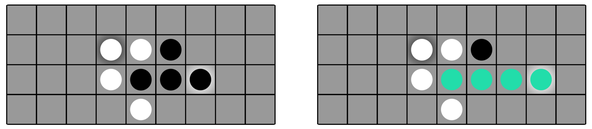
Schema Development and its Role in Memory in 4-in-a-row, a Two-Player Strategy Game

Jiawen Huang, Wei Ji Ma, Christopher Baldassano

Background

People use their schema, structural knowledge about the world, to understand and remember events (Alba & Hasher, 1983).
We used the 4-in-a-row game (van Opheusden et al., 2021) to study how complex schema develops and is used in memory.



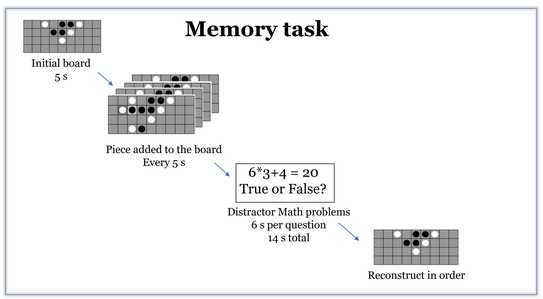
In the game, two players alternate to place a piece on a 4x9 board, and the first player to connect 4 pieces of their color in a row (either horizontal, vertical, or diagonal) wins.

Compared to previous studies on schema development, which typically involve simple schema (for a review, see Alonso et al., 2020), 4-in-a-row is more suitable because:

1. The game is complex enough to reflect 'real' schema, yet not too complex to model
2. Most people have never played the game (having no prior schema)
3. The game is easy enough to learn in a relatively short period of time

Method

Longitudinal study with 6 sessions (N=14), all online:
Session 1-5: Memory task + Gameplay
Session 6: Memory task



Memory task stimuli:

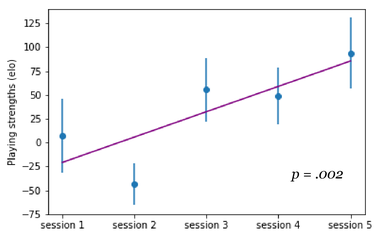
- Sequence lengths: 4-8
- 6 sequences per length (30 total)
- Generated from 2 medium strength AI playing against each other

Gameplay:

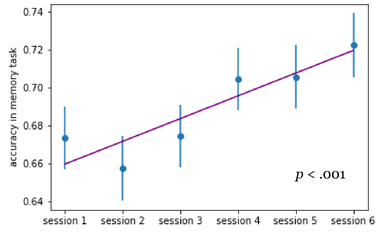
- Play 40 games against AI
- Staircasing procedure: if player wins, AI becomes stronger; if player loses, AI becomes weaker

Behavioral Results

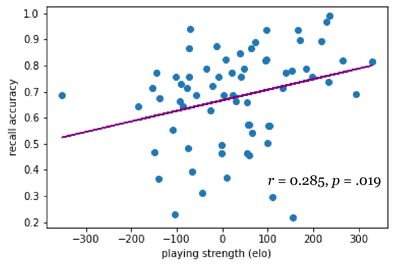
Playing strength across sessions



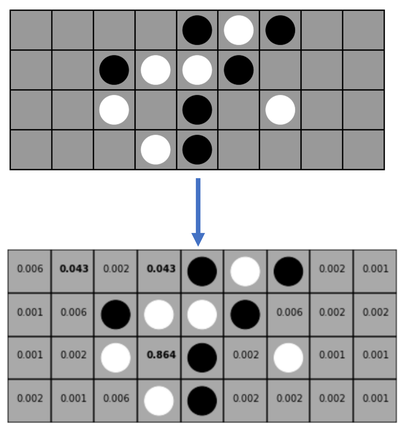
Training improves memory



Playing strength predicts memory performance in the next session



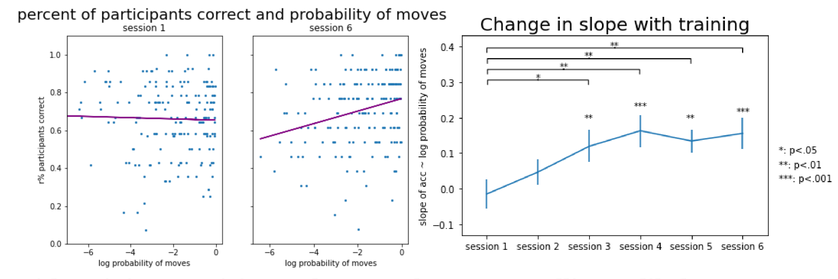
Modeling schema



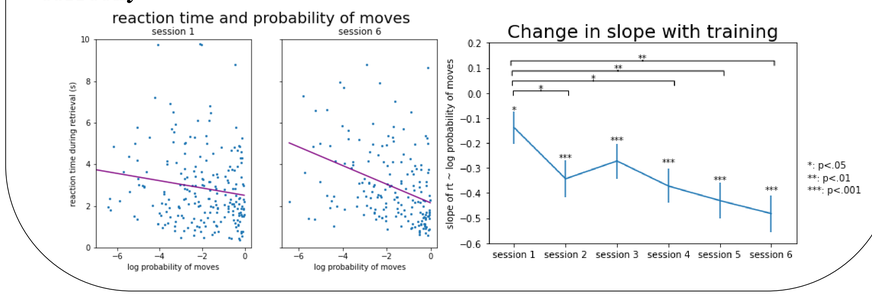
We trained a generalized linear model on 1000 games played by 100 users in a mobile platform (van Opheusden et. al., 2021) to predict which moves are likely or unlikely.

Effect of Schema on Memory

With training, participants become better at recalling likely vs. unlikely moves



With training, participants become slower at recalling unlikely moves correctly



Conclusion and Next Steps

By playing and remembering the games, people's memory for sequences in the game improves and it become easier for them to remember moves consistent with their schema. For next steps, we plan to:

1. Model how schema changes over time with participants' training data
2. Build a Bayesian model of sequence memory that combines schematic and episodic information
3. In-lab replication with another ~15 participants (with eye-tracking to look at how schema influence attention)

References

Alba, J. W., & Hasher, L. (1983). Is memory schematic? *Psychological Bulletin*, *93*(2), 203–231. https://doi.org/10.1037/0033-2909.93.2.203

Alonso, A., van der Meij, J., Tse, D., & Genzel, L. (2020). Naïve to expert: Considering the role of previous knowledge in memory. *Brain and Neuroscience Advances*, *4*, 2398212820948686. https://doi.org/10.1177/2398212820948686

van Opheusden, B., Galbiati, G., Kuperwajs, I., Bnaya, Z., li, Y., & Ji, W. (2021). *Revealing the impact of expertise on human planning with a two-player board game* [Preprint]. PsyArXiv. https://doi.org/10.31234/osf.io/rhq5j