandes



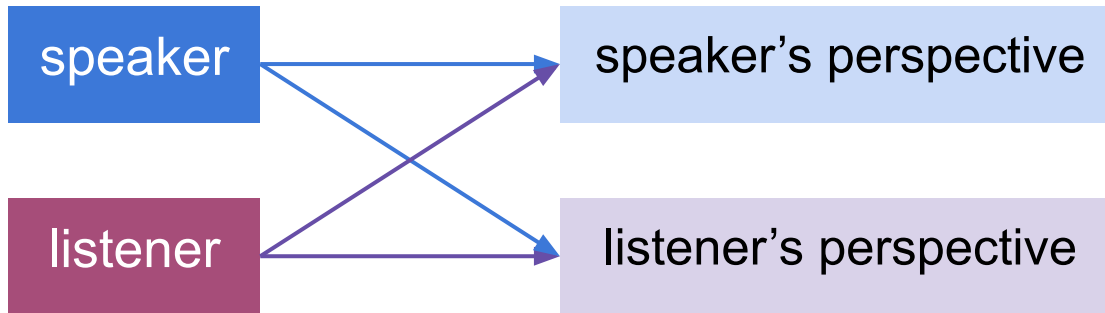
53rd Annual SLE conference

W11: Discourse marker use: from production to comprehension

27/Aug/2020

- Speakers and listeners consider **their own perspectives** as well as **their partners' perspective** in communication.

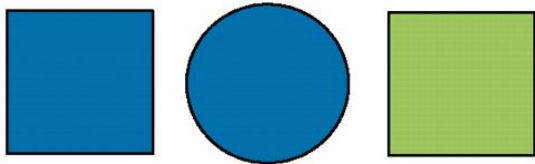
(Issacs and Clack, 1987; Wilkes-Gibbs and Clark, 1992, Brown-schmidt et al. 2008, Heller et al., 2008,)



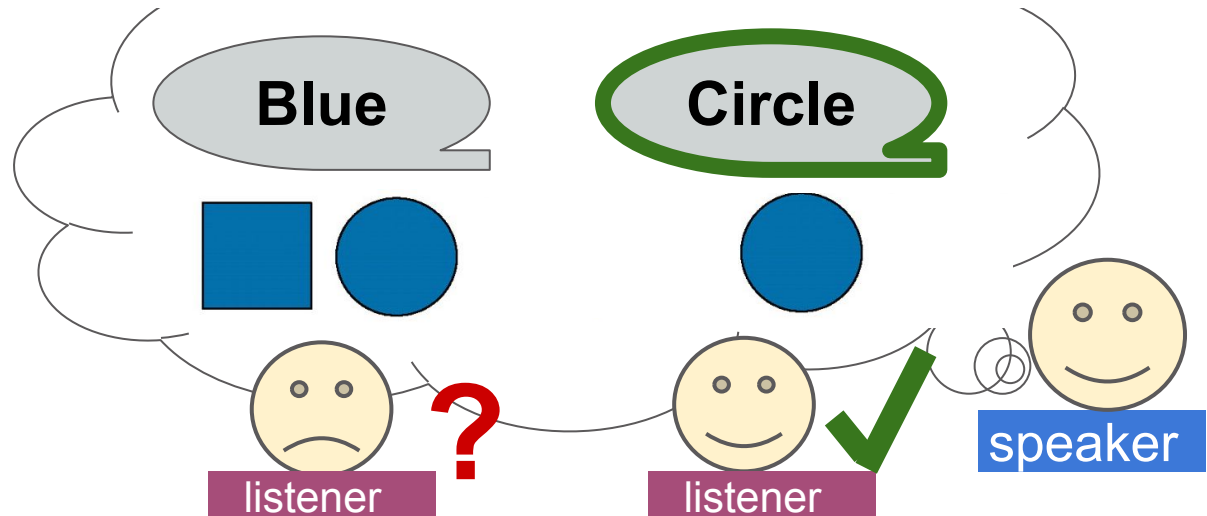
- This work studies how speakers estimates listeners' interpretation of **discourse connectives (dc)** in discourse relation production.

Background

- The **Rational Speech Act (RSA)** model is a unified framework that models the **interplay of language production and interpretation**.



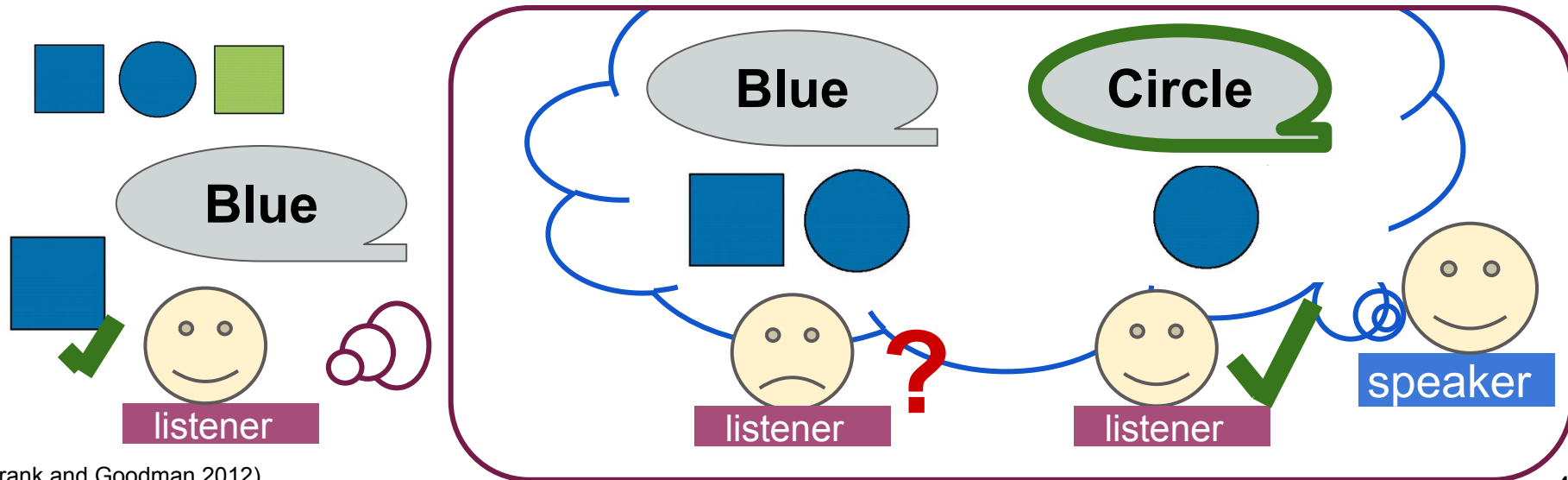
Imagine you are talking to someone, and you want to refer to the middle object. Which word would you use, “**blue**” or “**circle**”?



Background

- The **Rational Speech Act (RSA)** model is a unified framework that models the **interplay of language production and interpretation**.

