G53IDS

Demonstration of Project

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

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Summer Project

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

AU 01

AU 02

AU 04

AU 05

AU 06

AU 07

Facial

Action Unit [1]

AU 09

AU 10

AU 12

AU 14

AU 15

AU 17

AU 20

AU 23

AU 25

AU 26

AU 28

AU 45

Original Idea - I

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

Predict Facial Action Unit in Deep Learning

Thinking/Concentration Level

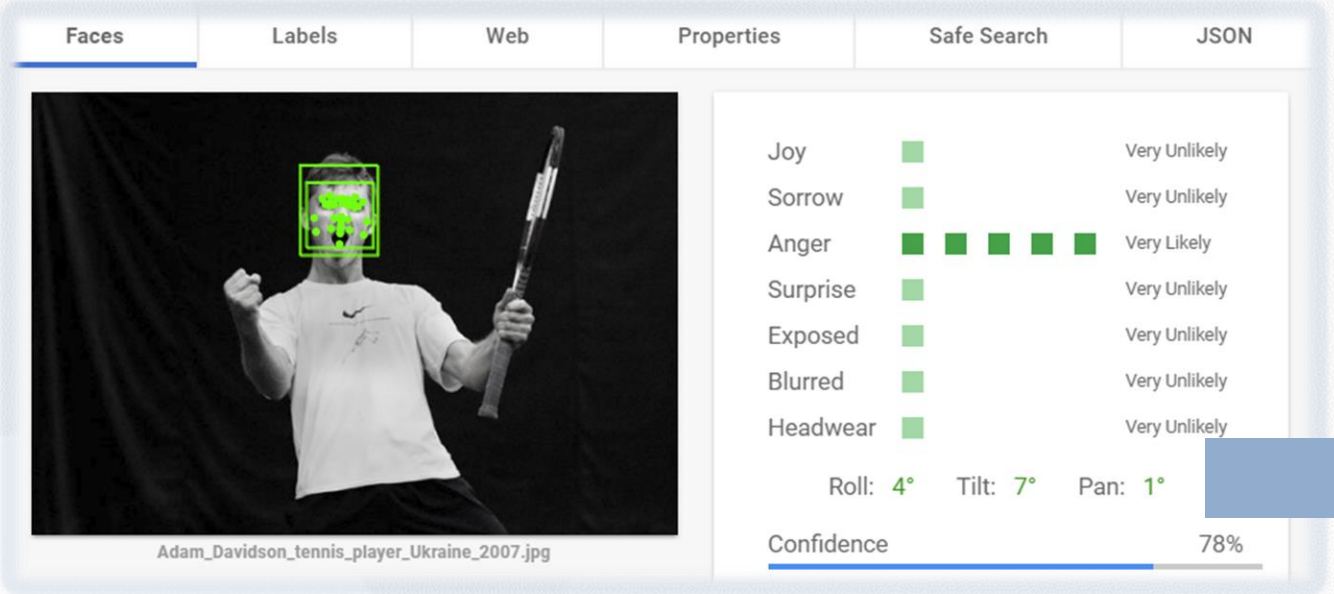
Lack of Data

Narrow the Context

Face Expression = Mental State ?

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

Joy



Anger

[2]

Original Idea - II

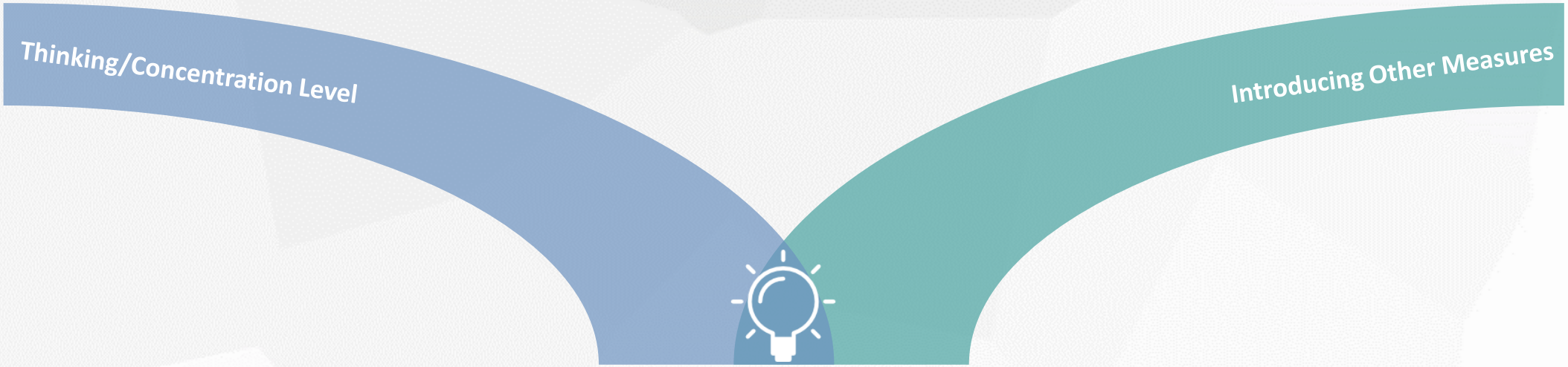
Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

