What do our eyes say about our estimation strategies?

MAYBÍ MORELL RUIZ, MAGNUS HAAKE & AGNETA GULZ

Numerical estimation

Numerical estimation, measured with the *Number Line Estimation Task* (*NLET*; Figure 1), is related to mathematical competence [1] and development of numerical knowledge [2].

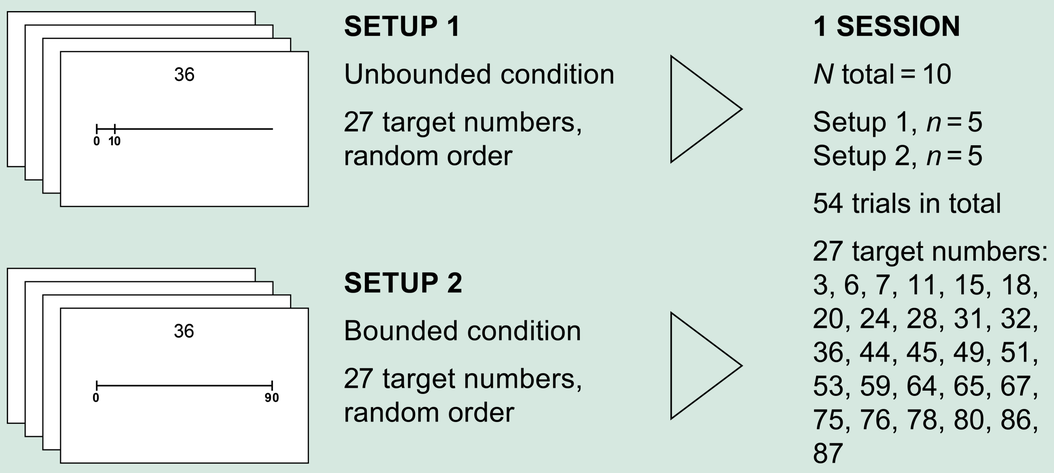


Figure 1. The study with the two conditions of the Number Line Estimation Task (NLET).

Eye-tracking

Eye-tracking methodology has shown promising results in developmental studies of number sense [1] and numerical magnitude [3] in children.

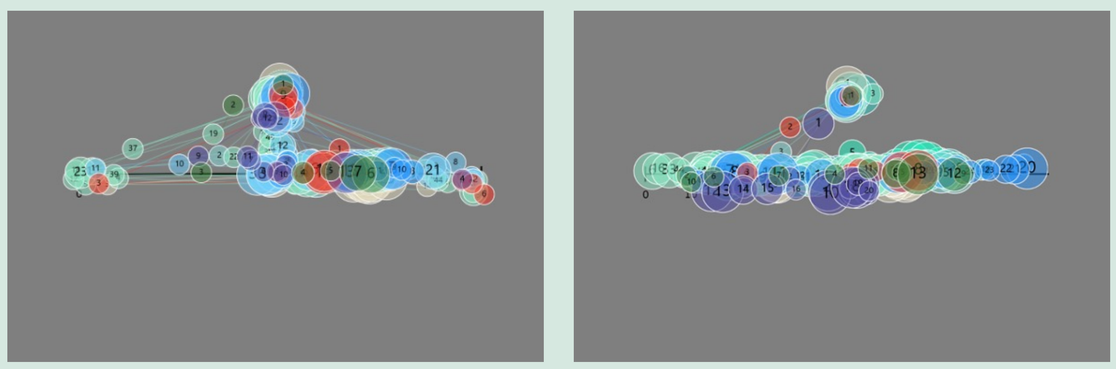


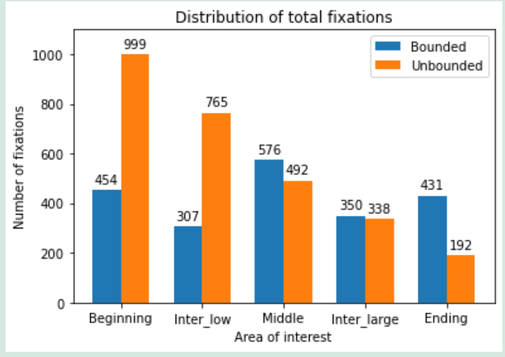
Figure 2. Recorded eye-tracking patterns from the Number Line Estimation Task (NLET).