(Frank and Goodman 2012, Goodman and Stuhlmüller 2013)



(Frank and Goodman 2012)

Background

- The **Rational Speech Act (RSA)** model is a unified framework that models the **interplay of language production and interpretation**.

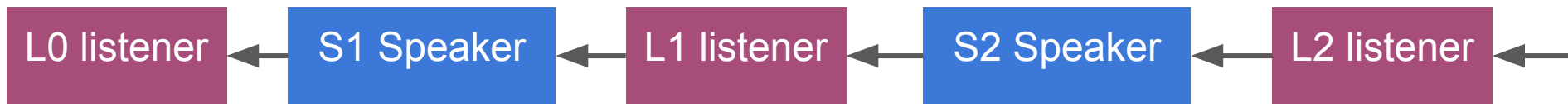
(Frank and Goodman 2012)

RSA **Speaker** model: $P_{S1}(dc \mid DR, C) \propto \exp(\alpha (\log L_0(DR \mid dc, C) - \text{Cost}(dc)))$

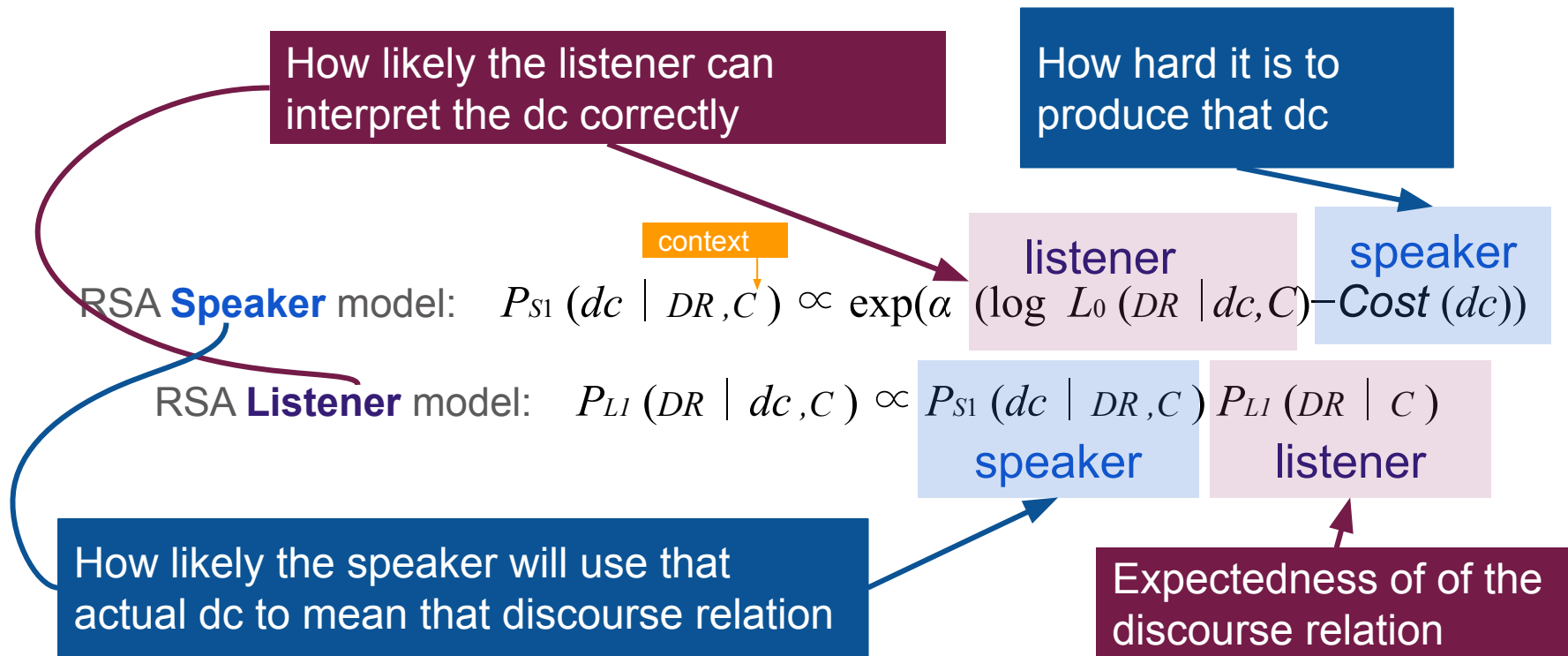
listener speaker

RSA **Listener** model: $P_{L1}(DR \mid dc, C) \propto P_{S1}(dc \mid DR, C) P_{L1}(DR \mid C)$

speaker listener



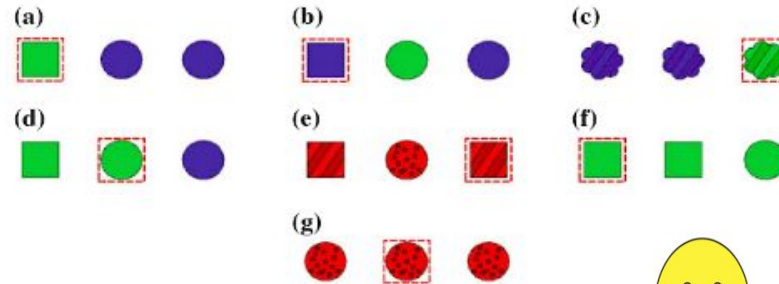
Background



Related work

- Evidence supporting the RSA model is found in the production and interpretation of e.g. **reference expressions** and **scalar implicature**.
- Typically, experiments are carried out in the form of a **language game**.

(Goodman and Stuhlmüller 2013, Qing and Frank, 2015, Frank et al., 2016, Degen et al 2019)



Related work

- The choice of **explicit and implicit DCs** was explained by RSA based on **corpus analysis**.
(Yung et al, 2017)
- An experimental setup was used to examine the production of a DC **given a discourse relation**, where each discourse relation was represented by a sentence continuation
(Yung and Demberg, 2018)

I had a very nice lunch with my old friend Chris today. I haven't seen him in a long time.
Chris loves music: he plays the saxophone _____ (**while / whereas / so**)

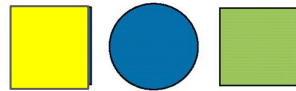
- A. his wife is a ballet dancer.
- B. he has two children.
- C. he owns two saxophones.

A is the **actual continuation**.
Your partner guesses it from A, B, C
based on the the word you choose.
**Which word will you choose to as a
hint for your partner ?**

Related work

- A similar setup was used to examine the production of a DC **given a discourse relation.**

Unambiguous condition



(No competitor in the give options that share dcs with the target continuation)

I had a very nice lunch with my old friend Chris today. I haven't seen him in a long time.
Chris loves music: he plays the saxophone _____ (while / whereas / so)

amb

unamb.

filler

- A. his wife is a ballet dancer.
- B. he has two children.
- C. he owns two saxophones.

amb

unamb.

filler

filler

A is the **actual continuation.**

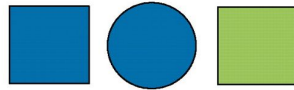
Your partner guesses it from A, B, C based on the the word you choose.

