T101

Assessing neural computations supporting memory in 4-year-olds using a latent variable approach

Work in progress

Hunor Kis[1,2,3], Borbála Brosig[2,3], Éva Kovaliczky[2,3], Patricia Dávid[2,3], Anna Horgonyi[2,3], Boróka Ferencz[2,3], Petra Kóródi[2,3], Zsófia Berke[2,3], Markus Werkle-Bergner[4], Chi T. Ngo[4], Ildikó Király[2], Attila Keresztes[3,2]

1. Institute of Psychology, ELTE Eötvös Loránd University, Budapest, Hungary; 2. Doctoral School of Psychology, ELTE Eötvös Loránd University, Budapest, Hungary; 3. Brain Imaging Centre, HUN-REN Research Centre For Natural Sciences, Budapest, Hungary, 4. Center for Lifespan Psychology, Max Planck Institute for Human Development, Berlin, Germany

HCCCL Hippocampal Circuit and Code for Cognition

ELTE Faculty of Education and Psychology

:kis.hunor@ttk.hu

:@kishun97

1. INTRODUCTION

Two distinct neural computations performed by the hippocampus contribute differentially to behavioral memory outcomes[1].

Pattern separation (PS)—supported by the dentate gyrus (DG) of the hippocampus—is a computation that transforms highly similar representations into non-overlapping representations, supporting specificity of memories [2].

Pattern completion (PC)—supported by the cornu ammonis 3(CA3) of the hippocampus—is a computation that restores degraded or incomplete representations based on previously stored information, supporting generalization [3].

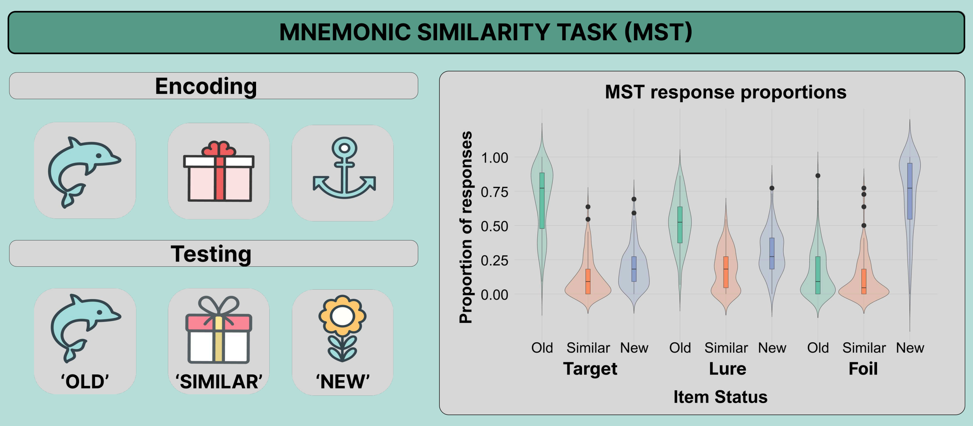
Differential development of PS and PC drives the shift from a focus on abstracting regularities through experience to remembering unique events in early ontogeny [4].

