

Increased Acuity of the Analog Magnitude System is Related to Spontaneous Focusing on Numerosity in Children and Adults



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Background

- Spontaneously focus on numerosity (SFON) is the spontaneous tendency to address numerical information without any external motivation.
- Several studies have found correlations between SFON and children’s mathematical abilities, but it is still unclear whether this relationship is due to SFON reflecting individual differences in quantitative processing.
- Therefore, this study examined the relationship between SFON tendency and quantity discrimination ratios in children and adults: we hypothesized that the tendency to spontaneously focus on numerosity will be correlated with better quantity discrimination.

Experiment 1: Children

Method

- Participants were 29 preschoolers (mean age = 3.85y, SD = 0.39, 10 males), recruited via WIZO (“Vitzo”) day care centers in Beer-Sheva.

SFON

- SFON was measured using imitation tasks developed by Hanuella and Lehtinen (2005):

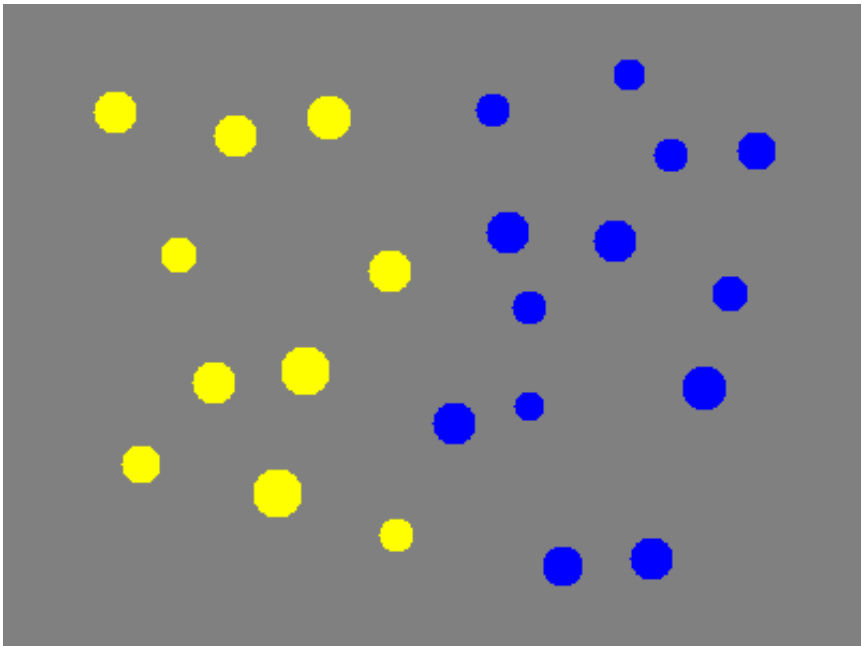
- Polly the parrot:** an experimenter fed Polly, a toy parrot, with one or two candy stones, after which the children were told “Now you do exactly like I did”.
- Dump Truck:** an experimenter scoops one or two scoops of gravel into a toy dump truck with a toy shovel, after which the children were told “Now you do exactly like I did”.



- The experimenter avoided using any wording which might suggest that the tasks were mathematical or quantitative.
- SFON was scored according to correct imitation of numerosity, or any quantifying acts.
- Each procedure was repeated 4 times. Equivalent forms reliability between the imitation tasks was $\alpha=.90$.

