

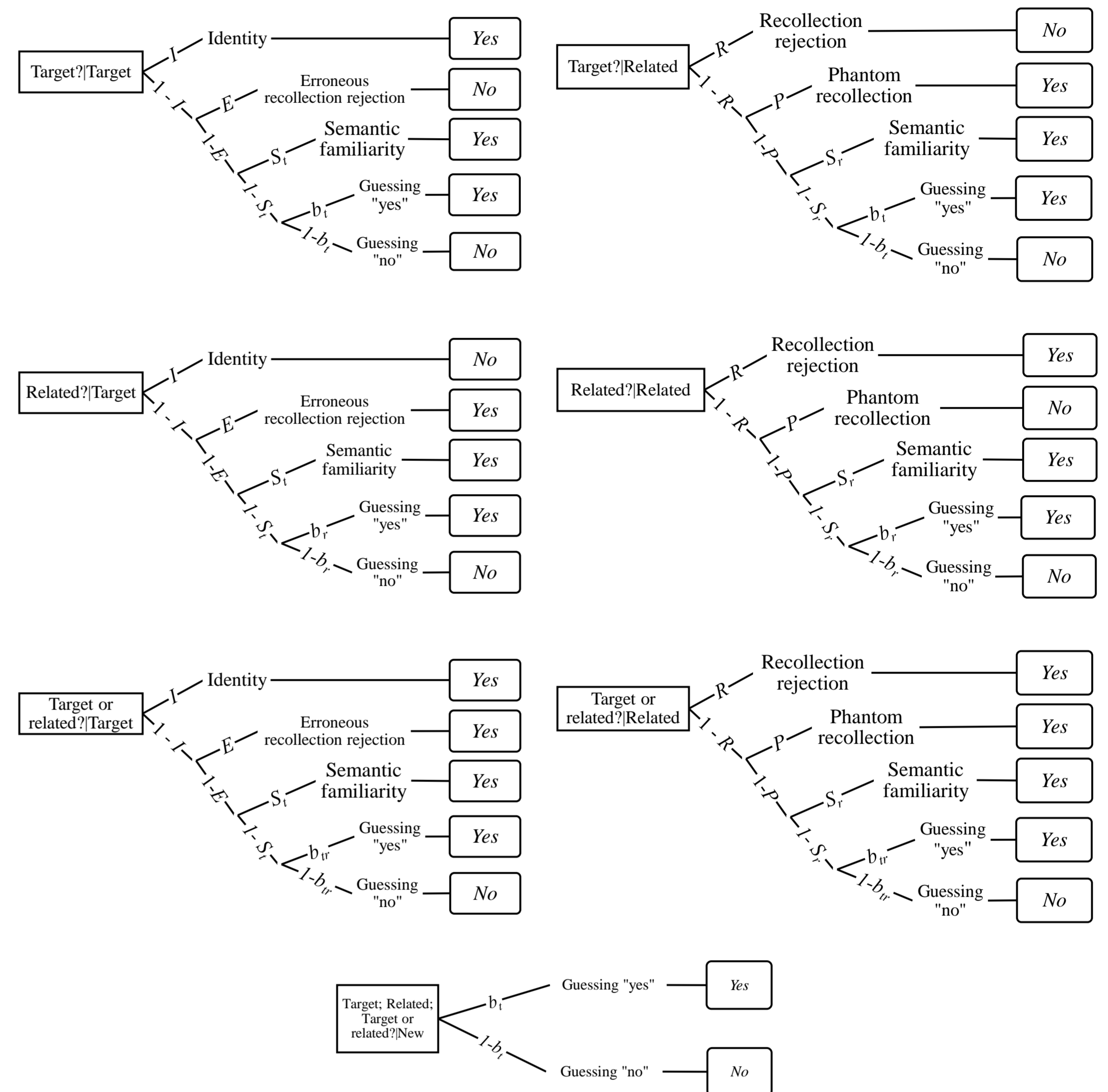
# The structure of long-term memory in developmental dyscalculia from a fuzzy-trace theory perspective: a registered report

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## Idea of the project:

- In the developmental dyscalculia studies, there is a significant lack of research concerning LTM, the cognitive process central to learning and knowledge (the impairment of which for mathematical facts is implied in DSM-5, F81.0, and ICD-11, 6A03.0).
- The proposed study attempts to fill this gap by using the Fuzzy-Trace Theory (FTT: Brainerd & Reyna, 2023), which has been neglected so far in dyscalculia research.
- According to FTT, information is encoded in two memory traces, namely, **gist** and **verbatim**:
  - The verbatim trace is a surface, symbolic and precise representation, capturing exact details such as exact numerical values (in numerical material);
  - The gist trace, on the other hand, is more related to the meaning of the presented information such as the general magnitude of numerical value (it is more fuzzy/less precise).
- Studies on developmental dyslexia show the applicability of FTT to research on learning disorders (e.g., Obidziński & Nieznański, 2017, 2022): FTT allows for more precise differentiation of cognitive processes, and thus prediction and analysis of specific memory effects. Therefore, it allows for a more precise study of memory functioning in dyscalculia, compared to the typically developing (TD) control group.
- The study aims to investigate verbal and numerical memory for verbatim and gist information in dyscalculia (in comparison with TD).