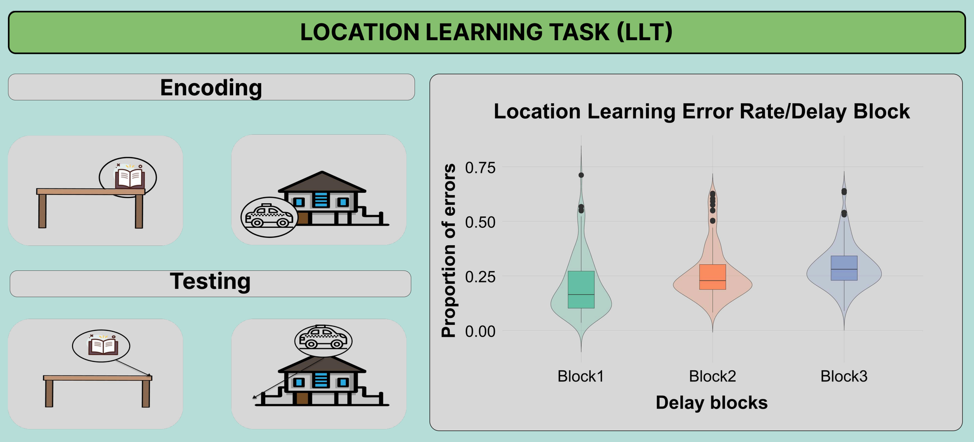
2. METHODS

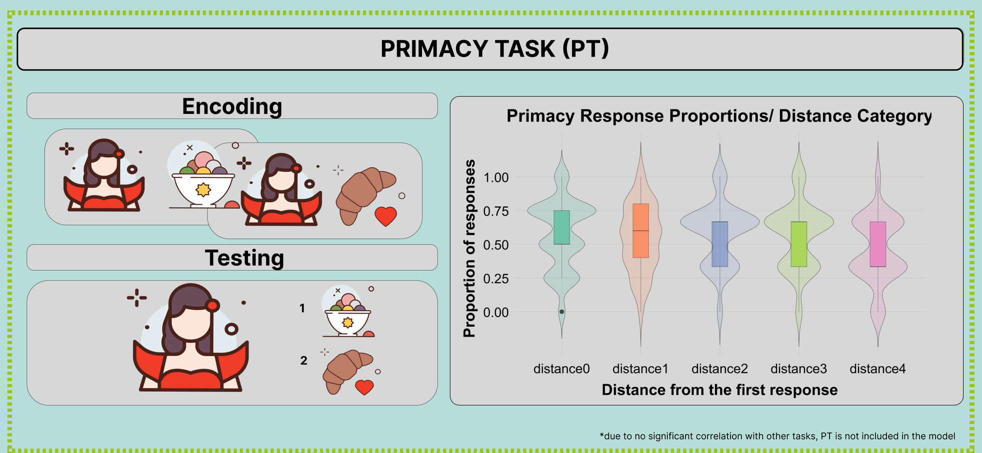
- First wave of a 3-year longitudinal study of 4–6-year-old children.
- Participants: 131 four-year-olds (mean age = 54.2 months, SD = 3.02; 62 female).
- No direct task exists to measure Pattern Separation (PS) and Pattern Completion (PC) → modeled as latent variables using Structural Equation Modelling (SEM).
- Compared a two-factor PC–PS model with a one-factor memory model.
- Hippocampal segmentation from MRI scans was performed to examine neural correlates of task performance.
- Hypothesis: In 4-year-old children, a latent memory structure can be identified, with a two-factor model providing a better explanation of individual differences than a one-factor model.