Workload

Limit Capacity of the Brain

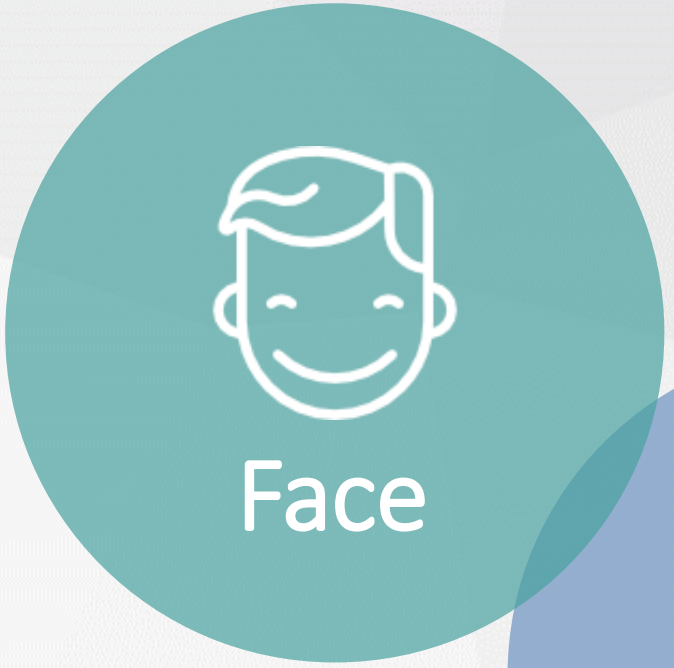
fNIRS

Best Physiological Measure



Project Outline

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task



01 Data Collection

- Task and Software
- Experimental Protocol
- The Dataset

02 Workload Evaluation

- Traditional Measurement
- Time Limit Comparison
- fNIRS Measurement

03 Facial Data Analysis

- OpenFace
- Ratio Measure
- Subject Count
- Blink Rate

PART 1

Data Collection

Task and Software | Experimental Protocol | The Dataset

Data Collection: Task and Software

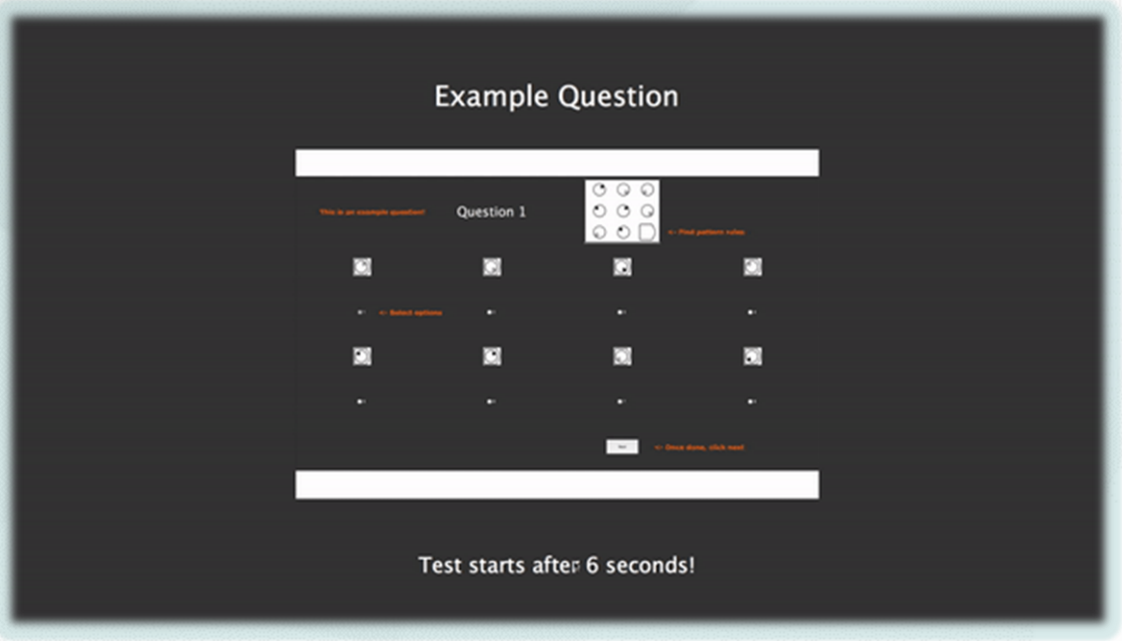
Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

