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Dynamic encoding of agreement features and its effects on interference

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Agreement attraction

Agreement dependencies are subject to **interference** from structurally irrelevant nouns:

SG   PL   PL

The key *to the* cabinets ***were*** *lost*

Bock & Miller, 1991; Wagers et al., 2009; a.o.

In this project, we investigate how this interference operates when multiple agreement dependencies are involved.

Agreement dependencies

Across languages, agreement features can be found not only on verbs, but also on adjectives and pronouns:

SG   SG   SG

*The nervous **dancer** **was** preparing **herself** for the show*

SG.F   SG.F   SG.F   SG.F

*ha-rakdan**it** ha-lexuc**a**   hexin**a**   et acm**a** la-hopa'a*   Hebrew

The dancer   the nervous   prepared herself   for the show

Alignment in multiple agreement sites

Setting agreement features of a verb seems to:

- **set the features of its complement** (Molinaro et al., 2008);

The dancer were *nervously preparing* **herself** | **themselves.**

Alignment in multiple agreement sites

Setting agreement features of a verb seems to:

- **set the features of its complement** (Molinaro et al., 2008); and
- **make the complement less susceptible to interference** (Keshev, 2021).

*The dancer were nervously preparing **herself** | **themselves.***

*The dancer with the nice friends was nervously preparing **herself** | **themselves.***

The current study

Here we test if these results generalize to cases where agreement sites are not directly associated, using **VP coordinations.**

The apprentice of the {chef | chefs} $\begin{matrix} works \\ worked \end{matrix}$ *diligently and **were** recruited by a top restaurant.*
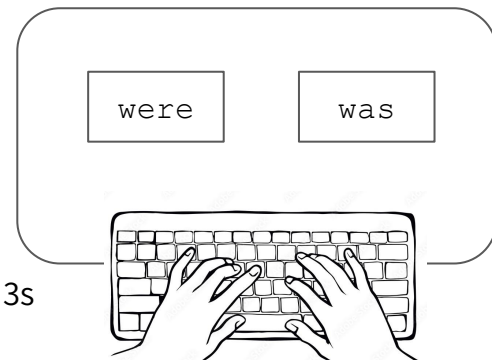
In English, number agreement on the first verb is manipulated by shifting its tense.
Attraction is measured on the second verb, by manipulating the features of the distractor noun.

