The role of response codes in spatial-numerical associations

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Background

- Mental representation of numbers on a mental number line with a horizontal left-to-right (in Western cultures; Dehaene et al., 1993) or vertical bottom-to-top orientation for small to large numbers (Winter et al., 2015)
- Horizontal spatial-numerical association of response codes (SNARC) effect: faster left/right responses for small/large numbers, respectively
- Recent studies suggest that vertical spatial-numerical associations (SNA) are more robust than horizontal SNAs: vertical SNAs might be conceptual, whereas horizontal SNAs might be an artefact of the respective paradigms (Shaki & Fischer, 2018; Sixtus et al., 2019)
- We now investigated the relationship between the typical horizontal SNARC effect and two-dimensional (horizontal and vertical) SNAs with and without spatially distributed response buttons. We thereby aim to address the questions:

→ **Is the SNARC effect an artefact of its response codes, i.e., spatially distributed response buttons?**

→ **How do SNAs that are spatially primed (i.e., SNARC) relate to conceptual SNAs?**

Methods

Three experiments with same participants tested for

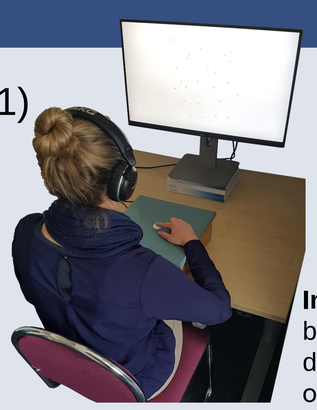
(1) 2D SNA: conceptual spatial-numerical associations in a Go/No-go setup with only one central response button

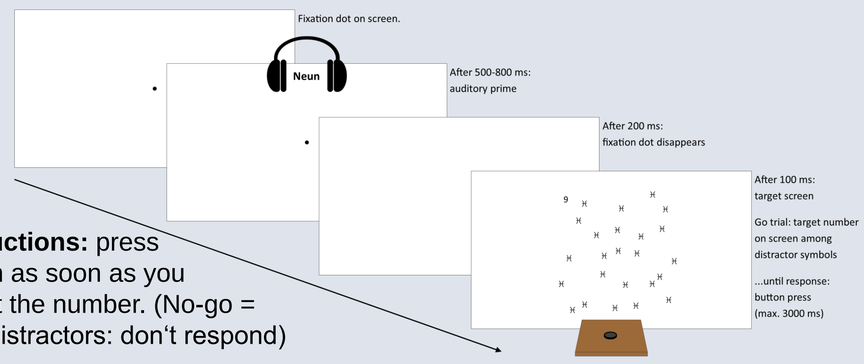
(2) 2D SNARC: SNAs in combination with alternating response codes including horizontally and vertically aligned response buttons

(3) 1D SNARC: conventional horizontal SNARC effect

Auditory target numbers: 1, 2, 8, 9

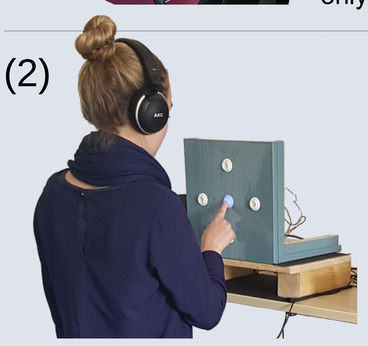
(1)

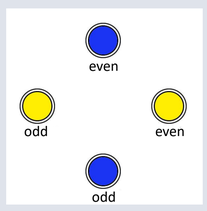




Instructions: press button as soon as you detect the number. (No-go = only distractors: don‘t respond)

(2)

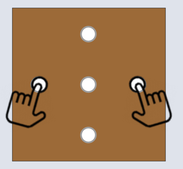




Instructions: depending on the colour of middle button, press right/left or upper/lower button for even/odd numbers (all four parity-to-position mappings in separate blocks)

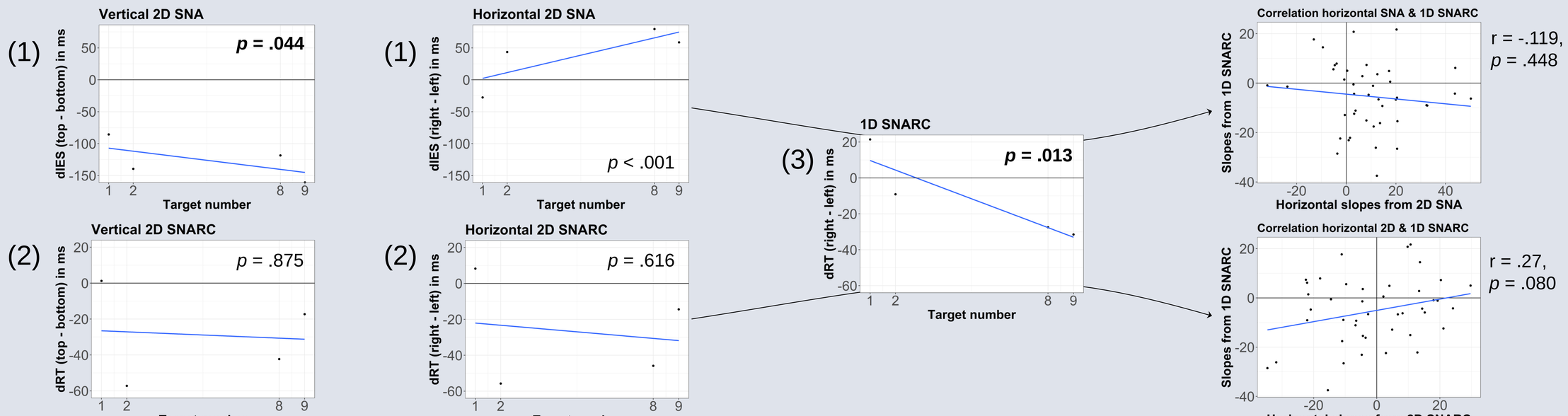
(3)

Instructions: press left/right button when number is even/odd (both mappings in separate blocks)



Analysis & main results

- N = 43
- Inverse efficiency score (IES) = $\frac{RT\ (of\ correct\ responses\ of\ go\ trials)}{accuracy\ (of\ go\ trials)}$
- DV SNA (1): dIES (IES for right/top minus left/bottom presentations) per target number
- DV SNARC (2 & 3): dRT (RT for right/top minus left/bottom responses) per target number
- *t*-tests: individual slope coefficients against zero
- Correlations between individual 1D SNARC slope coefficients and individual horizontal 2D SNA and 2D SNARC slope coefficients



Discussion

- Replication of Sixtus et al. (2019): vertical SNAs trump horizontal SNAs (in expected direction)
- Horizontally distributed response buttons (Exp. 3) strongly prime the given dimension while spatially distributed response buttons along alternating axes (Exp. 2) do not. No reliable correlations between strengths of individual SNA(RC)s
- A follow-up study should investigate whether blocked response axes in a paradigm like Exp. 2 yield a conventional SNARC effect
- Overall, results suggest that SNAs are highly malleable by situational factors

References

Dehaene, S., Bossini, S., & Giraux, P. (1993). The mental representation of parity and number magnitude. Journal of Experimental Psychology: General, 122(3), 371–396.
Shaki, S., & Fischer, M. H. (2018). Deconstructing spatial-numerical associations. Cognition, 175, 109–113.
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Winter, B., Matlock, T., Shaki, S., & Fischer, M. H. (2015). Mental number space in three dimensions. Neuroscience and Biobehavioral Reviews, 57, 209–219.