Integer Comparison and the Inverse Symbolic Distance Effect

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Introduction

The positive integers constitute the most well-studied number class. An important finding is the *symbolic distance effect* (SDE): the greater the distance between two positive integers, the faster they are compared (Moyer & Landauer, 1967). The SDE is important because it indicates that numerical symbols are understood in part as magnitudes, i.e., using a mental number line. The current study investigated whether the SDE holds for all integers – positive, negative, and zero.

Method

21 participants were recruited from the Stanford University community. Two repeated measures were varied orthogonally. Distance had two levels: far and near. Comparison type had four levels: positive (*x* vs. *y*), negative (-*x* vs. -*y*), mixed (*x* vs. -*y*), and zero (*x* vs. 0 (positive valence) and -*y* vs. 0 (negative valence)). The dependent variable was response time on correct trials

Results

A multivariate analysis revealed reliable main effects of comparison type ($F(3,18)=69.79$, $p<.001$) and distance ($F(1,18)=10.51$, $p<.005$) and a reliable interaction ($F(3,18)=15.13$, $p<.001$). Means, standard errors, and sample comparisons are shown in Figure 1. Positive comparisons showed an SDE ($t(20)=4.33$, $p<.001$), suggesting use of magnitude processing (i.e., a mental number line). Negative comparisons showed an SDE ($t(20)=4.43$, $p<.001$), also suggesting use of magnitude processing.

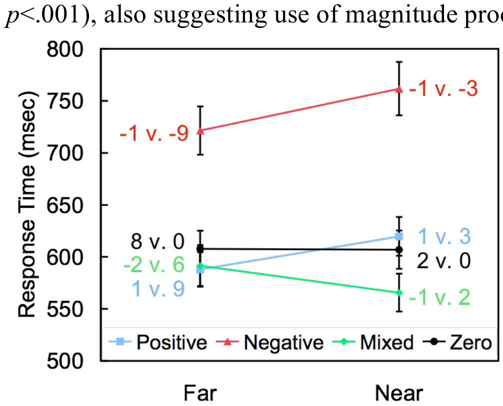

Figure 1: Symbolic distance effects.

Surprisingly, mixed comparisons showed an *inverse* SDE, with far comparisons slower than near comparisons ($t(20)=4.94$, $p<.001$). This is inconsistent with the use of magnitude processing, which predicts a conventional SDE. It is also inconsistent with the use of rules (e.g., "positives are greater than negatives"), which predicts a flat line.

Zero comparisons failed to show an SDE ($t(20)=.08$, $p>.93$). A natural interpretation is that participants used rules (e.g., "positives are greater than zero"), not magnitude processing. To test this interpretation, we conducted a multivariate analysis with two repeated measures, valence (i.e., the sign of the non-zero number) and distance. The interaction was reliable ($F(1,20)=6.57$, $p<.02$), as shown in Figure 2. Positive-valence comparisons show an SDE and negative-valence comparisons an inverse SDE.

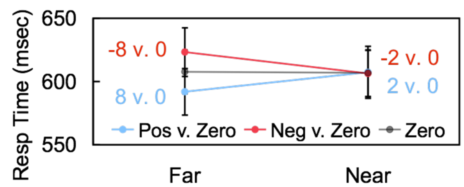

Figure 2: Valence effect.

Discussion

This study investigated the mental representation of integers. The results suggest that integers partition mentally into two classes, non-negative and negative. Comparisons within the same class show an SDE. This is consistent with conventional magnitude processing, i.e., a conventional mental number line stretching from $-\infty$ to ∞. By contrast, comparisons across classes (i.e., a negative integer to either a positive integer or zero) show an inverse SDE. This is inconsistent with conventional magnitude processing. We are developing a new (and unconventional) mathematical model to account for these results.

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Reference

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