Experiment 1: English 2AFC

+

The

apprent

of

the

chef

work

diliger

and

400ms per word
(250 + 150 ISI)
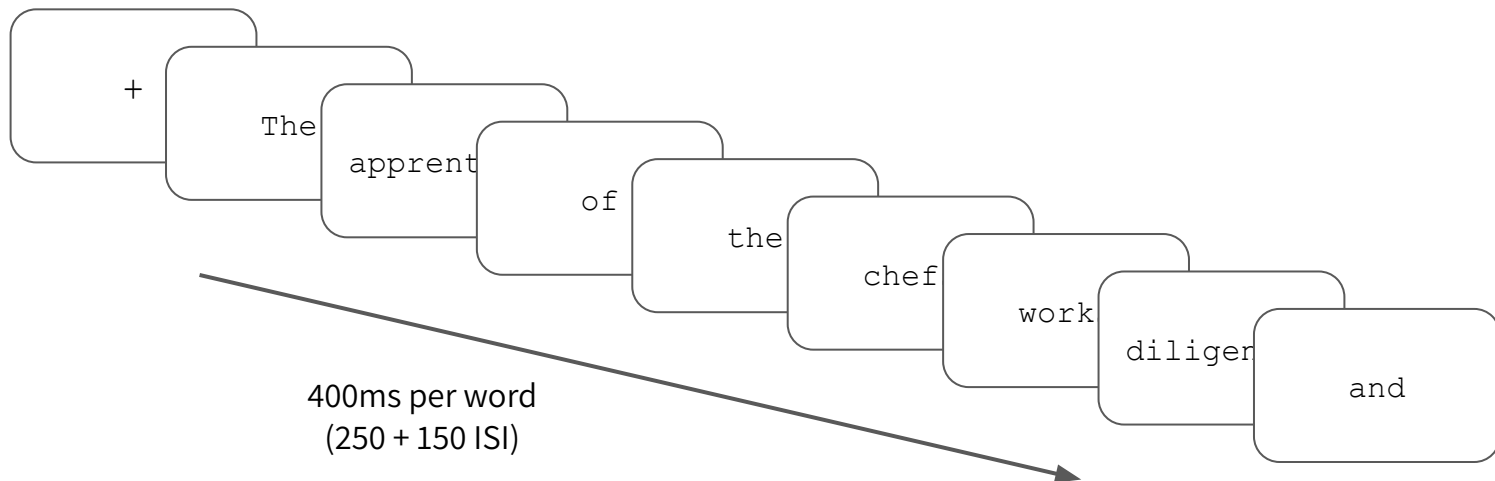
36 sets, half end with an auxiliary
& half with a present tense verb
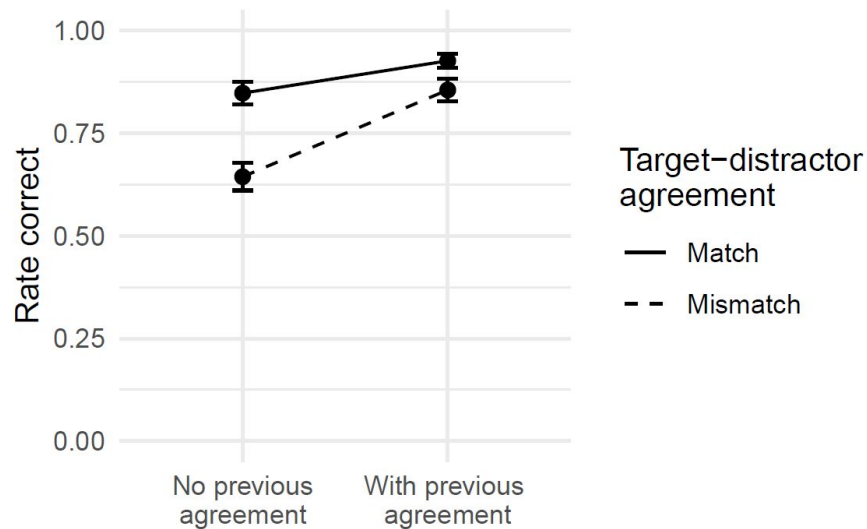
+108 filler items

were   was

Timeout after 3s

Experiment 1: English 2AFC

Interaction between the agreement of the distractor and availability of a previous agreement cue (BF=10.1).

The distractor impairs accuracy more when no agreement cue is available on the first verb (0.93 [0.62, 1.27] vs. 0.42 [0.02, 0.84]).

