



# 3D Flickers for Visually Evoked Potentials-based Brain Computer Interface Paradigm in Virtual Reality

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## **SHORT BIOGRAPHY**

Thibault PORSSUT, PhD

## **METHODS & RESULTS**

Procedure  
Preliminary Results

## **STUDY CONTEXT**

Introduction  
Objectives

## **DISCUSSION**

Conclusion  
Perspective



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## SHORT BIOGRAPHY





## **Thibault PORSSUT**

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Mind & Act  
Future of Health

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# SHORT BIOGRAPHY

## Education

- 2020: PhD in Virtual Reality and Neuroscience, EPFL, Lausanne, Switzerland
- 2016: Master Degree in Mechanical and Industrial Engineering, ENSAM, France
- 2016: Master Degree in Digital Mock-up and Virtual Immersion, ENSAM, France

## Core Experiences

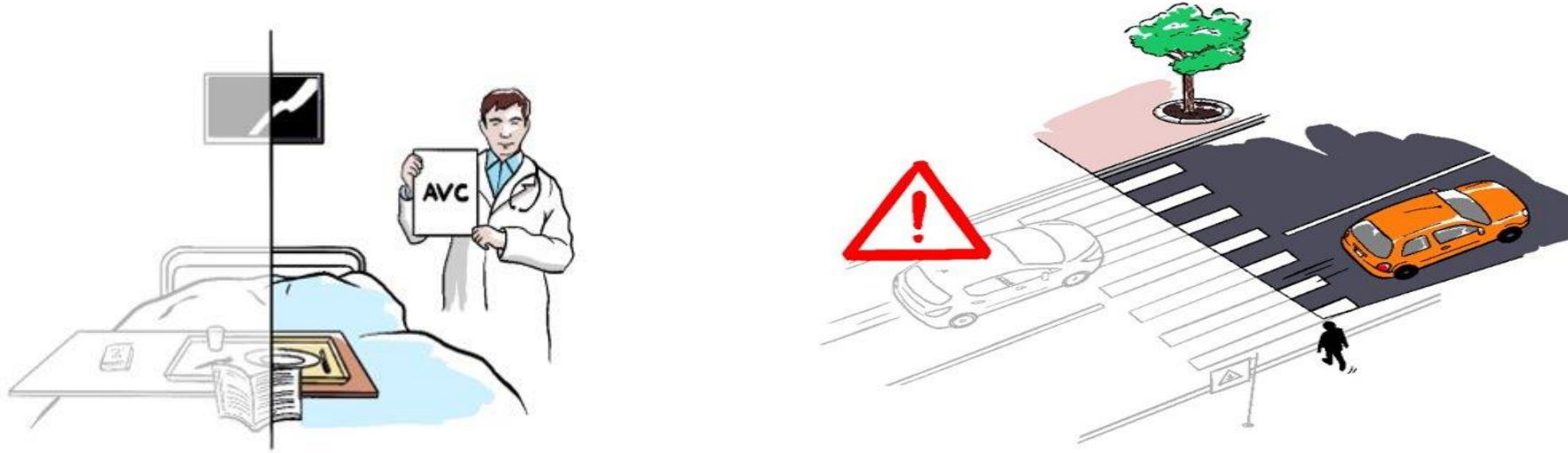
- March 2022 : Use Case Leader
- 2020-2021 : Postdoctoral Researcher, IIG lab, EPFL Lausanne, Suisse
- 2016-2020 : Teaching Assistant, EPFL, Lausanne, Suisse
- 2016 : Internship, Mechdyne and EVL, Chicago, USA

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## **INTRODUCTION : CONTEXT & OBJECTIVES**

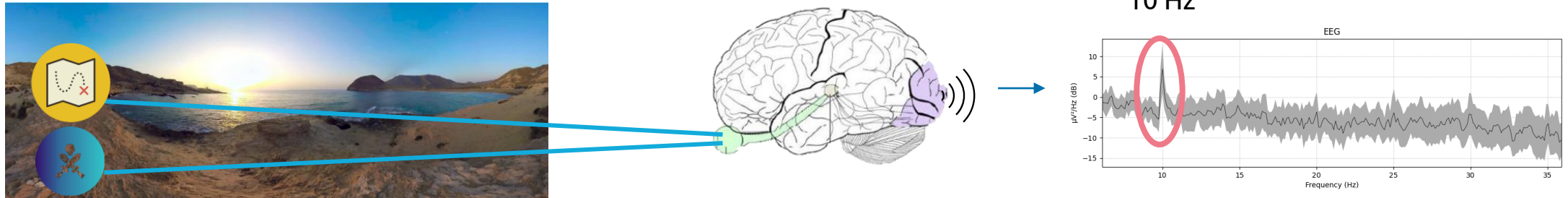


# Unilateral spatial neglect (USN)



« A failure to report, respond, or orient to sensory stimuli presented to the side contralateral to the stroke lesion site » (Heilman et al., 1985)