Which word will you choose to as a hint for your partner ?

Related work

- A similar setup was used to examine the production of a DC **given a discourse relation.** (Yung and Demberg, 2018)

Ambiguous condition



(With a competitor in the give options that share dcs with the target continuation)

I had a very nice lunch with my old friend Chris today. I haven't seen him in a long time.
Chris loves music: he plays the saxophone _____ (**while / whereas / so**)

amb

unamb.

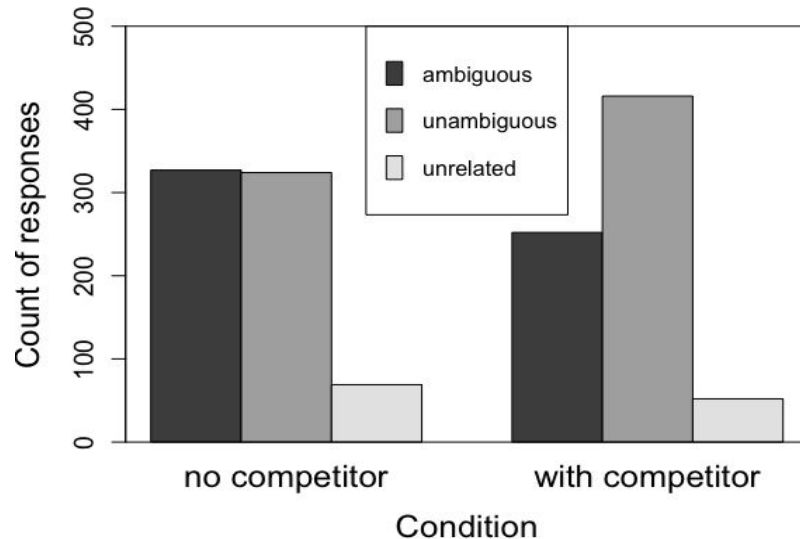
filler

- A. his wife is a ballet dancer. amb unamb.
- B. **he accompanies himself on the drums.** amb
- C. he owns two saxophones. filler

A is the **actual continuation**.
Your partner guesses it from A, B, C
based on the the word you choose.
**Which word will you choose to as a
hint for your partner ?**

- Evidence **supporting RSA / pragmatic reasoning** was confirmed.

(Yung and Demberg, 2018)



- Speakers **do not have a preference** when both literally correct dcs match the target continuation.
- Speaker **prefers an unambiguous DC** when (they think) the listeners may choose the wrong continuation.

Question

- Outside a language game, the set of interpretation **is not limited** and we normally **don't see them** !
- Will the result still hold **in real-life situations**?

I had a very nice lunch with my old friend Chris today. I haven't seen him in a long time. Chris loves music: he plays the saxophone _____ (**while / whereas / so**)

- A. his wife is a ballet dancer.
- B. **he accompanies himself on the drums.**
- C. he owns two saxophones.

A is the **actual continuation**.
Your partner guesses it from A, B, C based on the the word you choose.
Which word will you choose to as a hint for your partner ?

Method: unrestricted setting

- Test speakers' choice of “ambiguous” and “unambiguous” DCs **without showing the possible continuations.**
- To do so, instead of manipulating the set of possible options, we **manipulate the expectedness of the discourse relations in context.**

Method: unrestricted setting

Expected condition

(expected in context = **actual** continuation)

Chris is a professional artist and so is his wife. However, his talent is very different from hers: he plays the saxophone ...

_____ (**while / whereas / so**)
his wife is a ballet dancer.

Unexpected condition

(expected in context **!= actual** continuation)

I am going to the music festival with my friends next week. I look forward to the particular performance by a musician who can play two instruments at the same time: he plays the saxophone ...

_____ (**while / whereas / so**)
his wife is a ballet dancer.

Neutral condition

Neutral context
for comparison.

Prediction: for the same discourse relation, the speaker will use **an unambiguous DC (e.g. “whereas”) more in the unexpected condition** because it is harder for the listener to interpret.

Challenge

- We made new stimuli focusing on **three** ambiguous DCs: these work well in Yung and Demberng (2018) comparing with e.g. “when”, “and”
- 10-11 stimuli were made for each of the alternative meaning of each dc (**62 stimuli** in total)

as	reason (because)	synchronous (at the same time as)
since	reason (because)	precedence (ever since)
while	contrast (whereas)	synchronous (during the time when)

- We validated the new stimuli with **two pretests**. The results of the pretests are also used later in the analysis of the main experiment results.

Pretest 1: contrast between alternative meanings of the ambiguous dc

- For each continuation, **only one of the alternative readings** should work.

Choose between **since** and **ever since**:

James has been studying very hard **ever since** he entered secondary school 2 years ago.

James has been studying very hard ***because** he entered secondary school 2 years ago.

- Ask another group of workers to rate both versions. Each person sees only 1 version.

e.g.	1 star (worst)	2 stars	3 stars	4 stars (best)	average
ever since	0	0	2	13	3.87
*because	5	5	1	4	2.27

Discard stimuli
with low contrast.

Average contrast per
stimuli = 62%

(0: both readings are equal)

Contrast of the alternative meanings = $3.87 - 2.27 = 1.60$ (53%)

Pretest 2: bias of the contexts across conditions

- Ask another group of people to choose the better continuation given different contexts.

Contrast context: Chris is a professional artist and so is his wife. However, his talent is very different from hers:

Synchronous context : I am going to the music festival with my friends next week. I look forward to the particular performance by a musician who can play two instruments at the same time:

He plays the saxophone... - **whereas** his wife is a ballet dancer
- **at the same time as** he accompanies himself on the drums.

	“Whereas” continuation	“At the same time” continuation
Contrast-context	14 workers	1 worker
Synchronous-context	0 worker	15 workers

Contrast of contexts in the expected and unexpected condition =
 $14/15 = 93\%$

Discard stimuli
with low contrast
Average contrast per
stimuli = 68%
(0: both contexts are equal)

Experimental setup

- We constructed **31 pairs of stimuli** covering both meanings of “as”, “since” and “while”.
- To further confirm whether the new stimuli can detect RSA-inference, we first conduct the experiment in the **restricted “language game” setting**, as in Yung and Demberg 2018.
- All workers are recruited from Prolific.ac. The items and conditions are evenly distributed. The questions and option orders are randomly shuffled.

Experiment 1: replication of the “language game” experiment

Which word will you choose to hint your partner to choose continuation A ?

Unambiguous condition

(**No competitor** in the give options that share DCs with the target continuation)

(neutral context) I had a very nice lunch with my old friend Chris today. I haven't seen him in a long time. Chris loves music: he plays the saxophone...