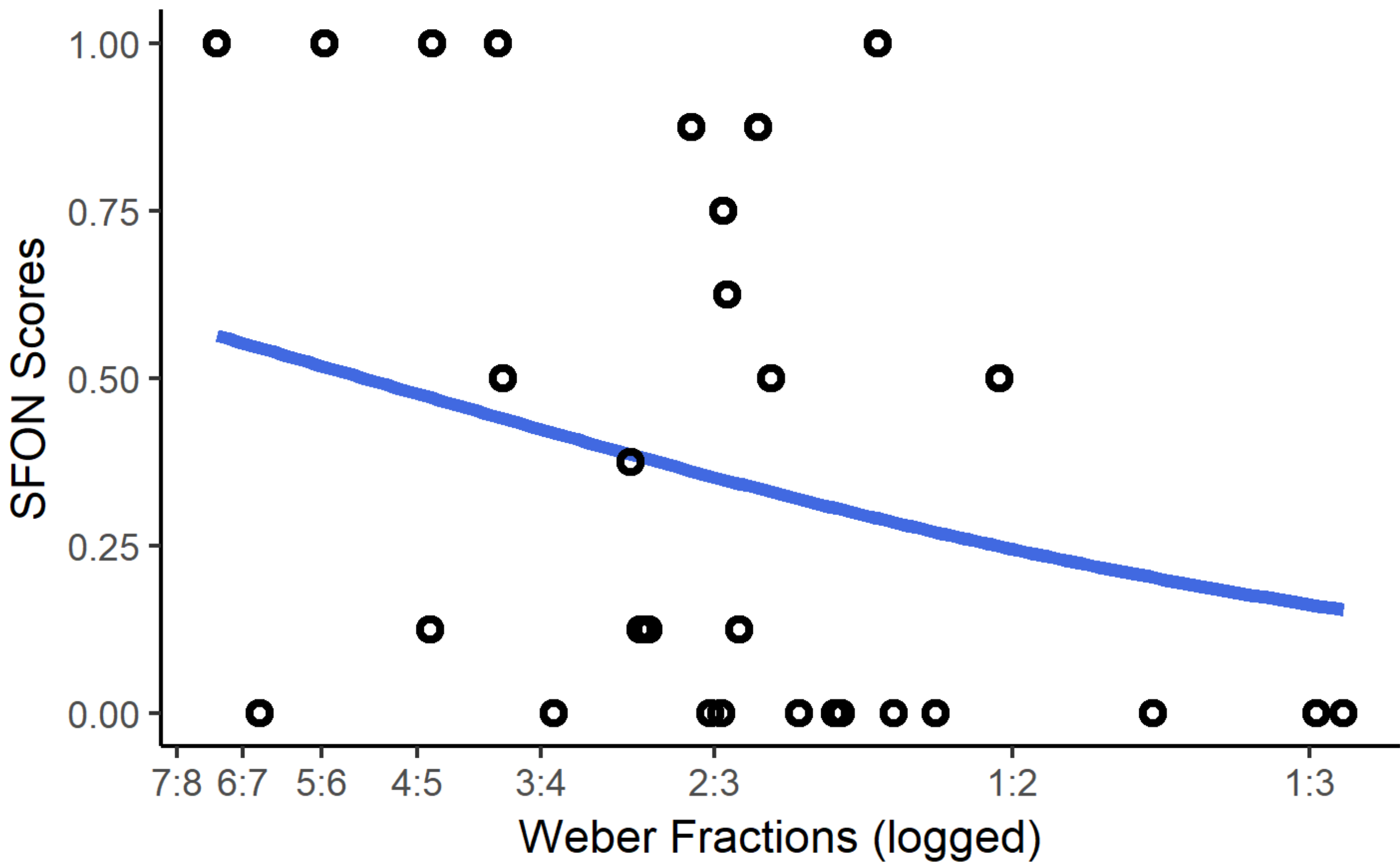
Discrimination Ratios

- Discrimination ratios were measured using a computerized dot-discrimination task (PANAMATH; Halberda et al., 2012).
- Weber fraction scores reflect the size of change in numerosity required to discriminate between the numerosities on 75% of the trials.



Results

Logistic regression analysis with SFON counts as the dependent variable, and Weber fractions as a predictor (controlling for age) revealed that children with better discrimination ratios were more likely to spontaneously attended to numerosity ($\log(Odds) = -0.52$, $z = -2.27$, $p = .024$). For example, compared to a child with a discrimination ratio of 1:2, a child with a discrimination ratio of 3:4 was 1.4 times more likely (95% $CI[1.52,1.95]$) to spontaneously focus on numerosity in the imitation tasks.



