Exploring systematic spatial association effects arising from language experience: a mouse-tracking experiment

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INTRODUCTION

Preliminaries

- Language may encode spatial relationships imposed by sensorimotor experience (Lowerse, 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

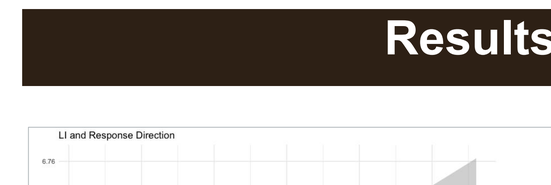
To test this, it is pertinent to explore whether words that are **not typically associated with spatial representations** can elicit attentional and/or motor effects depending on whether these words are implicitly associated with spatial locations along the vertical axis in natural language.

MATERIALS: Best-Worst Scaling Experiment

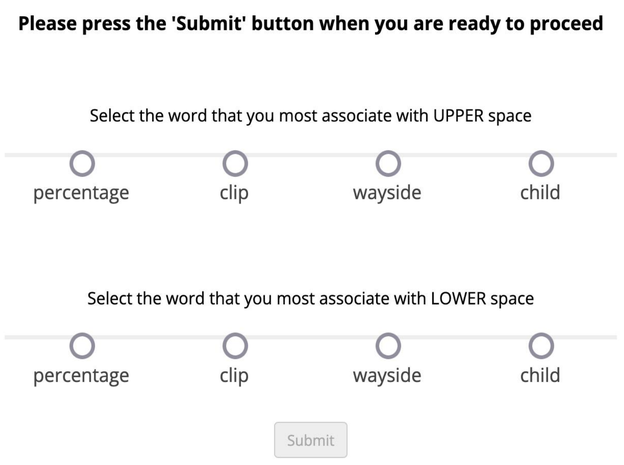
Stimuli

- **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)***

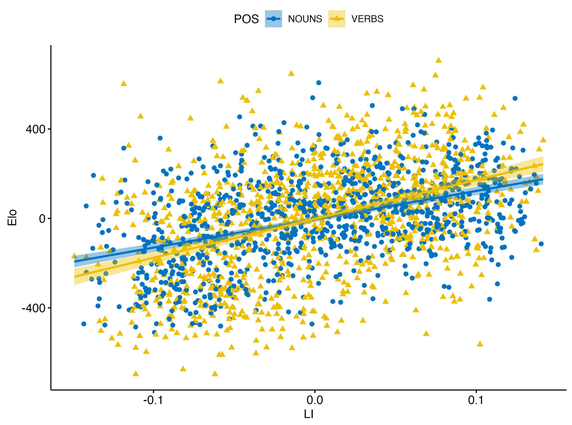
- ***Linguistic index:***
- **LI = [cos(k→, ‘up’→) - cos(k→, ‘down’→)]**



Procedure



Results

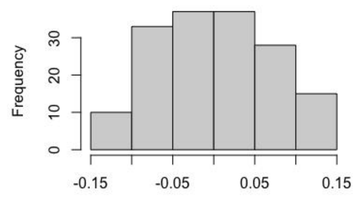


$F(1, 2078) = 472.0$, $p < .001$, $R^2_{adj} = .185$)

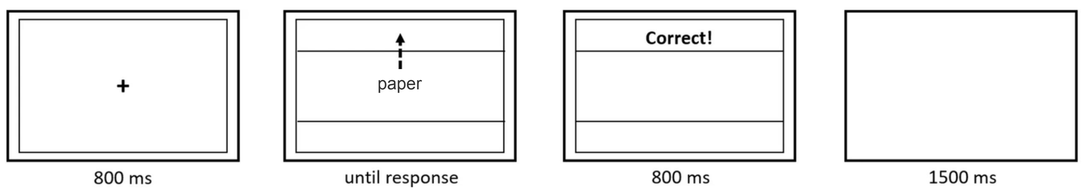
Mouse-tracking experiment

Stimuli

Stimuli: 160 nouns from BWS



Procedure and Design



Task: concrete or abstract?