36 items, 61 participants

The apprentice of the chef/chefs works/worked diligently and _____
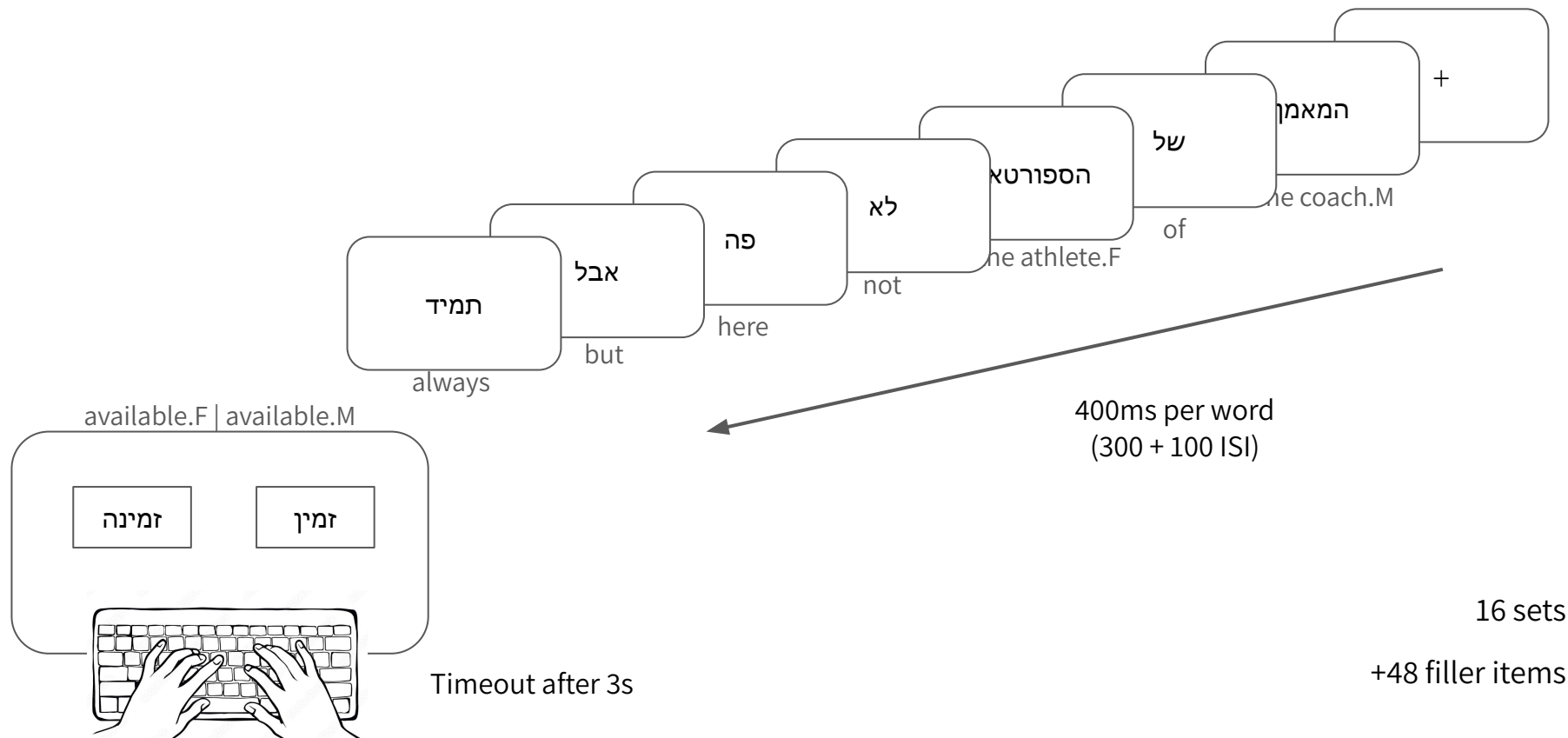
Experiment 2: Hebrew 2AFC

Experiment 2 uses the same task but assesses **gender attraction** in Hebrew.

The manipulation of cue availability was implemented through the option of nominal sentences, lacking a verb.

*ha-meamen Sel ha-sportai/t   lo   {nimca | ⌀} po   aval **zmina**   ba-telefon*

The coach.M of   the athlete.M/F not {located.M | ⌀} here but   **available.F** on the phone.

Experiment 2: Hebrew 2AFC

תמיד
always

אבל
but

פה
here

לא
not

הספורטא
he athlete.F

של
of

המאמן
he coach.M

+

400ms per word
(300 + 100 ISI)

available.F | available.M

זמינה

זמין

Timeout after 3s

16 sets

+48 filler items

Experiment 2: Hebrew 2AFC

No interaction (BF=8.48 for the null).