- Cognitive and sensory-motor impairments
- Deficit in **attention** to and **awareness** of one side of space
- Serious implications on daily-life activities



- Epileptogenic frequencies (12-15 Hz)
  - Beating effect of standard flickers
  - Possible **conflict** between visual fatigue, performance and immersion
- Stimulus choice remains a limitation, especially for VR-BCI

# Objectives and Motivations



## VEP-based BCI combined with VR

- High potential
- **Lack of 3D virtual stimuli** in the literature
- Need to improve stimuli **ergonomics**

## Objectives

1. Adapt efficient 2D VEP stimuli to 3D and propose new 3D VEP stimulation paradigms for VR –BCI
2. Evaluate these 3D flickers in terms of ergonomics and BCI feasibility

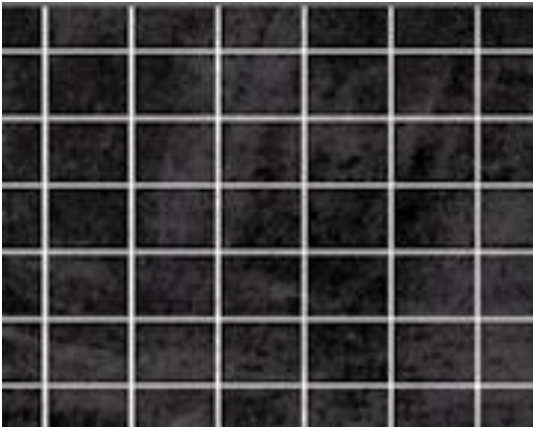
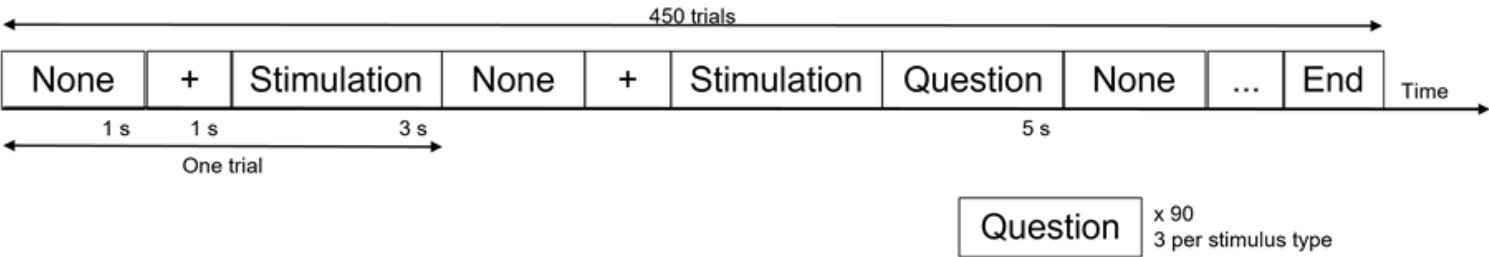


