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Technology-enhanced language learning interventions in children

Sari Ylinen

Logopedics, Faculty of Social Sciences, Tampere University

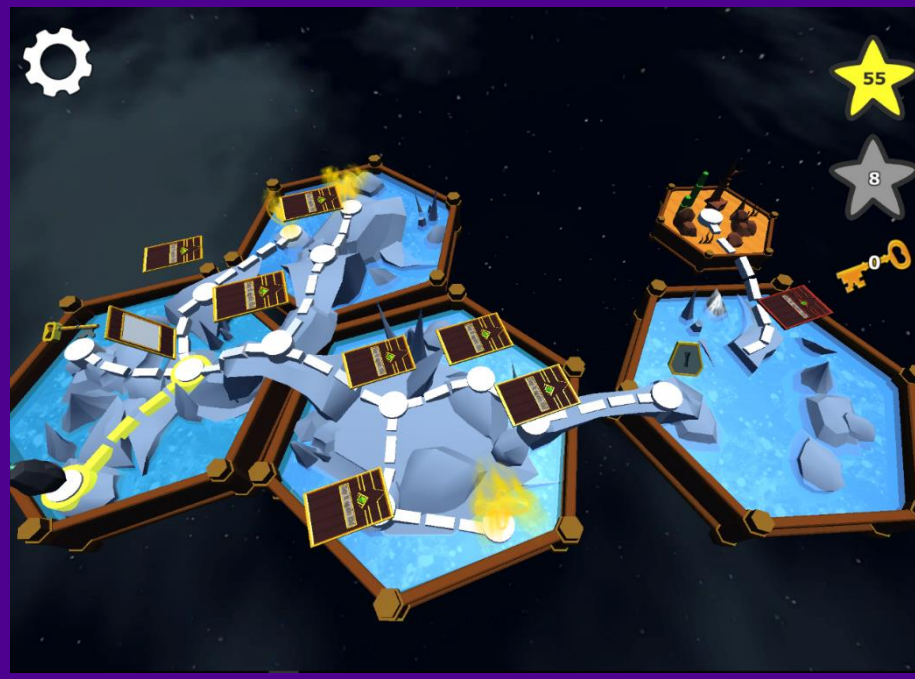
Digital language learning

- Learning foreign speech sounds is a challenge for many learners
- Digital language learning (DLL) opens new perspectives for language education (Li & Lan, 2021), including speech-sound training
- Possibility to use games, animations, pictures, and sound
- DLL apps can be made interactive by using touchscreen or automatic speech recognition

Brad Flickinger (flickr.com).

Gaming and technology-enhanced language learning

- A digital game for speech-based foreign-language learning
- Does not require reading skills
- Children are encouraged to produce foreign words aloud
- Automatic speech recognizer assesses the utterances and gives feedback (1-5 stars)
- Feedback is used as a gaming element



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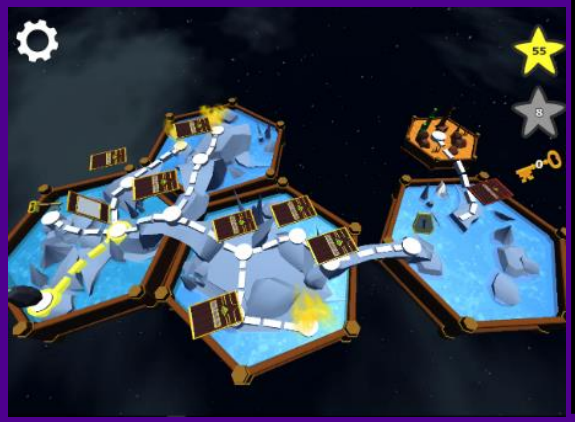
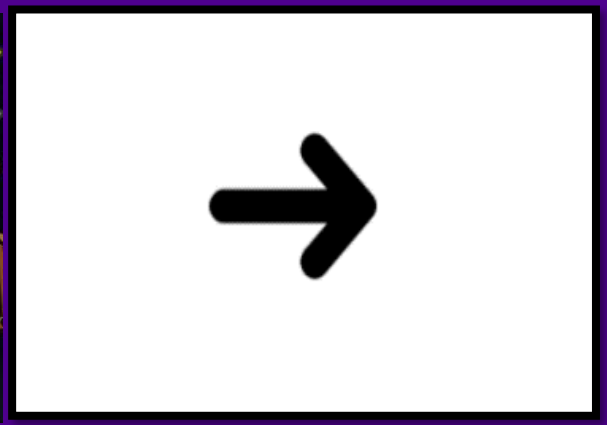
Study 1: Effects of gaming on language learning

- Does speech rehearsal during gaming support children's learning of foreign speech sounds or words more than speech rehearsal in a non-game?
- Comparison of learning a word with a foreign speech sound /θ/ as in *healthy* or /ð/ as in *feather* in a game or a non-game environment
- Method: ERP & MMN responses





Auditory event-related potential (ERP)

Acoustic events elicit electrophysiological responses that can be measured with EEG