Pattern Recognition Task

- 3 independent evaluators
- 20 selected questions out of 40
- 4 grouped question sets

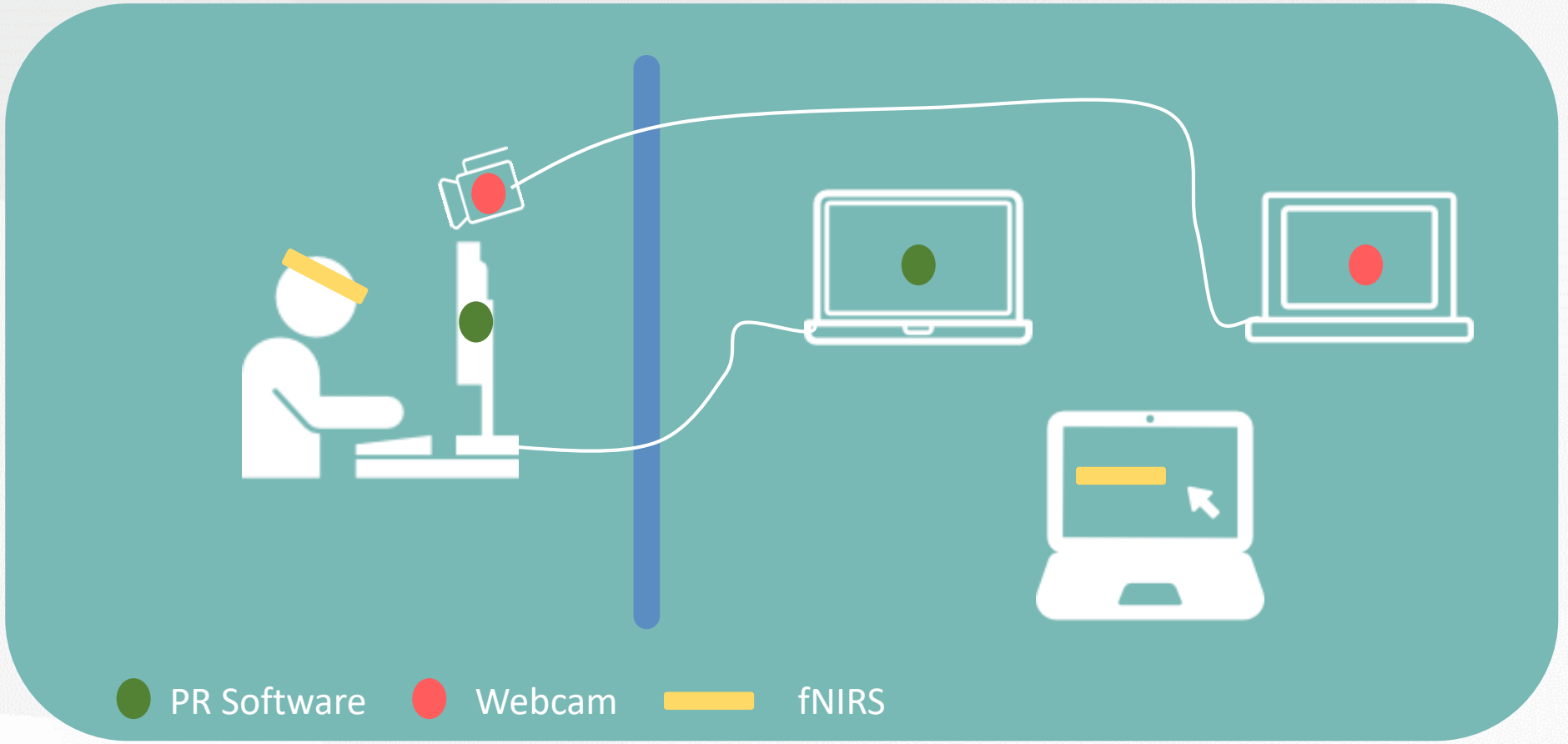
PR Software

- written in Python and PyQt5
- collect answer/ISA rating/time



Data Collection: Experimental Protocol – Devices

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task



Data Collection: Experimental Protocol – Two Problems (I)

