Neurocognitive Plasticity of Verb Bias Learning : An ERP Study

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Introduction

❖ The likelihood of structural alternatives for verbs (verb bias) plays a central role in guiding online ambiguity resolution.

A. Evidence from garden-path sentences:

(1) *"The referee warned the spectators **would** get too rowdy."*
Longer reading time and larger P600 at *would*, because *warn* is a direct-object biased verb [1, 2].

(2) *"Put the apple on the **napkin** in the box."*
Erroneous fixation to the incorrect destination at *napkin* in a visual world paradigm, because *put* requires a goal for the verb [3, 4].

B. Evidence from globally ambiguous sentences:

(3) *"Tickle the frog with the **feather**."* vs. "*Choose the frog with the **feather**.*" in an ambiguous visual world context.
More fixations to the target instrument at *feather* in the "*tickle*" sentence than in the "*choose*" sentence, because *tickle* is an instrument-biased verb and *choose* is a modifier-biased verb [5].

❖ Event-related potentials (ERP) have been used in the exploration of the neural processes underlying language learning.

A. Similar P600 pattern in statistical learning of artificial grammar as found in natural language processing [6].

B. N400 response to L2 ungrammatical sentences in learners with lower proficiency or during earlier learning stage was replaced by a P600 response at a later learning stage [7, 8]

Questions

- What are the real time electrophysiological processes underlying verb bias learning?
- Does newly learned verb bias serve the same role as familiar verb bias in guiding prediction and ambiguity resolution?

Design

- **EEG Training**
  - ✧4 novel verbs: *dak, glim, norge, veeb*. Each only appeared in one of the four sentence structures below.
  - ✧16 sentences repeated twice for each verb for each structure.

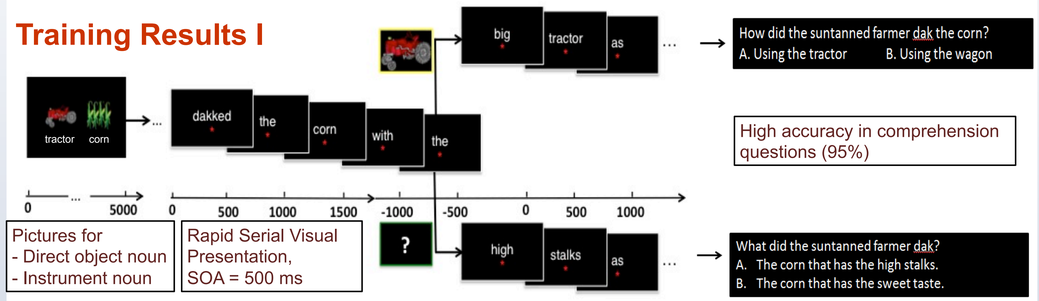
	Ambiguous	Unambiguous
Instrument	Verb + DO + with PP	Verb + DO + using
Modifier	Verb + DO + with PP	Verb + DO + that has

e.g. The suntanned farmer dakked the corn…
Instrument-Ambiguous / Unambiguous:
...with / using the big tractor as soon as he needed to harvest the crop.
Modifier-Ambiguous / Unambiguous:
…with / that has the high stalks as soon as he needed to use the tractor.

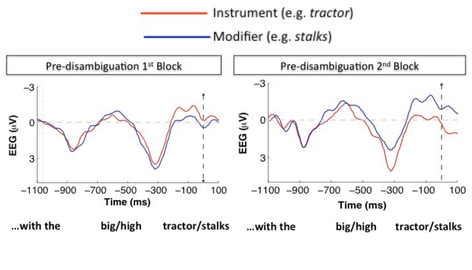
- **Behavioral Testing** with globally ambiguous sentences in picture-matching forced-choice task

The trained wizard dakked the witch with the powerful wand.

