Left of Zero: Representing Negative Numbers on the Mental Number line

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Introduction

How do people represent and use abstract mathematical notions that have few or no real-world counterparts? For example, how are we able to think of imaginary numbers, surreal numbers, or even negative numbers? One proposal is that abstract knowledge domains (such as number, time, ideas, ect.) are represented through analogical extensions from more concrete or more experience based domains (e.g., Lakoff & Johnson, 1980, Boroditsky 2000). Lakoff and Nunez (2001) have suggested that the same kinds of experience based may be used for all manner of mathematical concepts. This paper focuses on the domain of negative numbers.

Previous studies of positive number representations have found evidence for the psychological reality of a mental number-line (e.g., Dehaene, Bossini, & Giraux, 1993; Reynvoet & Brysbaert 1999). In these studies subjects were shown positive integers one at a time and asked to indicate whether the number was odd or even. The subjects made their response by pressing the 'odd' and 'even' buttons that were spaced far apart on the keyboard.

These studies found that people made an implicit association between spatial location and number magnitude called the Spatial Numerical Association Response Codes or SNARC effect.

We consider the new case of negative numbers. How will people represent numbers less than zero on the odd/even task described above? Does the SNARC effect hold only for positive numbers that can correspond to actual numbers of objects in the world? If negative numbers are represented on the mental number-line, will they be laid out according to magnitude or absolute value?

Experiment

Participants made speeded odd/even judgments on numbers –9 to 9. Numbers appeared in the center of a computer screen one at a time and in random order. For each number subjects were instructed to indicate whether the number was odd or even by pressing the corresponding key. Subjects were equally fast to respond to negative numbers as positive numbers.

Overall, the SNARC effect held, in fact was slightly stronger for negative numbers than positive numbers. The results show that participants were faster to make an odd/even judgment for large numbers when the response key was on the right, but faster for smaller and negative numbers when the response key was on the left. The equivalent point was around zero

It is especially surprising that the SNARC effect could be found for negative numbers even in a task that included positive numbers since participants did not at all need to consider whether a number was positive or negative in order to determine if it was odd or even. It is quite surprising that the mental number-line representation intruded even in this task.

The results suggest that negative numbers, like positive numbers, are represented with the help of a spatial mental number-line that is laid out left to right (at least for people who read left to right) according to magnitude that extends left of zero.

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