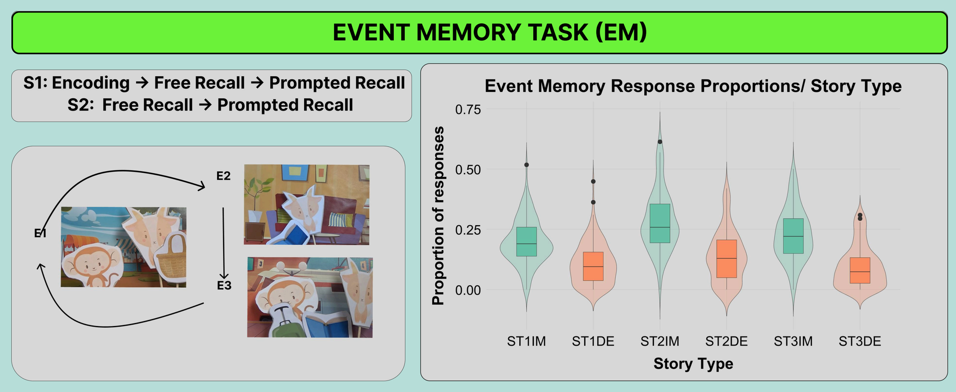
3. TASK BATTERY AND RESULTS

Pattern separation tasks and results

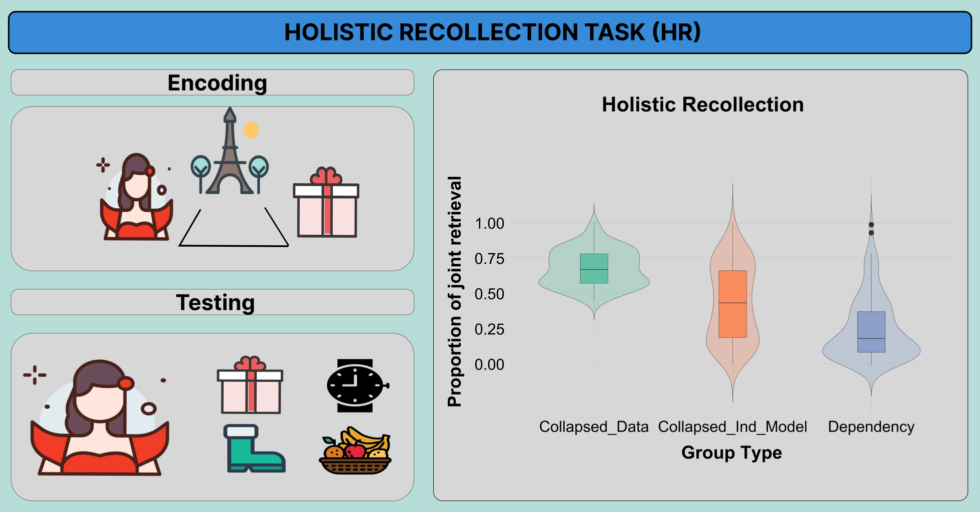


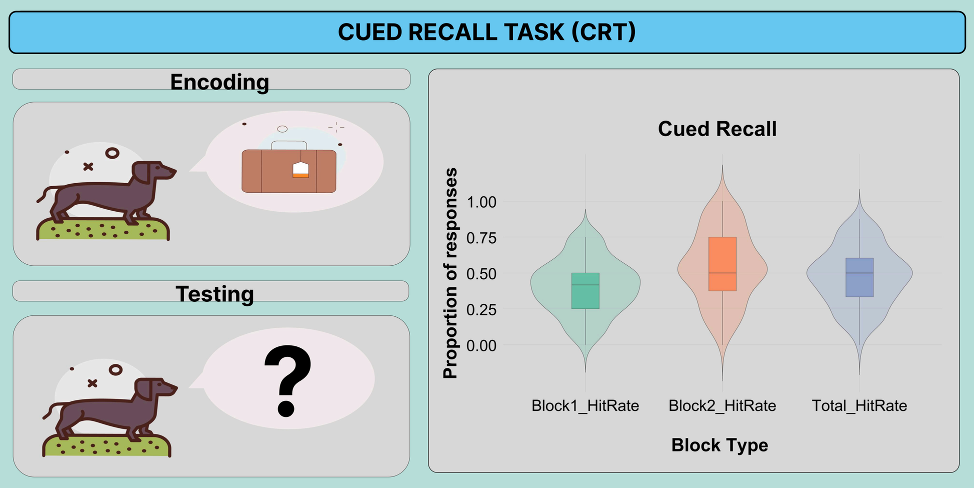


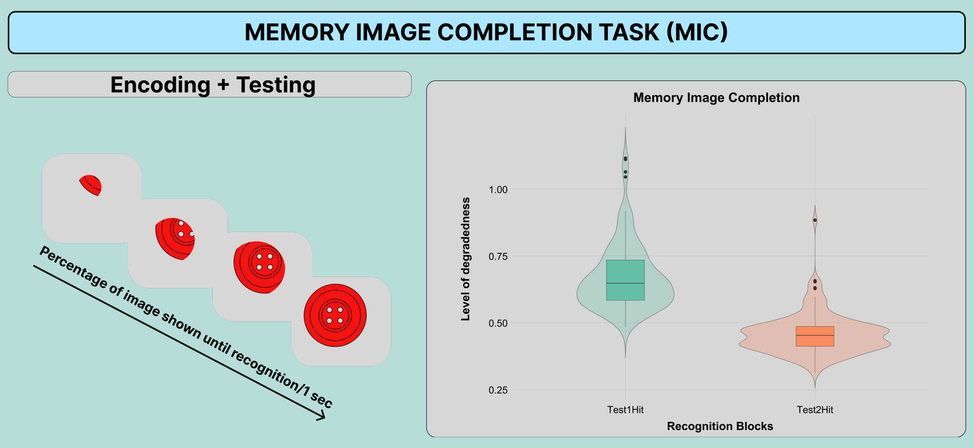




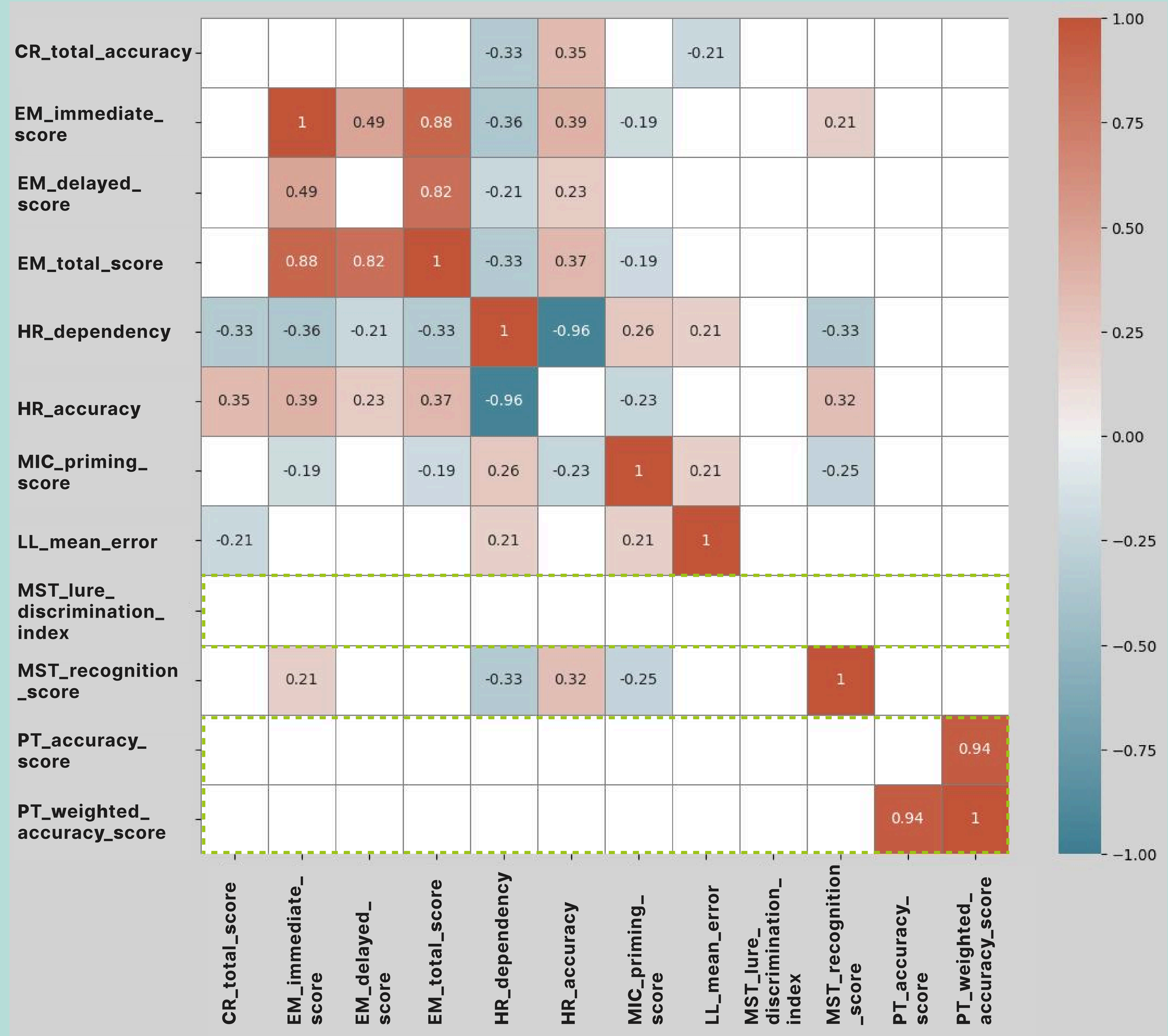
Pattern completion tasks and results







4. TASK CORRELATIONS



