

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

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## **ABSTRACT**

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

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.

### 1.1 Background

Ben: describe Neurofeedback background...

Competition / state of the art... Random studies  
 paid professional products  
 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

Solution: CENT platform. Advantages...  
 Brief history of CENT use, clinical trial (number)...

## 2 METHODS - ARCHITECTURE

The CENT platform is built on Qt...

## 3 RESULTS - VALIDATION

- Clinical trial
- artificial example?

## 4 DISCUSSION

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## 5 CONCLUSION

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## ACKNOWLEDGMENTS

Author credits (FYI JT, TI - I'm pretty sure we need to include some of BLStream in the authors, because we can't claim to have developed the software nor (I think! gotta check) can we publish something we 'just bought'):

- 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
- TI tested and debugged the CENT platform, co-authored the draft, etc, etc
- Arthur Zielazny co-designed the platform UI and the CENT Qt framework
- Robert Rabenel co-designed and developed the CENT Qt framework
- N. N. developed the CENT Qt framework(?) and the movie player application

## Some L<sup>A</sup>T<sub>E</sub>X Examples

Use section and subsection commands to organize your document. L<sup>A</sup>T<sub>E</sub>X handles all the formatting and numbering automatically. Use ref and label commands for cross-references.

## Figures and Tables

Use the table and tabular commands for basic tables — see Table 1, for example. You can upload a figure (JPEG, PNG or PDF) using the project menu. To include it in your document, use the includegraphics command.

| Item    | Quantity |
|---------|----------|
| Widgets | 42       |
| Gadgets | 13       |

**Table 1.** An example table.

## Citations

LaTeX formats citations and references automatically using the bibliography records in your .bib file, which you can edit via the project menu. Use the cite command for an inline citation, like Figueredo and Wolf (2009), and the citep command for a citation in parentheses (Figueredo and Wolf, 2009).

## Mathematics

L<sup>A</sup>T<sub>E</sub>X is great at typesetting mathematics. Let  $X_1, X_2, \dots, X_n$  be a sequence of independent and identically distributed random variables with  $E[X_i] = \mu$  and  $\text{Var}[X_i] = \sigma^2 < \infty$ , and let

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

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

## Lists

You can make lists with automatic numbering ...

1. Like this,
2. and like this.

... or bullet points ...

- Like this,
- and like this.

... or with words and descriptions ...

**Word** Definition

**Concept** Explanation

**Idea** Text

We hope you find writeL<sup>A</sup>T<sub>E</sub>X useful for your PeerJ submission, and please let us know if you have any feedback. Further examples with dummy text are included in the following pages.

## 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.