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

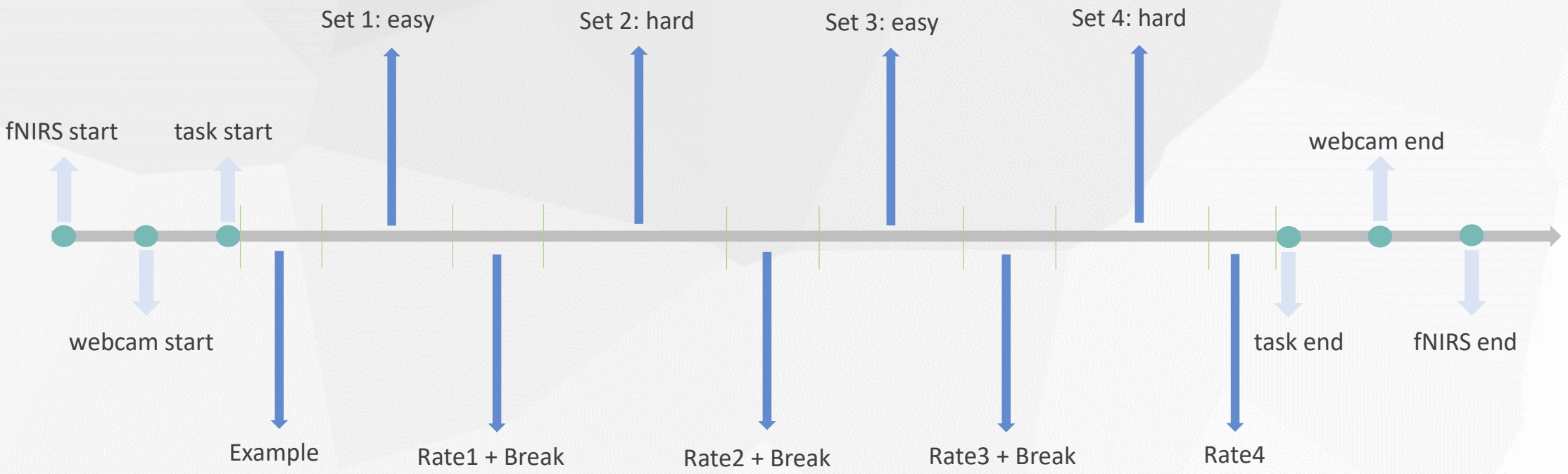
fNIRS Physiological Delay

- vary on individuals
- peak ≠ real peak

Solution: analyse period

Data Collection: Experimental Protocol – Timeline

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task



Data Collection: Experimental Protocol – Two Problems (II)

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

fNIRS Covers Forehead

- hide facial landmarks
- hide some AUs

Solution: separate dataset

Data Collection: Experimental Protocol – Study Protocol

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

Two Steps Analysis

- **Verify** distinct levels of mental workload
- **Compare** facial expression under the levels

Study Conditions

- **Step1**: fNIRS + 40s/q, fNIRS + no limit
- **Step2**: full face + 40s/q, full face + no limit

Data Collection: The Dataset – Raw Data

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

Raw Data

20

Participants

with the
average age 21.95

4

Study Conditions

with fNIRS recording?
with time limit?