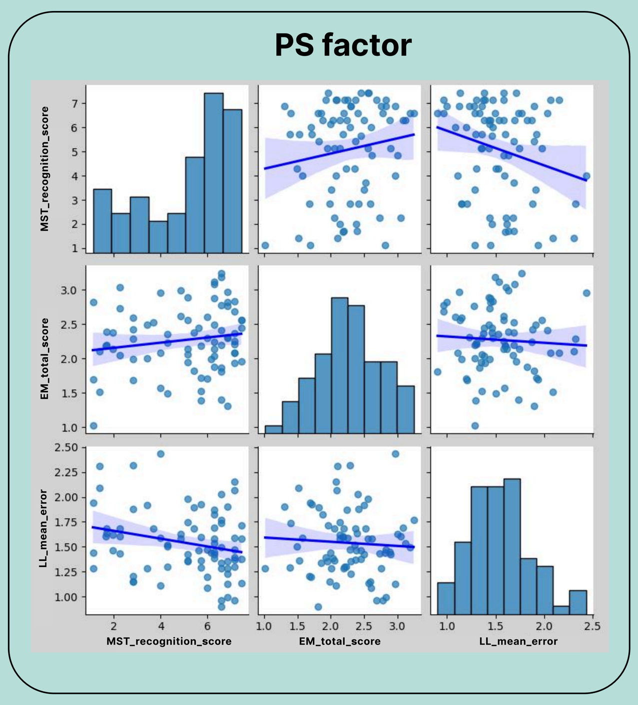
Variable Selection and Factor Structure

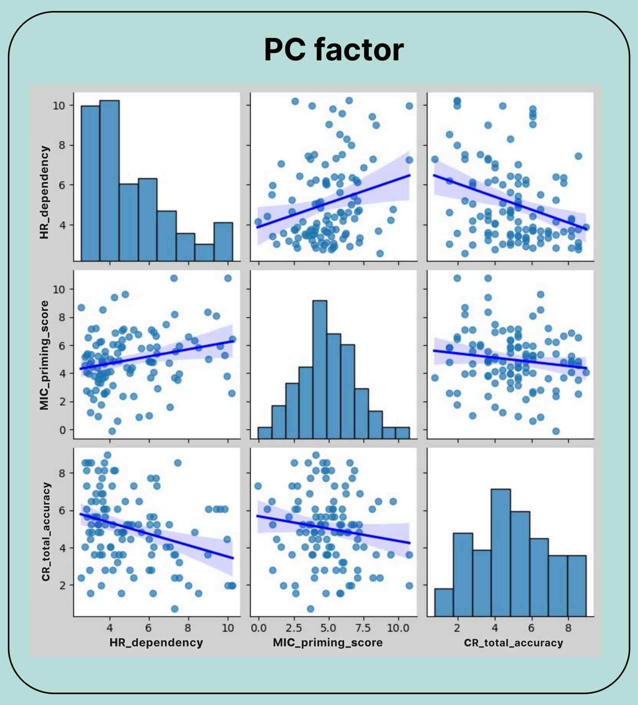
Based on the correlation matrix, none of the Primacy Task (PT) variables correlated significantly with other indicators and were excluded. For the Holistic Recollection Task, we retained the primary variable (HR_dependency). In the Mnemonic Similarity Task, the primary variable (MST_lure_discrimination_index) showed no significant correlations; therefore, we used the secondary measure (MST_recognition_score).

The resulting two-factor structure was:

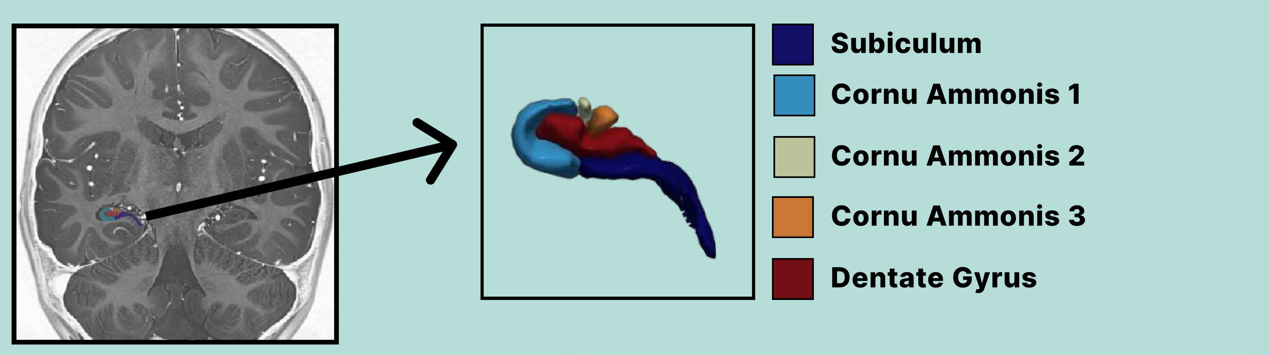
PS ← LLT (loclearning), MST (mst_rr), EM (em_total)

