

Oculomotor resonance during processing past and future tense in Russian and Hebrew

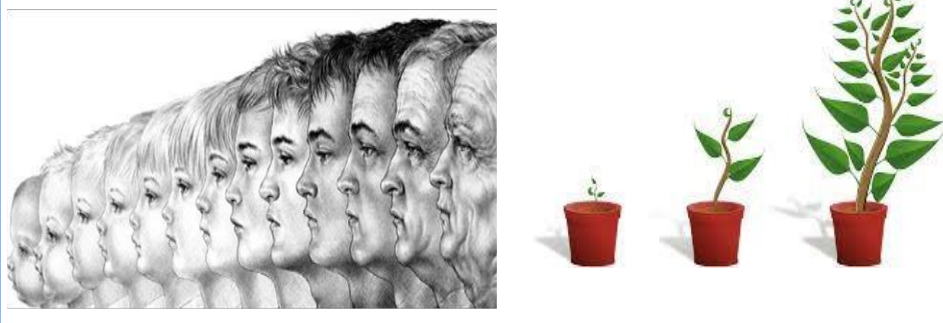
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Introduction

- Across languages and cultures, people think and talk about time in terms of space (Lakoff & Johnson, 1980; Boroditsky, 2001; Boroditsky & Gaby, 2010)
- The direction of the script in a language (left-to-right or right-to-left) affects how time and space are represented in the speaker's mind:
 - STARC effect (Spatial-temporal association of response codes (e.g., English speakers (left-to-right script) align temporally ordered events from left to right, while Arabic speakers (right-to-left script) – in the opposite direction (Tversky et al., 1991);
 - The processing of words of temporal semantics was shown to trigger perceptual biases in horizontal space with speakers associating words denoting past with the left and the words denoting future – with the right, space (Boroditsky, 2011);
 - Spatial-conceptual mapping is largely automatic and is observed in oculomotor resonance drift (e.g., during processing of number words (SNARC effect) (Myachykov, 2015; 2016).



Research question and predictions

Does direction of the writing script affect the mapping of temporal semantics in the mental space?

- Grammatically expressed **PAST** vs. **FUTURE** tense forms;
- **RUSSIAN** (left-to-right) vs. **HEBREW** (right-to-left)
- Russian speakers will show oculomotor drift to the right for future tense forms and to the left for past tense forms;
- Hebrew speakers will show the opposite pattern

Participants

- 62 native speakers of Russian and 62 speakers of Hebrew participated in an eye-tracking experiment;
- The same method and procedure was used for both experiments in this study;
- Age of participants from 18 to 45 years.

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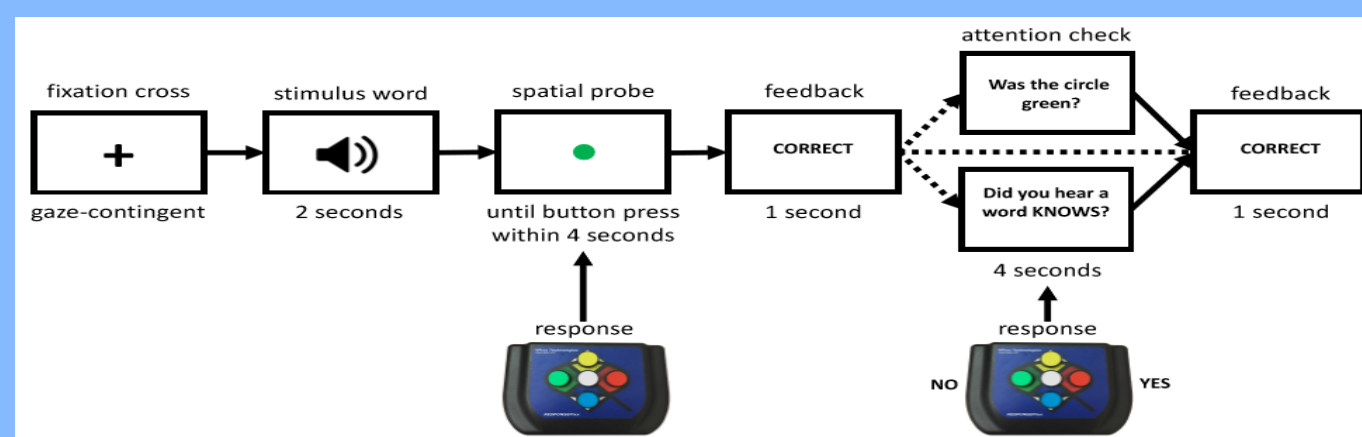
Stimuli

