READING EMOTIONS: AUTOMATIC RECOGNITION OF ENGAGEMENT USING FACIAL EXPRESSIONS AND PHYSIOLOGICAL MEASURES

ENGAGEMENT:

- A state of being involved, occupied, fully absorbed or engrossed in something (i.e. sustained attention), generating the consequences of a particular attraction or repulsion force. The more engaged individuals are to approach or repel a target, the more value is added to or subtracted from it.

WHY ENGAGEMENT IS IMPORTANT?

- Achievement – Drop Out.
- Performance – Burn out.
- Referral – Feedback.
- And many more.
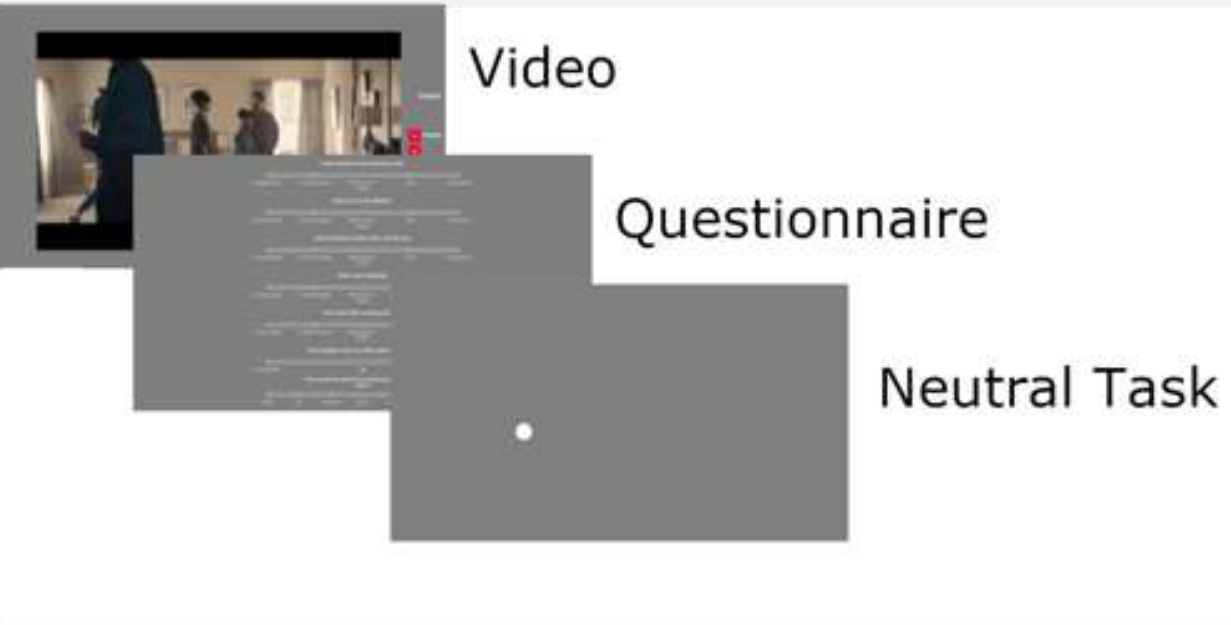
MEASUREMENT OF ENGAGEMENT

Questionnaires

- Social Desirability Bias
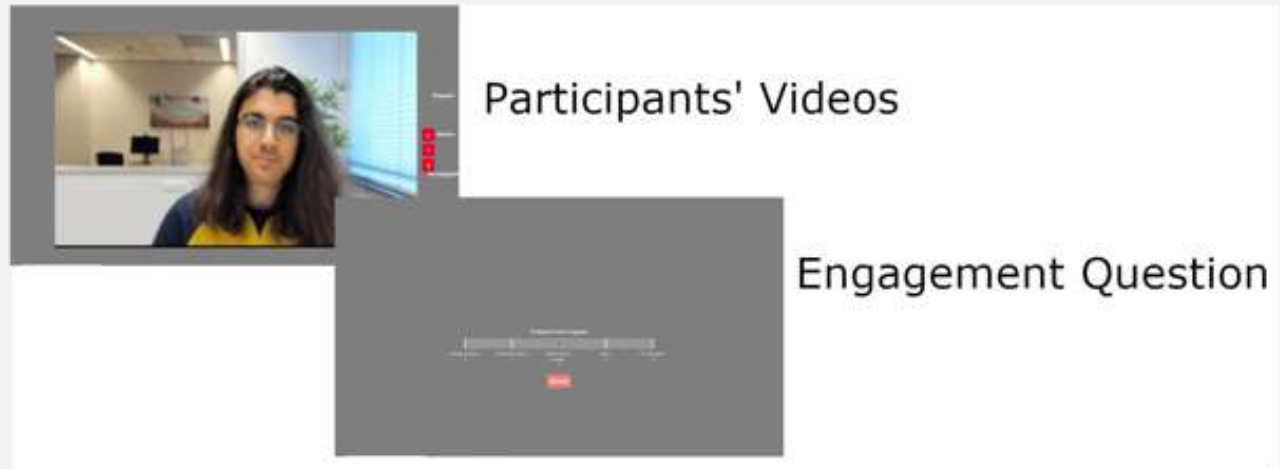
- Bias Ambiguity

