Exploring Systematic Spatial Association Effects Arising from Language Experience Alone

Oksana Tsaregorodtseva[1], Luca Rinaldi[2], Marco Marelli[1]

[1] *Psychology Department, University of Milano-Bicocca, Milano, Italy*

[2] *Department of Brain and Behavioral Sciences, University of Pavia, Pavia, Italy*

INTRODUCTION

Preliminaries

- Language may encode spatial relationships imposed by sensorimotor experience (Louwerse, 2008; Louwerse & Jeuniaux, 2010; Rinaldi & Marelli, 2020; Gatti et al., 2024)
- Distributional semantic models (DSMs), which represent words in high-dimensional vector spaces based on co-occurrences, provide evidence for this, replicating spatial structures like maps and body-related knowledge, and explaining human biases and judgments (Rinaldi & Marelli, 2020; Günther et al., 2019).

Research question

The question remains whether language – a non-spatial learning environment – can encode spatial information without the need for a dedicated spatial memory system

To test this, it is pertinent to explore whether words that are **not typically associated with spatial representations** can shape human spatial intuituons and elicit attentional and/or motor effects depending on whether these words are implicitly associated with spatial locations along the vertical axis in natural language.

1: Best-Worst Scaling Experiment

Stimuli

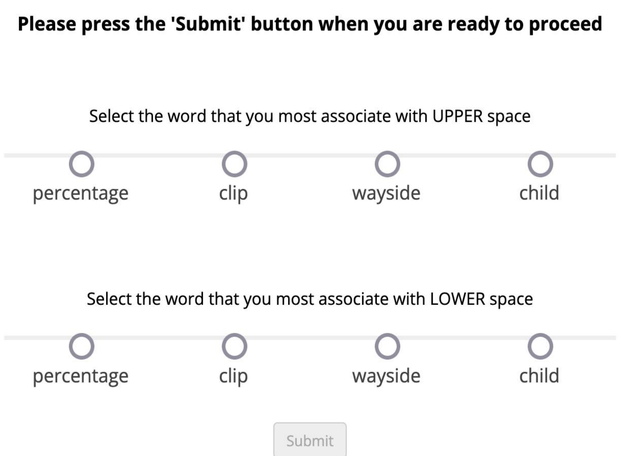
- **Stimuli:**
- **1040 nouns and 1040 verbs** from the SUBTLEX_UK + **anchor words**:

for **upper space**: ‘up’, ‘top’, ‘high’, ‘above’, ‘upper’,‘upward’;
for **lower space**: ‘down’, ‘bottom’, ‘low’, ‘below’,’lower’, ‘downward’

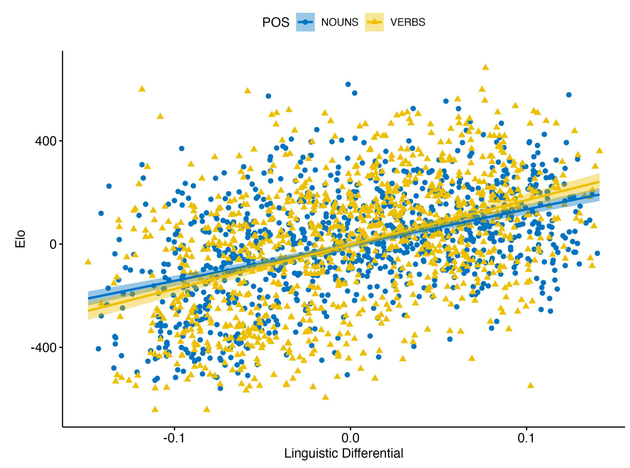
- ***fastText (English Common Crawl corpus)***

- ***Linguistic differential:***
- **LD = [cos(k→, ‘up’→) - cos(k→, ‘down’→)]**

Procedure



Results

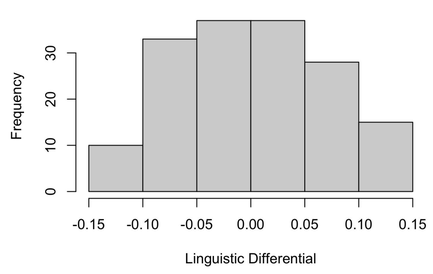


$F(1, 2078) = 515$, $p < .001$, $R^2_{adj} = .198$)