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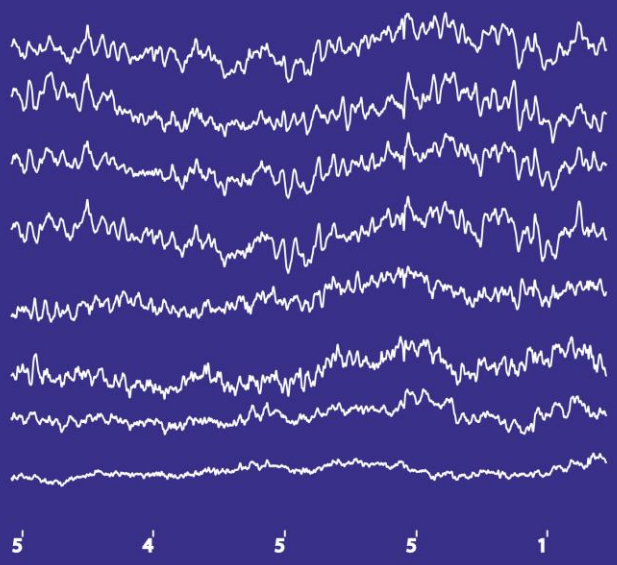
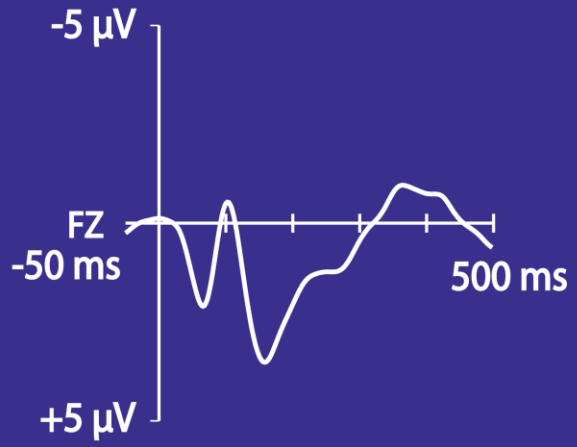
Auditory event-related potential (ERP)

Raw EEG signal → ERP response time-locked to auditory stimuli

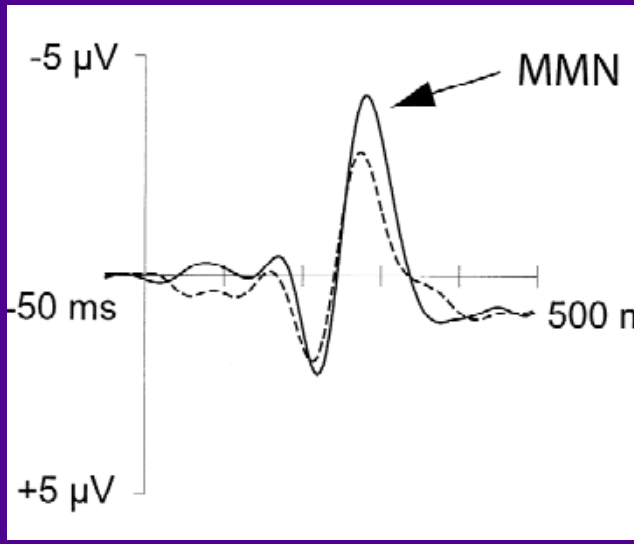


averaging



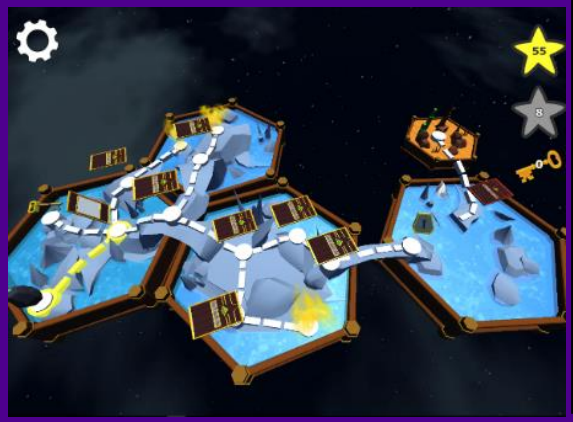
Mismatch negativity (MMN)

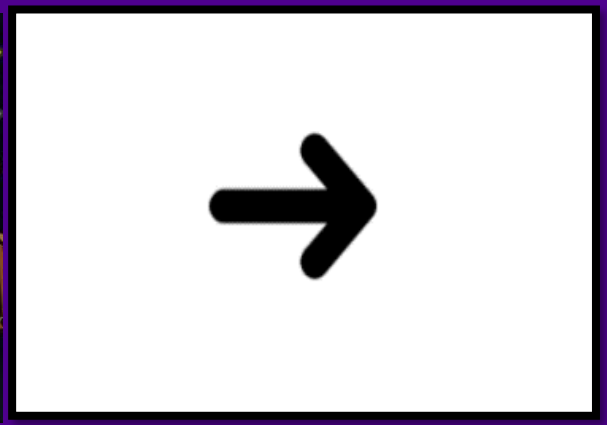
- A component of ERP
- MMN is elicited in a regular sound sequence and occasional deviant sounds
- MMN reflects
  - Detection of acoustic deviance
  - Ability to extract regularities and predict future input
  - Activation of long-term memory representations for speech sounds (Näätänen et al., 1997) and words (Pulvermüller et al., 2001)
  - Pre/post-training setting: learning and neuroplasticity



