Dynamic encoding of agreement features and its effects on interference

Maayan Keshev, Mandy Cartner, Anissa Neal, Aya Meltzer-Asscher, & Brian Dillon
Agreement attraction

Agreement dependencies are subject to interference from structurally irrelevant nouns:

*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:

The nervous dancer was preparing herself for the show

Hebrew

The dancer the nervous prepared herself for the show
Setting agreement features of a verb seems to:

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

\[
\text{The dancer were nervously preparing } \underline{\text{herself}} | \underline{\text{themselves}}.\]
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} worked 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.

See backup slide B for a full set
Experiment 1: English 2AFC

The apprentice of the chef works diligently and 400ms per word (250 + 150 ISI)

36 sets, half end with an auxiliary & half with a present tense verb
+108 filler items

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.

\[
\text{ha-meamen Sel ha-sportai/t lo \{nimca | \(\Box\) po aval zmina ba-telefon}
\]

The coach.\(\text{M}\) of the athlete.\(\text{M}/\text{F}\) not \{located.\(\text{M}\) | \(\Box\)\} here but **available.\(\text{F}\)** on the phone.
Experiment 2: Hebrew 2AFC

The coach. M

the athlete. F

Experiment 2: Hebrew 2AFC

The coach. M

the athlete. F

available. F | available. M

always

but

here

not

400ms per word
(300 + 100 ISI)

16 sets

+48 filler items

Timeout after 3s
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).

Experiment 2: Hebrew 2AFC

16 items, 62 participants

See backup slide C for RT data

*The coach.*₇ of the athlete.₇/F not ə/located.₇ here but ____
The apprentice of the chefs works diligently and were recruited by a top restaurant.

English eyetracking while reading (data collection in progress)

New and improved Hebrew 2AFC (planned)

See backup slides D-G for design and preliminary eye tracking data
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).
Thanks!

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Backup slides and extra materials
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).
### Experiments 1-2: Materials

<table>
<thead>
<tr>
<th>Target-distractor agreement</th>
<th>Availability of a previous cue</th>
<th>Sentence</th>
<th>Response options</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATCH</td>
<td>+AGREEMENT</td>
<td><em>The apprentice of the chef</em> works diligently and was</td>
<td>was</td>
</tr>
<tr>
<td>MISMATCH</td>
<td>+AGREEMENT</td>
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<tr>
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<td><em>hameamen šel hasportai</em> lo nimca po aval tamid the-coach.M of the-athlete.M not located.M here but always available.M</td>
<td>zamin</td>
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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).
The apprentice of the chefs works diligently and were recruited by a top restaurant.
Experiment 3: English eye-tracking while reading

Who was recruited by a top restaurant?

The chef    The apprentice
The chefs    The apprentices
Six conditions:

<table>
<thead>
<tr>
<th></th>
<th><strong>EARLY AGREEMENT CUE</strong></th>
<th><strong>NO AGREEMENT CUE</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>TARGET-VERB MATCH</td>
<td>The apprentices of the chef</td>
<td>work</td>
</tr>
<tr>
<td>DISTRACTER-VERB MATCH</td>
<td>The apprentice of the chefs</td>
<td>works</td>
</tr>
<tr>
<td>NO MATCH</td>
<td>The apprentice of the chef</td>
<td>works</td>
</tr>
</tbody>
</table>

diligently and **were recruited** by a top restaurant.
Experiment 3: Preliminary reading time data

NO MATCH

DISTRACTER MATCH

TARGET MATCH

---

The apprentice of the chef works | worked
diligently and were recruited by a top restaurant.

36 items, 19 participants (out of 96 planned)
Experiment 3: Preliminary reading time data

No clear reading time effects at the moment.

36 items, 19 participants (out of 96 planned)

<table>
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<th>The apprentice of the chef</th>
<th>works</th>
<th>worked</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISTRACTER MATCH</td>
<td>The apprentice of the chefs</td>
<td>works</td>
<td>worked</td>
</tr>
<tr>
<td>TARGET MATCH</td>
<td>The apprentices of the chef</td>
<td>work</td>
<td>worked</td>
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</table>

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

Discussion: Compatibility with models of attraction