

Eye Detection and Face Recognition for Visual Prostheses

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Outline

1 Introduction

2 Background

3 Methodologies

4 Results

5 Conclusion

Motivation

Normal Sight



Motivation

Acquired Blindness (Retinitis Pigmentosa [peripheral vision loss])



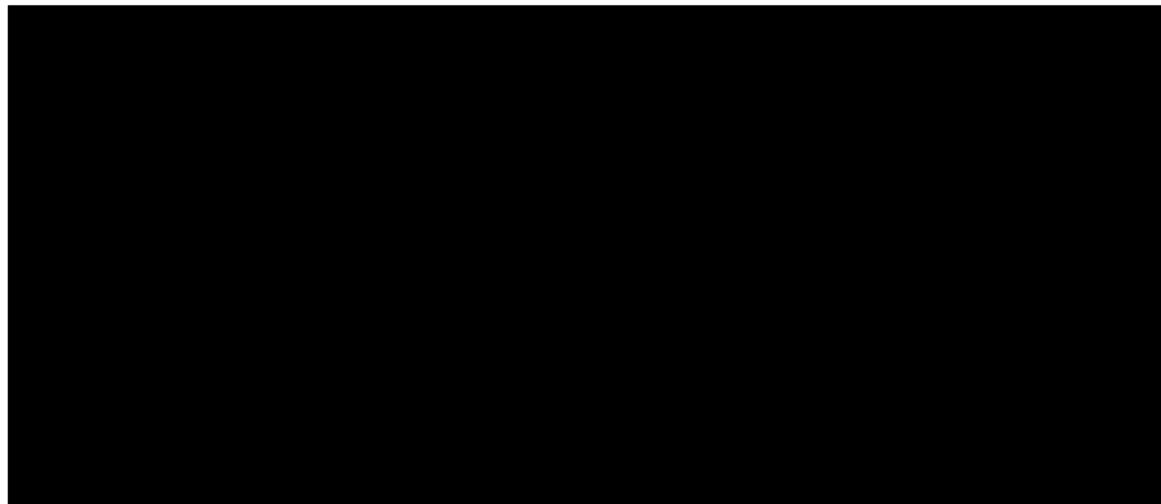
Motivation

Acquired Blindness (Retinitis Pigmentosa [peripheral vision loss])



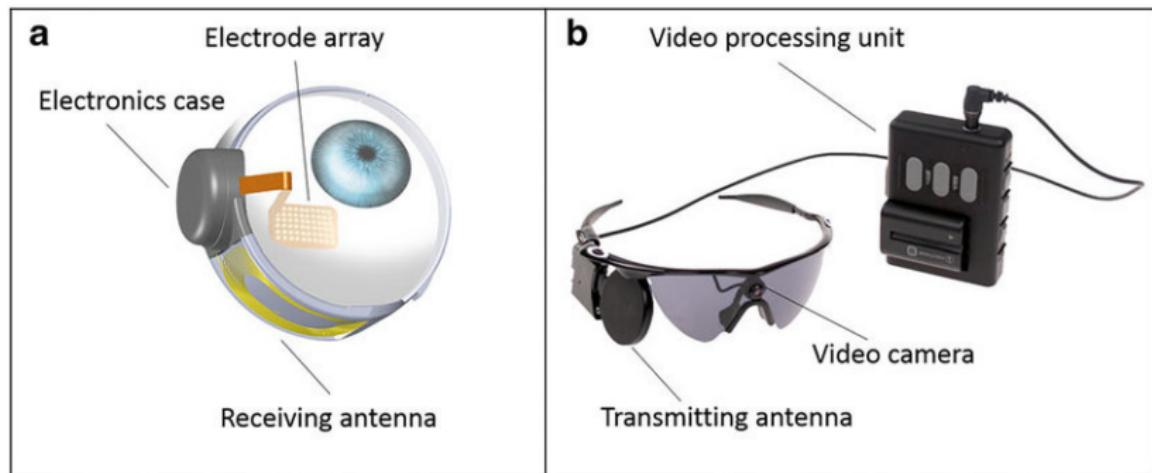
Motivation

Acquired Blindness (Retinitis Pigmentosa [total vision loss])



Motivation

Visual Prostheses system (Argus II)



Motivation

Visual Prostheses implantee



Motivation

Normal Sight



Motivation

Prosthetic Vision sight (low spatial resolution)



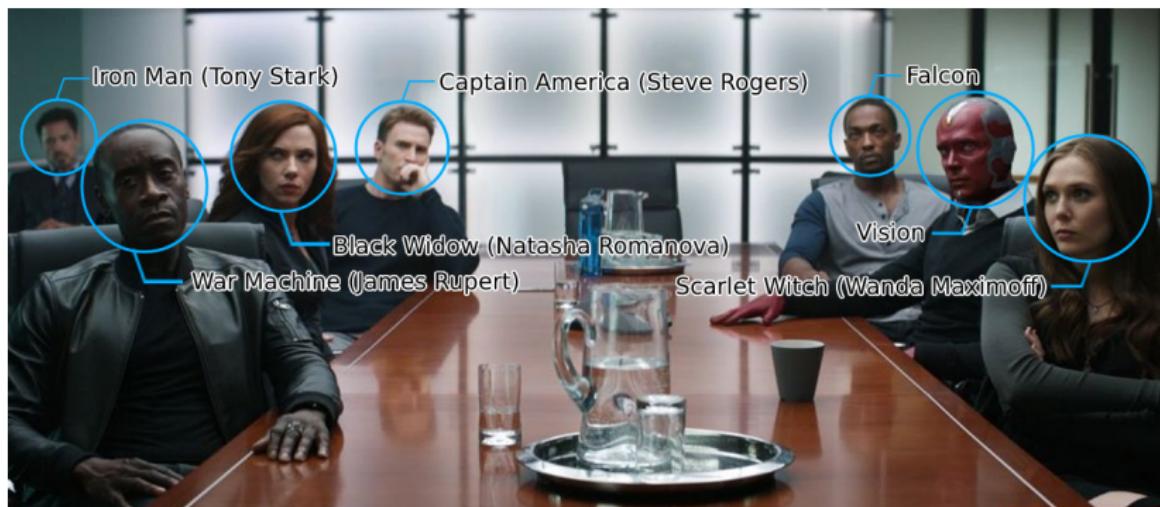
Objective

Improve visual prostheses implantees efficiency in group conversations.