Game intervention

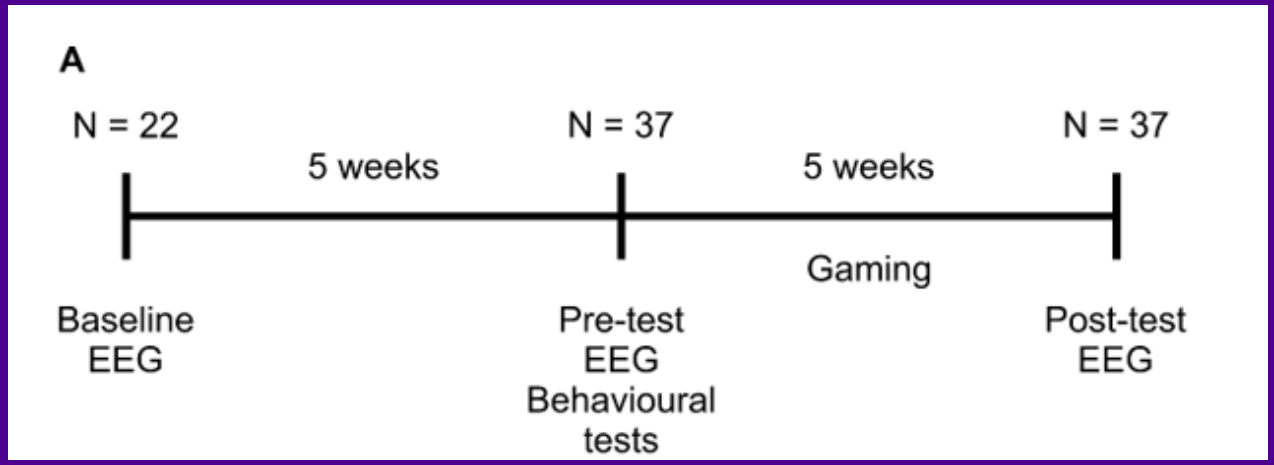
- Overall training 5 weeks, 4-5 days per week, 15 minutes per day.
- The game had 27 levels in total.
- Training the critical speech sounds and words within the game in 3 sessions and within the non-game in 3 sessions.
- A half of the participants learned /θ/ in the game and /ð/ in the non-game, and vice versa.
- The number of trained items was identical between the game and non-game.





Methods and timeline

- Participants: 37 children (7-11 years old)
- Stimuli:
  - feather vs. feder*
  - healthy vs. healty*



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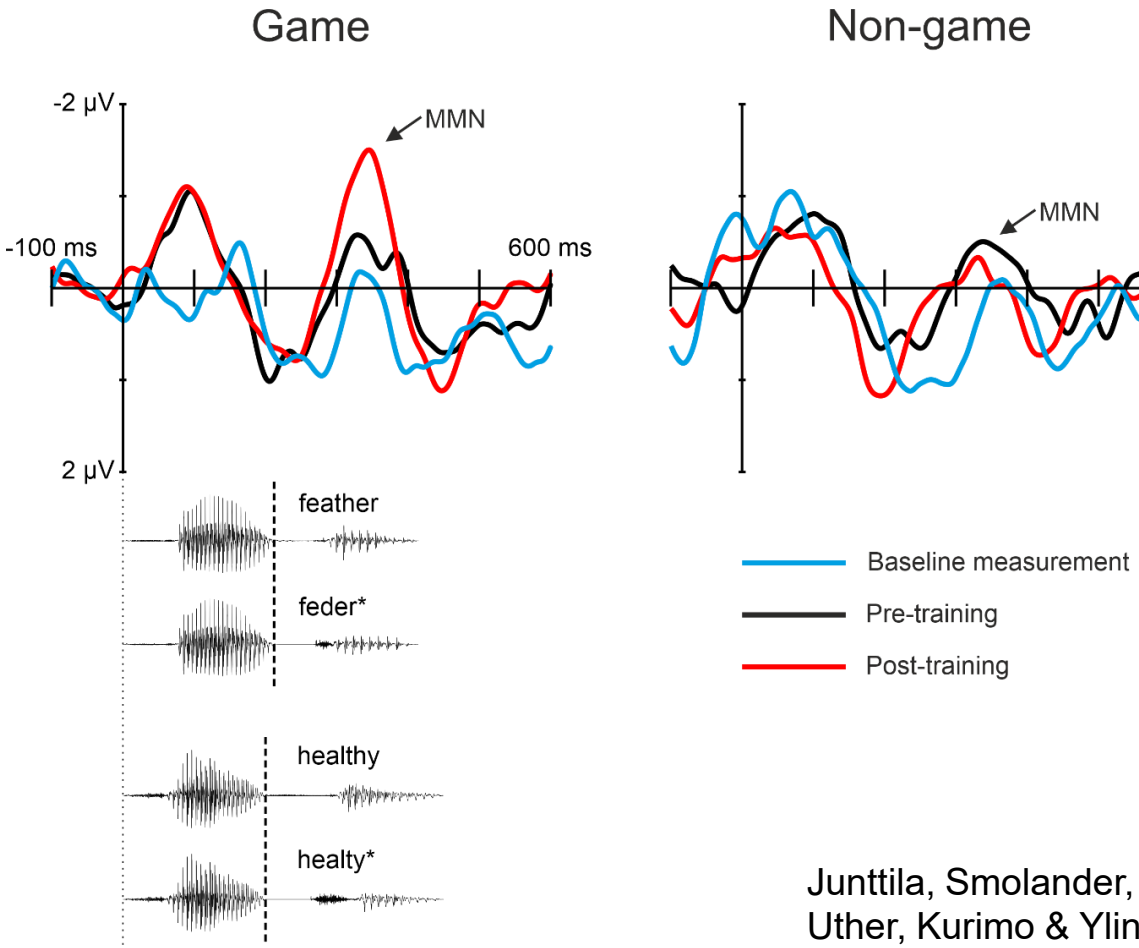
Results