Research and development

Combining numerical estimation and eye-tracking technologies opens up for developmental and educational studies of early math and the development of educational software to support preschoolers' development of numerical estimation [4].

As a first step (a methodological study) was conducted implementing NLET on a laptop with a non-intrusive eye-tracking sensor (Tobii 4c).

Results



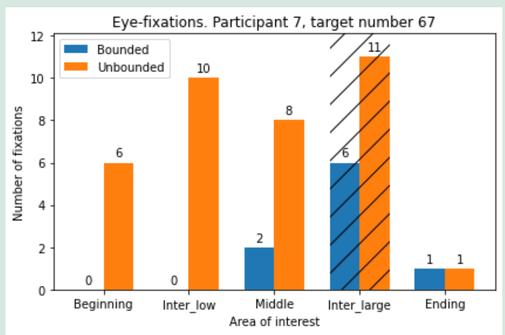
Absolute Estimation Error (AEE)

Unbounded: $M = 8.9$; $SD = 5.91$

Bounded: $M = 4.6$; $SD = 2.43$

t-test: $t(26) = 3{,}40$, $p < .001$; medium effect size, Cohen´s $d = 0.65$.

- Subjects make more estimation errors when they solve the task in the unbounded condition than in the bounded condition.
- The estimation strategies (eye-fixation patterns) differ between conditions.



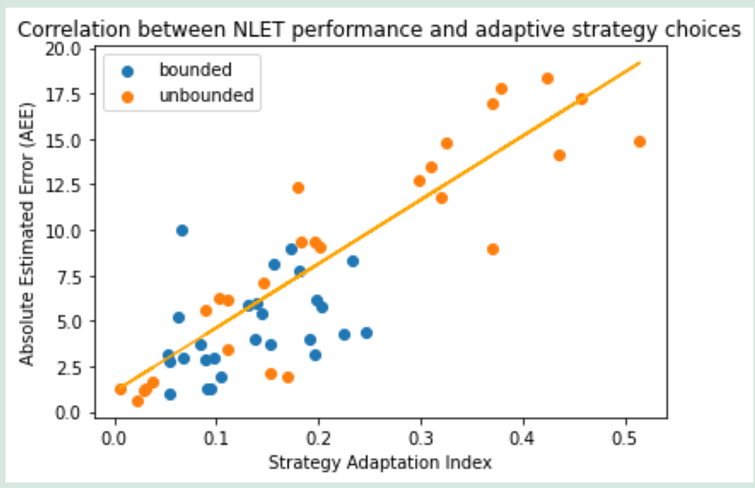
Strategy Adaption Index (SAI)

SAI: the average distance to the target for all fixations.

Unbounded: $M = 0.22$; $SD = 0.15$

Bounded: $M = 0.13$; $SD = 0.06$

- The estimation strategy adaptation index (the fixations' dispersion around the target number) was smaller in the bounded than in the un-bounded condition).



Correlations

Unbounded: $r(25) = .90$, $p < .001$

Bounded: $r(25) = .40$, $p = .04$

- The estimation strategy measure (SAI) correlated with the estimation performance (AEE).

References

[1] Schneider, M., Merz, S., Stricker, J., De Smedt, B., Torbeyns, J., Verschaffel, L., & Luwel K. (2018). Associations of number line estimation with mathematical competence: A meta-analysis. *Child Development*, *89*(5), 1467-1484.

[2] Siegler, R. S. (2022). Development of numerical knowledge. In O. Houdé & G. Borst (Eds.), *The Cambridge Handbook of Cognitive Development* (pp. 361-382). Cambridge Univ. Press.

[3] Reinert, R. M., Huber, S., Nuerk, H. C., & Moeller, K. (2015). Strategies in unbounded number line estimation? Evidence from eye-tracking. *Cognitive Processing*, *16*(1), 359-363.

[4] Gulz, A., Londos, L., & Haake, M. (2020). Preschoolers' understanding of a teachable agent-based game in early mathematics as reflected in their gaze behaviors – an experimental study. *International Journal of Artificial Intelligence in Education*, *30*, 38-73.

Lund University Cognitive Science

the Educational Technology Group

EDUCATIONAL TECHNOLOGY GROUP
http://www.lucs.lu.se/etg/