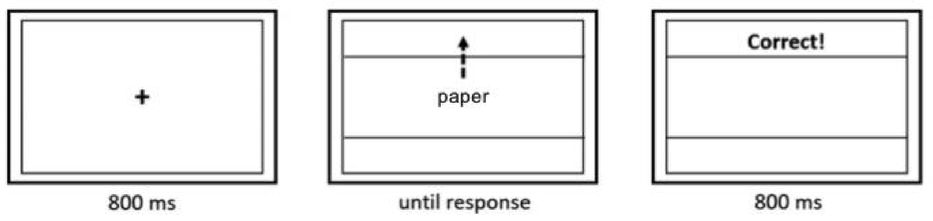
2. Mouse-tracking Experiment

Stimuli

Stimuli: 160 nouns from BWS



Procedure and Design



Task: concrete or abstract?

DVs: launch time, movement time, accuracy, mouse trajectory measures:
maximial angle deviation (MAD), avergae angle deviation, RT_MAD)

DV ~ linguitstic differential (LD) * response direction + concreteness*reponse direction + (1 | Subject) + (1 | Item)

Expectations

Expectations:
Interaction between linguistic differential and response (movement) direction:

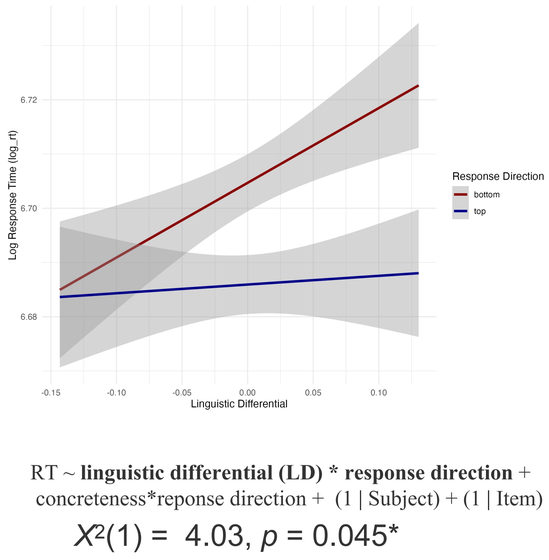
faster RT/ more accurate in congruent conditions:

more LD is associated with upper/lower space,
faster movement in a corresponding direction,
more accurate responses in a corresponding direction,

bigger deviation in non-congruent conditions

Results: LD and response direction

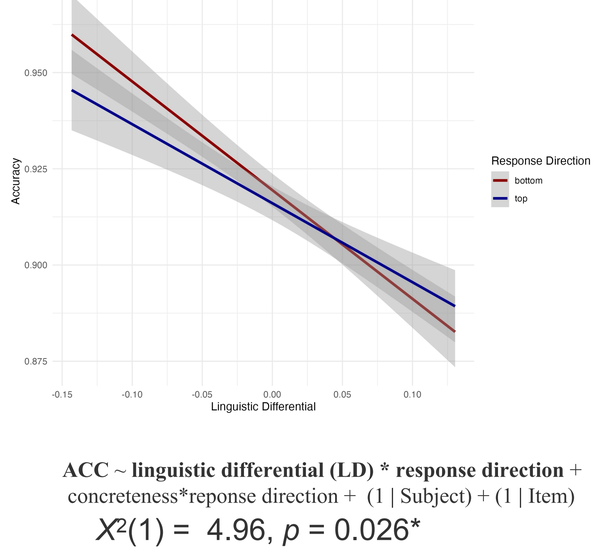
launch time



RT ~ **linguistic differential (LD) * response direction** + concreteness*reponse direction + (1 | Subject) + (1 | Item)

