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Hunting the SNARC in its Natural Habitat: Evidence for a Cognitive Number Line in a Equation-Writing Task

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Introduction

Dehaene et al (1993), found that subjects on a parity detection task over single digit numerals responded more quickly with their right hands to large numbers, and with their left hands to small numbers. Since then, this SNARC effect (Spatial-Numerical Association of Response Codes) has been observed in a number of different experimental measures, such as differential attention to the left or right visual fields (Fisher, 2003) which support an association between large numbers (5-9) and right-hand sides of screens or pages. The current study supports previous findings in illustrating the role the number line plays in cognitive processes, but extends them in two fundamental ways. First, rather than simply establishing an association of 'large' with 'right', the current study explores specifically metric properties of the cognitive number line, illustrating a connection between semantic distance and physical distance. Second, while most studies have explored behavior on fundamentally unnatural laboratory tasks, the current study examines produced spacing on a relatively typical task: writing out equations.

Experiment & Results

39 Indiana University undergraduate students read a page of word equations and were asked to write the corresponding Arabic-numeral equations. Participants were not asked to compute any actual values, only to write the expressions as though they were going to solve them. Equations contained additions, multiplications, and equalities. Spaces between the insides of the numerals on either side of + and * signs were measured.

Presented in figure 1 are mean physical spacings binned into 'large' and 'small' numerical distance categories. For small numerical distances less than 5, (mean numerical distance 2.125), the average physical space between operands was $8.82 \pm 0.3\text{mm}$; for large numerical distances (mean distance 6) was $9.64 \pm 0.3\text{mm}$. In order to evaluate the significance of this binned difference, we transformed each distance into a z-score for that participant, and performed a t-test over z-scores. The result was highly significant ($t=7.22$ $p<0.001$). Also, a Pearson's correlation test confirmed a relationship between raw (unbinned) numerical and physical distance ($r=0.156$, $5=4.8$, $p<0.001$). A linear regression estimated the slope of the correlation at 0.21mm/unit numerical distance.

Conclusions

That participants correlate inter-character physical spacing with numerical distance along the number line supports two extant claims: first, it supports and extends existing research on the SNARC effect, and supports the conclusion that a mental number line impacts general numerical cognition. Second, that physical space in constructed equations reflects semantic facts about the represented terms indicates that, contrary to many extant claims (e.g., Stenning, 2002), sentential notations are diagrammatic in addition to being concatenative, since metric properties of the constructions directly reflect semantic number facts.

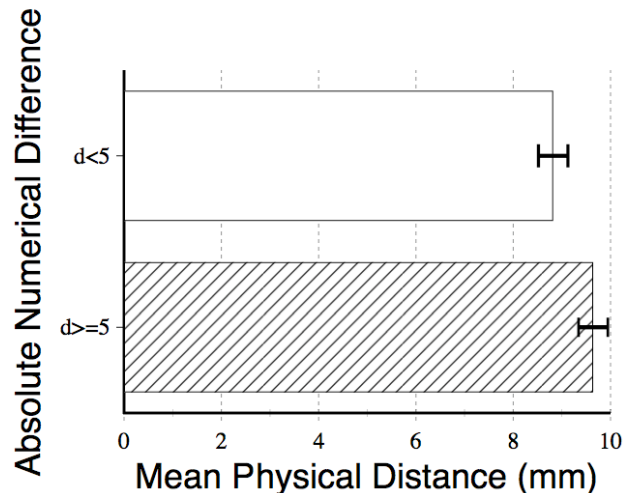


Figure 1: Results from the experiment. Participants produced wide spaces around equals signs. The interaction between addition/multiplication signs and operator 'mixing' is also significant, as can be seen in figure 2.

Acknowledgments

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