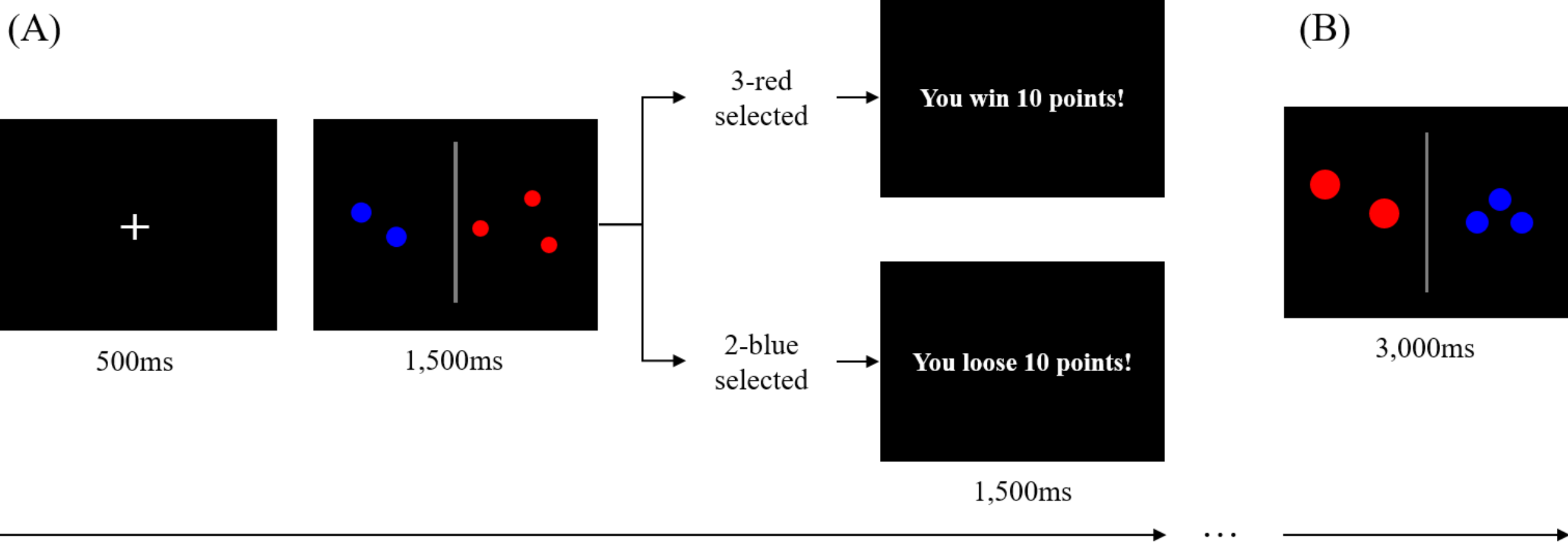
Experiment 2: Adults

Method

- Participants were 83 students (mean age = 23.68y, SD = 2.15, 27 males), from Ben-Gurion University of the Negev.

Numerical Bias Task – Adult SFON Estimation

- Participants were instructed to select one of two stimuli that would reward them with points.
- In the learning phase, participants learned to recognize the stimulus that always awarded them points. Each stimulus was comprised of two competing dimensions: the number of objects comprising the stimulus and the stimulus color.
- In the test phase, the pairing of the two dimensions comprising the stimuli were switched. This enabled us to identify whether the participant attended to the numerical dimension or the color dimension.