In a group conversation setting, it is very valuable for a group member to do the following efficiently:

Objective

- 1) Recognize other group members



Objective

- 2) Distinguish alike faces (general category and extra-face details)



Objective

3) Identify the talking person(s)



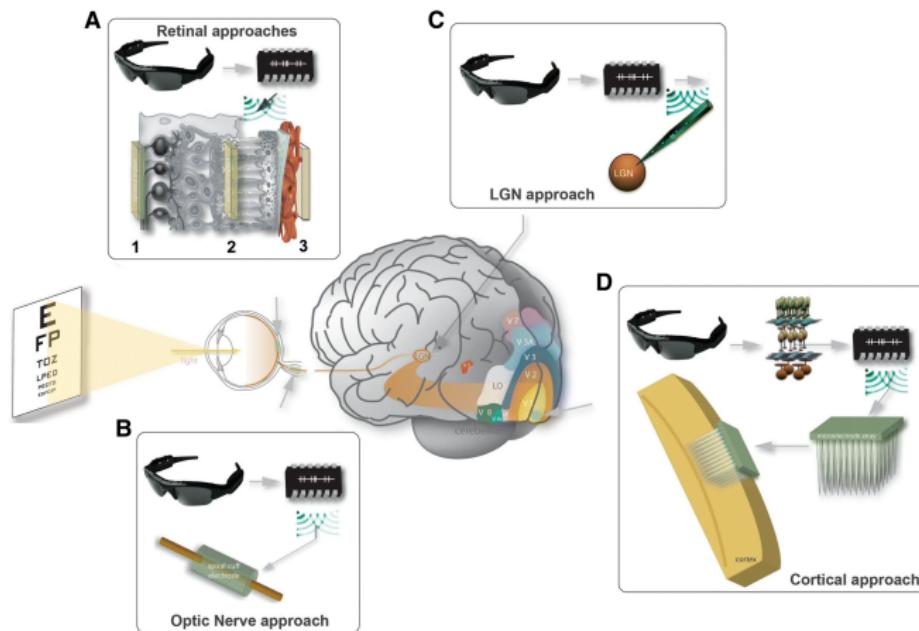
Objective

- 4) See facial expressions (convey emotions words cannot portray)



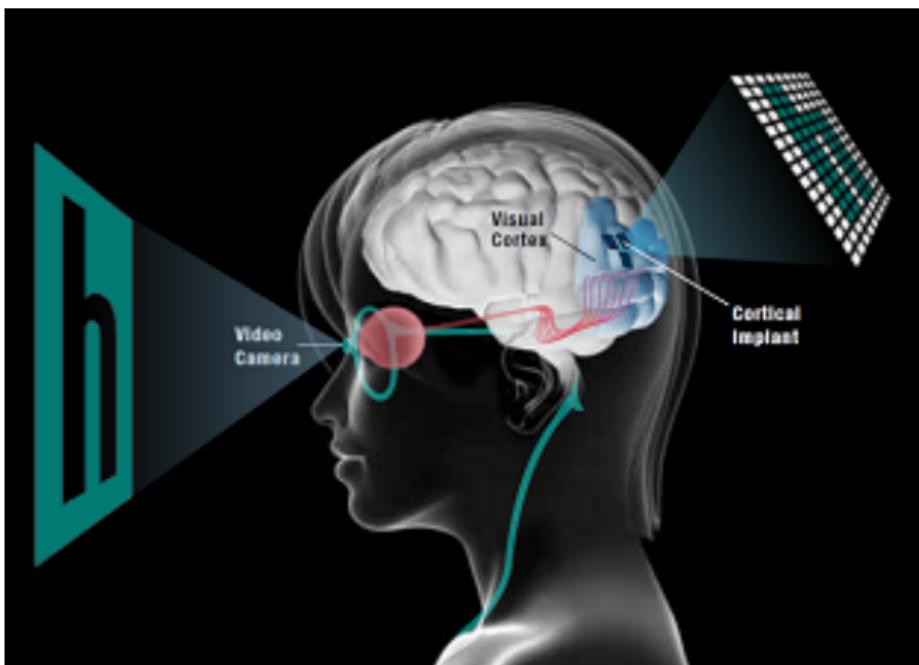
Visual Prostheses

Different approaches along the visual pathway



Phosphenes

Visual prostheses system



Phosphenes

Depiction of Phosphenes



Enhancing images

Processing of high resolution scene



Simulation

- No access to actual implantees
- Simulations applied to normally sighted subjects

Actual scene



Simulation

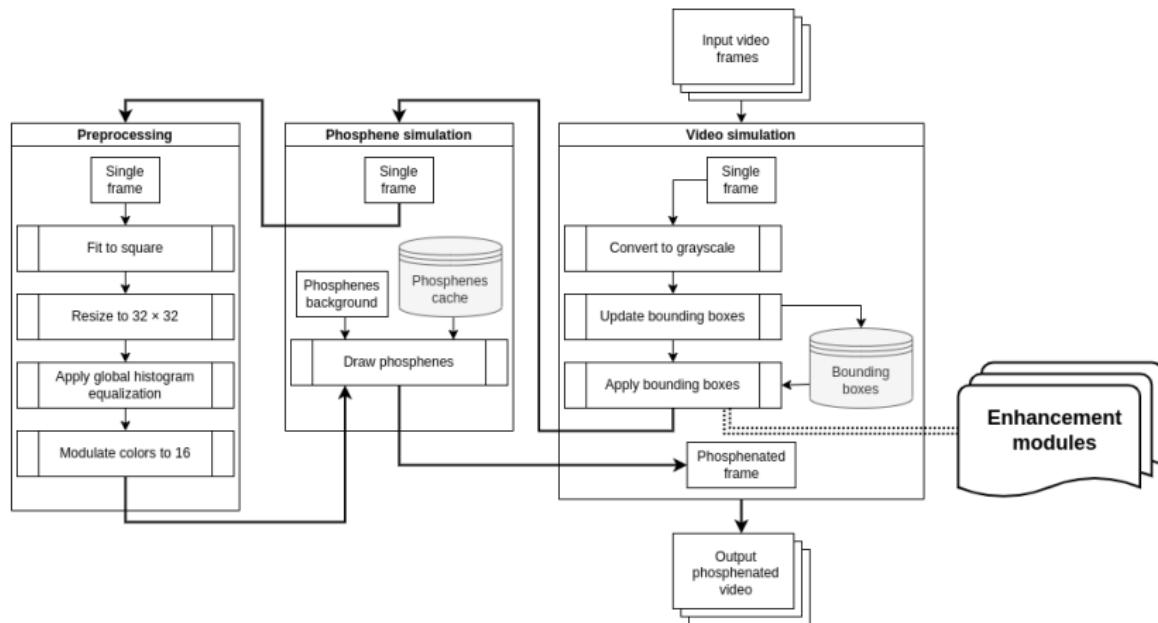
- No access to actual implantees
- Simulations applied to normally sighted subjects