_____ (**while / whereas / so**)

- **A. his wife is a ballet dancer. (target)**
- B. (filler continuation 1)
- C. (filler continuation 2)

Ambiguous condition

(**With a competitor** in the give options that share DCs with the target continuation)

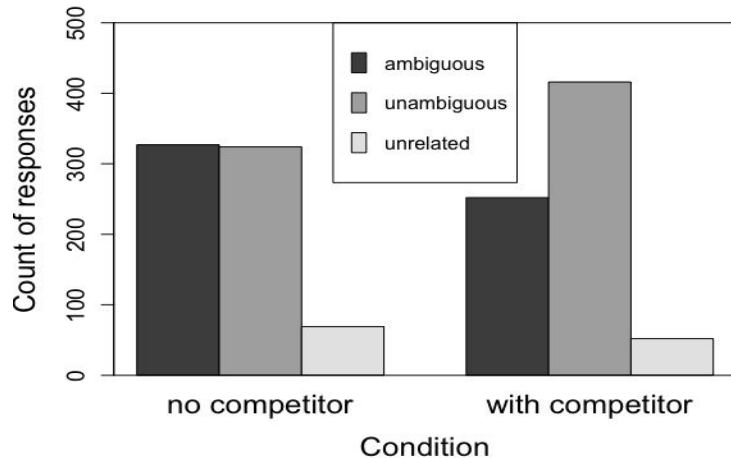
(neutral context) I had a very nice lunch with my old friend Chris today. I haven't seen him in a long time. Chris loves music: he plays the saxophone...

_____ (**while / whereas / so**)

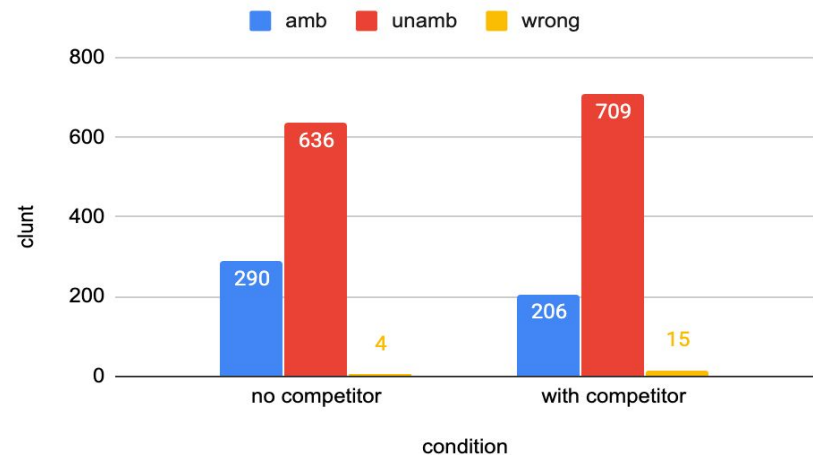
- **A. his wife is a ballet dancer. (target)**
- **B. he accompanies himself on the drums.**
- C. (filler continuation 2)

Results: RSA effect is also confirmed by the new stimuli under restricted setting

Yung and Demberg 2018
(36 stimuli x 12 workers x 2 conditions)



New stimuli
(62 stimuli x 15 workers x 2 conditions)



- 11% increase in **unambiguous** DC choice (significant difference (χ^2 p -value < 0.0001))
- The choice **was not as even** in the “no competitor” condition because this time we used “**because**” rather than “**as**” as the unambiguous option for “**since**”.

Experiment 2: Production of discourse relations in context without interpretation restriction

Recall:

Expected condition

(expected in context = **actual** continuation)

Chris is a professional artist and so is his wife. However, his talent is very different from hers: he plays the saxophone ...

_____ (**while / whereas / so**)
his wife is a ballet dancer.

Unexpected condition

(expected in context **!= actual** continuation)

I am going to the music festival with my friends next week. I look forward to the particular performance by a musician who can play two instruments at the same time: he plays the saxophone ...

_____ (**while / whereas / so**)
his wife is a ballet dancer.

Neutral condition

Neutral context
for comparison.

Prediction: for the same discourse relation, the speaker will use **an unambiguous DC (e.g. “whereas”) more in the unexpected condition** because it is harder for the listener to interpret.

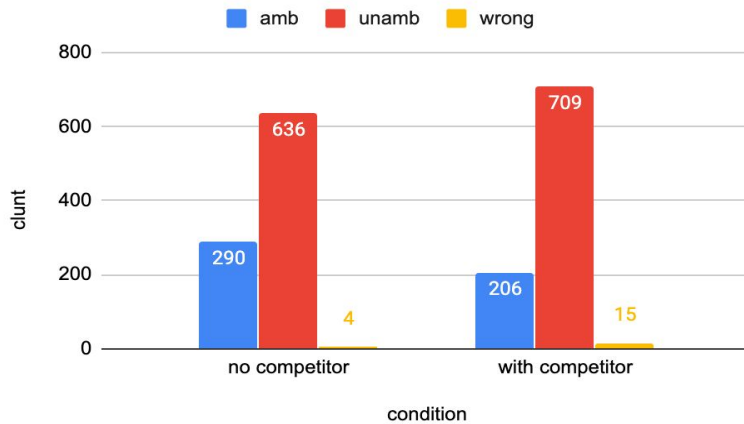
Experiment 2: Production of discourse relations in context without interpretation restriction

Instructions:

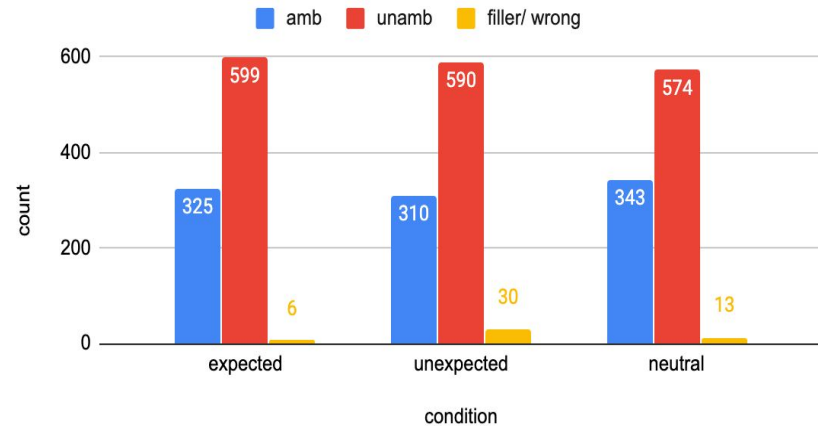
In each question you will see a few sentences, which are the first few sentences of a story. Imagine you are reading this to your friend over the phone, but somehow one of the words is blurred and you cannot read it at all. What word or phrase would you say in place of it? Please choose from the provided options.