Junttila, Smolander, Karhila, Giannakopoulou, Uther, Kurimo & Ylinen, 2022

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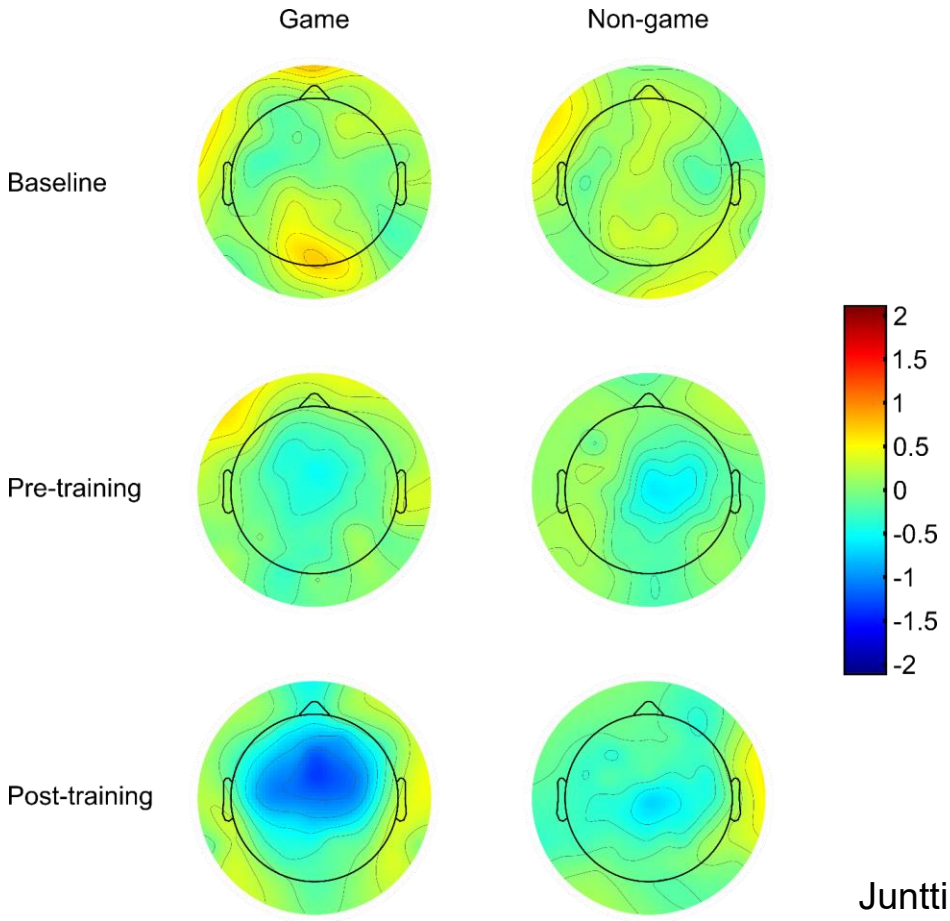
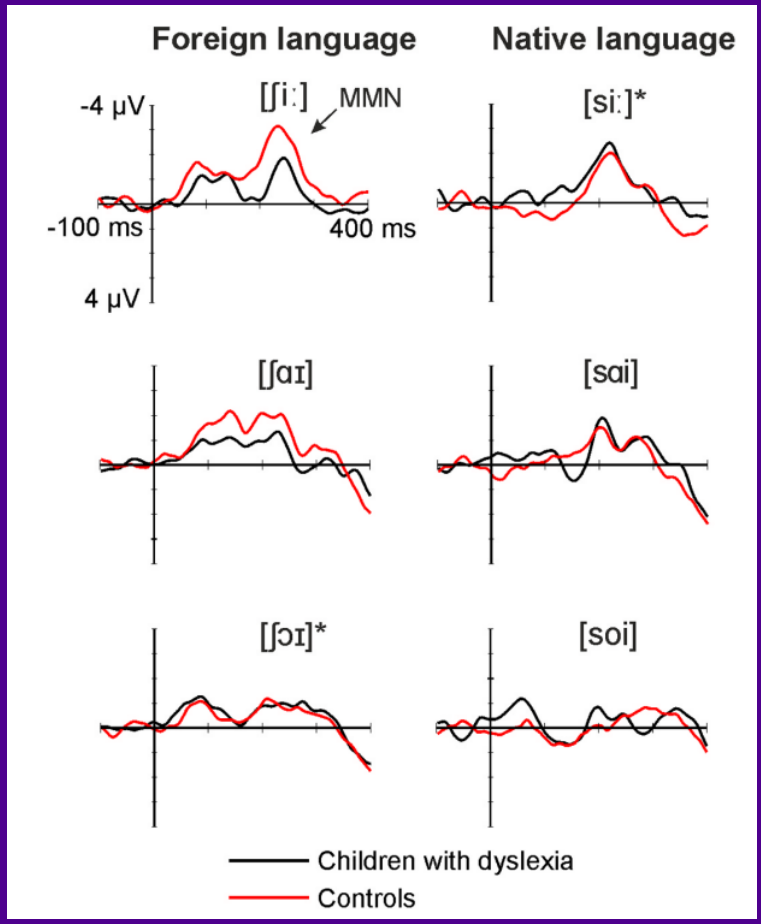
Results



