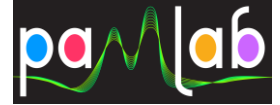


# Cultural Factors Weaken but Do Not Reverse Left-to-Right Spatial Biases in Numerosity Processing: Data from Readers of Arabic and English



Dominique Lopiccolo & Charles B. Chang  
 Department of Linguistics, Boston University  
 Abstract #1297



## Introduction

- Left-to-right (LR) response biases due to a conceptual link between space and number are known as the **SNARC effect**. [1]
- Script direction** has previously been noted to influence response biases and, therefore, the mental representation of number.
- Task instructions** also seem to alter response biases, most notably for nonsymbolic numerical stimuli. [2]
- Different **culture effects** (e.g., script knowledge, visual experience) are often conflated in the literature on numerical processing.
- Objective:** investigate the roles of quantity (Pair Size), task instructions (Condition), script direction (LR, RL, both), and visual experience (in Jordan or the US) during numerosity processing by incorporating specific (bi)directional (bi)literate groups, which made for a strong contrastive analysis.

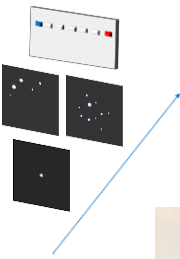
## Methods

### Participants:

- Arabic monoliterates (AMs)
- English monoliterates (EMs)
- Arabic-English biliterates in Jordan (AEBJOs)
- Arabic-English biliterates in the US (AEBUSs)

### Tasks & Stimuli:

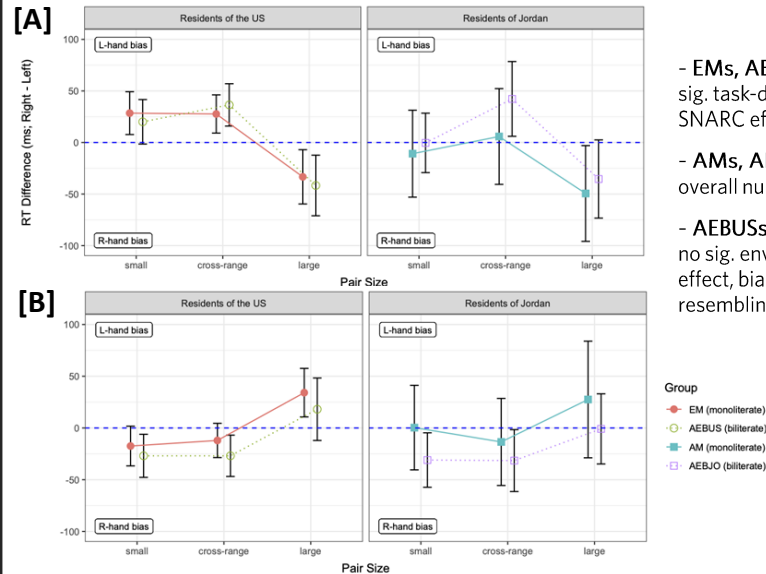
- pairwise **numerosity comparison task**
  - conditions: "choose *smaller*", "choose *larger*"
  - measures: response time (RT), accuracy
- language background and proficiency questionnaire
- Edinburgh Handedness Survey [3]
- numerosity stimuli created using MATLAB script of [4]
  - "small" (2-4), "large" (5-10), "cross-range" (1 small, 1 large)



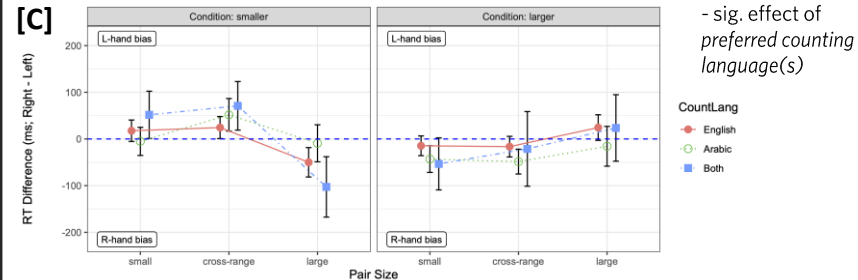
## Results

- DV: RT difference (right hand RT - left hand RT)
- IVs: Group, Pair Size, Condition

Mean RT differences (ms) in the *smaller* condition (A) and *larger* condition (B), by group, pair size, environment. Each pair size is the average over 3 different pairs. Dashed horizontal line marks zero RT difference (i.e., no hand bias). Error bars mark 95% CIs.



- EMs, AEBUSs: sig. task-dependent SNARC effect
- AMs, AEBJOs: overall null effect
- AEBUSs, AEBJOs: no sig. environment effect, biases resembling EMs'



- sig. effect of preferred counting language(s)

## Discussion

The lack of RL response biases in monoliterate Arabic (RL) script users supports the view that an **innate LR code** may be active during numerosity processing.

The task-dependency effect observed for monoliterate English (LR) script users replicates previous findings [2] and points to the effects of an **ordinal (task-based) code** during numerosity processing.

Environment (Jordan, US) did not have a significant impact on bidirectional biliterates' response biases, but (self-reported) **preferred counting language(s)** did: biliterates who reported both Arabic & English demonstrated biases more similar to EMs' than did the biliterates who reported English only.

Taken together, there seem to be several spatial-numerical mapping codes involved during numerosity processing: cardinal, ordinal, innate.

We explain these outcomes via our own **MULTIPLE COMPETING CODES THEORY (MCCT)**, wherein factors such as task instructions and demographics pose constraints on which of multiple codes are activated or suppressed.

## Future Directions

- Increasing the range of numerosities tested
- Adding neuroimaging and eye-tracking components
- Further investigation into the effects of bidirectional counting preferences on numerosity processing

## Acknowledgements

We thank ASC English and the Arabic Baptist Church in Boston, Tabor Baptist Church in Muncie, and the American Academy Jordan, the CMA Church, and the University of Petra in Jordan for providing logistical assistance. This research was also funded in part by the Phonetics, Acquisition, and Multilingualism Lab and the CURA Institute at Boston University and the Jordanian-American Binational Fulbright Commission.

## References

- Dehaene, S., Bossini, S., & Giraux, P. *JEP: General* 122(3), 371-96 (1993).
- Patro, K., & Shaki, S. *Cognitive Processing* 17(2), 127-37 (2016).
- Veale, J. F. *Laterality: Asymmetries of Brain, Behaviour, and Cognition* 19(2), 164-77 (2014).
- Gebuis, T., & Reynvoet, B. *Behavior Research Methods* 43(4), 981-86 (2011).