Experiment 2: Testing RSA speaker production without interpretation restriction

Language game version



Contextual expectedness version



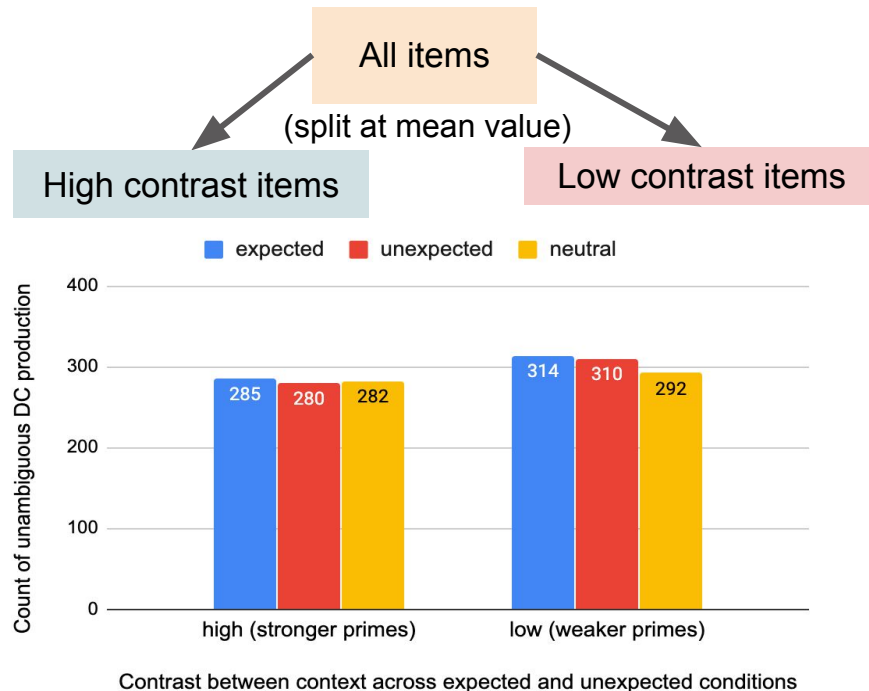
- **No significant difference** in proportion of “amb” and “unamb” DCs across conditions.
- Unexpected condition has **significantly more wrong** answers. (χ^2 *p-value* < 0.0001)
- The proportions **differ per DC and discourse relation**, but there was **no significant difference across conditions** in any of the dc or discourse relation groups.

RSA effect was not confirmed in the “contextual expectedness” experiment

- RSA effect is confirmed using a **new set** of stimuli under the **same restricted setting** as in previous work.
- However, using the **same set** of stimuli **under unrestricted setting**, the RSA effect is not confirmed.
- Speakers generally **prefer an unambiguous DC** for the target discourse relation **no matter if the discourse relation is expected or unexpected in context**.

Analysis based on pretest scores

- Pretest 2 scores each item by the “**bias between expected-unexpected contexts**”.

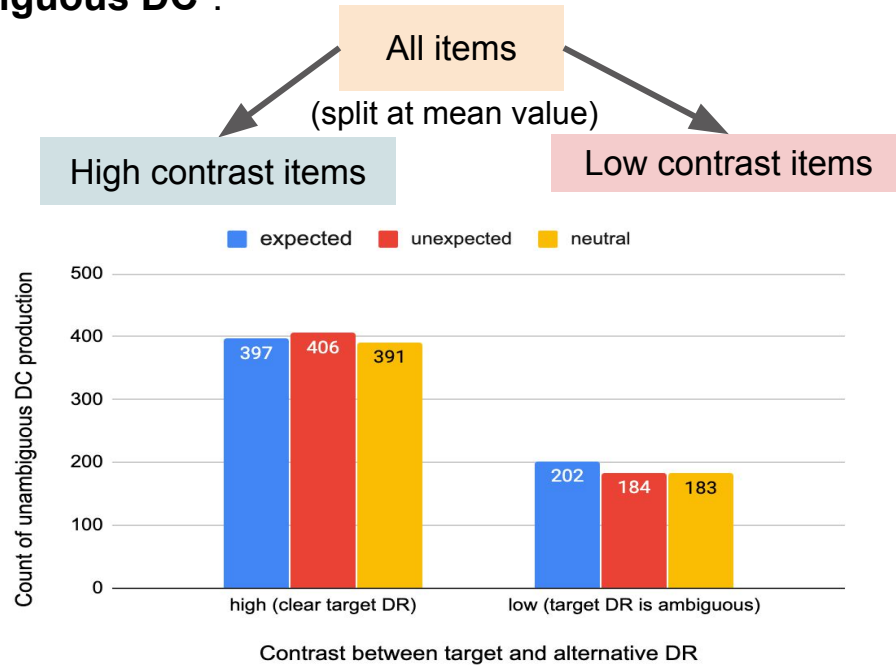


Is RSA effect shown in items where the **contrast between the cross-condition contexts is larger ?**

No. There isn't any significant difference across conditions in **both groups.**

Analysis based on pretest scores

- Pretest 1 scores each item by the “**contrast between alternative meanings of the ambiguous DC**”.



Is RSA effect shown in items where the **contrast between the alternative meanings is larger** ?

No. There isn't any significant difference across conditions **within both groups**. However, it is clear that speakers **use unambiguous dcs less often** when the contrast is small.

Why do speakers prefer ambiguous dcs when the contrast of alternative meanings is small?

- Speakers prefer ambiguous dcs when the **contrast between alternative meanings is small**.
- If the contrast is small, the target relation we want them to produce is **less clear**.

E.g. James has been studying very hard (since/ever since) **he entered secondary school 2 years ago....**

- Target production: *temporal* meaning
 - *Reason* reading is also possible.
- People may **prefer an ambiguous DC** because they are **not sure** which relation they are “producing”, or they want to “**produce**” **multiple relations**.
 - **Design drawback:** the participants are partially acting as “**listeners**”.
 - Nonetheless, this design is used in **both the restricted and unrestricted** settings, but cross-condition difference is seen **only in the restricted setting**.

- As **listeners**, people are sensitive to the **expectedness of discourse relations in context**. (pretest result)
- As **speakers**, people prefer to use **unambiguous DCs**.
 - Unless they think the target discourse relation has multiple senses
- The DC choice is **not affected** by the expectedness of DRs **even when the contrasts in expectedness and alternative readings are high**.
- Possible reasons:
 - When the number of **possible interpretation is not restricted to a small set**, the “unambiguous” dc option is **not much more useful**.

Comparing the restricted and unrestricted settings

- **Restricted “language game” setting**

...he plays the saxophone _____ (while / whereas / so) his wife is a ballet dancer.

Unambiguous condition

- B. (continuation that does not fit while/whereas)
- C. (continuation that does not fit while/whereas)

Ambiguous condition

- B. he accompanies himself on the drums.
- C. (continuation that does not fit while/whereas)

The listener will get it right no matter if I choose “while” or “whereas”



speaker

The listener may choose B if I choose “while”, so “whereas” is clearer.



speaker

Comparing the restricted and unrestricted settings

- Unrestricted “contextual expectedness” setting

Expected condition

Chris is a professional artist and so is his wife.
However, his talent is very different from hers.
Chris loves music:

Unexpected condition

I am going to the music festival with my friends next week. I look forward to the particular performance by a musician who can play two instruments at the same time:

he plays the saxophone _____ (**while / whereas / so**) **his wife is a ballet dancer.**

The continuation is natural / unexpected..
“**Whereas**” should avoid confusion anyway.