Training Results I



Learning to Predict



❖ -500 – 0 ms before the onset of the disambiguating word (average of P3, PZ and P4 electrodes)

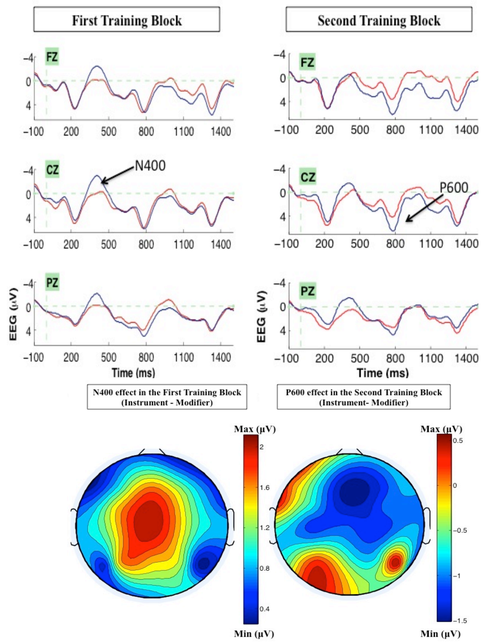
➢ Instrument Ambiguous training elicited larger positivity in the 2nd training block than Modifier Ambiguous training, indicating verb-specific anticipation for an instrument.

❖ Instrument critical noun (*e.g. tractor) vs.* Modifier critical noun (*e.g.* stalks):

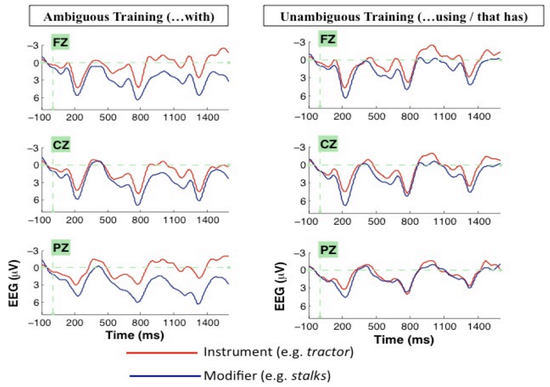
➢ First block: Reduced N400 (central-posterior) – Confirmation of an expected noun.

➢ Second block: Reduced P600 (central-frontal) – Generating structural preference

Learning the Structural Preference



Training Results II



❖ P600 effect continued in the 3rd and the 4th training blocks

❖ P600 effect was reliable only in the ambiguous condition, indicating more efficient rule-learning

Conclusion

❖ Rapid verb bias learning without the support of semantic information about the verbs

A. Newly-learned verb bias was retrieved during ambiguity resolution
- ➢Earlier stage of learning: N400 effect
- ➢Later stage of learning: P600 effect, mainly observed in ambiguous training.

B. Newly-learned verb bias guides online prediction
- ➢ Larger positivity before the arrival of the disambiguating word as readers' experience with verbs increased.

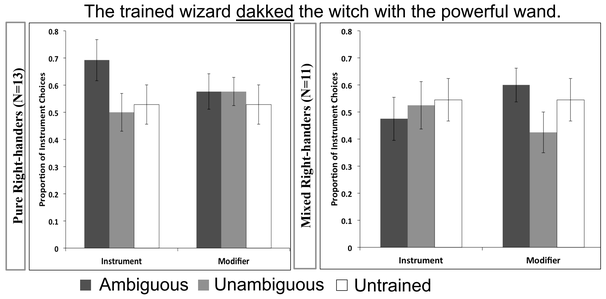
❖ Individual differences in familial handedness affected verb bias learning efficacy, possibly due to individual's sensitivity to verb bias and other parsing constraints.

❖ Future experiments will address the use of newly learned verb bias in resolving conflicts in garden-path sentences.

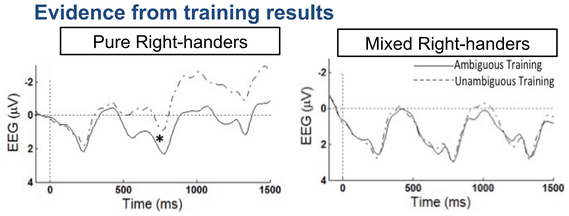
Individual Differences in Familial Handedness

Evidence from behavioral tests

The trained wizard dakked the witch with the powerful wand.



Evidence from training results



Pure Right-handers *vs.* Mixed Right-handers:

➢ More sensitive to familiar verb bias [9]

In the current experiment:

➢ More sensitive to disambiguating cues

➢ Learn verb bias from ambiguous training more efficiently than unambiguous training

References

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