# 3

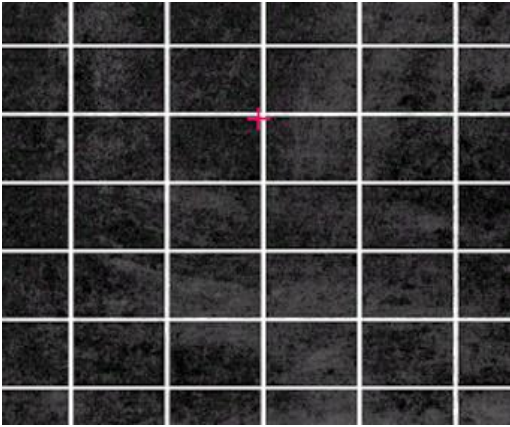
## METHODOLOGY & RESULTS



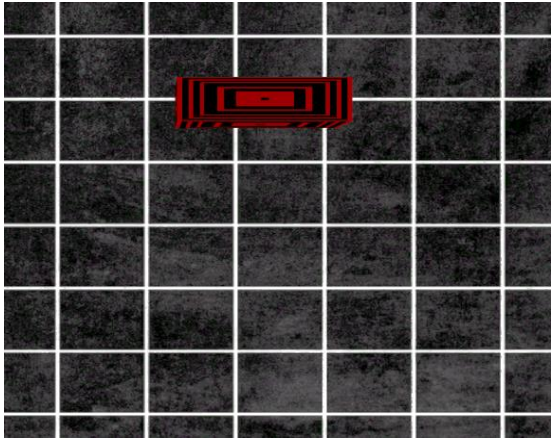
# Experimental protocol



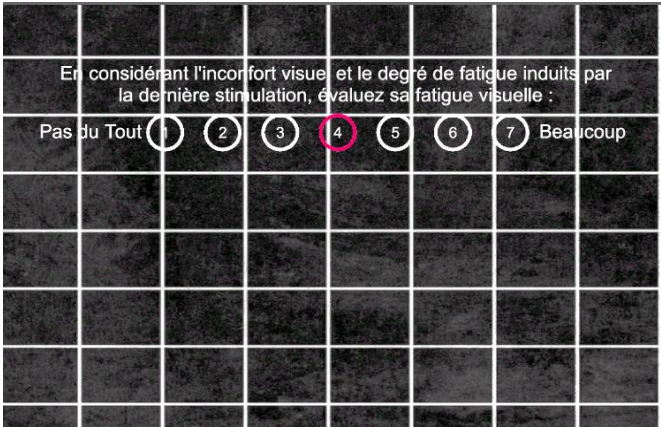
Virtual room



1. Find the cue



2. Focus on the target



3. Answer a question (20% trials)

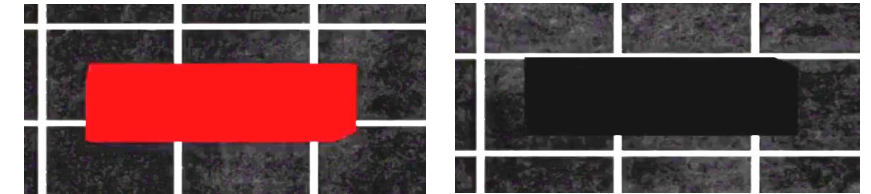
"Considering the visual discomfort and amount of tiredness induced by the last stimulation, rate its visual fatigue level" from 1 to 7.

N = 25 participants, data from only 12 participants were included (11 for the ergonomics analysis and 12 for the classification analysis respectively)

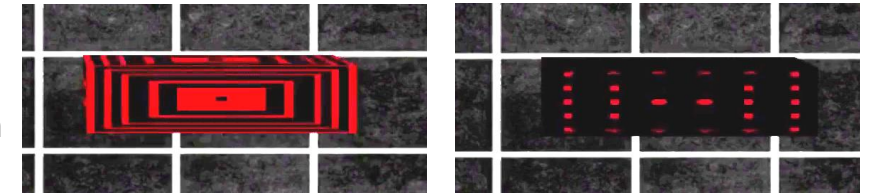
- Development of a 3D stimuli generator
- Combine up to 3 VEP stimuli with different characteristics

- Dark red cuboid (luminosity and contrast were enhanced for the purpose of the presentation)
- 8 Hz behavior modulations

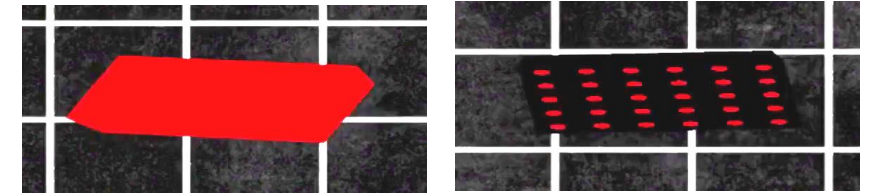
Sinusoidal flash



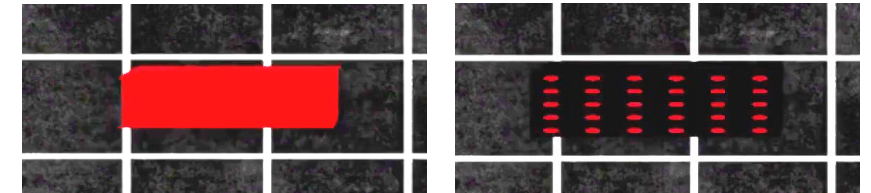
Newton's square rings inspired graphical variation