The superiority of “whereas” is **not clearer** in the unexpected condition.



speaker

Conclusion

- RSA predicts that when speakers think the listeners might have **difficulty interpreting a discourse relation**, a more **unambiguous DC** is used.
- We examined whether RSA prediction still holds in **less restricted conditions**.
- We manipulated **interpretation difficulty** by **expectedness of the discourse relation**
- It is challenging to test people's preference in DC production:
 - The difference between the DC choices is **subtle**.
 - It is not trivial to “instruct” the participants to **produce a particular discourse relation**.

Conclusion

- We first **replicated** the findings of Yung and Demberg 2018: confirming RSA prediction in DC production under **restricted condition where the set of possible interpretation is pre-defined**.
- However, we **did not find any significant difference** of DC preference between the expected and unexpected conditions when **the set of interpretation is not restricted**.
- It provides evidence that speakers **do not estimate interpretation difficulty in the same way** when the alternatives are restricted and unrestricted.

Next:

- The language game manipulates “**ambiguity**” but not “**expectedness**”.
Not direct comparison. We will next try a “**combined version**”.

expectedness version: unexpected condition
(expected in context != actual continuation)

I am going to the music festival with my friends next week. I look forward to the particular performance by a musician who can play two instruments at the same time: he plays the saxophone.

_____ (while / whereas / so)
his wife is a ballet dancer.

game version: ambiguous condition
(No competitor in the give options that share DCs with the target continuation)

(neutral context) I had a very nice lunch with my old friend Chris today. I haven't seen him in a long time. Chris loves music: he plays the saxophone...

_____ (while / whereas / so)

- A. his wife is a ballet dancer.
- B. he accompanies himself on the drums.
- C. (filler continuation 1)

Thank you

References:

- Isaacs, Ellen A., and Herbert H. Clark. "References in conversation between experts and novices." *Journal of experimental psychology: general* 116.1 (1987): 26.
- Wilkes-Gibbs, Deanna, and Herbert H. Clark. "Coordinating beliefs in conversation." *Journal of memory and language* 31.2 (1992): 183-194.
- Lane, Liane Wardlow, Michelle Groisman, and Victor S. Ferreira. "Don't talk about pink elephants! Speakers' control over leaking private information during language production." *Psychological science* 17.4 (2006): 273-277.
- Brown-Schmidt, Sarah, Christine Gunlogson, and Michael K. Tanenhaus. "Addressees distinguish shared from private information when interpreting questions during interactive conversation." *Cognition* 107.3 (2008): 1122-1134.
- Heller, Daphna, Daniel Grodner, and Michael K. Tanenhaus. "The role of perspective in identifying domains of reference." *Cognition* 108.3 (2008): 831-836.
- Frank, Michael C., and Noah D. Goodman. "Predicting pragmatic reasoning in language games." *Science* 336.6084 (2012): 998-998.
- Degen, Judith, Michael Franke, and Gerhard Jäger. "Cost-based pragmatic inference about referential expressions." *Proceedings of the annual meeting of the cognitive science society*. Vol. 35. No. 35th 2013.
- Goodman, Noah D., and Andreas Stuhlmüller. "Knowledge and implicature: Modeling language understanding as social cognition." *Topics in cognitive science* 5.1 (2013): 173-184.
- Qing, Ciyang, and Michael Franke. "Variations on a Bayesian theme: Comparing Bayesian models of referential reasoning." *Bayesian natural language semantics and pragmatics*. Springer, Cham, 2015. 201-220.
- Yung, Frances, et al. "A psycholinguistic model for the marking of discourse relations." *Dialogue & Discourse* 8.1 (2017): 106-131.

Questions? Comments?



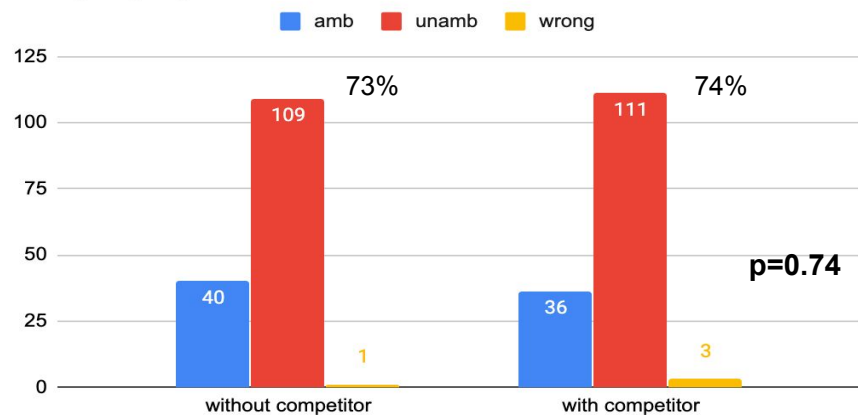
UNIVERSITÄT
DES
SAARLANDES

Acknowledgement:

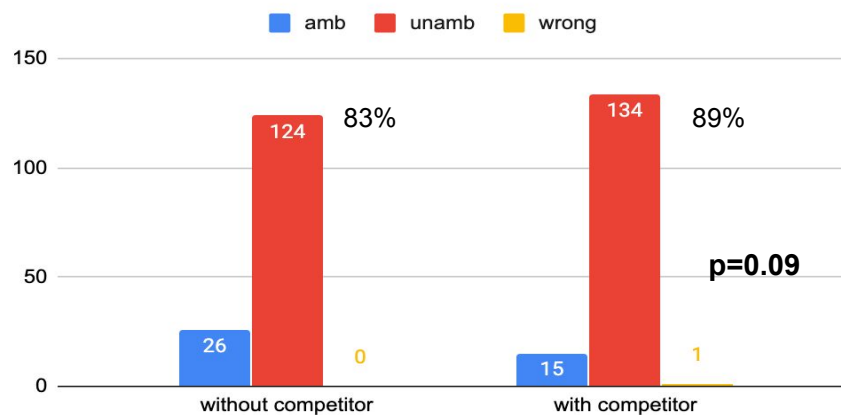
This research has been funded by the German Research Foundation (DFG) as part of SFB 1102 'Information Density and Linguistic Encoding' at the University of Saarland.

New stimuli: the difference is not significant when “because” is the unambiguous choice.

