Different factorisation approaches of the Delis-Kaplan Executive System Battery converge towards a bi-factor model

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Executive functions (EF) are essential for goal directed behaviour and are impaired in many psychiatric and neurological conditions. Understanding the relationships between different measures, and hence the latent structure of EF, is therefore crucial. Previous studies have investigated this question using different factorisation methods and (ad hoc) sets of EF tests resulting in diverse findings and conceptual models. [1;2]. Here, we aimed to identify a robust factorial structure of a widely-used standard battery, the Delis-Kaplan Executive Function System (D-KEFS, [3]). Our analysis capitalized on a novel unsupervised learning approach combined with extensive stability evaluation, as well as traditional factorization approaches, all applied to the same big dataset.

Orthonormal projective non-negative matrix factorization (OPNMF), was used to derive a low-rank representation of the primary measures of the D-KEFS using age-corrected standardised scores from 334 healthy adults from the Enhanced Nathan Kline Institute – Rockland Sample [4]. Cross-validation was performed through repeated split-half assessment and the most stable and optimal factor solution was selected by measuring adjusted rand index, concordance index and variation of information. The generalizability was assessed by measuring transfer reconstruction errors. Additionally, data was subjected to an exploratory factor analysis (EFA) and a principal component analysis (PCA), with promax rotation. Parallel analysis was used to select the number of factors/components in the latter two cases.

Based on results of the stability measures, the OPNMF analysis indicated a bi-factor model as the optimal solution, with one factor strongly loading on Colour-Word Interference scores, Verbal Fluency and moderately loading on switching components of the Design Fluency Test and the Trail Making Test. The second factor featured strong loadings from the Sorting Test, Proverbs Test, Word Context Test and the 20 Questions Test and a weaker loading for the Tower test. Both PCA and the EFA analyses resulted in similar structures (Figure 1). A strong correlation between the two factors, though, was found independent of the factorization method.

Our analyses suggest a division between tasks that require monitoring and task-switching, and more complex tasks that require concept formation, abstraction, problem-solving. A recent factorisation on D-KEFS scores using EFA revealed a 3-factor model composed of Conceptual Flexibility, Monitoring and Inhibition[1]. Our study supports the hypothesis of a factor for problem-solving and conceptual flexibility, however suggests a simpler, bi-factor model in which tasks representing monitoring and inhibition are grouped in one factor. Thus, our study promotes a bifactor model representing a highly stable feature of EF. Future studies should investigate the validity of more complex models, possibly reflecting second-order factors, that cannot be primarily evidenced in a general population.

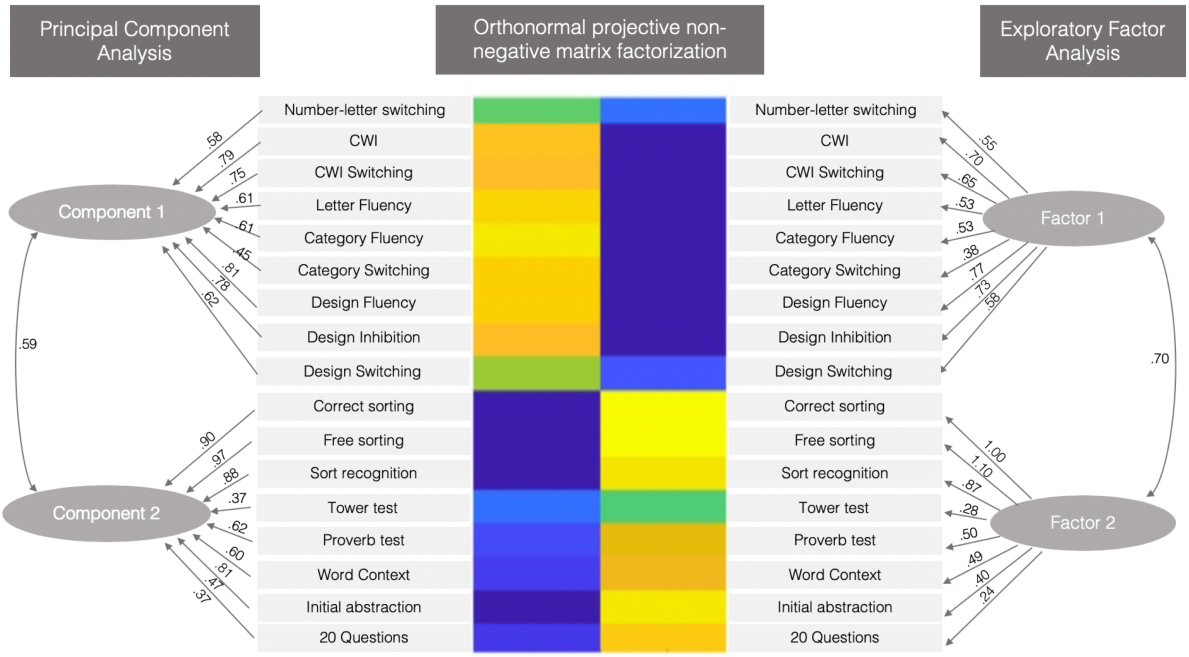

Figure 1.