Phosphenated (simulated) scene



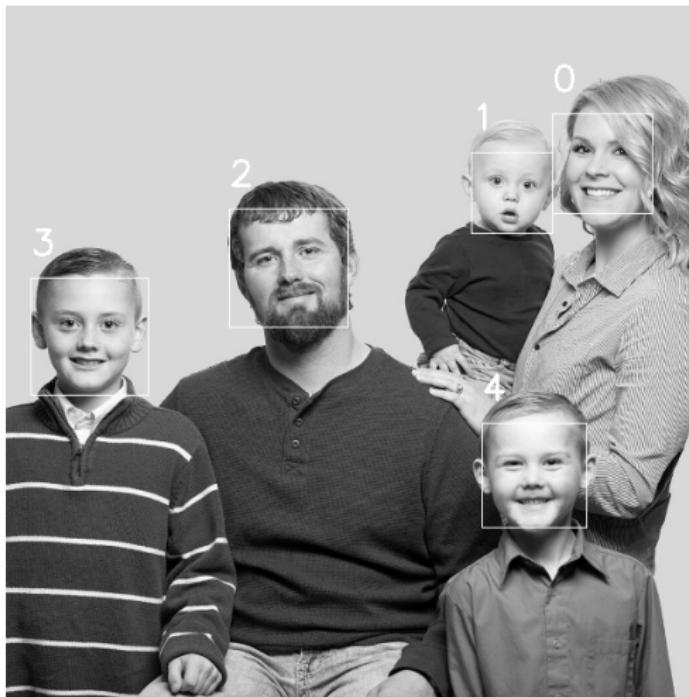
Simulation

<https://github.com/HeshamMoneer/Phosphenes-Simulation>



Simulation

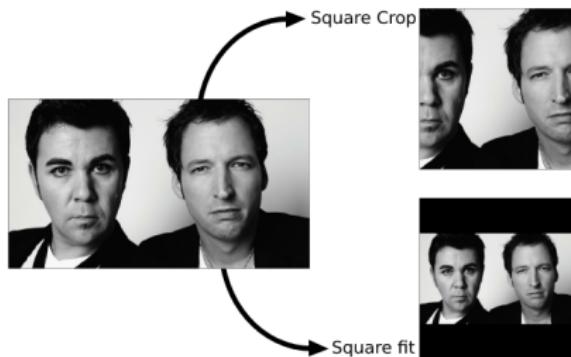
Faces Bounding Boxes (Viola Jones Haar Cascade Classifier)



Simulation

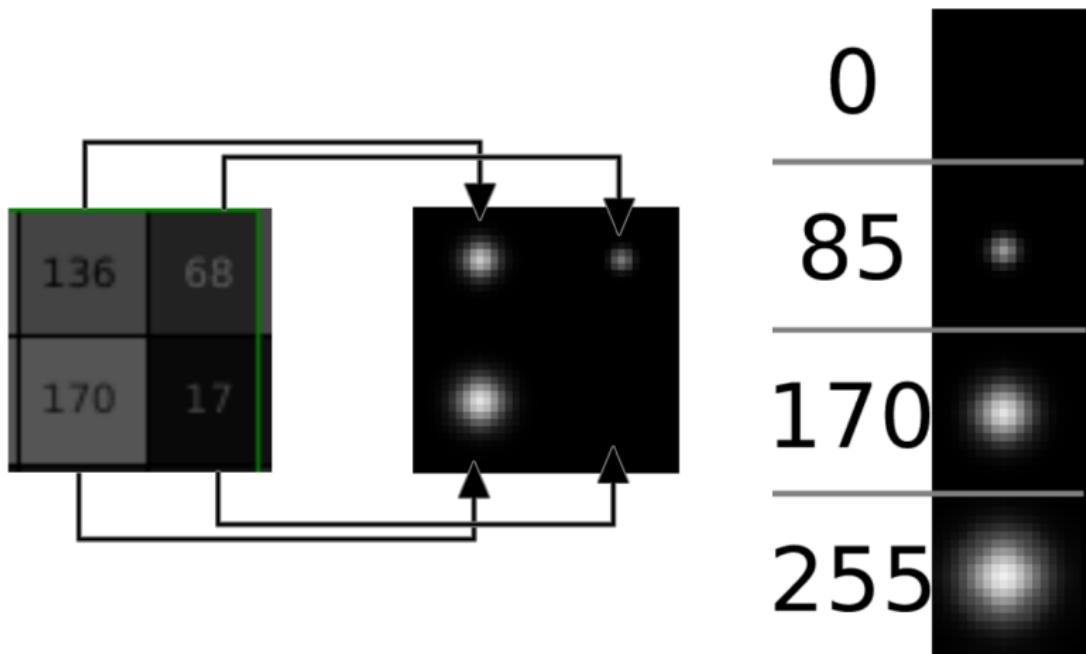
Image preprocessing

- ① Square fit
- ② Resize to 32×32 (bilinear interpolation)
- ③ Apply Histogram equalization
- ④ Modulate colors to 16