Junttila, Smolander, Karhila, Giannakopoulou, Uther, Kurimo & Ylinen, 2022

Study 2: Effects of gaming on language learning in dyslexia

- The activation of brain representations for familiar second-language words is weaker in children with dyslexia than in typical readers (Ylinen et al., 2019).
- Does speech rehearsal during gaming support language learning in children with dyslexia?



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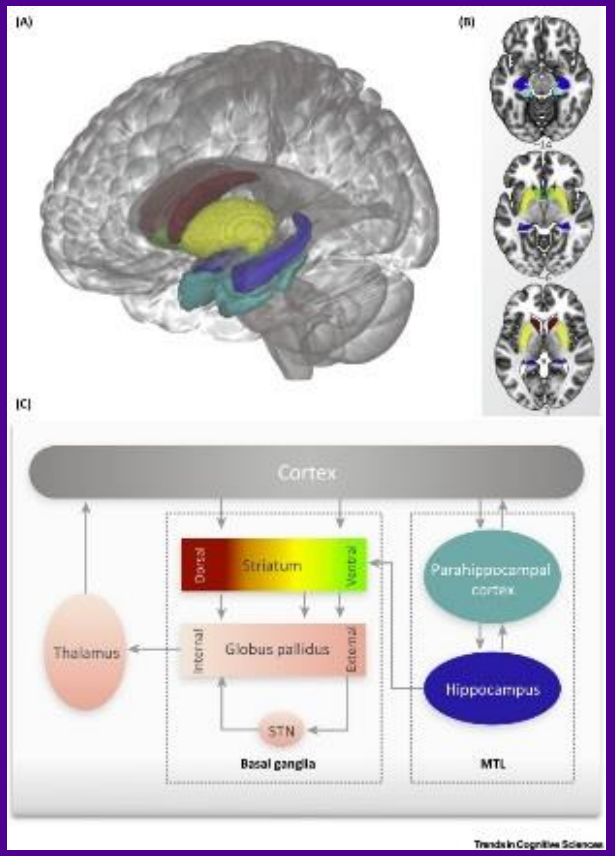
Study 2: Effects of gaming on language learning in dyslexia

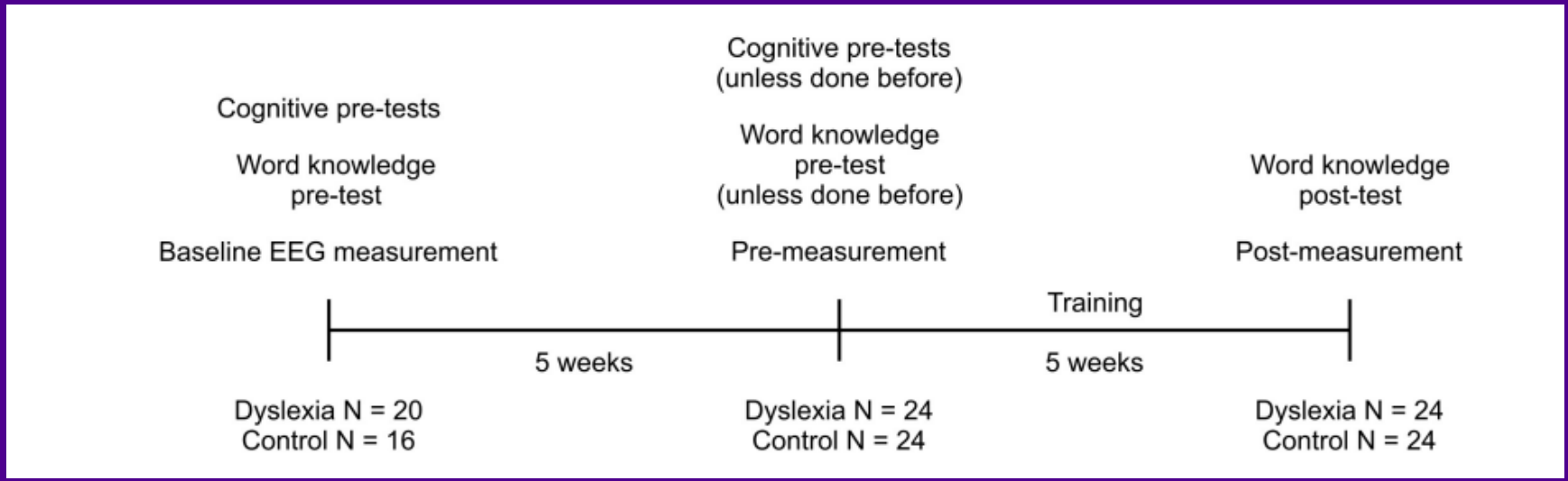
- H1: works, because the game is speech-based, no reading
- H2: does not work optimally
  - Feedback reinforces learning by activating the reward system in the brain, including striatum
  - Structural and functional abnormalities are seen in the striatum in children with language disorders (Krishnan, Watkins & Bishop, 2016)