Language game : "as" vs "because"



Language game: "since" vs "because"



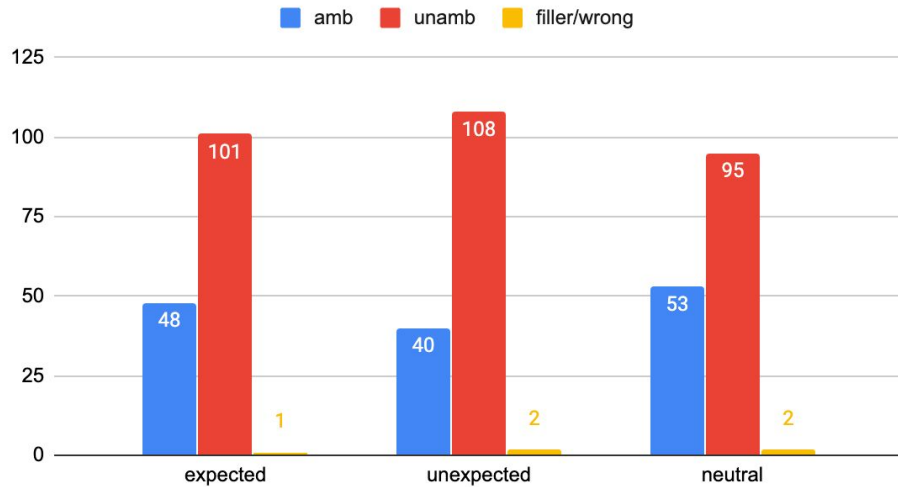
- The increase in unamb. DC choice is much clearer in other DC pairs

% of unamb. DC	w/o competitor	With competitor	Chi-sq test P-value
“Since” vs “ever since”	82%	93%	0.007209
“As” vs “when/while”	72%	81%	0.063
“While” vs “whereas/bus”	68%	81%	0.007011
“While” vs “at the same time”etc	36%	42%	0.1962

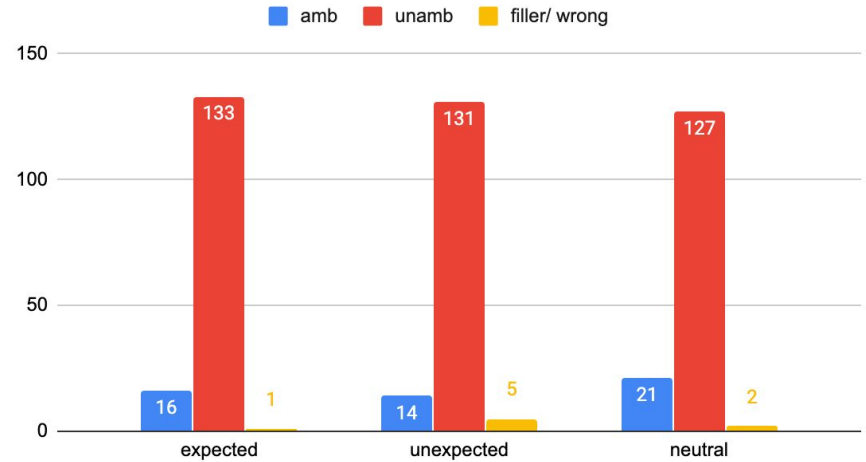
Grouped by target DR and dc options

When the *unambiguous* dc is more common

Reason ("as" vs "because")



Reason ("since" vs "because")

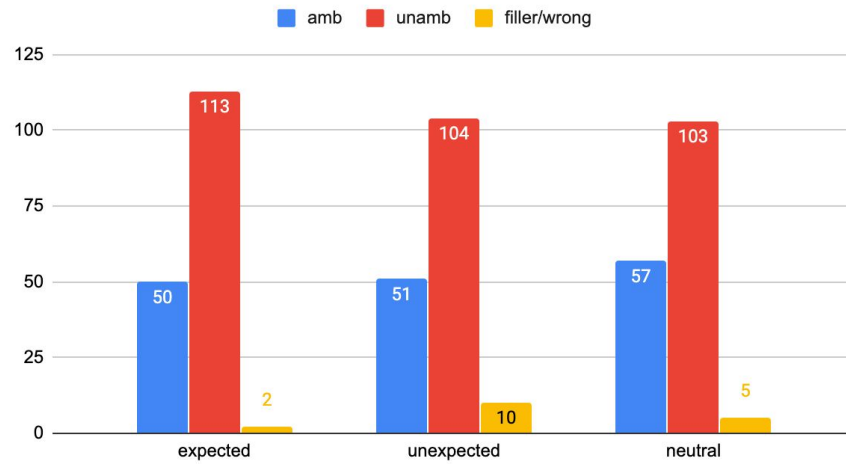


- “Because” is a dominant DC for “reason”: people prefer it all the time .
- No significant difference across conditions.

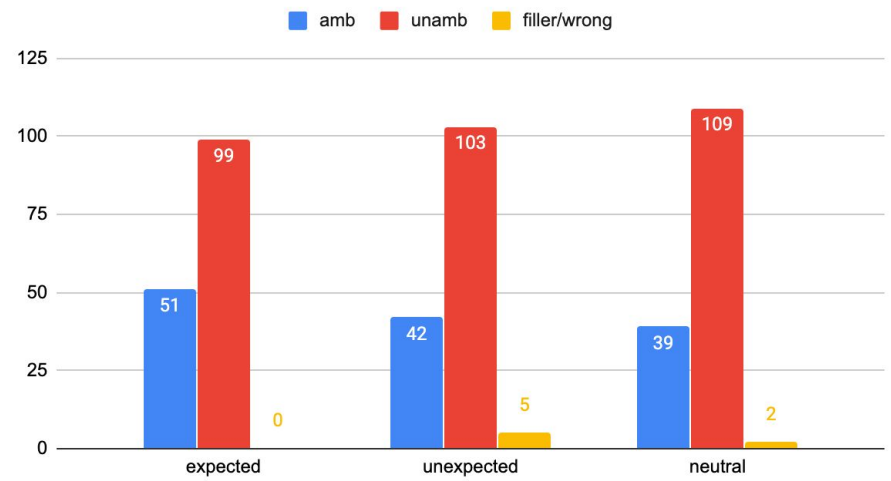
Grouped by target DR and dc options

When the *unambiguous* and *ambiguous* dcs are similarly common

Contrast ("while" vs "whereas/but")



Synchronous ("as" vs "when/while" etc.)

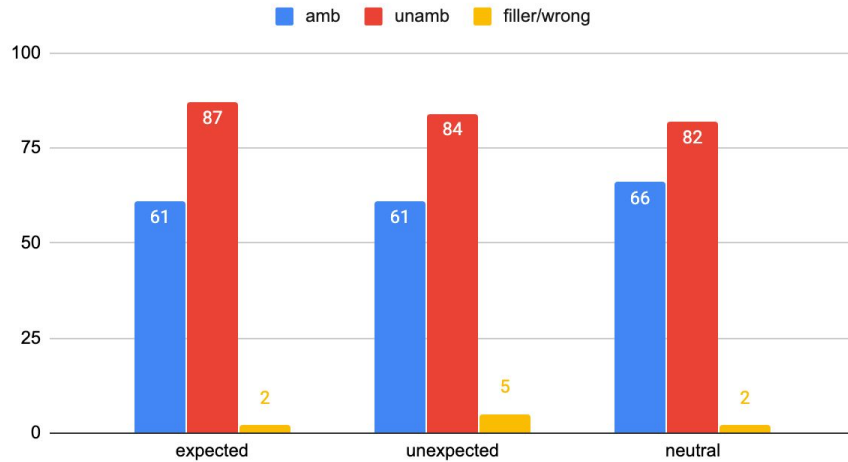


- The preference on the unamb. version is less strong than “because”, but still strong.
- No significant difference across conditions.

