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.

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.

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 -∞ 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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