Krishnan, Watkins & Bishop, 2016

Methods and timeline

- 24 children with dyslexia vs. 24 controls
- Cognitive testing:
  - Dyslexia < control: technical reading, dictation, WISC digit span, RAN letters, phonological awereness
  - Dyslexia, control: WISC block design, WISC vocabulary, WISC coding, RAN colors



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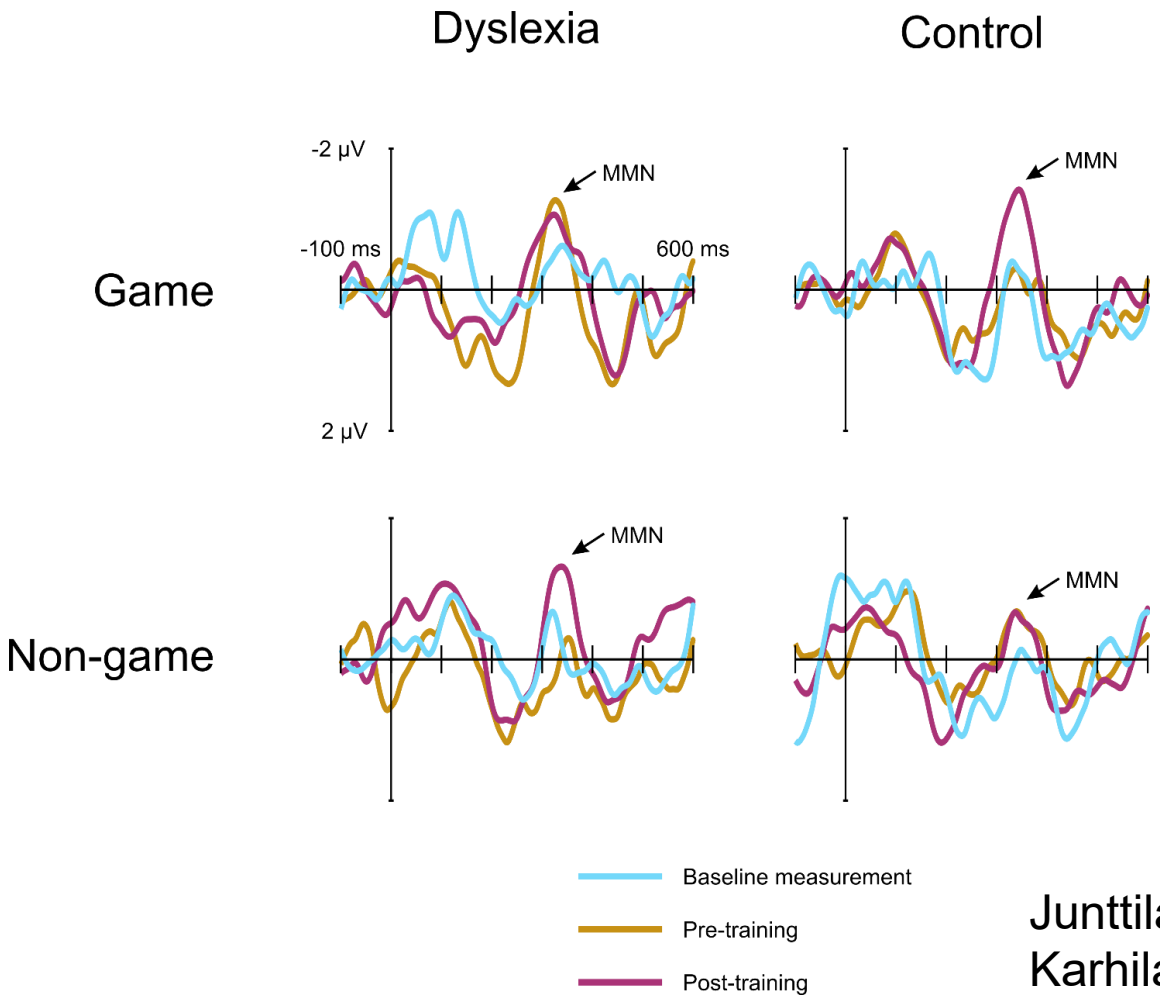
Results