PC ← MIC (mic), HR (holrec_dep), CR (cuedrecall)





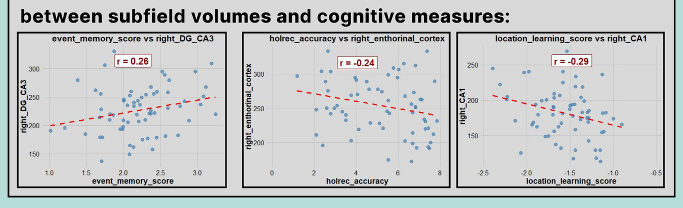
5. HIPPOCAMPAL SEGMENTATION PROGRESS



Manual and automated segmentation of high-resolution PD images (0.4×0.4×2 mm)

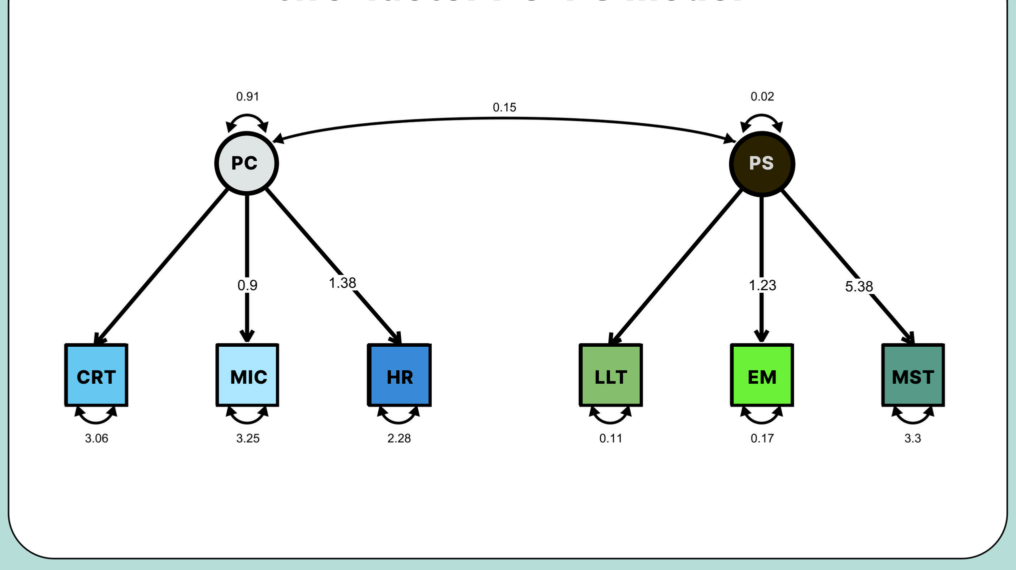
- Longitudinal analyses of target subfields changes using latent change score model
- Ongoing development of a child HC atlas, separating CA1–CA3–DG [5] (for more information check poster T41.)

Using our previous atlas, we observed significant correlations between subfield volumes and cognitive measures:

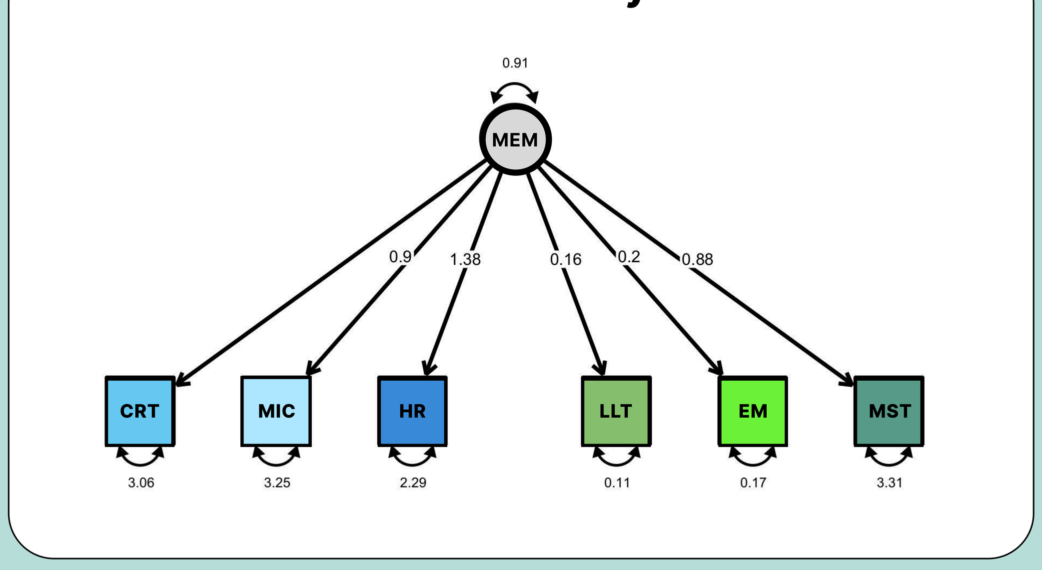


6. STUCTURAL EQUATION MODELLING

two-factor PC-PS model



one-factor memory model



Model Fit parameters: CFI = 1.058; RMSEA =0.00

Model Fit parameters: CFI = 1.08; RMSEA =0.00

Key Findings: 1. Both the one-factor and two-factor models showed excellent fit to the data based on CFI and RMSEA values, which were above the recommended cutoffs.

2. The Chi-square difference test was used to compare the nested models. The one-factor model demonstrated a significantly better fit ($\chi2$ (1)=16.856; p<0.001), indicating it is the statistically preferred model.

7. DISCUSSION

1. The findings suggest that memory-related computations may potentially be assessed assessed in 4-year-old children using a latent variable modeling approach.

2. Both the two-factor PC–PS model and the one-factor memory model fit the data; however, Chi-square comparisons indicated that the one-factor memory model provides the best fit.

3. Preliminary hippocampal segmentation analyses further suggest a potential link between behavioral performance and hippocampal subfield volume.

8. References

1. Marr, D., 1971. Simple memory: a theory for archicortex. Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences 262, 23–81.
2. Bakker, A., Kirwan, C. B., Miller, M., & Stark, C. E. L. (2008). Pattern Separation in the Human Hippocampal CA3 and Dentate Gyrus. Science, 319(5870), 1640–1642.
3. Yassa, M. A., & Stark, C. E. L. (2011). Pattern separation in the hippocampus. Trends in Neurosciences, 34(10), 515–525.Yassa, M. A., & Stark, C. E. L. (2011). Pattern separation in the hippocampus. Trends in Neurosciences, 34(10), 515–525.
4. Keresztes, A., Ngo, C. T., Lindenberger, U., Werkle-Bergner, M., & Newcombe, N. S. (2018). Hippocampal Maturation Drives Memory from Generalization to Specificity. Trends in Cognitive Sciences, 22(8), 676–686.
5. Daugherty, A., Canada, K., Rådman, G., Brown, T. T., Augustinack, J. C., Amunts, K., Bakker, A., Berron, D., Burggren, A., Chételat, G., de Flores, R., Ding, S.-L., Huang, Y., Insausti, R., Johnson, E. G., Kanel, P., Keresztes, A., Kedo, O., La Joie, R., Lee, J., Malykhin, N., Martinez, A., Mueller, S., Mulligan, E., Ofen, N., Olsen, R., Palombo, D. J., Pasquini, L., Pluta, J. B., Raz, N., Riggins, T., Saifullah, S., Schlichting, M. L., Stark, C. E., Steve, T. A., Wang, L., Wisse, L., Yushkevich, P., & Carr, V. (2023). Reliable consensus protocol to segment subfields within the hippocampal body on high-resolution in vivo MRI from the Hippocampal Subfields Group. Program No. PSTR108.13, 2023 Neuroscience Meeting Planner. Society for Neuroscience. Washington, D.C. Retrieved from https://www.hippocampalsubfields.com

This research was funded by the Hungarian National Research, Development and Innovation Office (FK146496) and a Max Planck Partner Group to A.K. from the Max Planck Society. A.K. was supported by the Bolyai János Research Scholarship of the Hungarian Academy of Sciences. H.K. was supported by the support program announced by the Local Council of Saint George for students defending their dissertations in 2025.