This could reflect a ceiling effect: a unified analysis suggested no difference between the Hebrew and English patterns, i.e. no three-way interaction (BF=51 for the null).
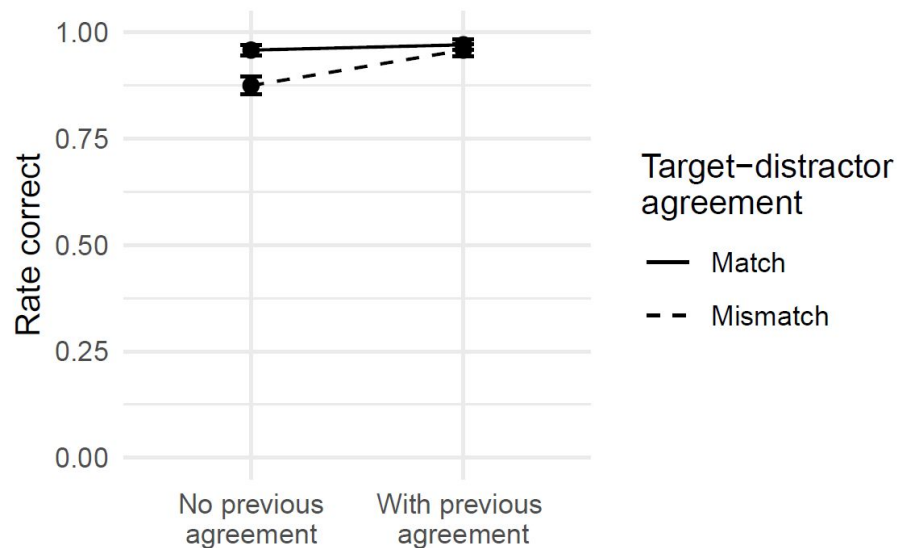
16 items, 62 participants

The coach.M of the athlete.M/F not ⃠/located.M here but _____

Next steps

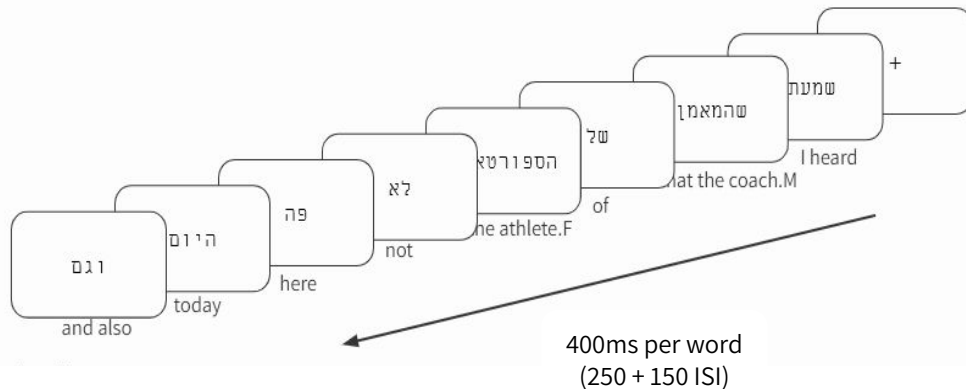English eyetracking while reading
(data collection in progress)

New and improved Hebrew 2AFC (planned)

The apprentice of the chefs works diligently and **were recruited** by a top restaurant.

400ms per word
(250 + 150 ISI)

See backup slides D-G for design and preliminary eye tracking data

Discussion: Mechanisms of agreement updating

We suggest that verbal agreement can be used to update the memory representation of the subject noun and its grammatical features.

This can arise in two ways:

- **Attractor function of the verb** Features migrate from the verb to the subject just as they migrate from distractor nouns (under a modified Marking & Morphing account, Paape et al., 2021).

- **Rational inference** The information on the verb reduces uncertainty about memory representations through choisy-channel (Ryskin et al., 2022).

See backup slides H-I additional discussion of the updating interpretation and models attraction

Thanks!

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FULBRIGHT

NSF BSF

Backup slides and extra materials

# Background: Alignment in multiple agreement sites

Setting agreement features of a verb seems to **set the features of its complement:**

- Production of an agreement error at the auxiliary verb is usually followed by a corresponding error in a subsequent predicative adjective, in Spanish (Antón-Méndez, Nicol, & Garrett 2002).

- English reflexive pronouns give rise to a P600 effect, canonically associated with ungrammaticality, when they mismatch the preceding verb despite matching the subject noun (Molinaro, Kim, Vespignani, & Job 2008).

- In 2AFC completion in Hebrew, an agreeing verb (either grammatical or ungrammatical) counteracts the effect of an attractor in a subsequent reflexive pronouns (Keshev, 2021).