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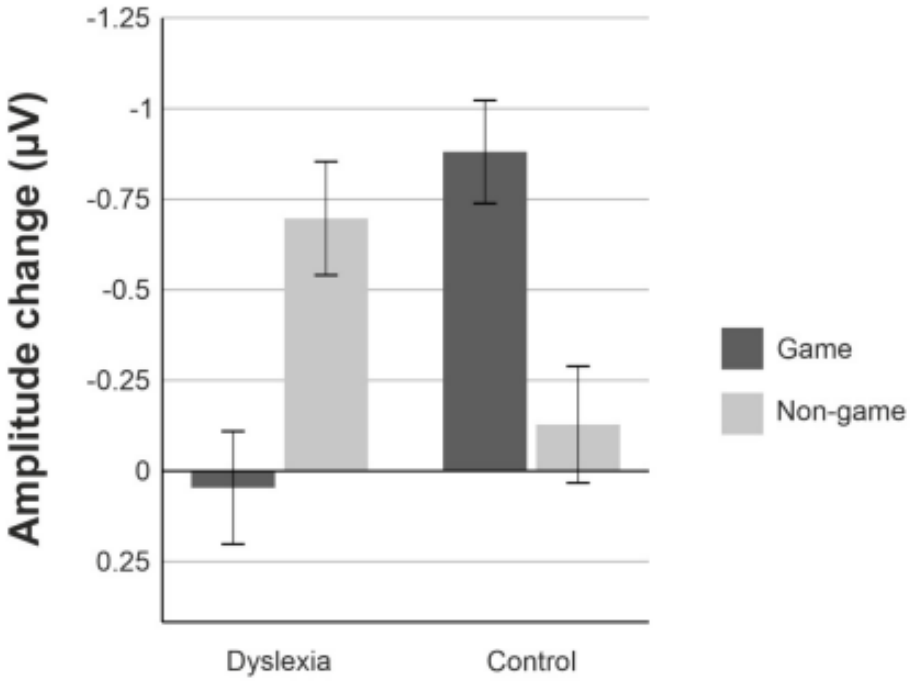
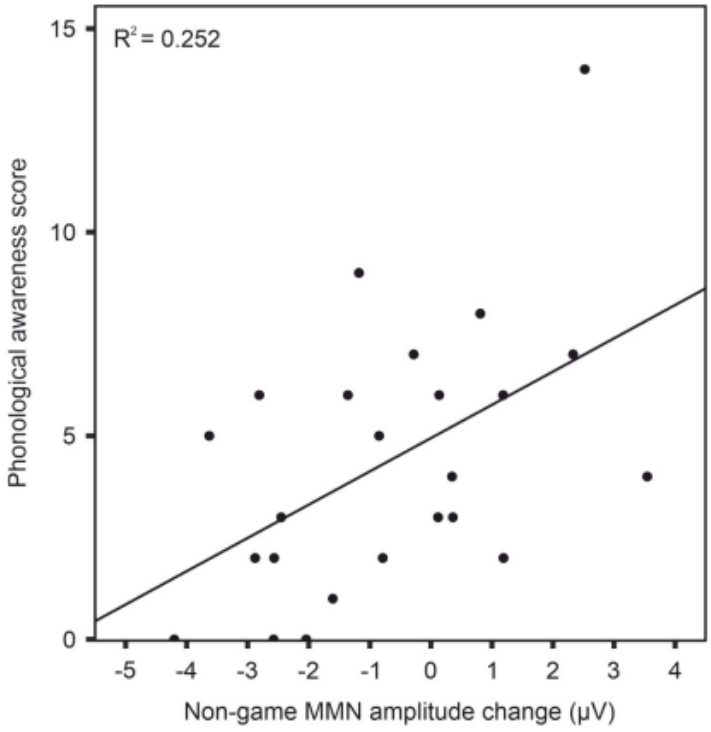
Results





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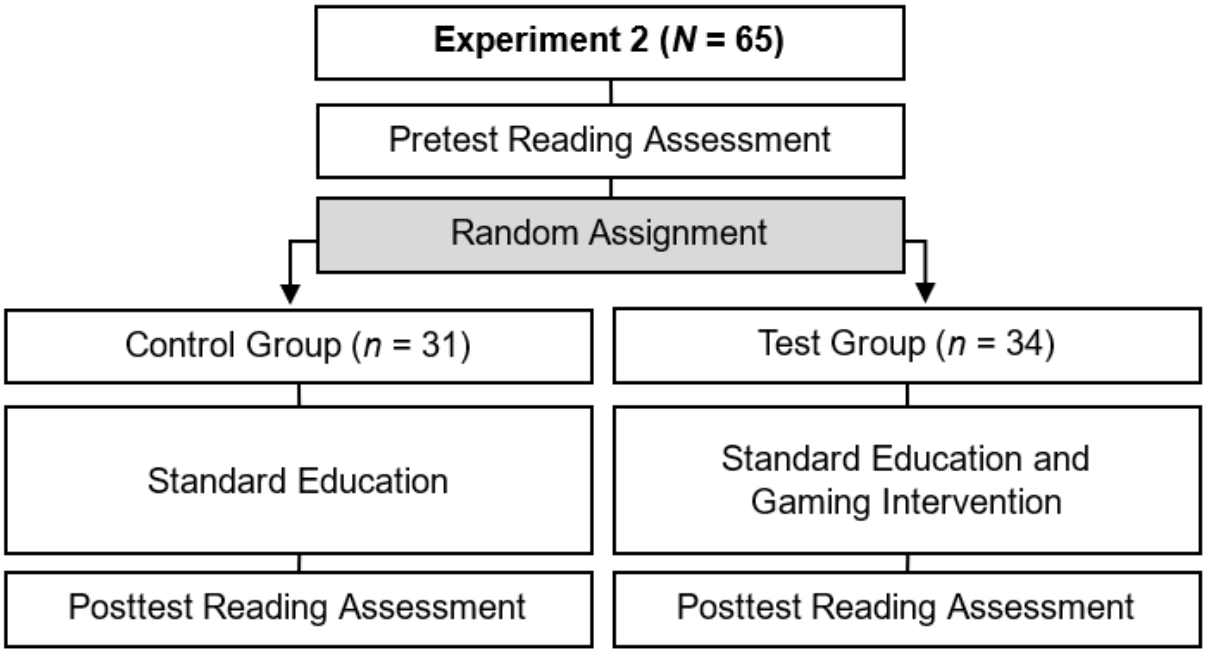
Study 3: L2 gaming intervention and L1 reading skills in 1st graders