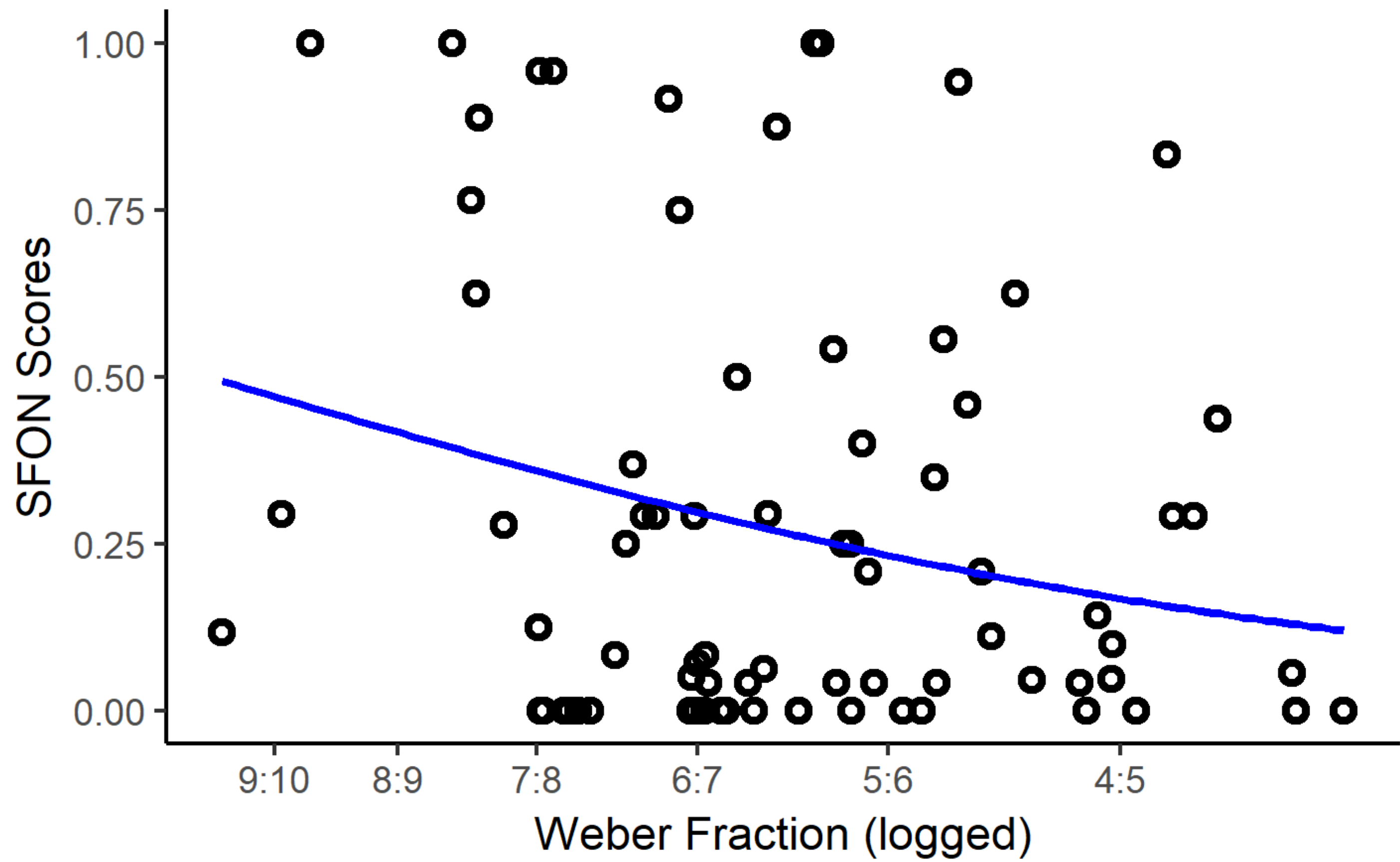


Additional Measures

- Discrimination ratios were estimated with the PANAMATH task.
- Mathematical skill was estimated via Quantitative Reasoning scores from participants’ Psychometric Test (range = 50-150).

Results

Parameter	Log(Odds)	Z Value	P-Value
(Intercept)	-12.00	-9.15	<.001
Weber Fraction	-1.35	-6.18	<.001
Quantitative Reasoning scores	0.05	5.30	<.001



Discussion

- As in children, adults showed individual differences in SFON tendency.
- In both populations, higher SFON scores were associated with better numerical discrimination, and in adults SFON was also associated with higher mathematical skills.
- These results suggest that increased acuity of the analog magnitude system (AMS) makes numerosity information more salient in the environment, therefore increasing the chances that the individual would attend to this aspect of the environment.
- Additionally, these results support the existence of a relationship between non-symbolic numerosity processing and symbolic-academic skills.

References

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