20

Questions

in pattern recognition
questionnaire, alone
with the ISA rating

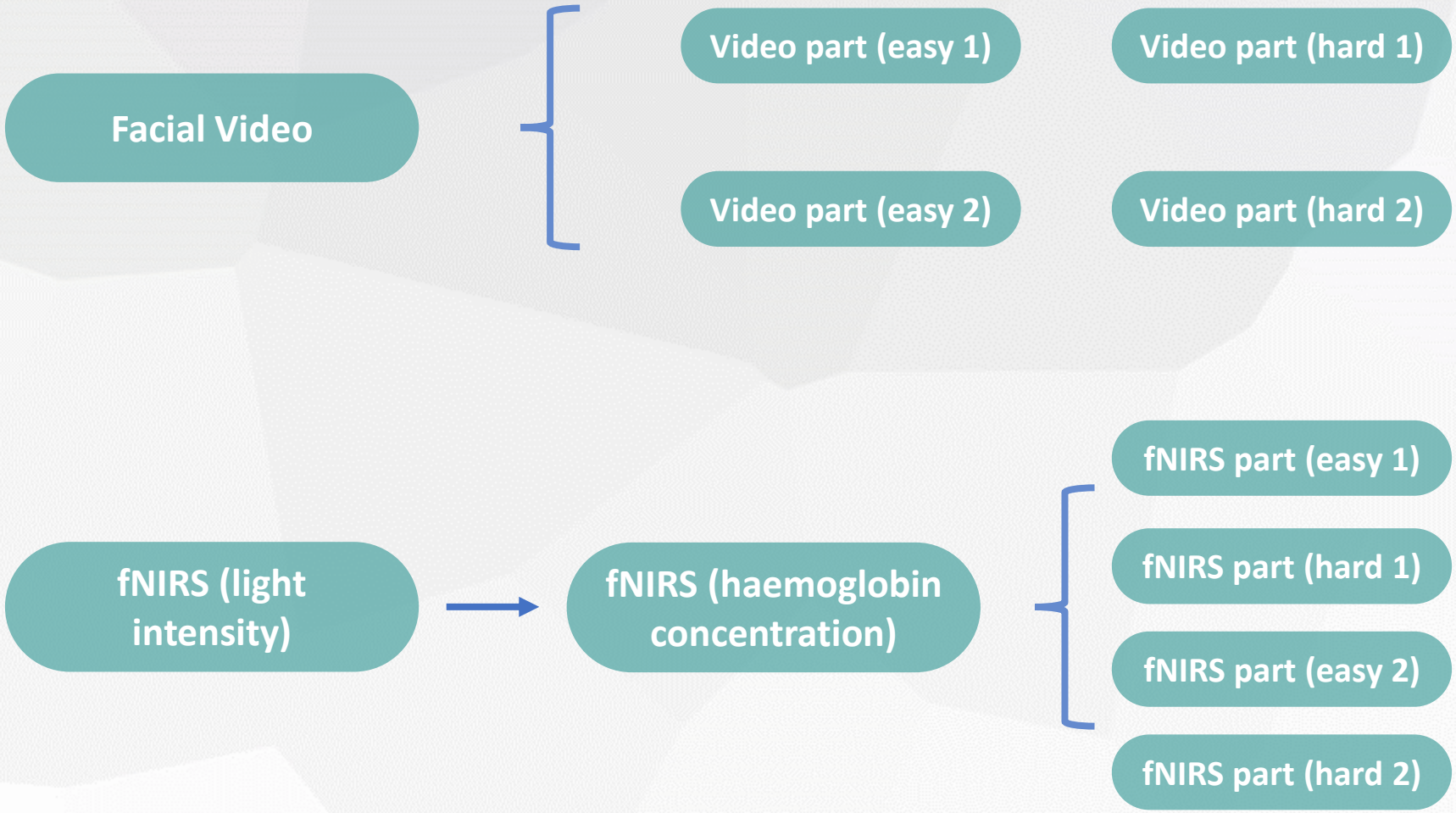
4

Time Periods

2 in easy, 2 in hard
question sets

Data Collection: The Dataset – Data Pre-processing

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task



PART 2

Workload Evaluation

Traditional Measurement | Time Limit Comparison | fNIRS Measurement

