Uncertainty resolution in numerosity comparison: The moderating role of **math ability**

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SUMMARY

- Many decisions are guided by our basic intuitions of quantity, which is supported by the **Approximate Number System (ANS)**.
- Individual differences in a numerosity comparison task used to index ANS acuity are associated with formal math ability[1].
- This variation may also reflect differences in attention or uncertainty resolution, which can be approximated by eye movements that reflect attention switching between targets to gather information[2].

We find that people who tend to switch between targets more often in a numerosity comparison task generally perform better, particularly if they have high math ability.

METHOD

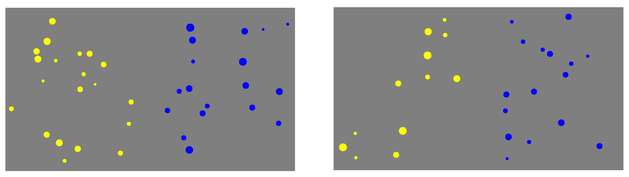
154 adults (73 females, M_{age}=19.86 years, SD_{age}=3.95) participated in a study examining the ANS and related cognitive functions. For this project, they completed 2 tasks.

1 Numerosity comparison task[3] (ANS precision)

Try the task here!

- Presented with 2 arrays of dots and asked: "Are there more blue or yellow dots?"
- Task difficulty is indexed by the ratio of the larger to smaller # of dots. Ratios → 1 represent more difficult trials.

Example trials:



20 to 18 dots (ratio: 1.11) 16:12 dots (ratio: 1.33)

2 Standardized math test

Completed math word problems from the Woodcock-Johnson Applied Problems subtest[4].

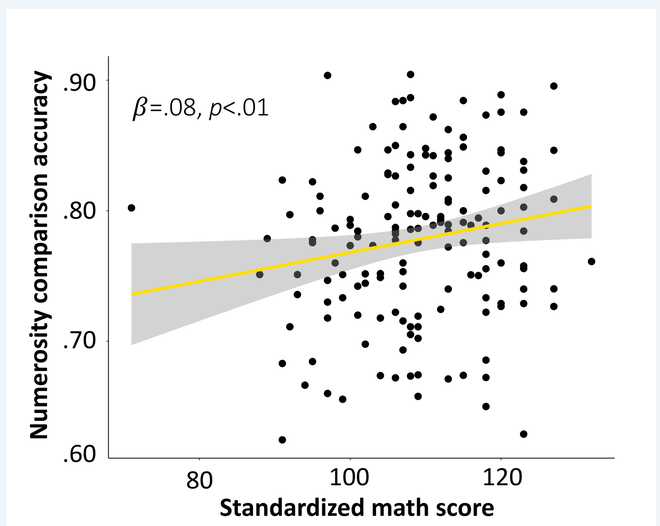
Descriptive statistics

Measure	Description	Mean (SD)	Range
Numerosity comparison			
Accuracy	% of correct trials	.78 (.06)	.62-.90
Response time (RT)	Average RT across trials	1.01 (.28)	.61-2.07
Switching frequency	Average frequency with which individuals switch between the dot arrays	2.66 (.92)	.12-4.48
Standardized math	Normed score from # of correct items	109.19 (9.91)	71-132

RESULTS

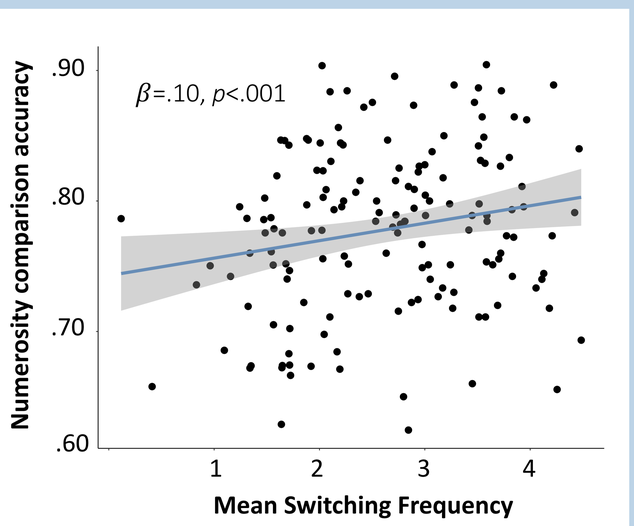
*Hierarchical linear regression models relating numerosity comparison accuracy to math ability and switching frequency were conducted.

Consistent with past research, math ability is positively related to ANS acuity.



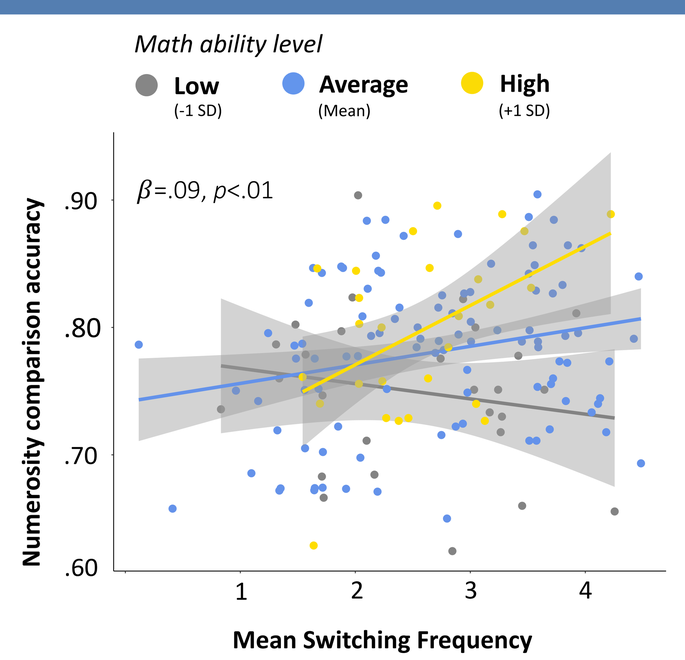
*Model 1: ANS acuity = Math ability + Task difficulty + RT

Switching frequency in dot comparison is positively related to ANS acuity.



*Model 2: ANS acuity = Math ability + Switching Frequency + Task difficulty + RT

The relation between switching frequency and ANS acuity is stronger for those with higher math ability.



*Model 3: ANS acuity = Math + Switching + Math * Switching + Task difficulty + RT

DISCUSSION

If we believe that switching frequency indicates the extent of uncertainty resolution or information gathered, then it is possible that:

- Individuals with high math ability are generally better than those with low math at obtaining and processing relevant information to compare numerosities.

Another possibility is that switches reflect different states or processes for different groups of people, e.g.,

- Switches may index how much info was gathered or a double-checking strategy for high math people.
- Switches may index a state of uncertainty or difficulty with the task for low math people.

Future work should include additional eye-tracking metrics and cognitive measures.

References

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[2] Cassey, T. C., Evens, D. R., Bogacz, R., Marshall, J. A. R., & Ludwig, C. J. H. (2013). Adaptive sampling of information in perceptual decision-making. *PLoS ONE, 8*(11), e78993. doi: 10.1371/journal.pone.0078993
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