

# Came Out of Left Field: Cross-Linguistic Comparison of the Effects of Reading Direction on Sentence Production in First- And Second-Language

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## Background & Aims



**Which do you prefer?**  
**The firefighter stands next to the doctor.**  
**The doctor stands next to the firefighter.**

**Mental representations** of action sentences were thought to be universally generated from **left to right (LTR)** due to **hemispheric specialization** (Maass & Russo, 2003; Chatterjee et al., 1999).

However, while the LTR bias was reported in English speakers, people who speak **right to left (RTL) languages** (e.g., Hebrew) prefer to draw actions sentences from right to left (Dobel, Diesendruck & Bölte, 2007) and describe scenes from right to left (Bergen & Chan, 2005; Esaulova et al., 2021).

The different biases may be explained by **differential scanning habits** that are learned within a certain **culture** (Paulesu et al., 2000). However, there is lack of direct evidence that visual scanning is biased in language processing. This cultural hypothesis is also challenged by an RTL bias in RTL speakers who live in an LTR culture (Bergen & Chan, 2005; Esaulova et al., 2021).

The current study seeks to determine which mechanism underpins the spatial biases of language representations:

1. Attentional allocation that is consistent with the language's reading direction (Suitner & Maass, 2016)
2. Language-specific characteristics that are independent of attention or cultural influences

In two pre-registered experiments ([10.17605/OSF.IO/M67CV](https://osf.io/M67CV)), we addressed the two aims above by examining the visuospatial biases created during sentence production by *English monolinguals from England, Hebrew-English bilinguals from Israel and Persian-English bilinguals living in Europe/America.*

## Methods

### Materials and design

**Experiment 1** - Mixed design: 3 Group (English, Hebrew, Persian) X 2 Image location (Left, Right), Group as between-subject variable and image location as a within-subject variable.

**Experiment 2** - Within-subject design: 2 Input language (LTR (English), RTL (Hebrew/Persian)) X 2 Image location (Left, Right).

### Participants

**Experiment 1** - English speakers N=21, Hebrew speakers N=21, Persian speakers N=21

**Experiment 2** - Hebrew speakers N=20, Persian speakers N=19

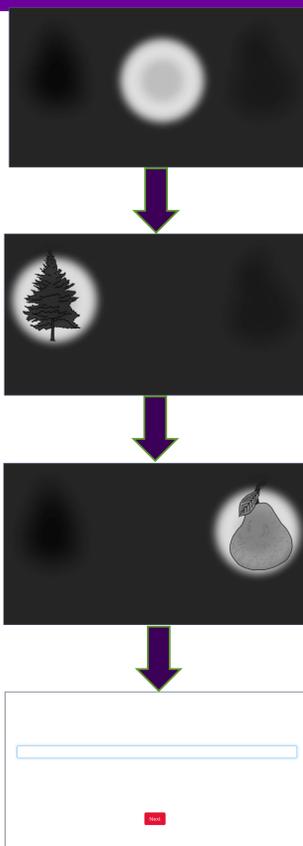
### Sentence Forming task

#### Experiment 1

- Participants viewed two blurred images of people/objects displayed side-by-side.
- They moved their mouse to see the images, and their mouse movements were tracked.
- They then formed sentences in their native language, describing how the two people/objects interact.

#### Experiment 2

- The same Hebrew and Persian speakers completed this task in English.
- They also completed an English test to assess their English proficiency.
- They were asked about their level of English daily use (1-4) and the number of years they lived abroad (in an LTR environment).



## Results

**Experiment 1** – For analysing the participants' mouse-tracking data and responses, we fitted two General Linear Mixed Models:

**Attention allocation:** significant differences between Hebrew and English speakers ( $p < .001$ ) and between Persian and English speakers ( $p = .03$ ) in the initial allocation of attention (figure A).

**Image location:** significant differences between Hebrew and English ( $p < .001$ ) and between Persian and English ( $p < .001$ ) in the preferences to use the left/right image as the subject/first-mentioned object (figure B).