- 90 critical verbs were previously normalized (verbs should have a concrete motor meaning, matched in length, etc.):
тронул - тронет
- 90 fillers were added to the experimental verbs: бокал-пилот (mimic past/future tense flexions);
- 4 presentation lists

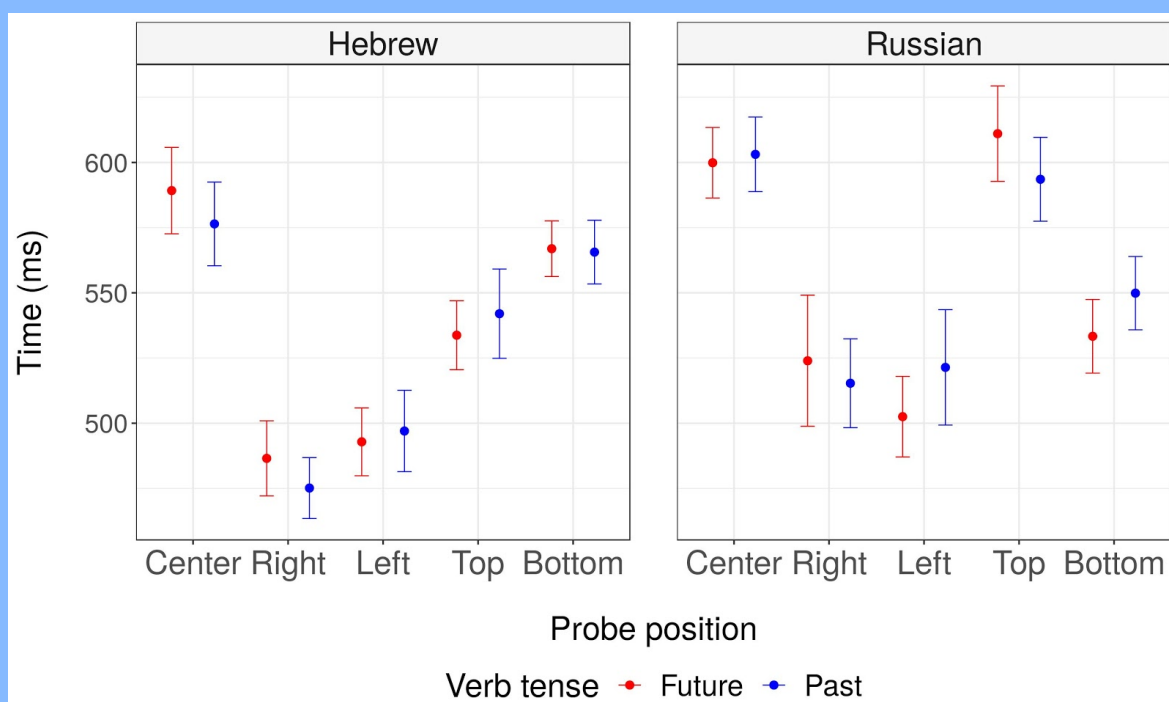
Method

- Participants were tested on the EyeLink 1000+
- Spatial probe: a green or a blue circle appearing in different screen locations:
 - center/right/left/bottom
- task: press the corresponding button on the game pad to indicate the location of the visual probe