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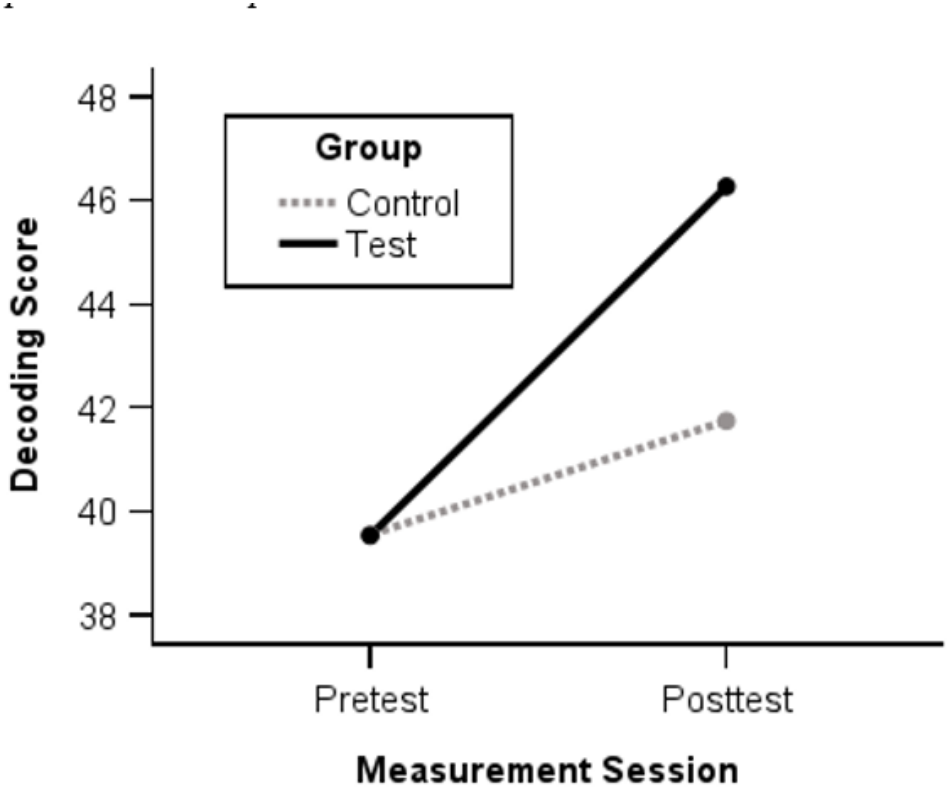
L2 gaming intervention and L1 reading skills in 1st graders



Tervo, Smolander, Junttila, Grósz, Kurimo & Ylinen, submitted

Conclusions

L2 speech-sound learning

- In typically developing children, gaming induced most robust plastic changes in the brain.
- Children with dyslexia seem to benefit more from simple speech rehearsal than from a visually rich game.

Reading skills: L1 decoding

- L1 decoding skills were improved by L2 speech-sound intervention, likely via phonological awareness

Thank you!

- Contact: sari.p.ylinen@tuni.fi

- Junttila, K., Smolander, A.-R., Karhila, R., Giannakopoulou, A., Uther, M., Kurimo, M., & Ylinen, S. (2022). Gaming enhances learning-induced plastic changes in the brain. *Brain & Language,* 230, 105124. https://doi.org/10.1016/j.bandl.2022.105124
- Junttila, K., Smolander, A.-R., Karhila, R., Kurimo, M., & Ylinen, S. (2023). Non-game like training benefits spoken foreign-language processing in children with dyslexia. *Frontiers in Human Neuroscience,* 17, 1122886. https://doi.org/10.3389/fnhum.2023.1122886
- Tervo, T., Smolander, A.-R., Junttila, K., Grósz, T., Kurimo, M. & Ylinen, S. (submitted). The effect of game-based foreign language speech-sound training on native-language decoding.