Figure A

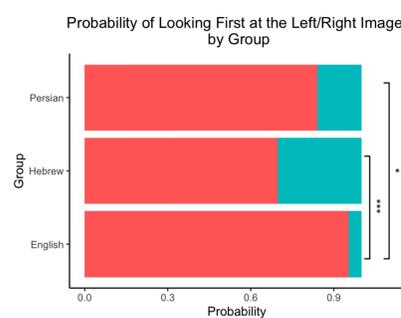
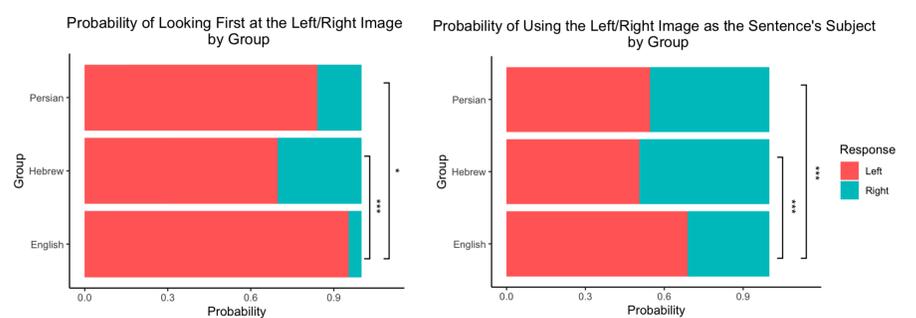


Figure B



We found a significant main effect of **first viewed image**, but it was found to **predict** the responses only for **Hebrew and Persian speakers**.

**Experiment 2** - We analysed the differences between the participants' data in their **L1 vs L2:**

**Hebrew speakers** when tested in English:

- They used the **left image** as the sentence's subject/first-mentioned object in their responses significantly ( $p = .013$ ) more often than when tested in Hebrew
- They allocated their attention toward the **left image** first significantly ( $p < .001$ ) more often

**Persian speakers** did not exhibit significantly different patterns when tested in English compared to Persian.

We found a significant main effect of **first viewed image** but it **did not predict** significantly the bilinguals' responses in English.

**We examined whether the left bias in English can be predicted by English proficiency or level of cultural exposure:**

The **Persian speakers'** level of **English proficiency** significantly **predicted** their extent of **left bias** observed when tested in English ( $p = .013$ ).

## Conclusions

- Our findings provide novel evidence for the **differences in attention** allocation in language production between speakers of LTR and RTL languages.
- The results only partially support the account of **attention allocation** as the mechanism underlying sentence representation in language production.
- The overall preference of all groups to initially allocate their attention to the left side provides evidence for the **hemispheric specialization** hypothesis.
- The findings demonstrate the influence of **habitual scanning bias** on visuospatial representation in language production.
- Our results partially support the explanation that the reversed biases are caused by **language-specific characteristics**.

## References

1. Chatterjee, A., Southwood, M. H., & Basilico, D. (1999). Verbs, events and spatial representations. *Neuropsychologia*, 37(4), 395-402.
2. Maass, A., & Russo, A. (2003). Directional bias in the mental representation of spatial events: Nature or culture?. *Psychological science*, 14(4), 296-301.
3. Dobel, C., Diesendruck, G., & Bölte, J. (2007). How writing system and age influence spatial representations of actions: A developmental, cross-linguistic study. *Psychological science*, 18(6), 487-491.
4. Bergen, B., & Chan, T. T. (2005). Writing direction influences spatial cognition. In *Proceedings of the Annual Meeting of the Cognitive Science Society* (Vol. 27, No. 27).
5. Esaulova, Y., Dolscheid, S., Reuters, S., & Penke, M. (2021). The alignment of agent-first preferences with visual event representations: Contrasting German and Arabic. *Journal of Psycholinguistic Research*, 50(4), 843-861.
6. Paulesu, E., McCrory, E., Fazio, F., Menoncello, L., Brunswick, N., Cappa, S. F., & Frith, U. (2000). A cultural effect on brain function. *Nature neuroscience*, 3(1), 91-96.
7. Suitner, C., & Maass, A. (2016). Spatial agency bias: Representing people in space. In *Advances in experimental social psychology* (Vol. 53, pp. 245-301). Academic Press.