A

Experiments 1-2: Materials

Target-distractor agreement	Availability of a previous cue	Sentence	Response options
MATCH	+AGREEMENT	*The apprentice of the chef works diligently and*	*was* | *were*
MISMATCH	+AGREEMENT	*The apprentice of the chefs works diligently and*	*was* | *were*
MATCH	-AGREEMENT	*The apprentice of the chef worked diligently and*	*was* | *were*
MISMATCH	-AGREEMENT	*The apprentice of the chefs worked diligently and*	*was* | *were*
MATCH	+AGREEMENT	*hameamen šel hasportai lo nimca po aval tamid* the-coach.M of the-athlete.M not located.M here but always	*zamin* | *zmina* available.M | F
MISMATCH	+AGREEMENT	*hameamen šel hasportait lo nimca po aval tamid* the-coach.M of the-athlete.F not located.M here but always	*zamin* | *zmina* available.M | F
MATCH	-AGREEMENT	*hameamen šel hasportai lo po aval tamid* the-coach.M of the-athlete.M not here but always	*zamin* | *zmina* available.M | F
MISMATCH	-AGREEMENT	*hameamen šel hasportait lo po aval tamid* the-coach.M of the-athlete.F not here but always	*zamin* | *zmina* available.M | F

B

Experiments 1-2: Response times in the 2AFC task
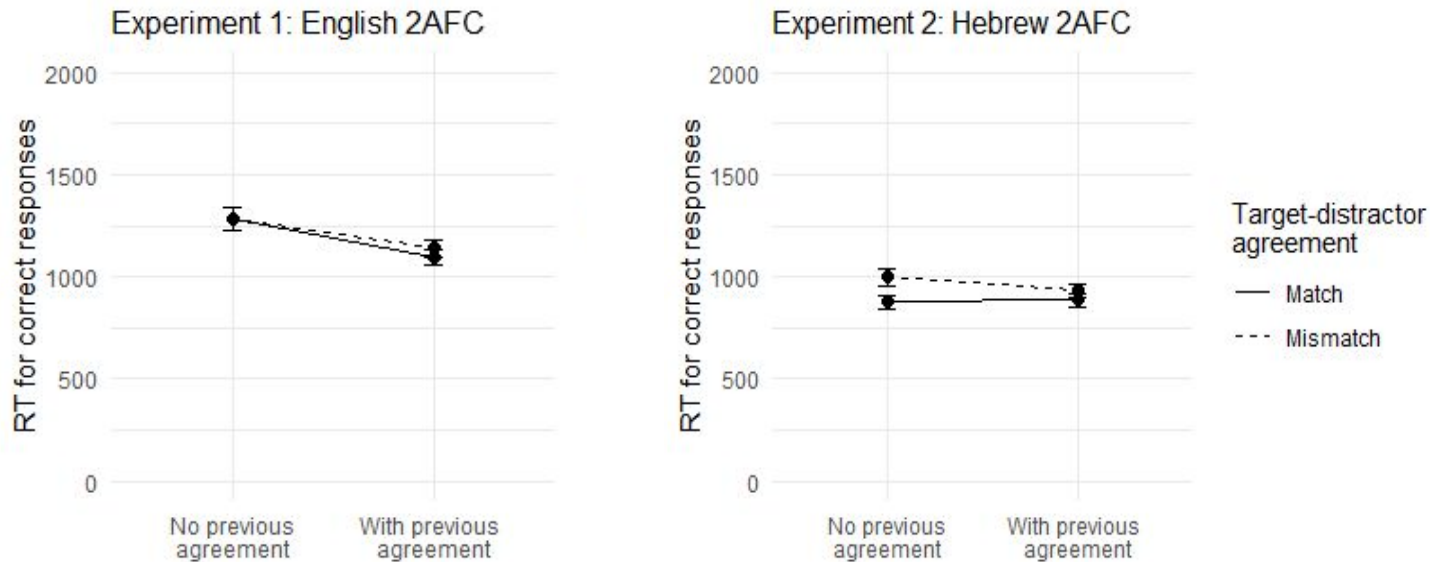
No RT effects in English. The pattern of Hebrew RTs align predictions but effects are not reliable (evidence for the null over an interaction model).

C

Experiment 3: English eye-tracking while reading

The apprentice of the chefs works diligently and **were recruited** by a top restaurant.