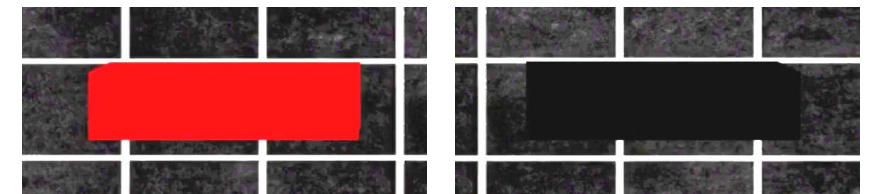
Spinning motion



Grow-shrink motion



Pseudo-random flash

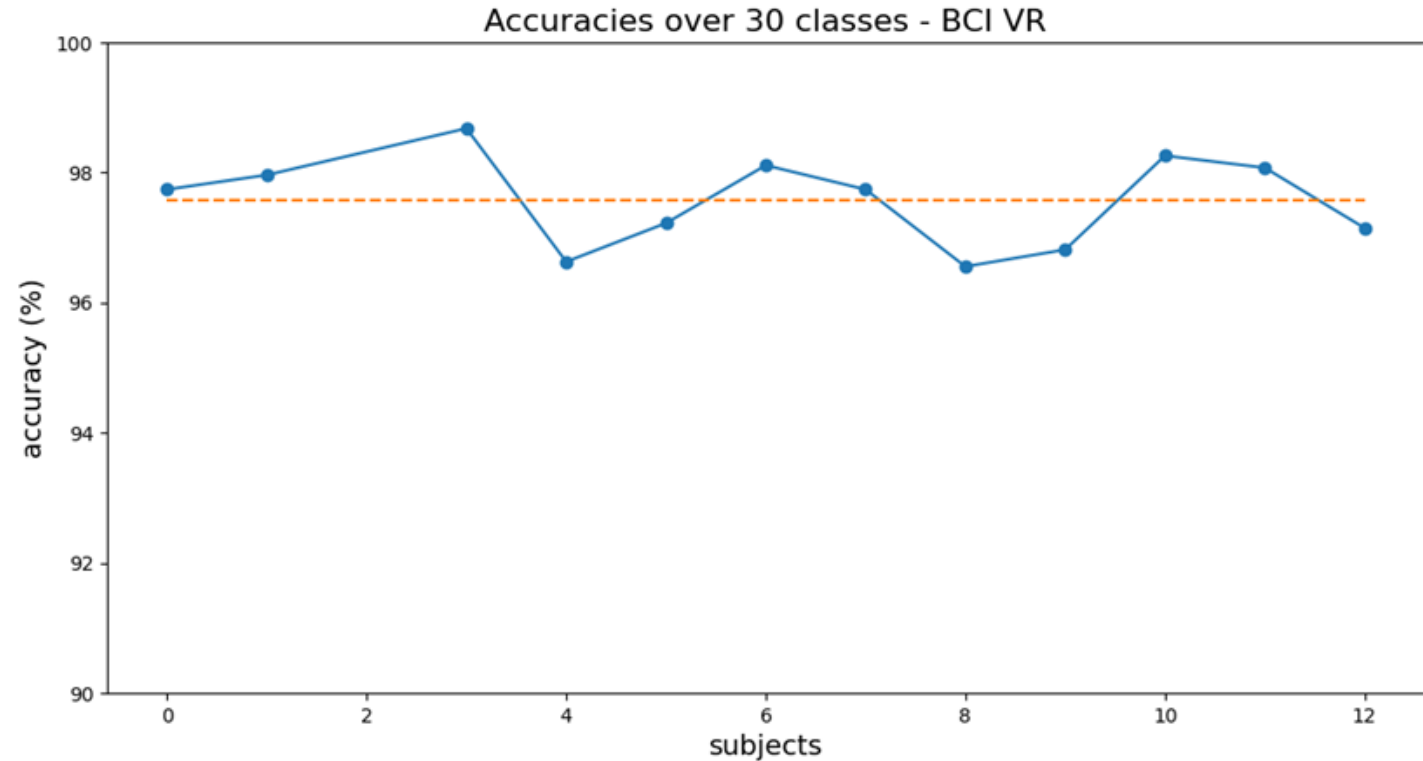
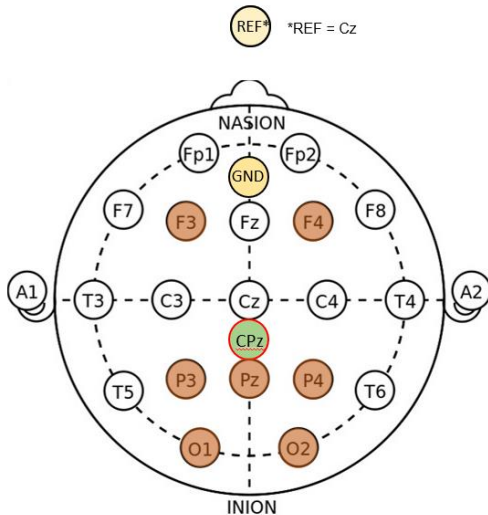