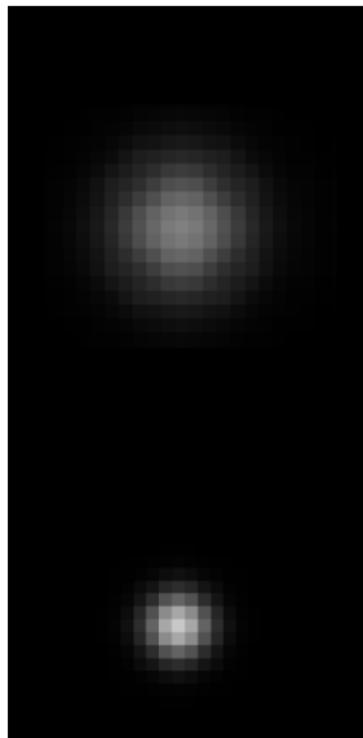


Simulation

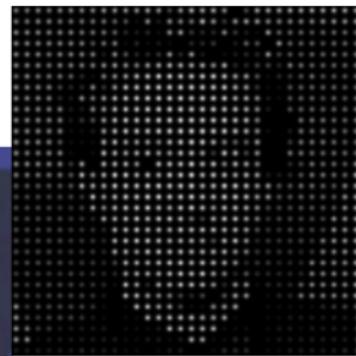
Draw Phosphenes



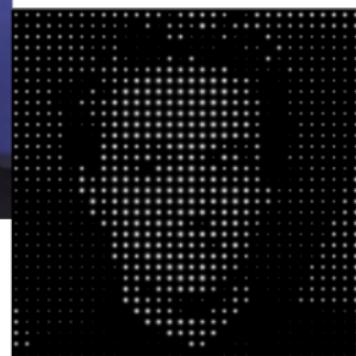
Phosphenes modulation



Color Modulated



Size Moudulated



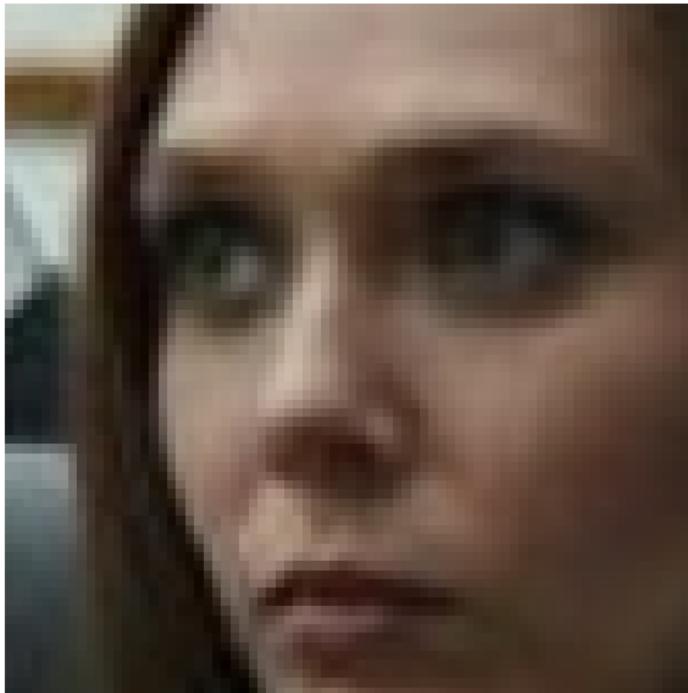
Enhancement Modules

Region of interest (ROI) magnification



Enhancement Modules

Region of interest (ROI) magnification



Enhancement Modules

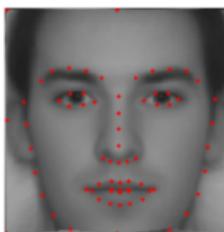
Caricaturing

- Opposite of face morphing

Average Face



Average Landmarks



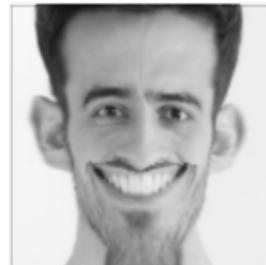
Veridical Face



Face Detection
Face Landmarks
Delaunay Triangulation



Caricatured Face



Enhancement Modules

Face-specific histogram equalization (FSHE)



Enhancement Modules

Talking Detection (RNN)



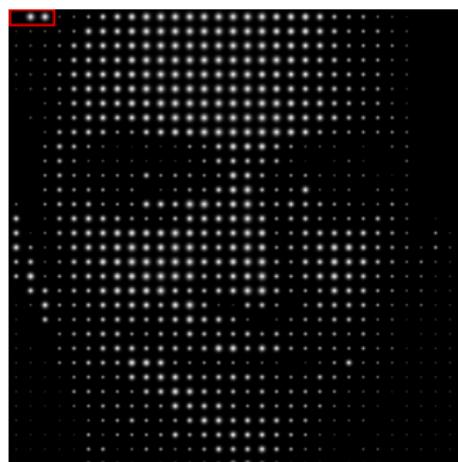
Enhancement Modules

Emotion Recognition (CNN)



Applied Enhancements

- ① Mere magnification
- ② Magnification with Caricaturing
- ③ Magnification with FSHE
- ④ Magnification with Talking Detection
- ⑤ Magnification with Emotion Recognition



Computer Screen Experiment



Computer Screen Experiment

Size Modulated phosphenes

Experiment Groups (5 participants per group)

- ① Control group
- ② Magnification group
- ③ Caricaturing group
- ④ FSHE group
- ⑤ Talking detection group
- ⑥ Emotion recognition group

Experiment Tests

- ① Recognition test
- ② Talking test
- ③ Distinction test

Virtual Reality Experiment



Virtual Reality Experiment

Best performing groups in computer screen experiment

Color Modulated phosphenes

Experiment Groups (5 participants per group)

- ① Control group
- ② Magnification group
- ③ Caricaturing group

Experiment Tests

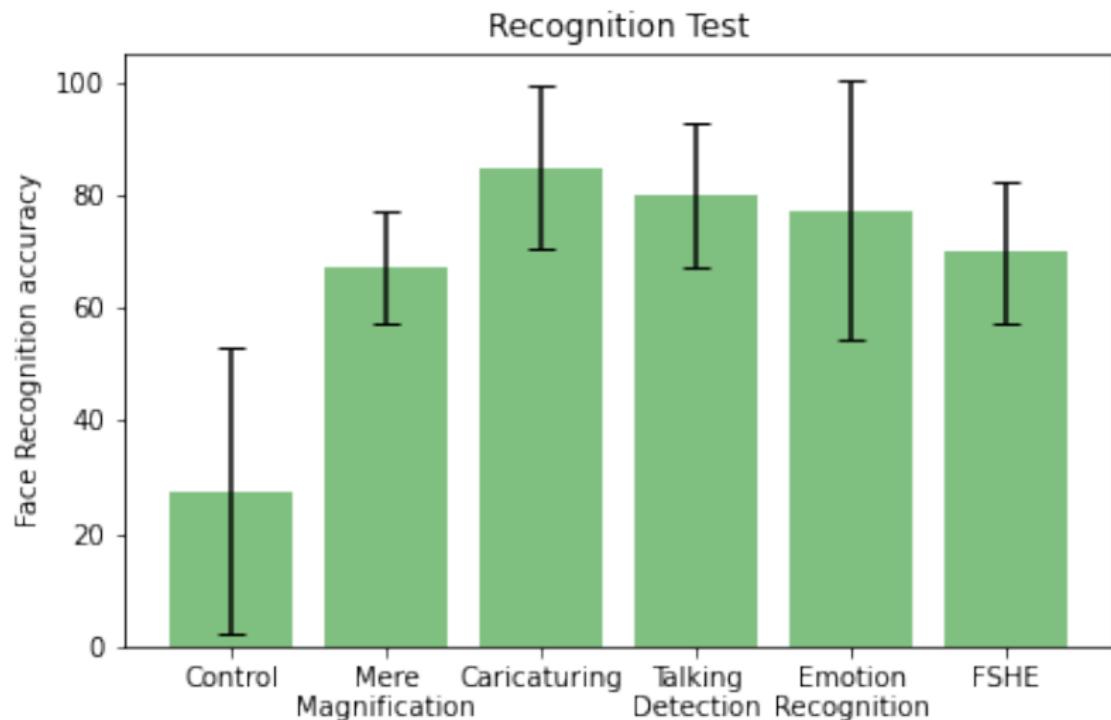
- ① Recognition test
- ② Expressions test
- ③ Distinction test