$X^2(1) = 4.03$, $p = 0.045$*

accuracy

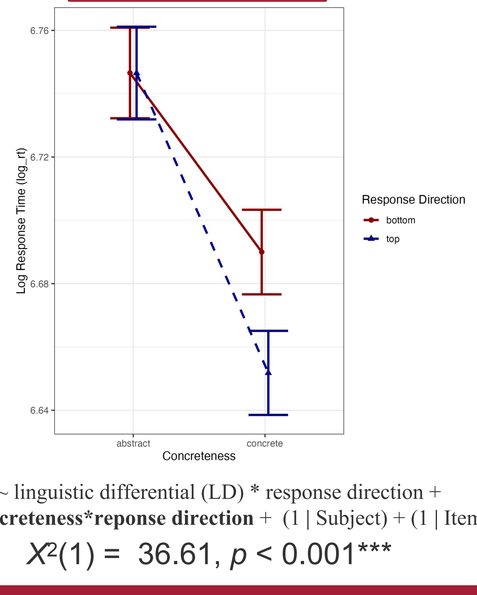


ACC ~ **linguistic differential (LD) * response direction** + concreteness*reponse direction + (1 | Subject) + (1 | Item)

$X^2(1) = 4.96$, $p = 0.026$*

Results: concreteness and response direction

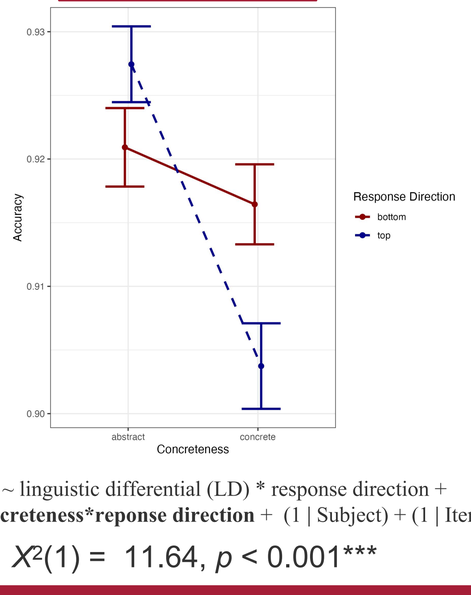
launch time



RT ~ linguistic differential (LD) * response direction + **concreteness*reponse direction** + (1 | Subject) + (1 | Item)

$X^2(1) = 36.61$, $p < 0.001$***

accuracy



Acc ~ linguistic differential (LD) * response direction + **concreteness*reponse direction** + (1 | Subject) + (1 | Item)

$X^2(1) = 11.64$, $p < 0.001$***

CONCLUSIONS

The results suggest that language alone can shape spatial knowledge, indicating that linguistic exposure – without direct sensorimotor experience– can influence how we process and respond to spatial information. This challenges strong embodiment theories and highlights the need to consider language as a key factor in shaping spatial cognition and motor behavior.

Funding

Funded by the European Union
NextGenerationEU

European Union—NextGenerationEU—
Project Title “The World in Words: Moving beyond a spatiocentric view of the human mind (acronym: WoWo)”,
Project code 2022TE3XMT, CUP (Marelli) H53D23004370006,
CUP (Rinaldi) F53D23004850006.

References

Gatti, D., Anceresi, G., Marelli, M., Vecchi, T., & Rinaldi, L. (2024). Decomposing geographical judgments into spatial, temporal and linguistic components. *Psychological research, 88*(5), 1590-1601.

Rinaldi, L., & Marelli, M. (2020). Maps and space are entangled with language experience. *Trends in Cognitive Sciences, 24*(11), 853-855.

Louwerse, M. M. (2008). Embodied relations are encoded in language. *Psychonomic Bulletin & Review, 15*, 838-844.

Louwerse, M. M., & Jeuniaux, P. (2010). The linguistic and embodied nature of conceptual processing. *Cognition, 114*(1), 96-104.