- Basic stimuli + combinations: **30** stimulation types

# Offline classification results



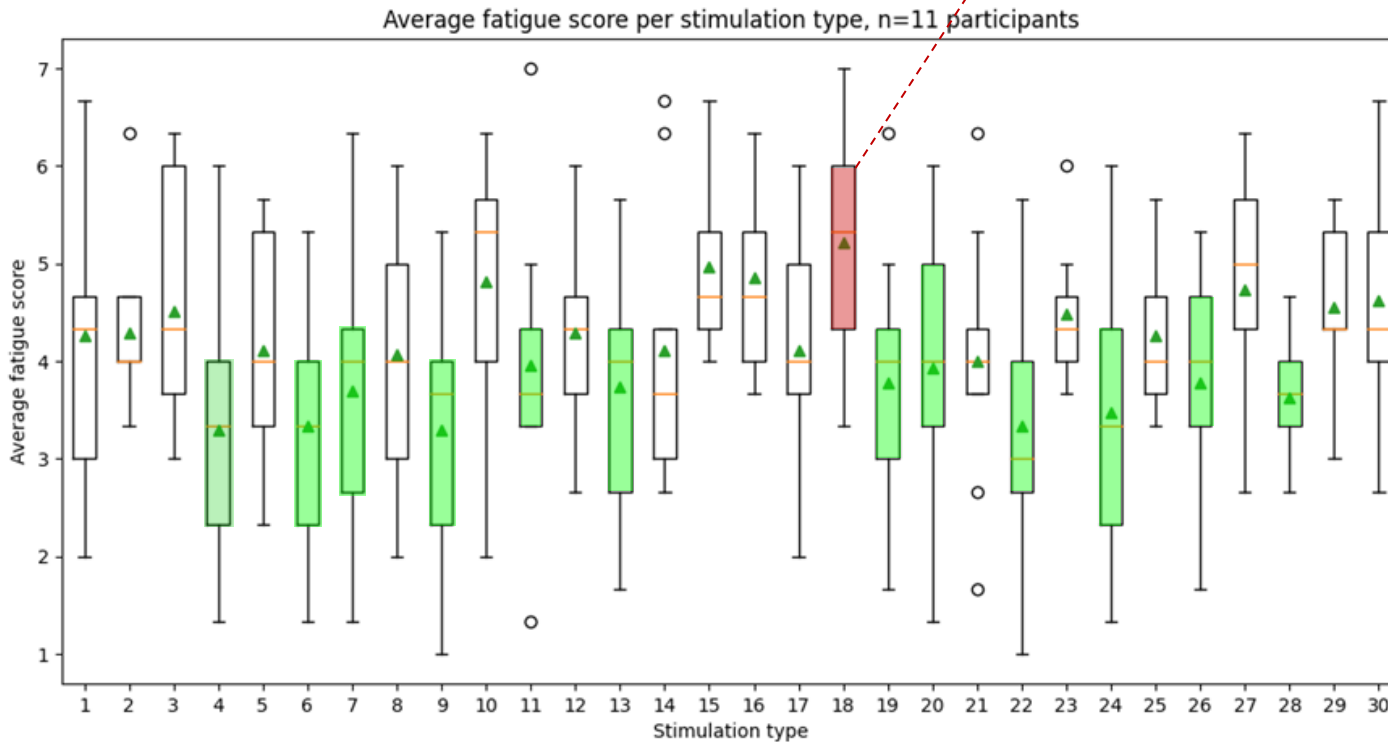
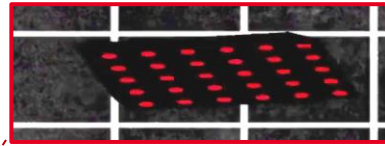
- EEGNet model (Lawhern et al., 2018)
- Electrodes: 'Ground', 'O1', 'O2', 'P3', 'P4', 'CPz', 'Cz', 'F3' and 'F4' (10-20 international system)