Workload Evaluation: Traditional Measurement

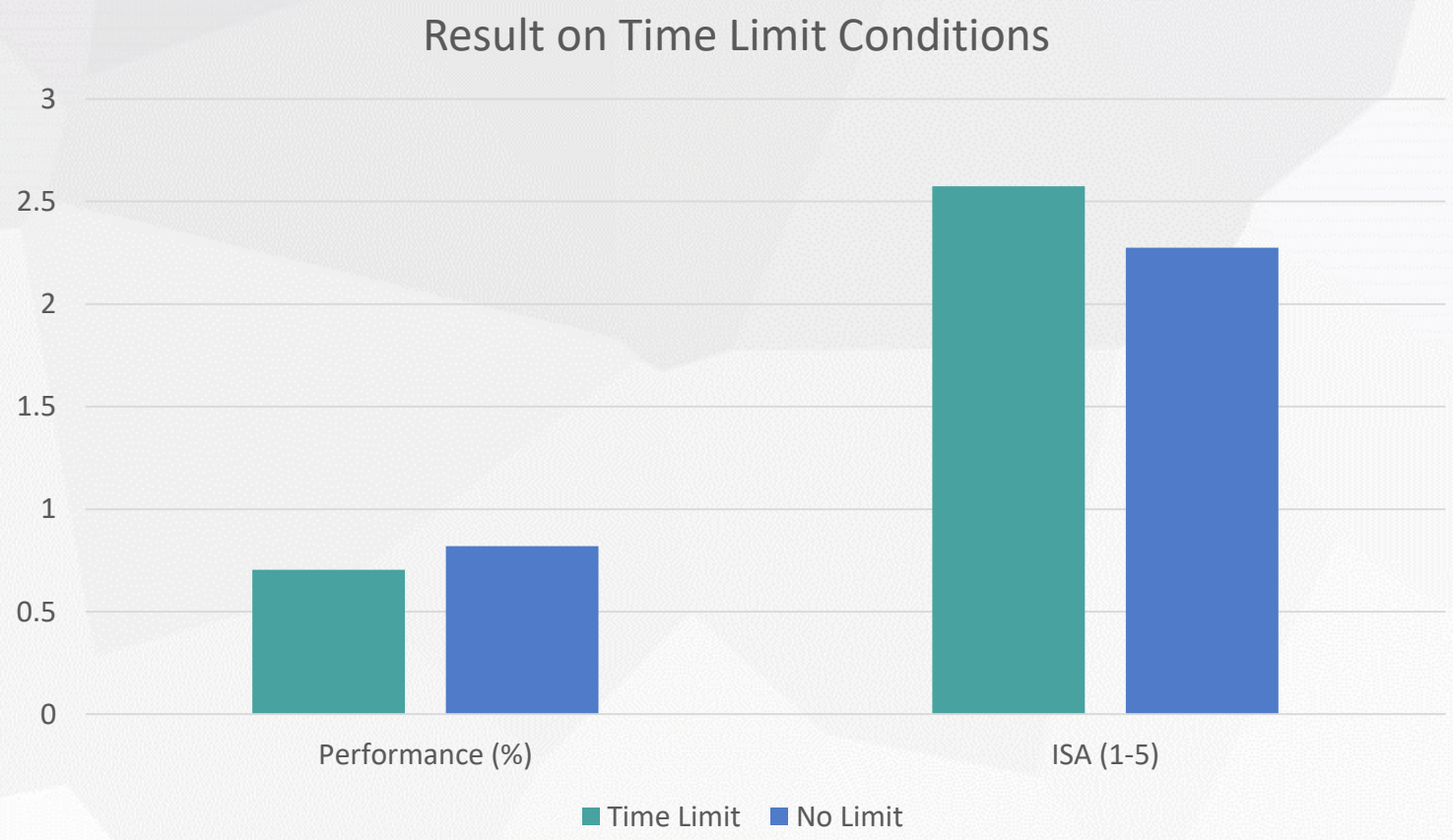
Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

Question Set	Difficulty(1-5)	Subjective(1-5)	Primary(%)	Secondary(s)
e1	1.60	1.25	97	72.40
h1	3.27	3.35	60	173.42
e2	1.73	1.60	89	87.13
h2	3.20	3.50	59	195.93

Traditional measures result table

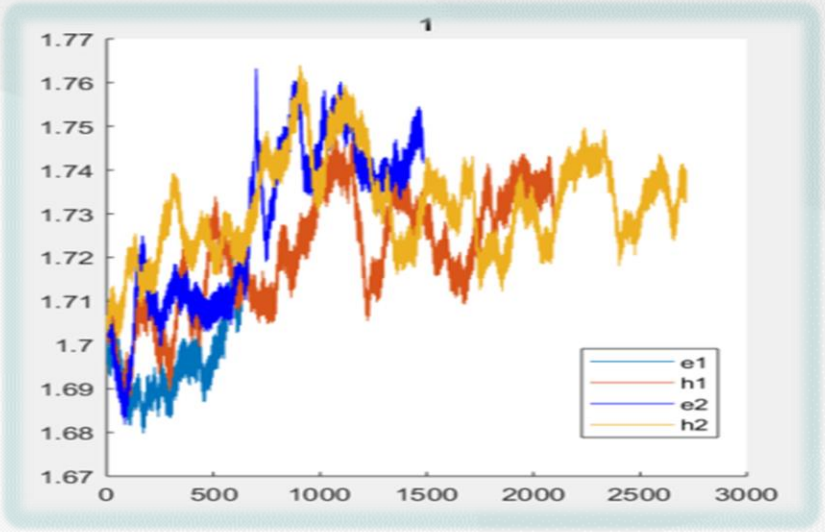
Workload Evaluation: Time Limit Comparison