D

Experiment 3: English eye-tracking while reading

```
Who was recruited by a top restaurant?

    The chef        The apprentice
    The chefsThe apprentices
```
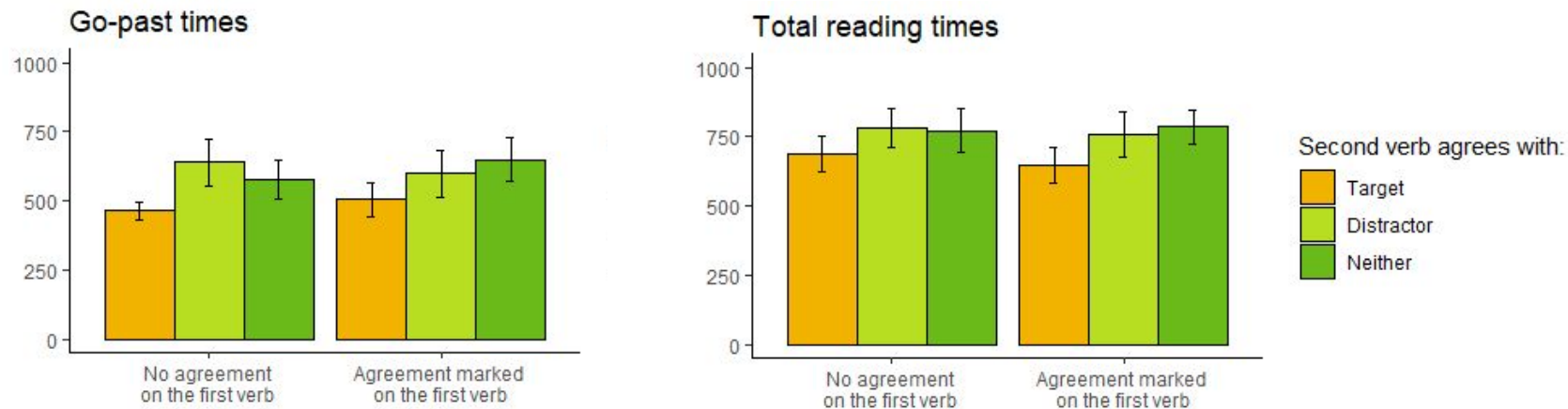
D

Experiment 3: English eye-tracking while reading

Six conditions:

	EARLY AGREEMENT CUE	NO AGREEMENT CUE
<u>TARGET-VERB MATCH</u>	*The **apprentices** of the chef*	*work* | *worked*
<u>DISTRACTOR-VERB MATCH</u>	*The apprentice of the **chefs***	*works* | *worked*
<u>NO MATCH</u>	*The apprentice of the chef*	*works* | *worked*

diligently and ***were recruited*** *by a top restaurant.*

E

Experiment 3: Preliminary reading time data

Go-past times

Total reading times

Second verb agrees with:
- Target
- Distractor
- Neither

NO MATCH   *The apprentice of the chef   works | worked*
DISTRACTOR MATCH   *The apprentice of the chef**s**   works | worked*   36 items, 19 participants (out of 96 planned)
TARGET MATCH   *The apprentice**s** of the chef   work | worked*

   *diligently and **were recruited** by a top restaurant.*

F

Experiment 3: Preliminary reading time data

No clear reading time effects at the moment.
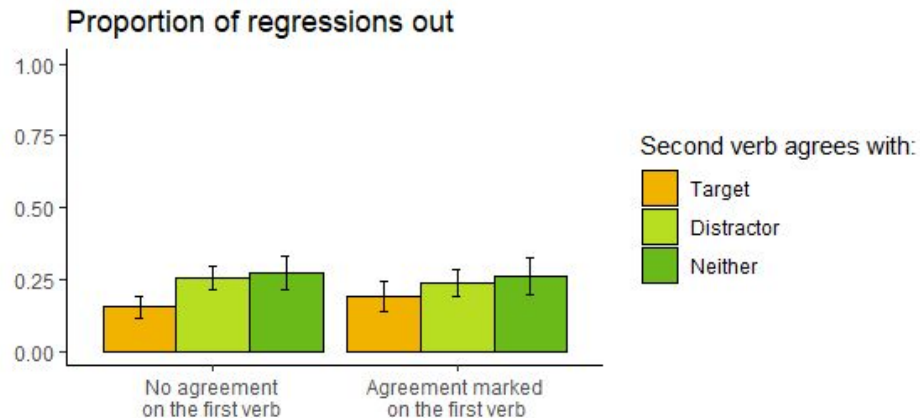
Proportion of regressions out