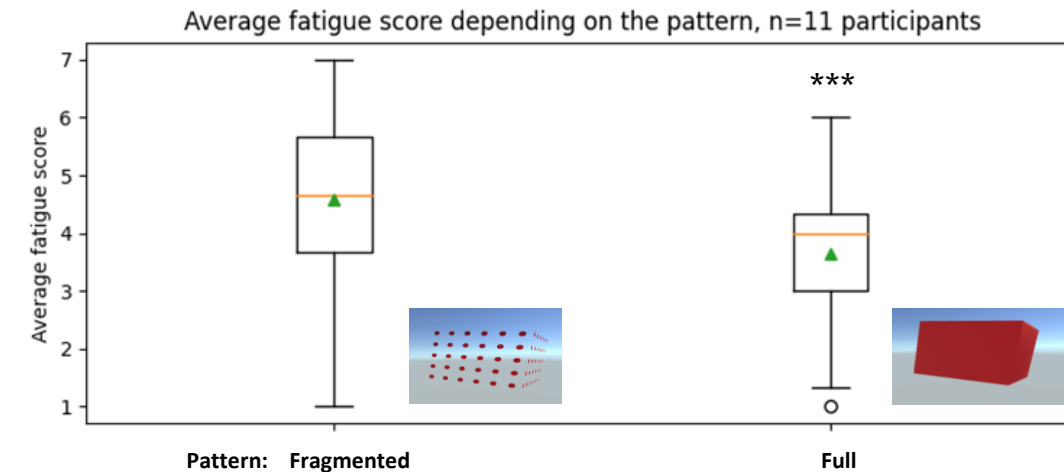
- **Surprisingly high** accuracy:  $97.58 \pm 0.01$
- 3D stimuli **could be classified** according to their visual



# Ergonomics results



- **No significant difference** depending on the stimulation type, high standard deviations
- 3D virtual targets are **not that uncomfortable**



- **Full** stimuli could be more comfortable than fragmented stimuli

# 4

## CONCLUSION & PERSPECTIVES



# Conclusion & perspectives



## Results

New efficient stimulation paradigms

3D stimuli could be classified

*Could broaden VEP-based BCI stimulation possibilities*

## Limitations

Small number of participants

High standard deviations

Role of the virtual environment

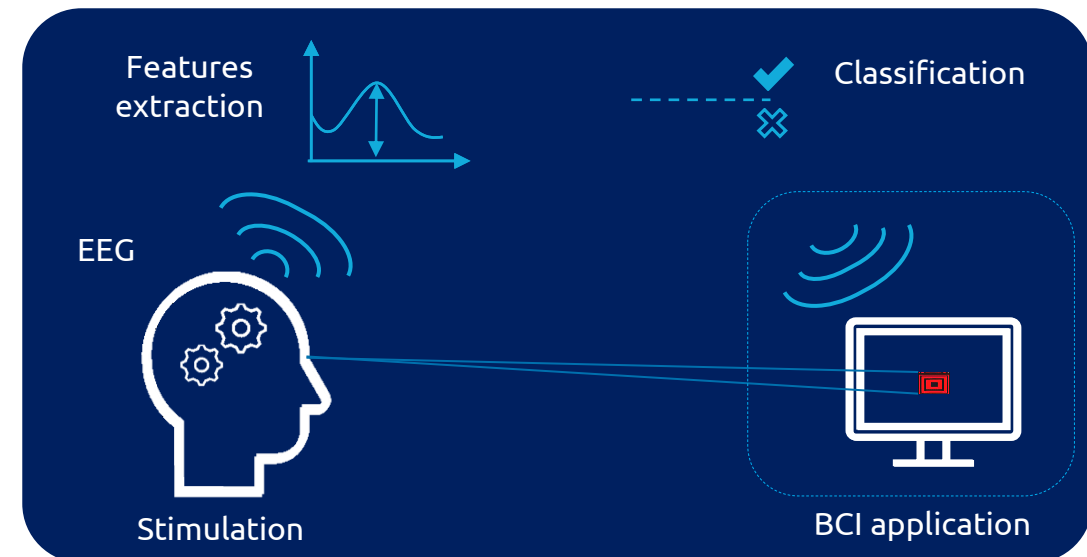
## What's next?

Include more participants

Get complementary results

Offline → Online

Integration into the game



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**GET THE  
FUTURE  
YOU WANT**