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

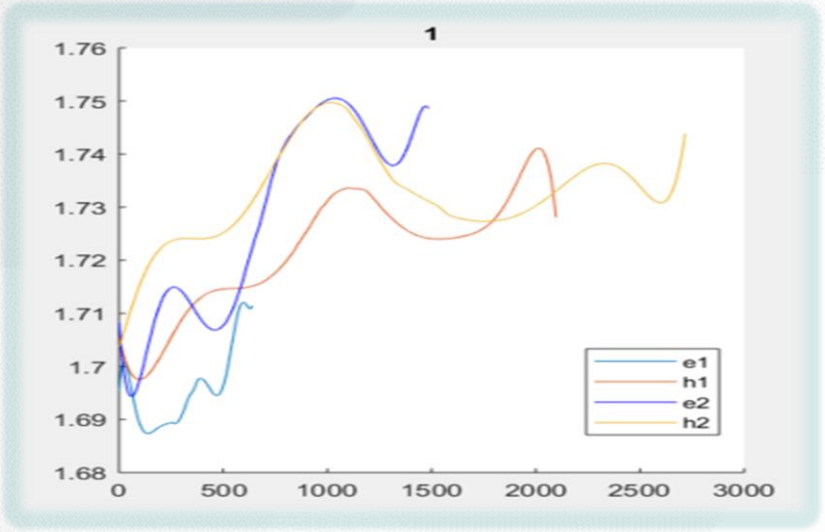


Workload Evaluation: fNIRS Measurement – Noise Removal

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task



low-pass + Savitzky Golay filter



Workload Evaluation: fNIRS Measurement – Feature Extraction

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

- **Feature = HbO2 - mean($HbO2_{baseline}$)**
- **Attribute = mean**

For each subject:

- 4 time periods and 8 channels
- binary classification labels

points : [4 x 8 $_{double}$]
labels : [4 x 1 $_{binary}$]

Workload Evaluation: fNIRS Measurement – Classification

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

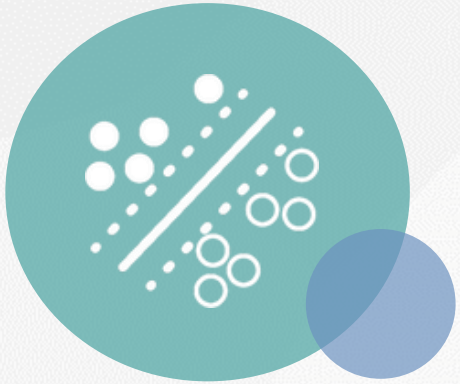
points : [4 x 8 $_{double}$]
labels : [4 x 1 $_{binary}$]

→ selection →

points : [2 x 8 $_{double}$]
labels : [2 x 1 $_{binary}$]

→ 10 subjects →

points : [20 x 8 $_{double}$]
labels : [20 x 1 $_{binary}$]



SVM (polynomial)