Applicability in Real-time

- Experiment images and videos were phosphinated in real-time
- No lag was observed by the subjects nor the tests conductor
- The total duration of simulating and playing a video did not exceed the actual duration of the video

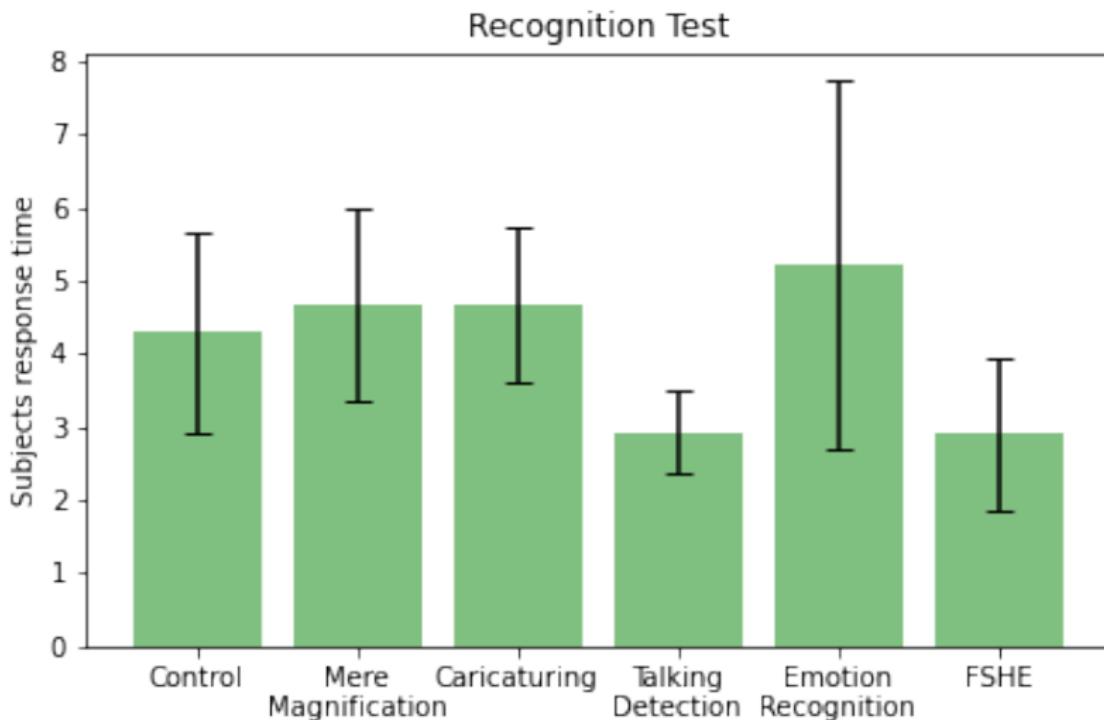
Computer Screen Experiment

Recognition Test accuracy



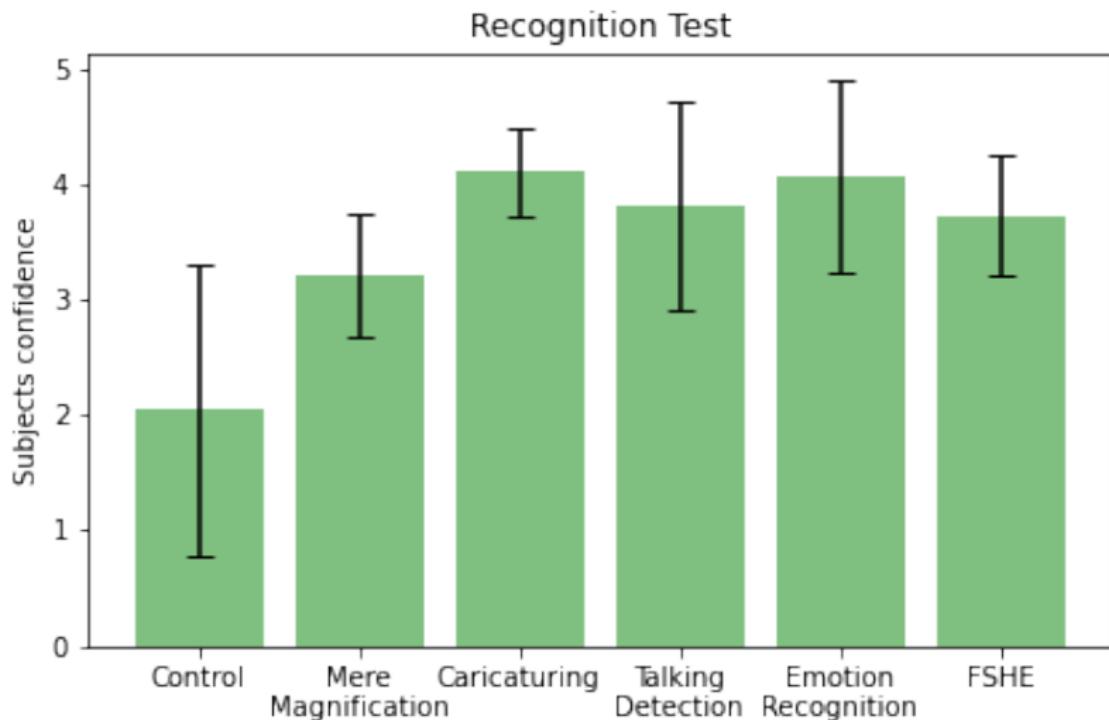
Computer Screen Experiment

Recognition Test response times



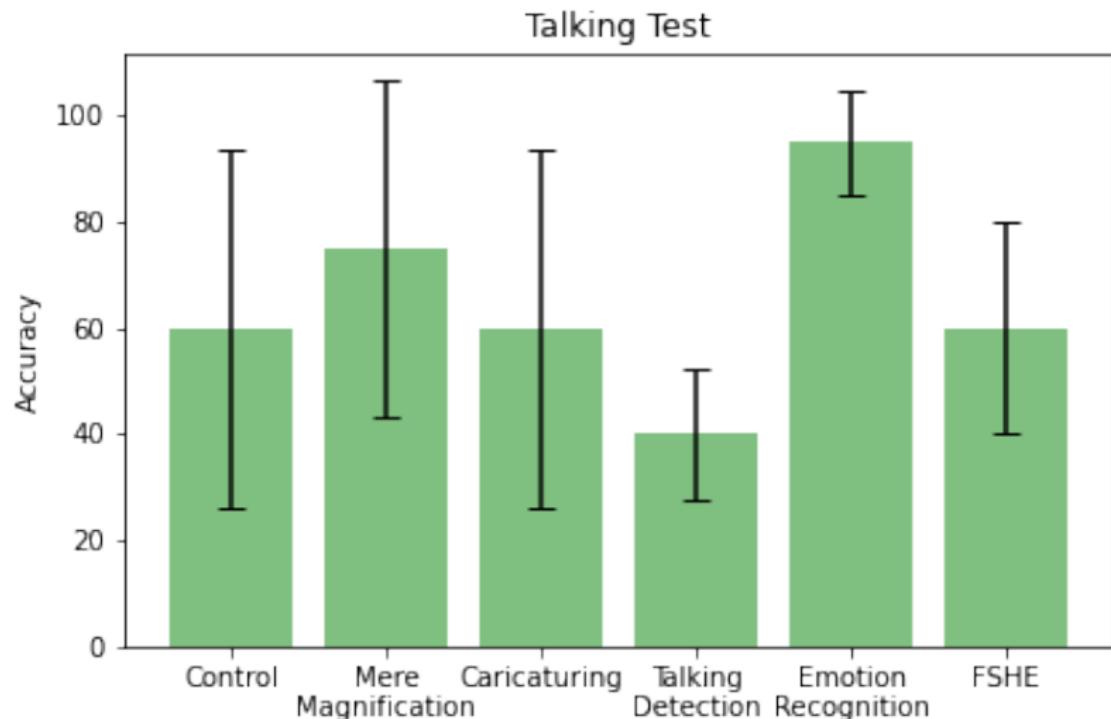
