Delimiting and Leveraging Children's Natural Sense of Proportion

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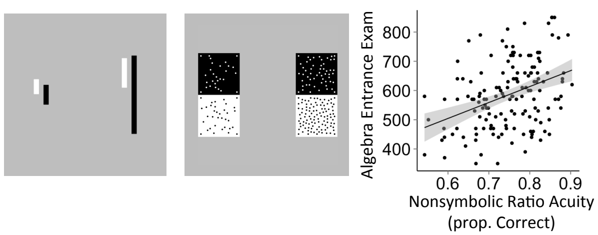
Introduction

Understanding fractions, particularly understanding their relative sizes, is critical for the development of mathematical competence.[1-2] However, both children and adults often struggle to understand fractions. Several theorists have proposed that fraction concepts are difficult because they are fundamentally incompatible with the core neurocognitive architectures that support mathematical cognition.[3-4] On this account, fractions are difficult because they lack an intuitive basis, whereas whole number understanding can be grounded in our native perceptual abilities.

One competing view is a perceptual access account. This account hypothesizes that humans (and nonhuman primates) have an intuitive sense of nonsymbolic ratio magnitude that allows them to perceive and judge fraction magnitudes.[5-9] This intuitions for fractions may provide a basis for building symbolic fractions knowledge and general mathematical competence. Indeed, in prior work, we have found that individual differences in performance on nonsymbolic ratio discrimination tasks was correlated with college mathematics entrance examination scores[5].



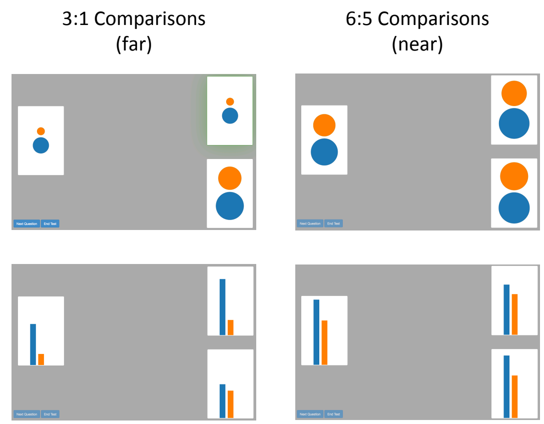
Much remains unknown about the nature of these ratio processing abilities including: a) how acuity develops over time and b) how acuity varies among different nonsymbolic ratio formats. We used match-to-sample tasks to investigate nonsymbolic ratio perception abilities among preschool children who have yet to receive formal instruction on fractions and other rational number concepts.

Method

Sixteen Preschool children (M_{age} = 5.13, *SD* = .76) were presented with target nonsymbolic ratios corresponding to specific fraction magnitudes and asked to choose which of two stimuli matched each target magnitude. Nonsymbolic ratios took two forms – ratios of circle areas and ratios of line segment lengths.

Method (continued)

Stimuli were presented on tablet computers. The ratios between matching and distractor stimuli were presented in each of five bins to assess discrimination acuity – 6:5, 4:3, 3:2, 2:1, and 3:1. Note that each bins indicates a *ratio of ratios*. For instance, pairing a nonsymbolic $^{1}/_{2}$ with a nonsymbolic $^{1}/_{6}$ corresponds to a ratio of 3:1. Larger ratios indicate larger distances between match and distractor stimulus sizes.

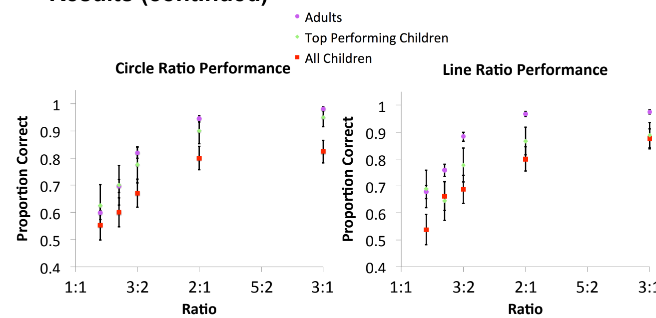


Results

1) Preschool children successfully completed the task at far distances (i.e. ratio bins of 3:1), and accuracy decreased as distances between choices decreased. This performance with nonsymbolic ratio values rivals that shown by children of the same age on numerosity discrimination tasks.[10]

2) The highest performing children (6 of 17) exhibited performance that that approached adult levels, despite children's lack of formal instruction on fractions and other rational number concepts.

Results (continued)



Discussion

These results suggest that children do indeed have intuitive, perceptually based sensitivity to fraction values when they instantiated in some nonsymbolic formats. Moreover, they suggest that this sensitivity may be characterized by a distance effect (i.e., accuracy increases with increasing distance between comparison stimuli). This is compatible with general conceptions of an internal number line.[11]

Future work will investigate whether this perceptual sensitivity to nonsymbolic ratios can be leveraged to support children's understandings for the meanings of symbolic fractions (e.g. $^{2}/_{5}$).

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