

CENT - Computer Enabled Neuroplasticity Treatment: a modular, extensible platform for neurofeedback with lightweight wearable EEG devices

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ABSTRACT

Biofeedback/neurofeedback is a growing clinical field. Tools for administering feedback treatment tend to be proprietary and fixed/non-extensible. Thus there is a need for a biofeedback platform which is entirely open source, extensible and free. We present the Computer Enabled Neuroplasticity Treatment (CENT) platform to meet this need.

Keywords: neurofeedback, electroencephalography, ADHD, computer-enabled, Qt

Story/structure is:

1. Introduction + motivation

- we needed a NFB platform and didn't find anything suitable (why not?)
- we developed CENT platform at the same time as setting up the clinical trial
- we aimed for lots of good things: modular, extensible, state of the art technology, effective but simple UI, minimal but extensible feature set
- other systems exist but CENT fills a niche because...

2. Related work

- Other neurofeedback platforms
- Abundance of wearable EEG devices

3. Architecture - describe the tech. Show where to get it and the compatible parts

- CENT-core
- CENT-extensions

4. Validation

- Malmi therapy?
- Can other validation evidence be generated?

5. Discussion

- We saw a need and filled it
- Pros and cons
- CENT vs. "Meditation toys"
- Usage scenario
- Future work: Interfacing with bestest systems (like MIDAS)

6. Conclusion: CENT platform is great, buy 6!

1 INTRODUCTION

Neurofeedback/Biofeedback (NFB) is a growing field, with extensive clinical use, a large body of research literature, and applications also in performance enhancement, entertainment, and stress relief.

Tools for administering feedback treatment tend to be proprietary and fixed/non-extensible. Thus there is a need for a biofeedback platform which is entirely open source, extensible and free. We present the Computer Enabled Neuroplasticity Treatment (CENT) platform to meet this need.

1.1 Background

Ben: describe Neurofeedback background...

Competition / state of the art... Random studies
paid professional products Neuroelectrics Neurosurfer 'VR' environment
23 repos (maybe 2 or 3 decent-looking ones)
helpful wikipedia page - lists 6 open or GPL warez, inc OpenVIBE
Free software for specific hardware: Nova Tech! Vilistus

1.2 CENT platform

development: brief history of CENT use, clinical trial (number)

The CENT platform was developed to facilitate the CENT clinical trial of NFB treatment for adult ADHD, conducted at the University of Helsinki, Finland (REF).

specifics: CENT platform. Advantages

The CENT platform was designed to connect light-weight EEG amplifiers to a simple, easy-to-use interface for running NFB sessions. The platform's workflow is fixed but adaptable, with configurable settings for personalisation of the treatment.

1. ...modifiers for the baseline values ...
2. ...different games...
3. ...performance review options...

2 METHODS - ARCHITECTURE

platform technology

The CENT platform is built on Qt...

signal server technology

CENT connects the amplifier to the interface via the brain-computer-interface (BCI) signal acquisition system OpenVibe. OpenVibe is an open-source, graphical programming environment...

modular, extensible

The core software defines a workflow for NFB sessions, but can be extended by three means (short of actually adapting the source):

1. *plugins*
2. *OV scenarios*
3. *menu functions*

3 RESULTS - VALIDATION

- Clinical trial
- artificial example?

4 DISCUSSION

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5 CONCLUSION

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ACKNOWLEDGMENTS

Author credits:

- BC co-designed the platform UI, designed the clinical trial where it was used, developed the Matlab tool for results review, and co-authored the draft
- JT co-designed and developed the OpenVibe ‘scenarios’, co-authored the draft, etc, etc [insert what you did]
- TI tested and debugged the CENT platform, co-authored the draft, etc, etc [insert what you did]

The authors thank the software engineers:

- Arthur Zielazny co-designed the platform UI and the CENT Qt framework
- Robert Rabenel co-designed and developed the CENT Qt framework
- N. N. co-developed the CENT Qt framework(?) and the movie player application

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Item	Quantity
Widgets	42
Gadgets	13

Table 1. An example table.

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$$S_n = \frac{X_1 + X_2 + \dots + X_n}{n} = \frac{1}{n} \sum_i^n X_i$$

denote their mean. Then as n approaches infinity, the random variables $\sqrt{n}(S_n - \mu)$ converge in distribution to a normal $\mathcal{N}(0, \sigma^2)$.

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You can make lists with automatic numbering ...

1. Like this,
2. and like this.

... or bullet points ...

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- and like this.

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REFERENCES

Figueredo, A. J. and Wolf, P. S. A. (2009). Assortative pairing and life history strategy - a cross-cultural study. *Human Nature*, 20:317–330.