Therapy software for enhancing numerical cognition

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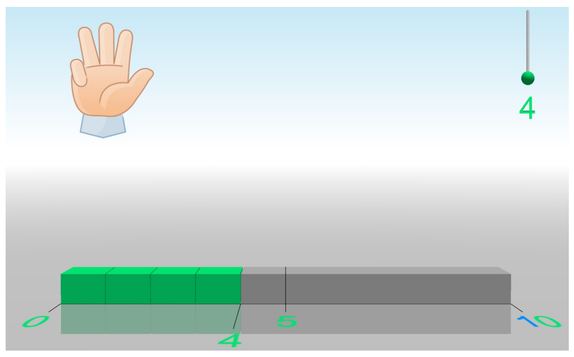
Overview

- Software for the acquisition of central components of number processing and representation
- Learning process supported through multimodal cues encoding different properties of number
- Learning environment with 3D graphics and interaction components
- Adaptation to user through Bayes net user model
- Builds up on a computer-based training program for children with developmental dyscalculia evaluated in a previous study. Results have proven, that the training induces neuroplastic changes and improves the spatial representation of numbers and arithmetical performance. [2]

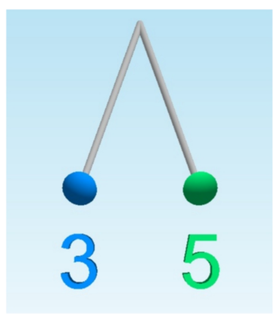


Number representation

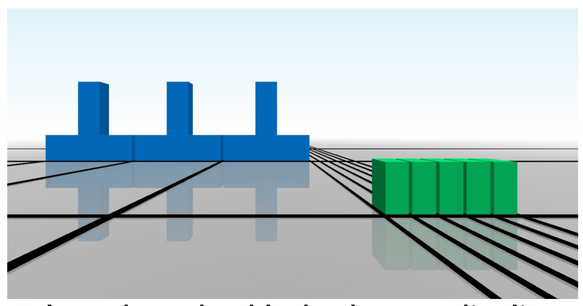
The software is based on current neuro-cognitive models of number processing:

- A modular system for number representation is assumed [1]
- The modular system develops hierachically over time depending on capacity and availability of domain specific and domain general functions [3]

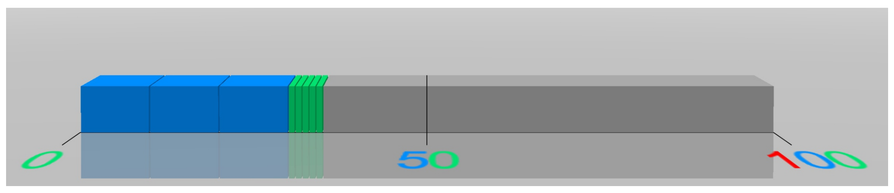
The number design of the software enhances these representations through encoding properties of numbers with visual cues such as color, form and topology.



Number graph and colors emphasize place-value system.



Coloured number blocks show cardinality of number.



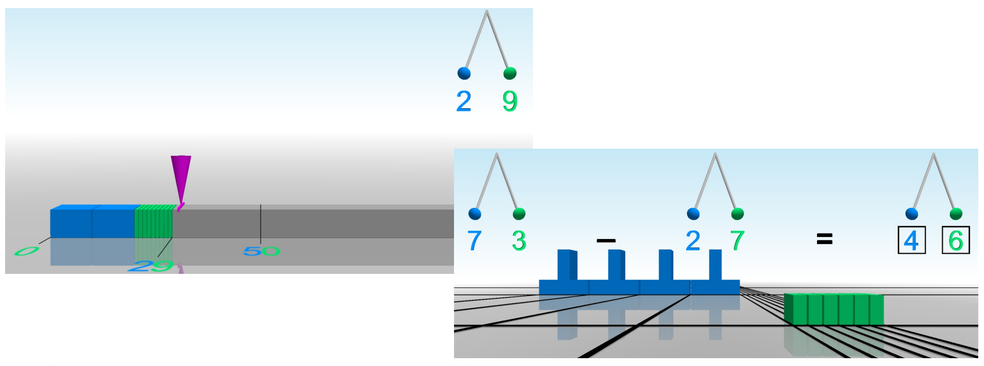
Analogue magnitude representation: The coloured blocks are integrated in the number ray.

The different number designs are shown simultaneously in each sub-game of the software.

Games

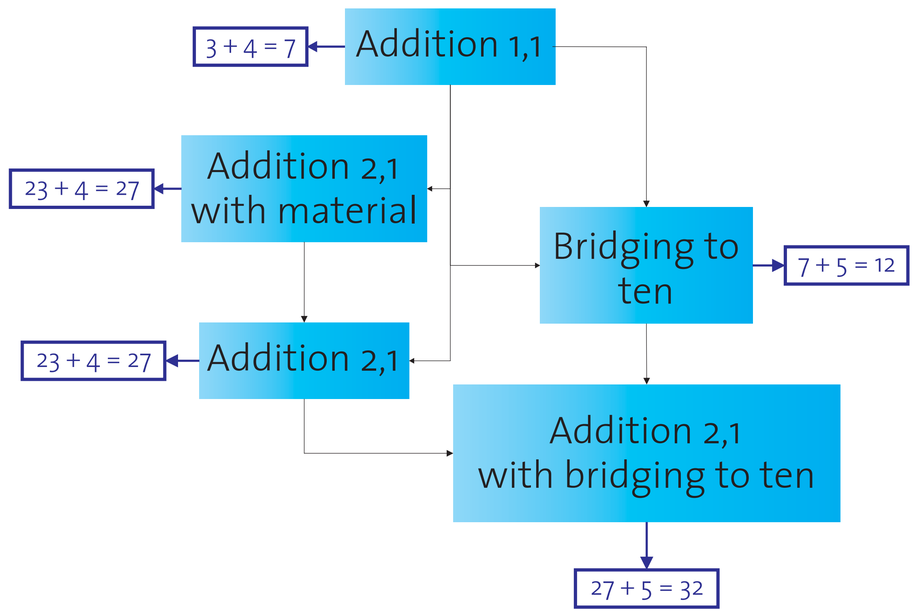
Software is structured into two areas

- Cognitive number representation and numerical understanding: Games in this area feature translations between different number representations or highlight aspects of numerosity
- Cognitive operations and procedures: Games in this area train mathematical operations at a specific difficulty level



Software adapts to needs of a specific user

- Actual knowledge state of user is estimated after each input
- Software holds internal representation of user's knowledge
- Knowledge is represented through a graph consisting of different mathematical skills and dependencies among them and thus forms a dynamic Bayes net
- Skills cannot be observed directly, but have to be inferred by posing specific tasks and evaluating user actions



Current Study

- Multi-center study in Zurich, Berlin and Potsdam
- Evaluation of therapy concept with normally achieving and dyscalculic children
- Cross-over design, both groups will be divided into a training group, a control training group and a waiting group
- 5 trainings of 20 minutes per week, during 6 weeks
- Collection of psychometric data to prove effect and temporal stability of training

References

[1] Dehaene S (1992) *Varieties of numerical abilities*. Cognition, 44: 1-42

[2] Kucian K, Grond U, Rotzer S, Henzi B, Schönmann C, Plangger F, Gälli M, Martin E, von Aster M (2011) *Mental Number Line Training in Children with Developmental Dyscalculia*. NeuroImage

[3] von Aster MG & Shalev R (2007) *Number development and developmental Dyscalculia*. Developmental Medicine and Child Neurology, 49: 868-873

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