DVs: launch time, movement time, accuracy
mouse trajectory (maximial angle deviation)

DV ~ spatial linguistic association (LI) * response direction + concreteness*reponse direction + (1 | Subject) + (1 | Item)

Expectations

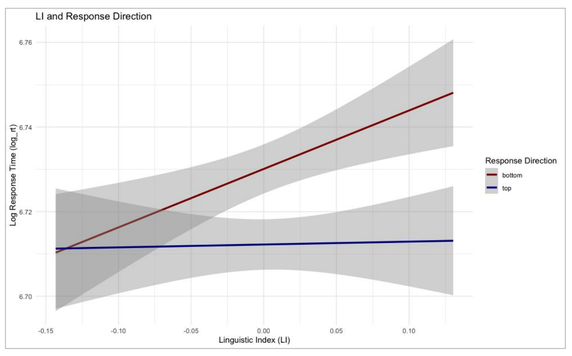
Expectations:
Interaction between linguistic index and response (movement) direction:

faster RT/ more accurate in congruent conditions:

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

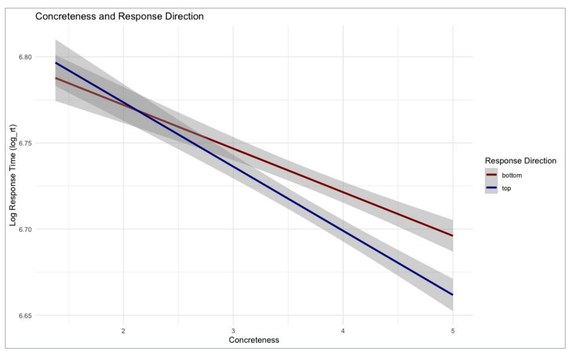
bigger deviation in non-congruent conditions

Results: launch time



RT ~ **spatial linguistic association (LI) * response direction** + concreteness*reponse direction + (1 | Subject) + (1 | Item)

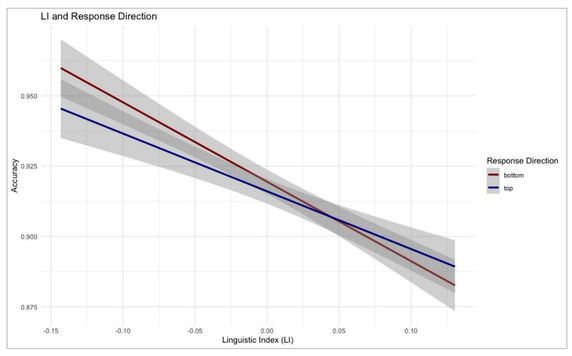
$X^2(1) = 4.03$, $p = 0.045$*



RT ~ spatial linguistic association (LI) * response direction + **concreteness*reponse direction** + (1 | Subject) + (1 | Item)

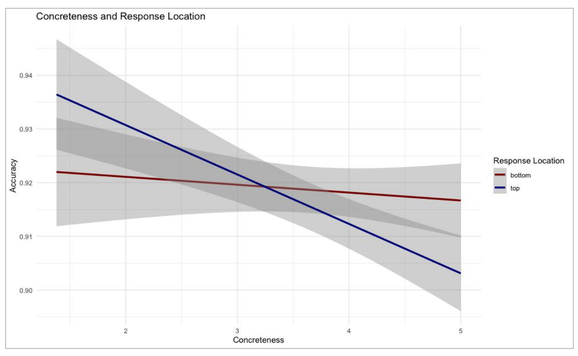
$X^2(1) = 36.61$, $p < 0.001$***

Results: accuracy



Acc~ **spatial linguistic association (LI) * response direction** + concreteness*reponse direction + (1 | Subject) + (1 | Item)

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



Acc ~ spatial linguistic association (LI) * 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.

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