Computer Screen Experiment

Recognition Test confidence levels



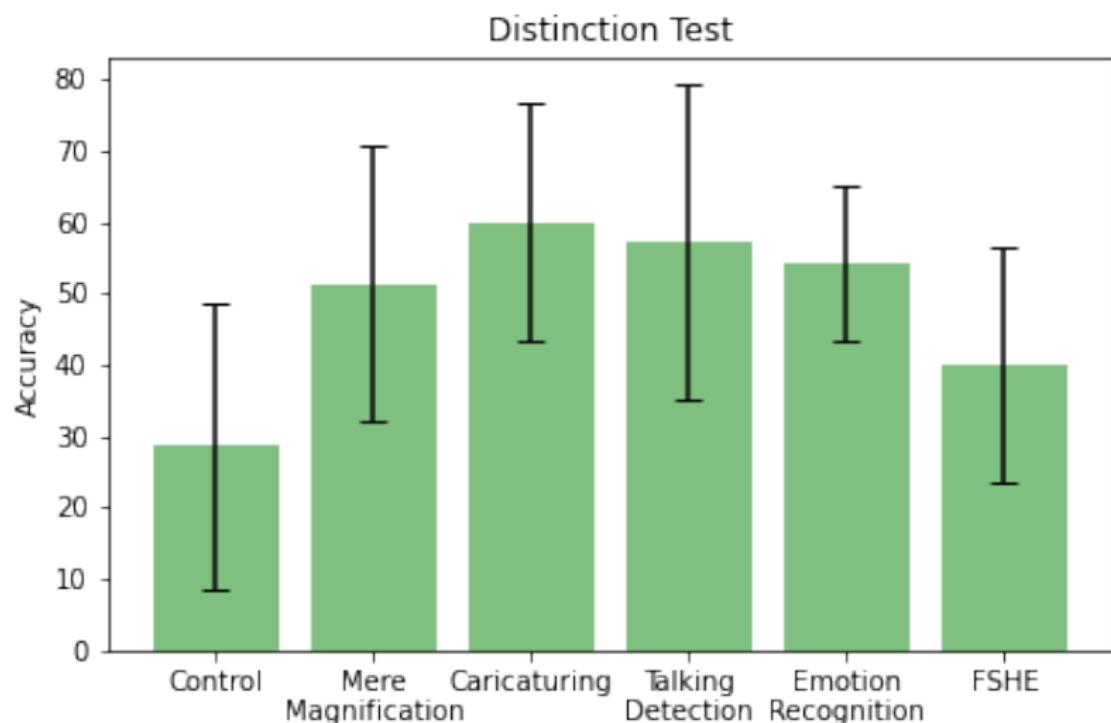
Computer Screen Experiment

Talking Test accuracy



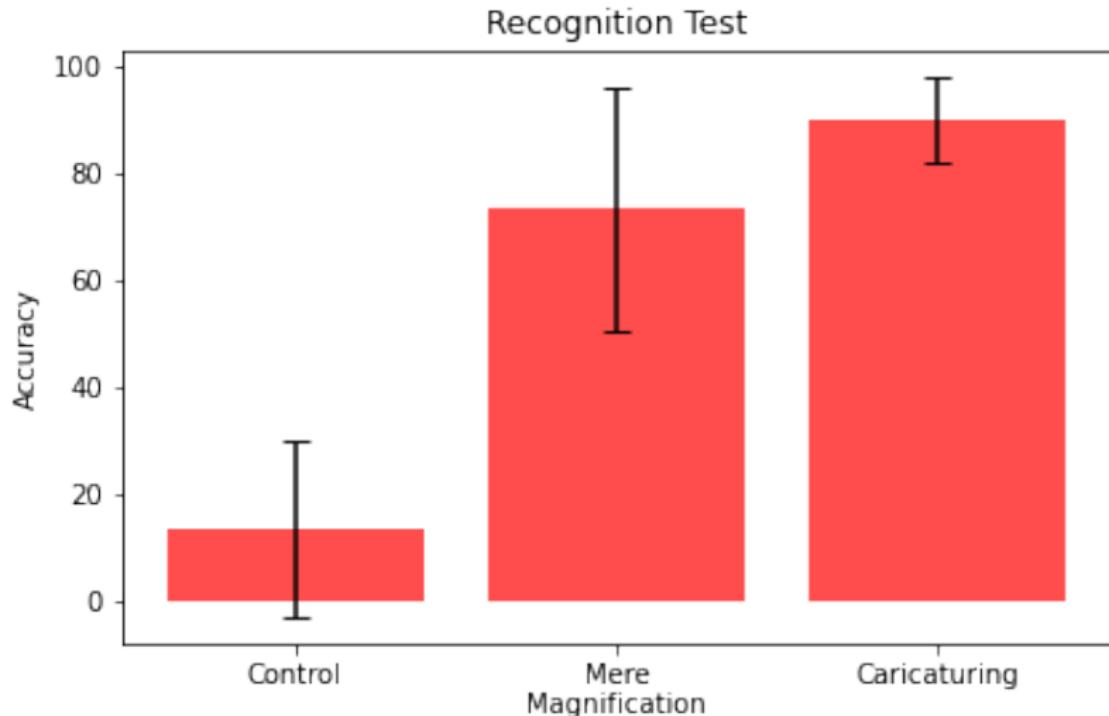
Computer Screen Experiment

Distinction Test accuracy



Virtual Reality Experiment

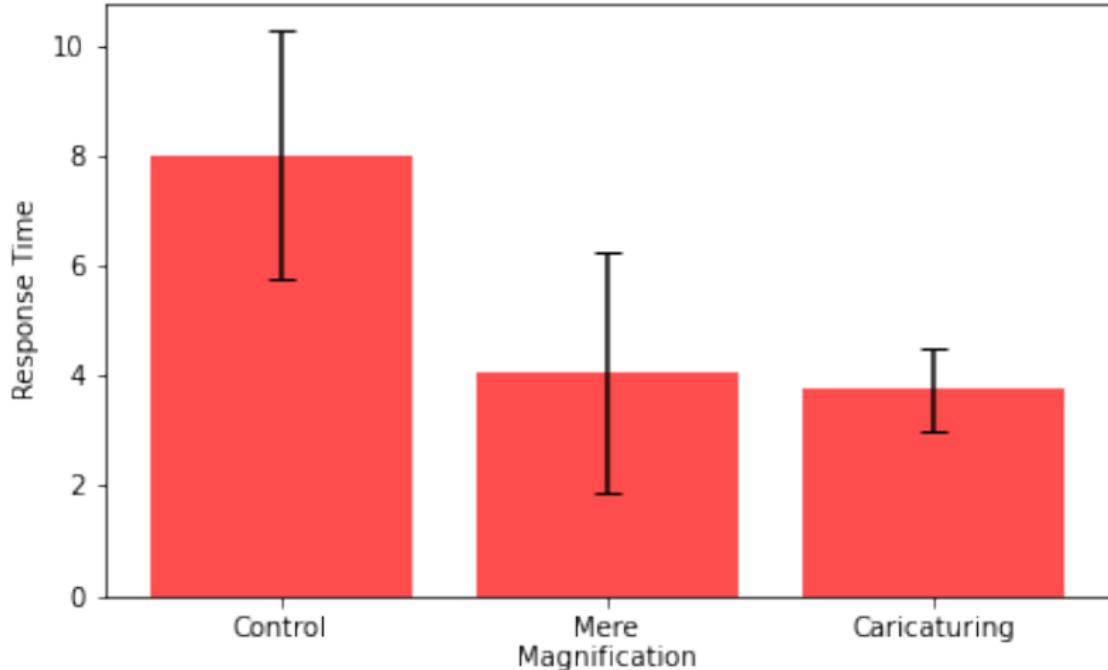
Recognition Test accuracy



Virtual Reality Experiment

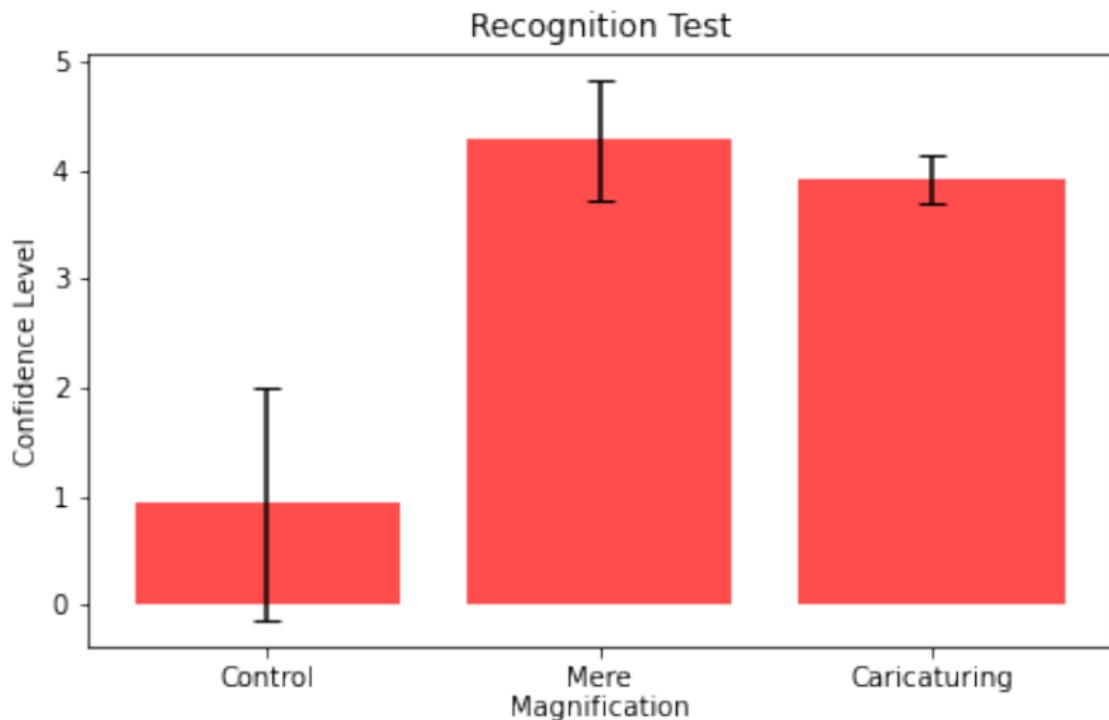
Recognition Test response times

Recognition Test