f1 score: **73.3%**

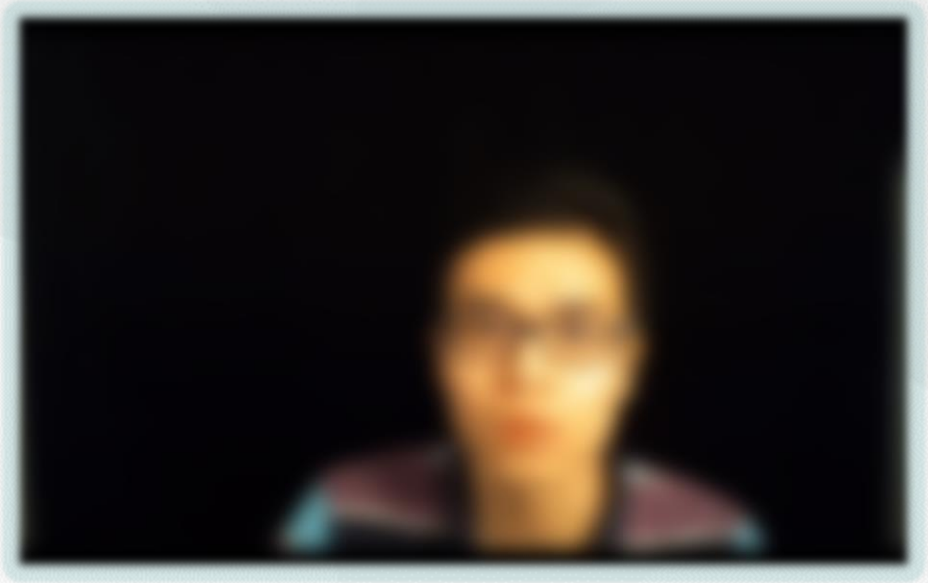
PART 3

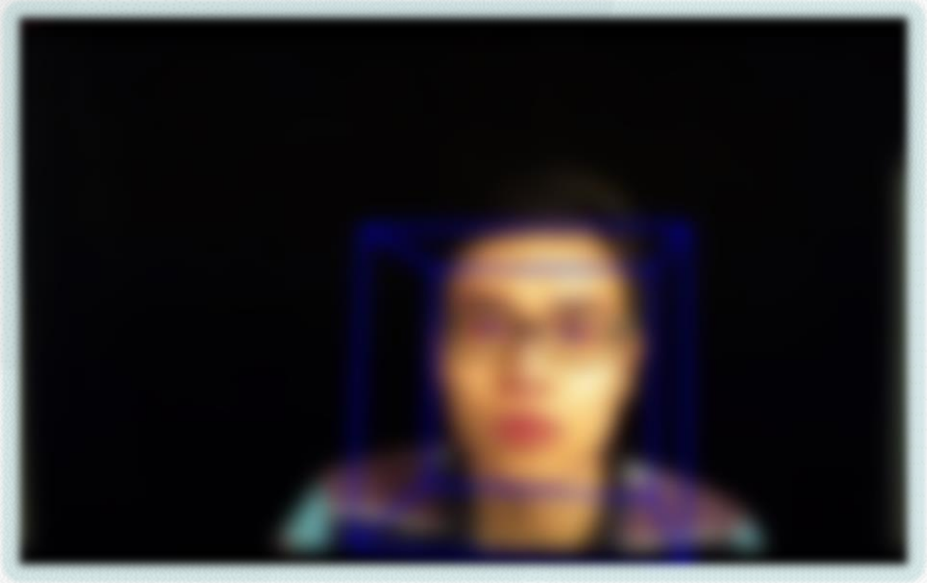
Facial Data Analysis

OpenFace | Ratio Measure | Subject Count | Blink Rate

Facial Data Analysis: OpenFace

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task





OpenFace [3]

The state-of-art facial analysis toolkit

Facial Data Analysis: Ratio Measure

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

$$ratio = \frac{\sum_{n-1}^{S} Re_n}{\sum_{n-1}^{S} Rh_n}$$

distinction line

- 0.3 | **+ 0.3**

AU	01	02	04	05	06	07	09	10
ratio	0.8489	0.8105	0.8840	1.2390	1.0512	0.9019	0.7784	1.1215
AU	**12**	**14**	**15**	**17**	**20**	**23**	**25**	**26**
ratio	1.2514	1.1745	0.7696	0.9213	0.9157	0.6672	1.1530	0.8192

Average AU intensity value per frame

AU	01	02	04	05	06	07	09	10	
ratio	0.917	0.943	0.906	1.055	0.046	1.034	0.376	0.608	
AU	**12**	**14**	**15**	**17**	**20**	**23**	**25**	**26**	**28**
ratio	0.131	1.492	0.599	0.907	0.599	0.950	0.714	0.507	0.879

Average AU presence value per frame

Facial Data Analysis: Subject Count

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

distinction line
3:7 or lower
7:3 or higher

$AU_{i/p}$	05_i	06_i	09_i	15_i	23_i	25_i	15_p	26_p	28_p
count(l:h)	9:1	3:7	3:7	2:8	2:8	7:3	2:8	2:8	3:7

Subject count table

Facial Data Analysis: Result

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

AU 15 - Presence

AU 26 - Presence

Higher Workload

AU 23 - Intensity

Facial Data Analysis: Blink Rate

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

Condition	1	2	3	4	5
low($x10^{-3}$)	13.6674	27.2647	10.4408	25.8929	17.4263
high($x10^{-3}$)	9.2854	32.8400	16.1290	16.2369	11.8778
Condition	**6**	**7**	**8**	**9**	**10**
low($x10^{-3}$)	15.8893	11.2245	20.6084	18.2440	14.8233
high($x10^{-3}$)	17.8326	25.4586	20.2753	24.1158	11.7146

Blink rate table

Conclusion

No Strong Correlations

References

[1] iMotions. Facial action coding system(facs) - a visual guidebook. https://imotions.com/blog/facial-action-coding-system/ . Accessed: 2018-04-09.

[2] Anne Z., The state of emotion recognition via facial expressions, https://emotionknow.com/2017/10/27/the-state-of-emotion-recognition-via-facial-expressions-reviewing-google-amazon-microsoft-affectiva-kairos-and-clarifai/. Accessed: 2018-04-20.

[3] T. Baltruˇsaitis, P. Robinson, and L.-P. Morency. Openface: an open source facial behavior analysis toolkit. In Applications of Computer Vision (WACV), 2016 IEEE Winter Conference on, pages 1–10. IEEE, 2016.

Q & A

Data Collection and Analysis of the Linkage between **Mental Workload** and Spontaneous **Facial Expression** on Pattern Recognition Task

Questions?