Fonds National de la Recherche Luxembourg

Project Numtest

Assessing basic number competence without language

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Why?

Some estimated 5-7% of children suffer from math learning difficulties. Universally valid diagnostic instruments are lacking, as existing test batteries are based on language instructions. Therefore, their measurements are dependent on the language context of their administration.

This is problematic because:

- Test results are partially dependent on language skills
- It leads to assessment difficulties in increasingly multilingual populations

The findings presented here stem from a task developed in the context of a research project that pursues to build non-verbal screening methods through the use of video instructions and animated task demands.

Methods

Crossmodal Audiovisual Addition Task : Procedure

Sample
71 children
48% female
age: 7 y 2 m

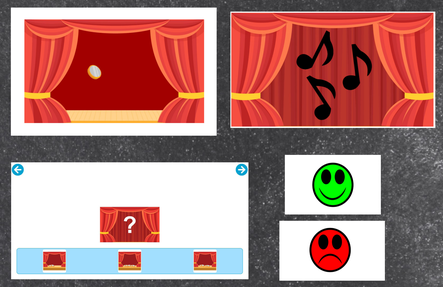
Participants see & hear coins dropping on a floor. A curtain closes. More coins are heard dropping, after which they are presented with three images showing different amounts of coins on the floor. The implicit question is: "How many coins are on the floor (in total) ?

Scan me

Video instruction showing successful task completion

Three instruction items

Three Practice items with visual feedback



In case of mistake: repititon of all practice items!

Items

Item structure:
(Audio)visual + Audio

Instruction	Practice
1 + 1	1 + 3
1 + 2	2 + 1
3 + 1	2 + 2

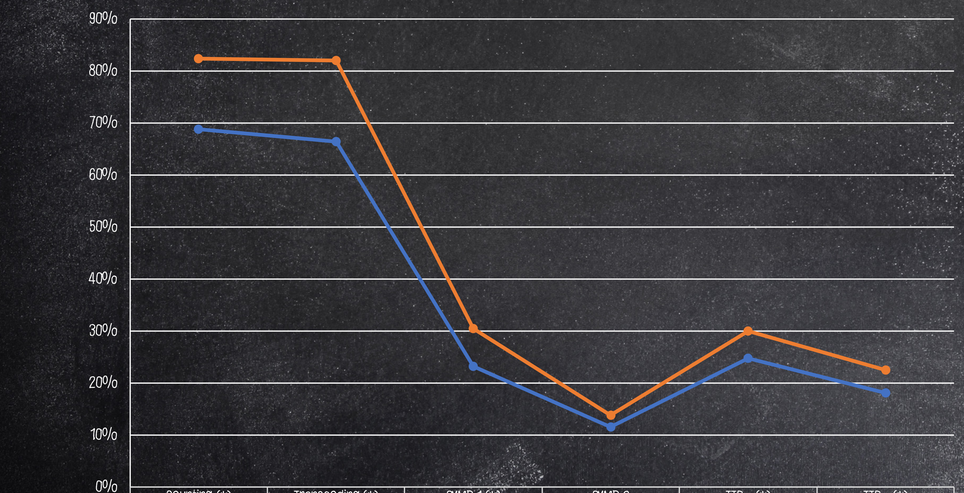
Control measures

1. Tempo Test Rekenen (Addition & Subtraction)
2. SYMP Test (Symbolic number comparison; 1-digit & 2-digit)
3. Counting (Oral response)
4. Transcoding (Oral -> Symbolic)

After data collection, we split participants into two groups: One group contained the participants that made a mistake during the practice session and thus repeated the three items (Repeaters, N= 25). The other group contained the participants that solved all practice items on their first try (Non-repeaters, N= 46).
As item difficulty was kept very low, we can assume that a mistake during the practice session can be safely attributed to misunderstanding the video instruction. During exploration of the data, we observed a consistent pattern of lower performance on all control measures in the group of repeaters. Using MANOVA, we examined if these differences reached statistical significance. As there are no plausible reasons for repeaters performing better than non-repeaters on different measures of numerical competence, we proceeded to test a directional hypothesis: Non-repeaters perform better than repeaters.

Results

Performance on control measures by group (% of max. performance)



	Counting (*)	Transcoding (*)	SYMP 1 (*)	SYMP 2	TTR + (*)	TTR – (*)
Repeater	68.80%	66.40%	23.20%	11.60%	24.70%	18.10%
Non-repeater	82.30%	82%	30.50%	13.80%	30%	22.50%

MANOVA revealed a significant effect of practice session repitition ($F=4.84$, $p<.05$). Subsequent univariate analyses revealed significant differences in mean performance between repeaters and non-repeaters in all control measures, with the exception of the two-digit symbolic number comparison task (SYMP 2).

Discussion

The nature of our task requires participants to tap into a non-symbolic, format-independent representation of quantity. While storage and manipulation of information in WM could be of linguistic nature by relying on an accumulating verbal counting chain, quantitative input from two different senses must be abstracted and combined before being recoded into a visual representation to choose the correct image. Participants that spontaneously grasped the nature of the task by watching someone succeed and subsequently solved three different practice items, seem to perform better, not only on counting and transcoding scales, but also on measures of symbolic number comparison and basic arithmetic.
This is interesting when considered in the light of ongoing debates on the nature of symbolic mapping to abstract quantity representations (see e.g. Barth. et al and Lyons et al. for opposing views). If abstract quantity representations are completely unrelated to symbolic number processing, then performance on our non-symbolic nonverbal paradigm should not be related to performance on symbolic number comparison nor symbolic arithmetic tasks. While this finding must be experimentally reproduced and investigated, our preliminary data indicates that the nature of our task taps into a form of "abstract numerical intelligence" that is predictive of performance on both non-symbolic and symbolic measures of basic numerical competence.
Furthermore, these results are promising when considering that performance on this very short instruction-practice paradigm of our non-verbal cross-modal addition task could potentially be used as a predictor for precursor abilities of basic math competence in many linguistically heterogeneous settings.

References

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