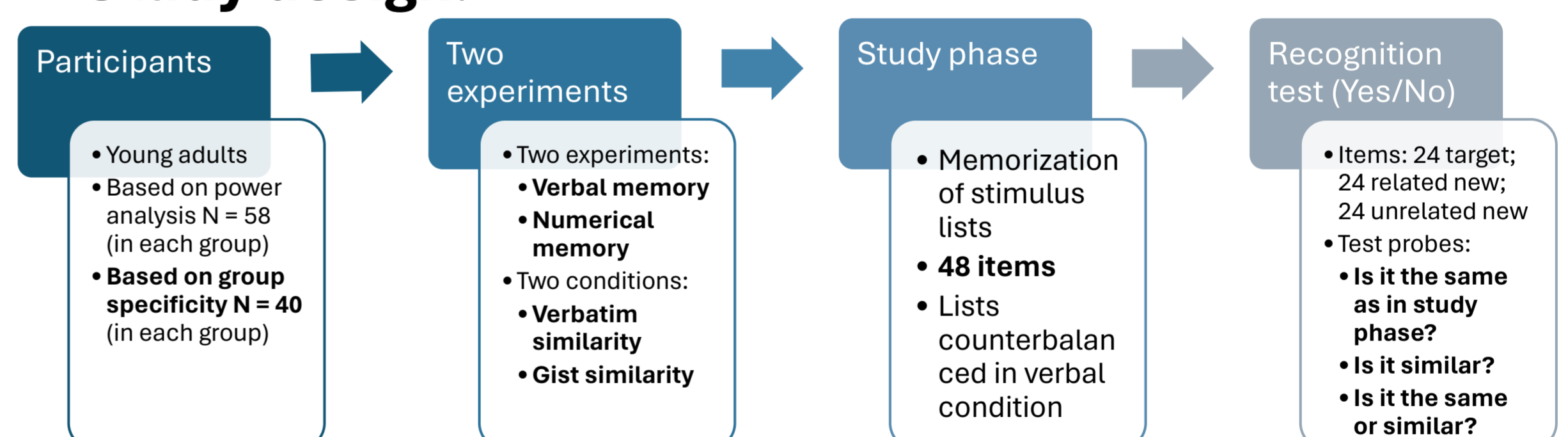
Conjoint-recognition multinomial model (Brainerd et al., 2022) based on Nieznański et al. (2023). Multinomial model shows for memory processes described in FTT.

As trees for unrelated new stimuli are the same, they are presented only once, with all three probe types in the root description.

## Study Material:

- For the proposed study, new memory material – based on the triad procedure conjoint-recognition items (Obidziński & Nieznański, 2017) - was created:
  - Sofa - Soda (verbatim similarity) - Couch (gist similarity)
- Verbatim condition material based on the sum equation.
  - Target stimulus presents the number of two elements and their sum: e.g. *In the kitchen, there are 34 utensils, including 27 forks and 7 spoons*
  - Related new stimulus presents the same elements and the same sum as in the target, but with a changed number of elements: e.g. *In the kitchen, there are 34 utensils, including 26 forks and 8 spoons*
  - Unrelated new stimulus presents the same elements but with a change to both their number and their sum: e.g. *In the kitchen, there are 32 utensils, including 14 forks and 18 spoons*
- Gist condition material based on the comparison of objects' numerosity.
  - Target stimulus presents the number of two elements, where one is bigger than another: e.g. *Farmer has 7 dogs and 11 horses (a < b)*
  - Related new stimulus presents the same elements that are in the same relation (bigger-smaller) as in the target, but with a changed number of elements: e.g. *The farmer has 10 dogs and 15 horses (a < b)*
  - Unrelated new stimulus presents the same elements but with a change to both their number and the relation between them: e.g. *The farmer has 20 dogs and 9 horses (a > b)*

## Study design:



## Possible scenarios for the study's results:

- Based on FTT, the understanding of dyscalculia, and empirical evidence, we consider the following 3 scenarios of the link between dyscalculia and number-related memory to be tested.
  - N1: impaired gist memory & enhanced verbatim memory**
    - The gist seems to be related to the Approximate Number System
    - The inability to extract the gist from presented information can lead to poor performance in mathematical and scientific problem-solving tasks
    - Verbatim memory could work as the compensatory mechanism
  - N2: enhanced gist memory & impaired verbatim memory**
    - Based on this fact and the FTT assumption of verbatim reliance in early development and that dyscalculia is observed from childhood
    - Precision and analytical reasoning are necessary for the emergence of further mathematical skills
    - Greater reliance on gist processing, leading to new heuristics and reasoning strategies, could compensate for the verbatim impairment
  - N3: both verbatim and gist memory impaired**
- Scenarios for verbal memory:
  - V1: enhanced gist memory & impaired verbatim memory**
    - This pattern of verbal memory functioning in dyscalculia because of its frequent co-occurrence with dyslexia
  - V2: no difference between DD and TD verbatim or gist memory.**

## References:

- Brainerd, C. J., Bialer, D. M., & Chang, M. (2022). Fuzzy-trace theory and false memory: Meta-analysis of conjoint recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 48(11), 1680–1697. <https://doi.org/10.1037/xlm0001040>
- Reyna, V. F., & Brainerd, C. J. (2023). Numeracy, gist, literal thinking and the value of nothing in decision making. *Nature Reviews Psychology*. <https://doi.org/10.1038/s44159-023-00188-7>
- Nieznański, M., Ford, D., & Obidziński, M. (2023). Representation of shared surface information and false memory for abstract versus concrete pictures in the conjoint recognition paradigm. *Psychological Research*. <https://doi.org/10.1007/s00426-023-01899-5>
- Obidziński, M., & Nieznański, M. (2017). False memory for orthographically versus semantically similar words in adolescents with dyslexia: A fuzzy-trace theory perspective. *Annals of Dyslexia*, 67(3), 318–332. <https://doi.org/10.1007/s11881-017-0146-6>
- Obidziński, M., & Nieznański, M. (2022). Context and target recollection for words and pictures in young adults with developmental dyslexia. *Frontiers in Psychology*, 13, 993384. <https://doi.org/10.3389/fpsyg.2022.993384>