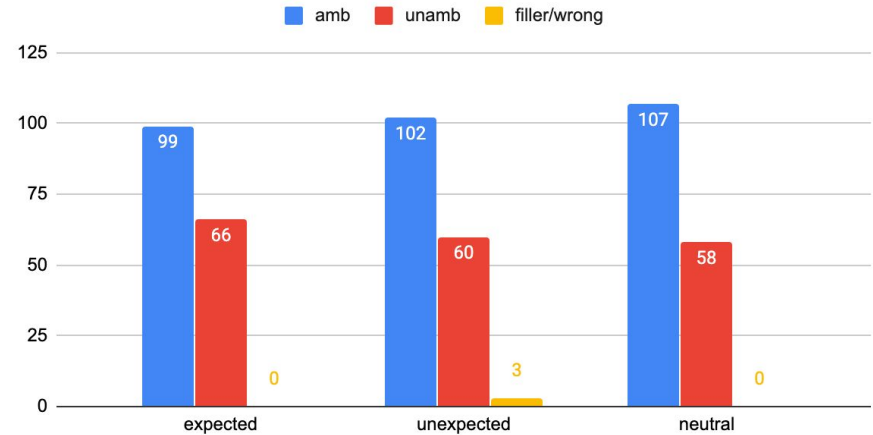
Grouped by target DR and dc options

When the *unambiguous* is rare / hard to produce

Succession ("since" vs "ever since")



Synchronous ("while" vs "when/during the time when/at the same time as" etc.)



- People **choose the ambiguous "while"** if the unambiguous alternative is long.
- Still, no significant difference across conditions.

But not the case in the "language game" version. Why?

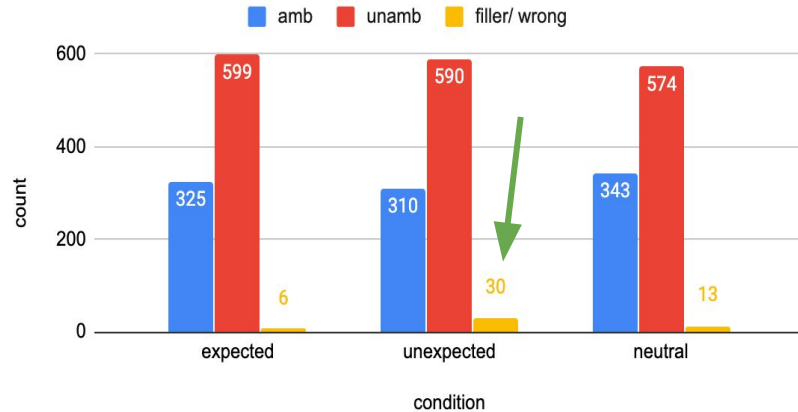
Analysis based on pretest results

- “Speakers” may be **unsure** about what relation they are “**producing**”.

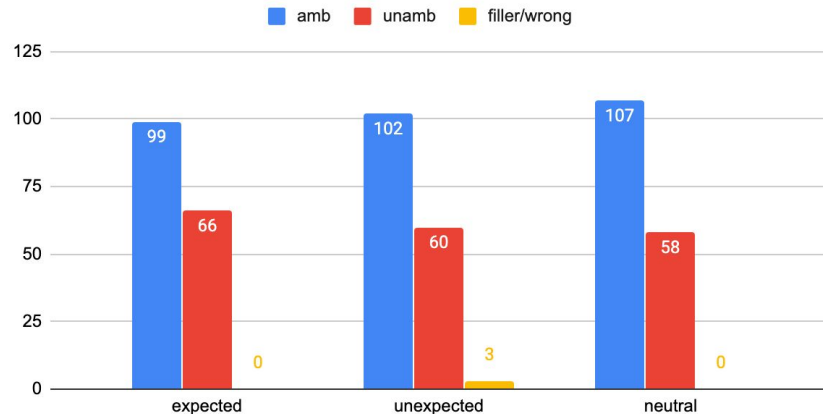
Significantly **more wrong answers** in “unexpected” condition.)

Contrast between alternative readings of the “as” items: 65% “since”: 67% “while” : **56%**

Overall



Synchronous (“while” vs “when/during the time when/at the same time as” etc.)



Explanation by RSA speaker model

RSA Speaker model:

$$P_{S1}(dc \mid DR, C) \propto \exp(\alpha (\log L_0(DR \mid dc, C) - Cost(dc)))$$

$$= (1 / \text{no. of } DR \text{ marked by } dc) P(DR \mid C) \text{ expectedness}$$

Limit the possible interpretations:

	Ambiguous DC (while)	Unambiguous DC (whereas)
No. of DRs in unambiguous condition	1	1
No. of DRs in ambiguous condition	2 $L_0(DR \mid dc, C) = 0.5$	1 $L_0(DR \mid dc, C) = 1$

Individual differences:

Some people clearly used pragmatic reasoning:

- I tried my best to use process of elimination by going through each word.
- Tried to select a word that would not fit with the two wrong statements rather than the first one I read which made sense. e.g. using "ever since" instead of "since" for a time related reason.
- process of elimination to see which fits best!
- tried to match each of the connective with all the options to find the one that only made sense with the target sentence, to reduce ambiguity.
- I went with what was grammatically correct and, sometimes, if more than one option worked I read through the other choices to see what would not fit those answers.
- If there were sentences that could fit multiple connectives, I tried to match all 3 up to their own connectives and every time it eliminated any overlap from my initial method.

Some said they did not use any strategy or consider the alternatives

- I tried to choose the most grammatically correct option that also made sense from a tense perspective.
- I just read the sentence fully to see which conjunction made sense.
- I did not use any strategy, since I am a native speaker the right answers come naturally to me.
- I just picked the answer that sounded best for the sentence in my head.
- I read the lines out loud...then it made more sense to me.
- No strategy at all. just picked the one conjunction that actually made sense in the context.
- I chose the word that made the most sense. Sometimes there were multiple options that made sense, in which case I chose the word that went most naturally in my opinion

Some learnt it as the game proceeded.

- I aimed to use the connective which couldn't work with the other sentence endings provided. Although, I only learned that this was the optimal strategy after a few rounds.
- Initially I was using obvious completion and then when it was more ambiguous, I was looking to exclude the other options as well.

Questions

- Is it a matter of choice? Can people use pragmatic reasoning if they choose to use it, e.g. when they want to win a language game?
- Do people use pragmatic reasoning outside a language game? Or is the effect out-weighted by other factors in natural speech production?
- Concerning those people who said they did not use pragmatic reasoning, did they choose not to use it or did they not know how?
- Did they actually use pragmatic reasoning without knowing it?