Using In-Ear Electroencephalography to Extend Human-Computer Interaction for Virtual Reality Applications

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Abstract

Different HCI possibilities in VR applications: 6 degrees of freedom, controllers, hand tracking, treadmill, joysticks, etc. The goal of VR is full immersion, which means that human sensory input and output must be as natural as possible, e.g. high-resolution screens, spatial high definition audio, etc.

Some interaction still relies on intermediaries such as pressing buttons on the controller or a joystick etc. Some are useful, but others are relics of today's computing: mice with pointers, keyboards, etc. They are intermediaries because technology in the 1970s was not yet ready to develop, for example, reliable multi-touch screens for the first wave of personal computers. The same thing is already happening in VR with, e.g. the hand controllers, as hand tracking was still a long way from becoming trustworthy.

But there are still interaction possibilities where the use of, e.g. our hands becomes very limited or uncomfortable, e.g. moving distant objects in a virtual 3D space, so it makes sense to use, e.g. a joystick. As with sensory information to achieve full-immersion in VR, there are countless opportunities and possibilities to achieve it.

With my work, I use a proprietary in-ear EEG sensor to extend the interaction possibilities with the help of the brain and facial artefacts like eye movement etc., to make the experience in the virtual world more natural in the meaning of using sensory output from our body and brain to interact with a virtual world.

There are several possibilities to use an in-ear located EEG sensors, e.g. eye movement, chewing, speaking, blinking, brain waves etc. More draft information coming soon.

I would like to dedicate this thesis to the people from IDUN Technologies for supporting me in my path to entering the neurotechnology industry . . .

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Chapter 1

Introduction

1.1 First paragraph

Goal: Show why your topic is important and attract the reader to your paper. Start with a broad statement and then make it more specific. - Understanding X is one of the primary objectives of... - Decades of research have focussed on the question... - The theory that.... is central to... - It is widely assumed that... - There has been a long-standing interest in... - There is general consensus that X is a serious problem...

1.2 Middle Paragraph

Goal: Give an overview of the relevant scientific literature. What is known? Which questions remain open? Are there conflicts in the literature? - Several studies have shown that... - While some studies suggested that X (References) other studies pointed in the opposite direction (References) - The findings of some studies suggested that X (References). In contrast, other studies have shown that Y (References) - Two theories have been proposed to explain this phenomenon. According to theory X.... - Three lines of research are relevant to this question. First,... - Devin et al. (2003) were one of the first who found evidence that... - Overall, it has remained unclear whether... - Taken together, it remains an open question whether...

1.3 Last Paragraph(s)

Goal 1: State your research question - The goal of the present article is to... - The research question of the present article is... Goal 2: State your hypotheses/ predictions - We hypothesize that... - We predict that... - Two hypotheses are conceivable... - Our primary hypothesis is that... - Drawing on theory X, we hypothesize that... Goal 3: Give a rough outline of your research - We tested whether patients with a diagnosed major depression would report less depressive feelings after treatment X compared to a placebo treatment.

- To test this hypothesis, we .... - To answer this question, we ... - For this purpose, we conducted three studies. First,... Second,... Third,... - To shed more light on this, we used a combination of computer simulations and empirical studies. First, we used computer simulations to determine what behaviour would arise if theory 3 X is true and what behaviour would arise if theory Y was true. Next, we tested these two predictions in three empirical studies. - The present article consists of three sections. In section 1, ... In section 2,... In section 3

1.4 Goals

o Does your introduction go from broad (topic) to specific (your research)? o Did you make clear why your topic is important? o Did you describe just enough research so that readers can understand how your research is the next logical step? o Did you make clear how your research is novel? o Did you make clear what is speculation, and what are established facts? o Did you add citations for everything you present as facts? o Did you use common scientific jargon? o Did you explain the jargon you use?

Chapter 2

Context

2.1 Lorem ipsum

Akademischer Hintergrund: Vorbilder, Referenzmaterial, Eingrenzung und vertiefte Begründung der Zielformulierung. Grundlagenforschung im Bereich vergleichbarer Medienprodukte. Kenntnis der fachspezifischen Theorien und Techniken. Hier muss umfassende Fach- und Handwerkskenntnis gezeigt werden. Es sollen möglichst viele Informationen verwendet werden, die helfen sollen Entscheidungen für die Erstellung des eigenen Medienprodukts zu treffen und Vorgehensweisen beim Entstehungsprozess des eigenen Medienprodukts zu begründen. Ebenso soll begründet werden, inwiefern die verwendeten Quellen für die Zielsetzung und deren Umsetzung geeignet sind.

Chapter 3

Methodologies

3.1 Participants

Forty-three patients of the psychiatric clinic with diagnosed major depression (12 male, Mage = 36.35, SDage = 7.92) participated in this study for monetary compensation (10 USD).

