Deep Learning-based Neurofeedback Targeting Semantic Memory in Alzheimer's Disease

L. La Fisca[1], T Dutoit[1], L. Lefebvre[2], I. Simoes Loureiro[2], L. Ris[3], B. Gosselin[1]

[1]ISIA Lab, Faculty of Engineering, University of Mons
[2]PC$_{\&}$N Lab, Faculty of Psychology and Educational Science, University of Mons
[3]Neuroscience Department, Faculty of Medicine and Phamarcy, University of Mons

Overview

Semantic memory is the cognitive function that stores concepts and their meanings. Although no consensus has yet been found, more and more scientists support the following hypotheses:

- Semantic memory is part of an integrated memory system grounded in the sensorimotor system [1].
- The way a concept is stored depends on the acquisition method [2].
- Memory decline in Alzheimer's Disease (AD) follows the inverse mechanism than memory development during childhood (retrogenesis) [3].

This research project aims to identify the interaction between the sensorimotor cortex and the semantic memory in taxonomic vs. thematic links. This knowledge will lead to the development of a neurofeedback prototype targeting semantic memory loss in AD patients.

IDENTIFICATION

1. Neural sources (cf. fig. 1)
2. Interaction (cf. fig. 2)
3. Dynamics (microstates analysis and HMM)
4. Evolution over lifespan (retrogenesis hypothesis)

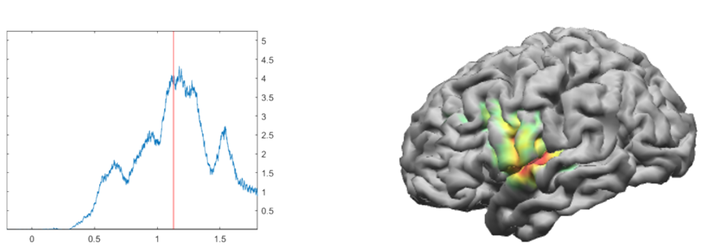

Figure 1: source reconstruction

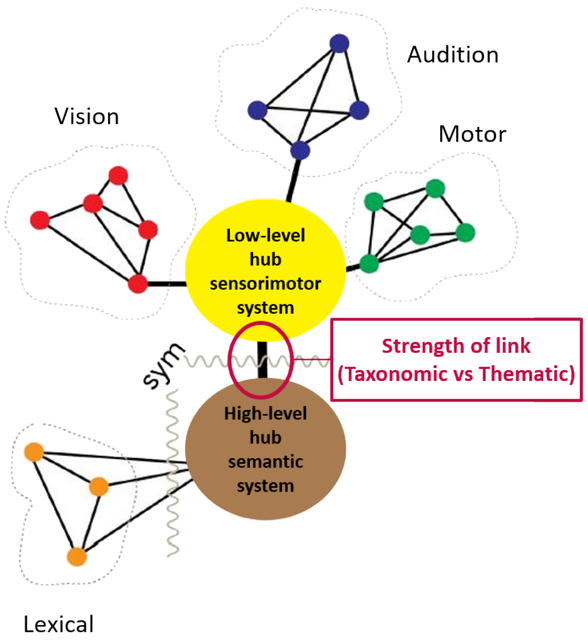

Figure 2: sensorimotor - semantic interaction [1]

MODELING

1. Labeling (co-activation state)
2. Classification through Convolutional Neural Network (CNN)
3. Interpretation (latent space analysis) (cf. fig. 3) [4]

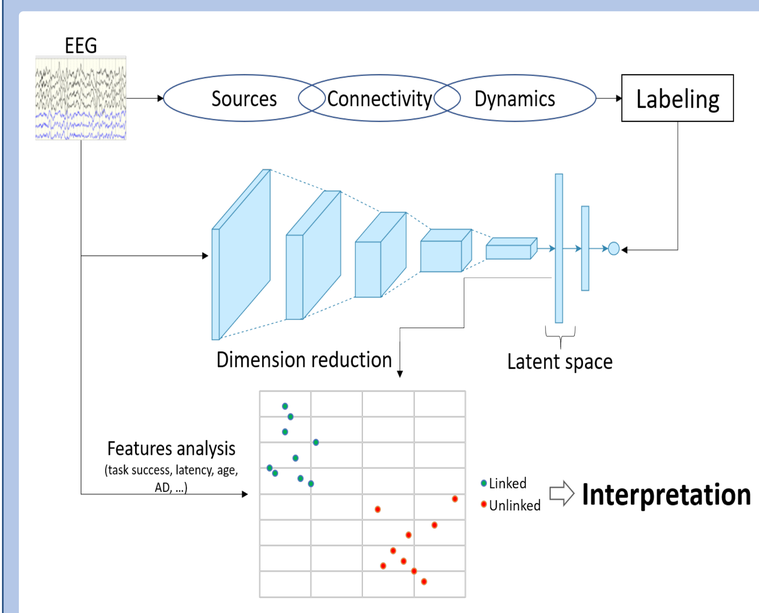

Figure 3: interpretable convolutional neural network

Dataset:

210 subjects including:

- 90 children
- 30 young adults
- 30 healthy elderly people
- 30 early AD people ($20 \leq \text{MMSE} \leq 25$)
- 30 moderated AD people ($15 \leq \text{MMSE} \leq 19$)

NEUROFEEDBACK

1. Integration in existing system
2. Customization (transfer learning)
3. Final prototype (cf. fig. 4)

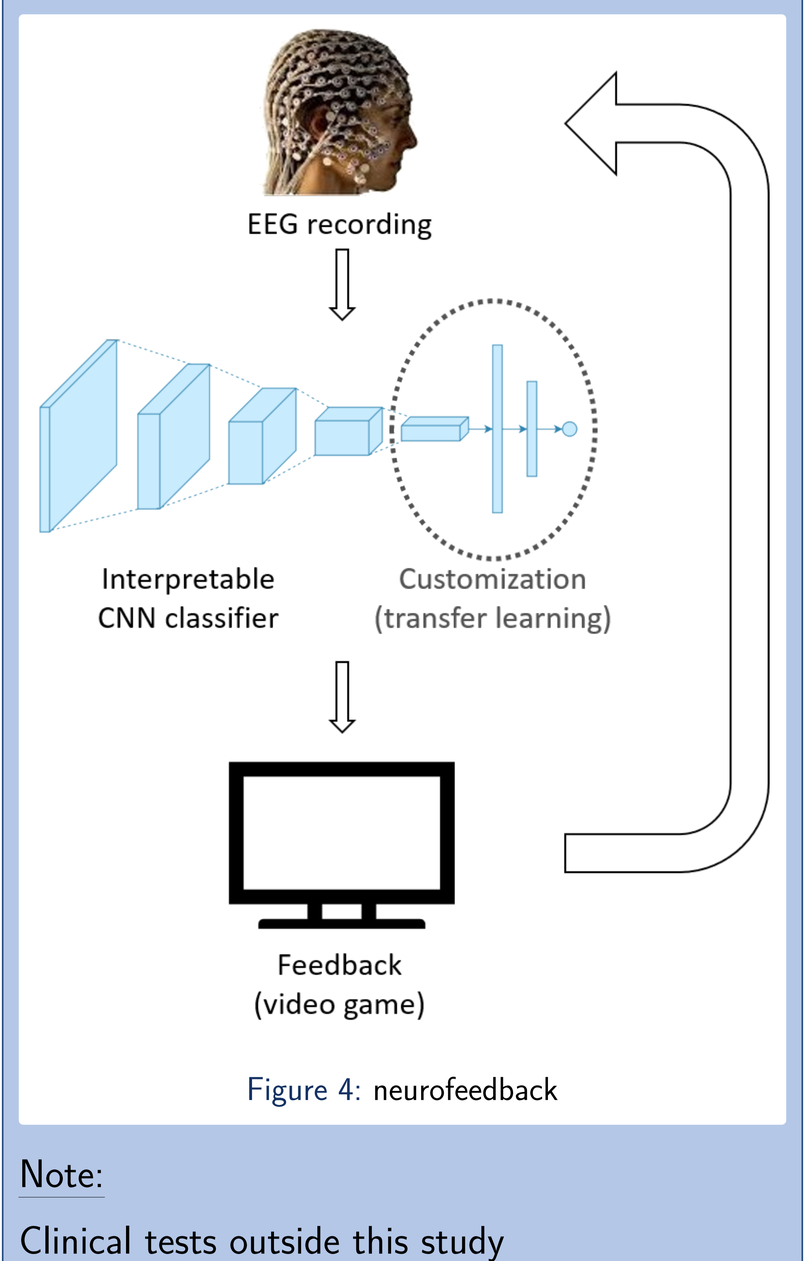

Figure 4: neurofeedback

Note:

Clinical tests outside this study

Expected outcomes

- Unveil interaction between sensorimotor cortex and semantic memory over the lifespan for specific concepts (taxonomic and thematic links).
- Build up a robust and interpretable inter-patient classifier to detect the co-activation of the targeted neural systems.
- Develop a neurofeedback prototype to slow down semantic memory loss in AD patients.

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[3] B. Reisberg, E. H. Franssen, L. E. M. Souren, S. R. Auer, I. Akram, and S. Kenowsky, "Evidence and mechanisms of retrogenesis in Alzheimer's and other dementias: Management and treatment import," *American Journal of Alzheimer's Disease and Other Dementias*, vol. 17, no. 4, pp. 202–212, 2002. DOI: 10.1177/153331750201700411.

[4] N. Tits, F. Wang, K. E. Haddad, V. Pagel, and T. Dutoit, "Visualization and Interpretation of Latent Spaces for Controlling Expressive Speech Synthesis Through Audio Analysis," in *Proc. Interspeech 2019*, 2019, pp. 4475–4479. DOI: 10.21437/Interspeech.2019-1426.