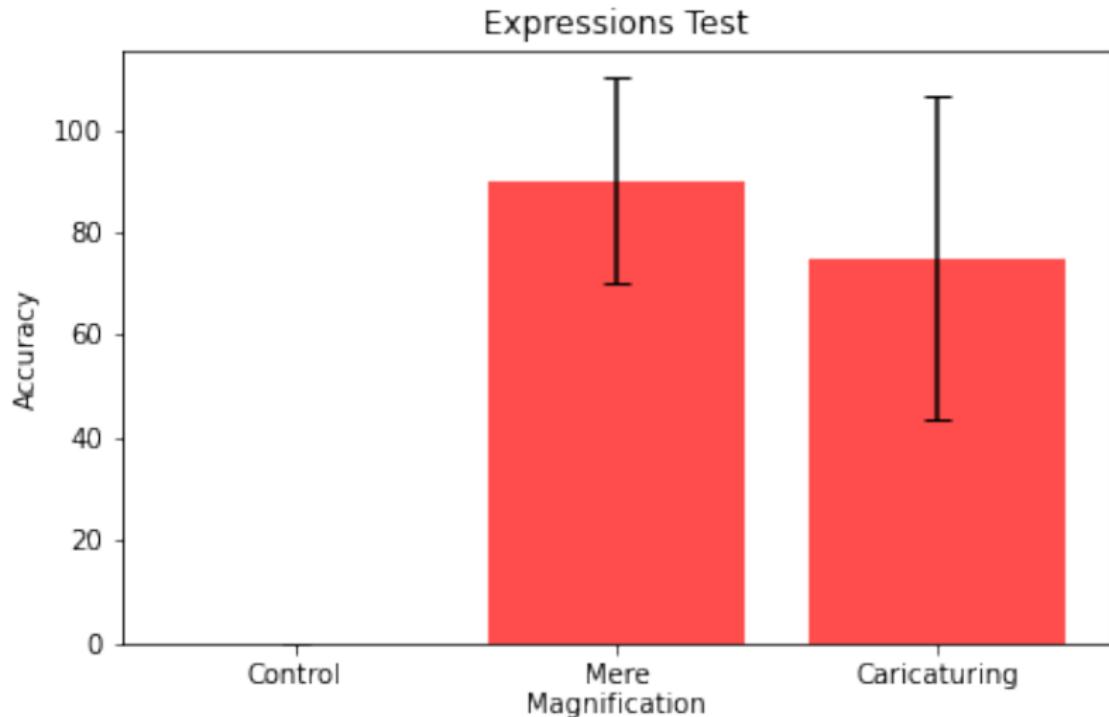
Virtual Reality Experiment

Recognition Test confidence levels



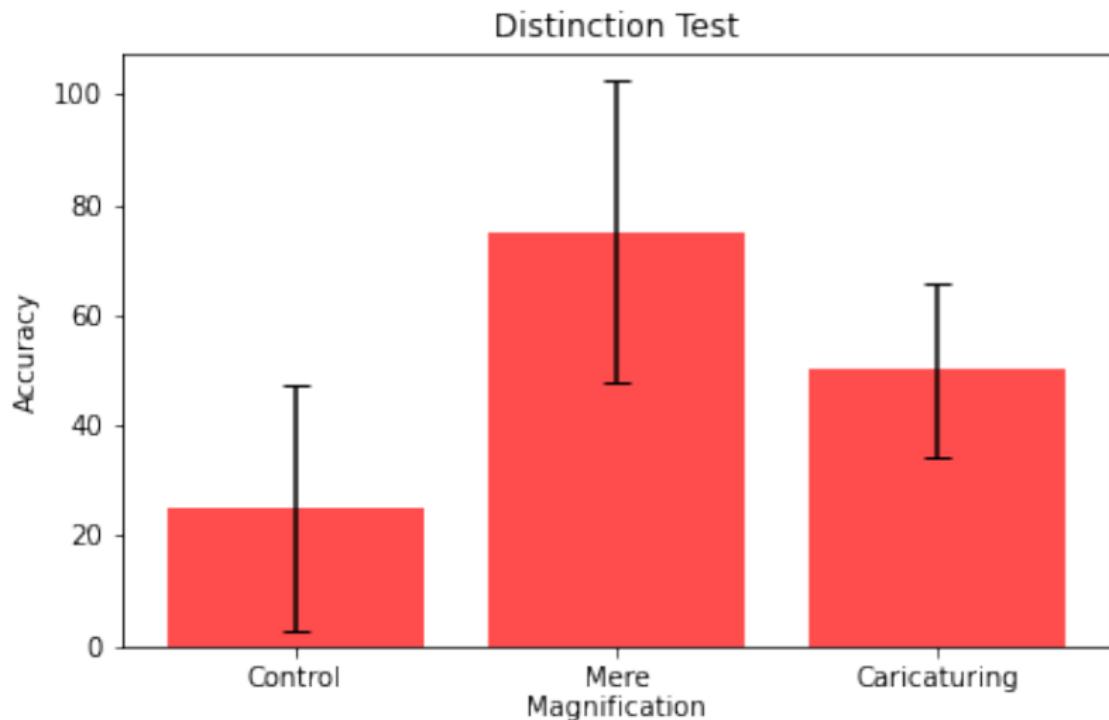
Virtual Reality Experiment

Expressions Test accuracy



Virtual Reality Experiment

Distinction Test accuracy



Conclusion

ROI magnification	??	recognize faces
Caricaturing	??	distinguish similar faces
FSHE	??	see facial details
Talking detection	??	detect the talking person
Emotion recognition	??	see facial expressions

Conclusion

ROI magnification	\Rightarrow	recognize faces
Caricaturing	\Rightarrow	distinguish similar faces
FSHE	$\not\Rightarrow$	see facial details
Talking detection	$\not\Rightarrow$	detect the talking person
Emotion recognition	$\not\Rightarrow$	see facial expressions

Future work

Future work

- More participants and more questions
- Actual implantees experiment
- Higher quality Caricaturing algorithm (e.g. CariGAN)
- More facial landmarks (e.g. Mediapipe 468 landmarks)

*Thank You
Any Questions?*