Second verb agrees with:
- Target
- Distractor
- Neither

NO MATCH   *The apprentice of the chef   works | worked*
DISTRACTOR MATCH   *The apprentice of the chef**s**   works | worked*   36 items, 19 participants (out of 96 planned)
TARGET MATCH   *The apprentice**s** of the chef   work | worked*
                    *diligently and **were recruited** by a top restaurant.*

F

Experiment 3: Preliminary comprehension accuracy data

The agreement cue at the first verb might increase comprehension accuracy.

36 items, 19 participants (out of 96 planned)

G
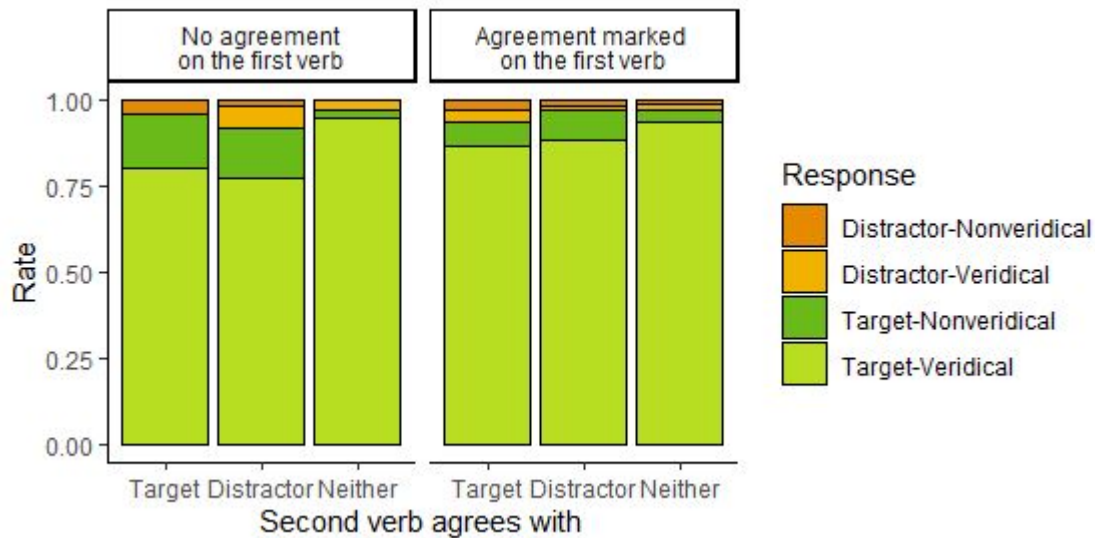
Discussion: Mechanisms of agreement updating

Why should we take this effect to reflect updating of the subject's representation rather than direct copying of features from one verb to another?

Agreement cues (on verbs\pronouns) affect the memory of the target noun in offline comprehension, on top of the effect of the distractor:

- Plural verbs can lead readers to understand the subject of the sentence to be plural even without a plural distractor noun (English - Brehm et al., 2019, 2021; Patson & Husband, 2016)

- Grammatical resumptive pronoun can help readers remember the gender of the filler (Hebrew - Koesterich et al., 2021)

H

Discussion: Compatibility with models of attraction

The effect of an intermediate cue on attraction rates can be accommodated in models where the distractor creates uncertainty about:

- the subject's feature content, i.e. Marking and Morphing (Eberhard et al., 2005); or
- the structural relations in the sentence, i.e. Self-Organizing Sentence Processing (Smith et al., 2018).

The Cue-Based Retrieval model (Lewis & Vasishth, 2005), which derives interference from activation of veridical memory representations, currently does not accommodate such effects since the activation of the distractor is similar, regardless of the form of the verb in the first conjunct.