3.2 Design

- The study used a between-subject design (treatment group, control group) with the depression score on the XXX depression scale as dependent variable. - The study used a within-subject design (pre-treatment measurement, post-treatment measurement) with the depression score on the XXX depression scale as dependent variable. - The study used a mixed design with the between-subject factor group (treatment, control) and the within-subject factor time (pre-treatment, post-treatment). The depression score on the XXX depression scale served as the dependent variable.

3.3 Materials

- Three types of materials were used. First,... Second,... Third,...

3.4 Procedure

- Before the experiment started, participants were randomly assigned to two groups: the X group and the Y group. - The experiment consistent of two phases. In the first phase,..... In the second phase,..... - The order of these two phases was counterbalanced - First, participants had to... next... subsequently... finally... - Simultaneously,... - After participants finished X, they... (**swan_future_2016**)

3.5 Data Analysis

- First, they were randomly assigned to treatment and placebo group - Both groups: 60 minutes intervention - Treatment group: first,... next,... - Placebo group: first, ...next,... - Finally, they filled out the depression questionnaire

3.6 Goals

o Did you describe everything that is needed to replicate your research? o Did you cite the sources of your methods or paradigms?

Chapter 4

Implementation

4.1 Lorem ipsum

Umfassende und anschauliche (idealerweise Bildmaterial, Screenshots, Zwischenstände. Auch Fehlschläge dokumentieren) Dokumentation, was genau getan / erstellt / programmiert / produziert / etc. wurde. Welche Auffälligkeiten gab es? Welche Entscheidungen wurden getroffen? Welche Änderungen / Einschränkungen / Erweiterungen wurden vorgenommen?

Chapter 5

Results

5.1 Steps Before The Analysis

- Before we analysed the data, we removed all reaction times that were larger than 2000 ms (2% of all observations) based on the assumption that such reaction times are unlikely to reflect spontaneous responses. - The data of two participants were excluded from the analyses because they did not complete the whole study. - Functional images were re-aligned, unwarped, corrected for slice timing, and spatially smoothed using an 8 mm smoothing kernel.

5.2 Main Results

- First, we investigated whether X (research question) - We used an Independent samples t test with groups as independent variable and the depression score as dependent variable - The results showed that the difference between the groups/ conditions was significant - The results showed a significant correlation between... - The results showed a significant interaction between... - Specifically, the average depressions score was lower in the treatment group (M=3.45, SD = 2.18) compared to the placebo group (M=4.83, SD = 2.02).

5.3 Figures And Tables

Add figures to make important results easier to interpret or to provide more information. Use tables to add extensive amounts of information that would be hard to read in text-form.

5.4 Goals

o Did you describe everything that is needed to replicate your results? o Did you describe all pre-processing steps before the main analyses? o Did you mention to which research question each analysis belongs? o Did you avoid interpreting your results? o Did you add

figures for making your key results easy to understand (or are they very simple)? o Did you add tables for extensive amounts of (numerical) information?

o Does your discussion go from specific (interpretation) to broad (implications)? o Did you draw conclusions with reservations? ("A possible interpretation is. . . ") o If you expressed a preference for one explanation over another, did provide clear support for this preference? o Did you describe how your research connects to previous research? o Did you make clear what your research adds to existing research? o Did you describe how your research advance our understanding or how they may inspire future applications? o Did you clearly admit limitations before qualifying them? o Did you remind the reader of the value/implications of your research at the end? o Did you include some pointers for future research? (optional)

Chapter 6

Discussion

6.1 Summary

- Research question: Does the REFOCUS treatment work? - Study: treatment group and placebo group with self-reported depression measured afterwards - Findings: Depression was lower after the REFOCUS treatment compared to placebo

6.2 Interpretation

- Explanation 1: REFOCUS treatment reduced depression - Explanation 2: placebo treatment increased depression - However, explanation 2 is unlikely because the same placebo was used in studies A, B, C and there it didn't increase depression

6.3 Integration

- Previous research focused on the question of how unprocessed traumas could cause depression - We are the first who tested the "focus" explanation of depression

6.4 Implications

- It is widely believed that depression is caused by unprocessed traumas - Our findings offer a novel perspective: depression is caused by information processing style - Hence, new approach, new line of research to understand depression, new types of treatment

6.5 Limitations

- We had no measure of depression prior to the treatment - Reason: asking people to score their depression twice can lead to problems (references) - Consequence: we don't know

whether depression decreased in treatment group (explanation 1) or increased in placebo group (explanation 2) - However, as mentioned before, it is unlikely that depression increased - Sample size was relatively low - Reason: it's hard to find enough people with a major depression - However, our results were significant despite the low sample size. This speaks to the effectiveness of the treatment

6.6 Conclusion

- We investigated whether depression can be treated by training a positive focus - Our findings confirm this - Novel perspective on depression - More research needed, more treatments that follow this approach should be developed

Appendix A

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Appendix B

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