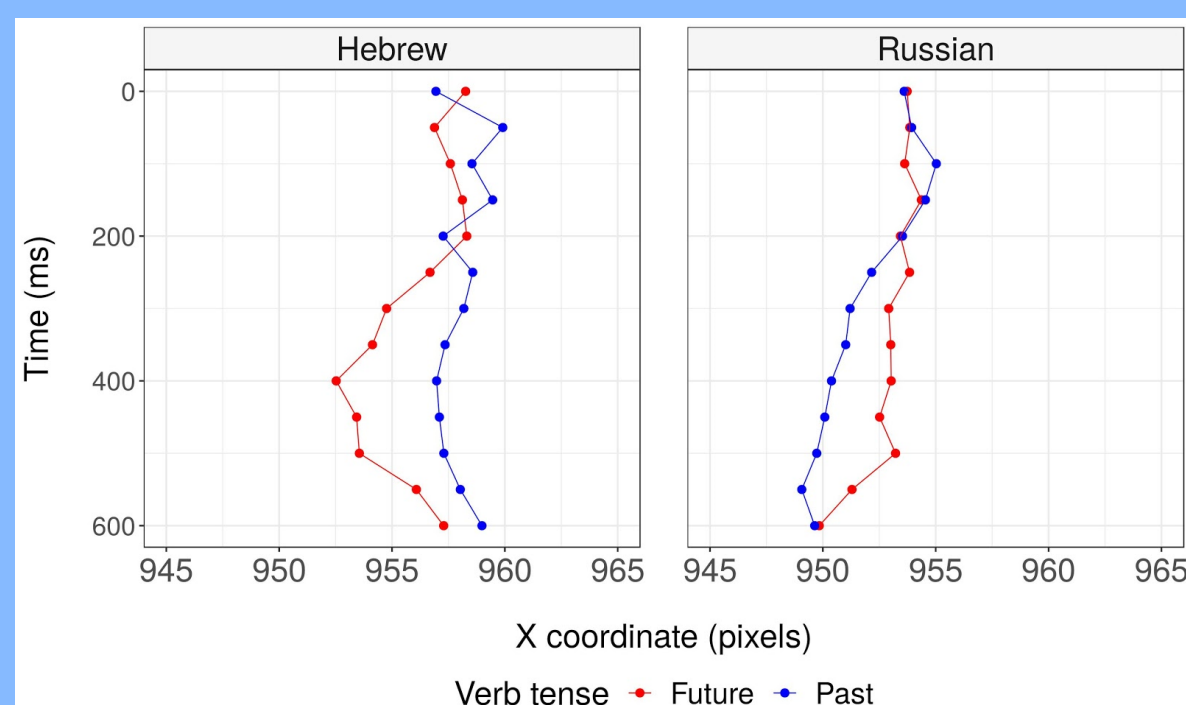
An example of an experimental trial



Reaction times to the visual spatial probes as a function of experimental condition (means and 95% CI)



Gaze coordinates averaged across conditions (Time = 0 corresponds to the stimuli's uniqueness point).



Analysis

Uniqueness point (UP) was defined in critical verb pairs;
Window of analysis: from UP (time = 0) until spatial probe on the screen (~400-600 ms);
Within this time window, 1-ms gaze samples were averaged over 50-ms bins (Barr, 2008)

Statistical modeling of gaze coordinates (in pixels) as a function of experimental condition

Predictors	Estimate	Gaze coordinate on X axis Highest Density Interval (95%)
Intercept	953.38	948.46 – 958.29
Tense	1.22	0.39 – 1.97*
Tense x Language	-1.76	-2.83 – -0.68*
Time	-0.88	-3.19 – 2.67
Observations	141060	

Conclusions

- While no significant effect of verb tense was observed in reaction time data, condition-related oculomotor resonance drift emerged ~200 ms after the verbs' uniqueness point and significantly differed in the two language groups:
- Russian speakers' gaze shifted to the left during listening to the past tense verbs, and to the right during future tense verbs (left-to-right language); an opposite effect was observed in the Hebrew-speaking group.
- The results provide evidence that the direction of the written script influences how people map and process temporal semantics of the grammatically expressed tense.