External Observers

External Sensors and Machine Learning Algorithms

EXPERIMENT

Testing

Video

Questionnaire

Neutral Task

Labeling

Participants' Videos

Engagement Question

Facial Action Units

Upper Face Action Units					
AU 1	AU 2	AU 4	AU 5	AU 6	AU 7
Inner Brow Raiser	Outer Brow Raiser	Brow Lowerer	Upper Lid Raiser	Cheek Raiser	Lid Tightener
*AU 41	*AU 42	*AU 43	AU 44	AU 45	AU 46
Lid Droop	Slit	Eyes Closed	Squint	Blink	Wink

Lower Face Action Units					
AU 9	AU 10	AU 11	AU 12	AU 13	AU 14
Nose Wrinkler	Upper Lip Raiser	Nasolabial Deepener	Lip Corner Puller	Cheek Puffer	Dimpler
AU 15	AU 16	AU 17	AU 18	AU 20	AU 22
Lip Corner Depressor	Lower Lip Depressor	Chin Raiser	Lip Puckerer	Lip Stretcher	Lip Funneler
AU 23	AU 24	*AU 25	*AU 26	*AU 27	AU 28
Lip Tightener	Lip Pressor	Lips Part	Jaw Drop	Mouth Stretch	Lip Suck

Happiness

Action Unit 6

Action Unit 12

Disgust

Action Unit 4

Action Unit 5

Action Unit 7

Action Unit 23

Head Orientation
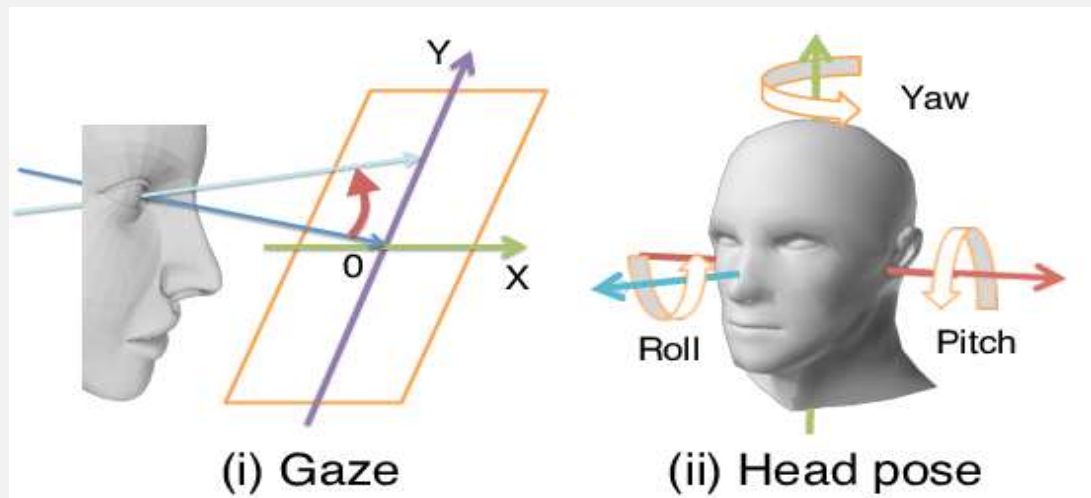
Electrodermal Activity

Pupil Size
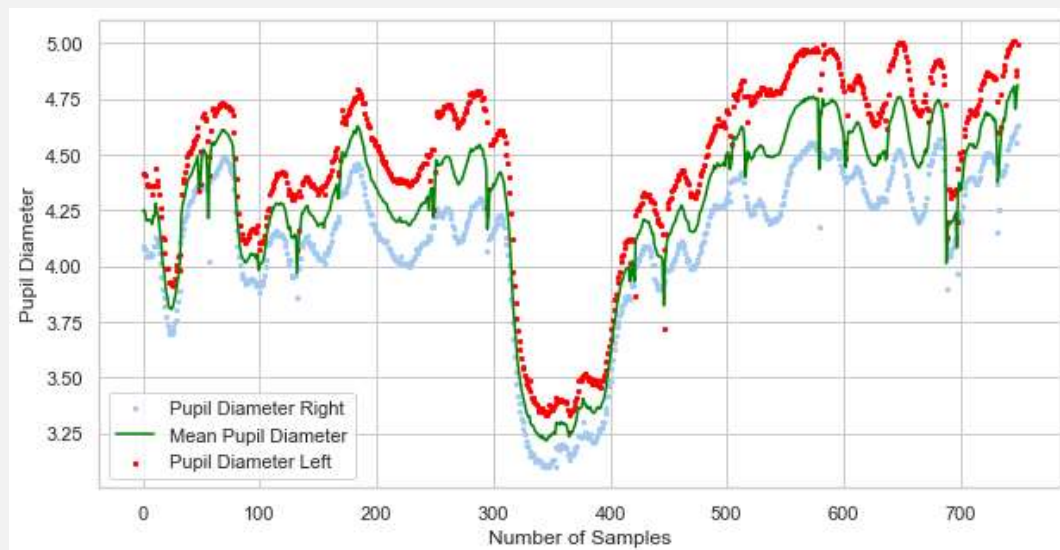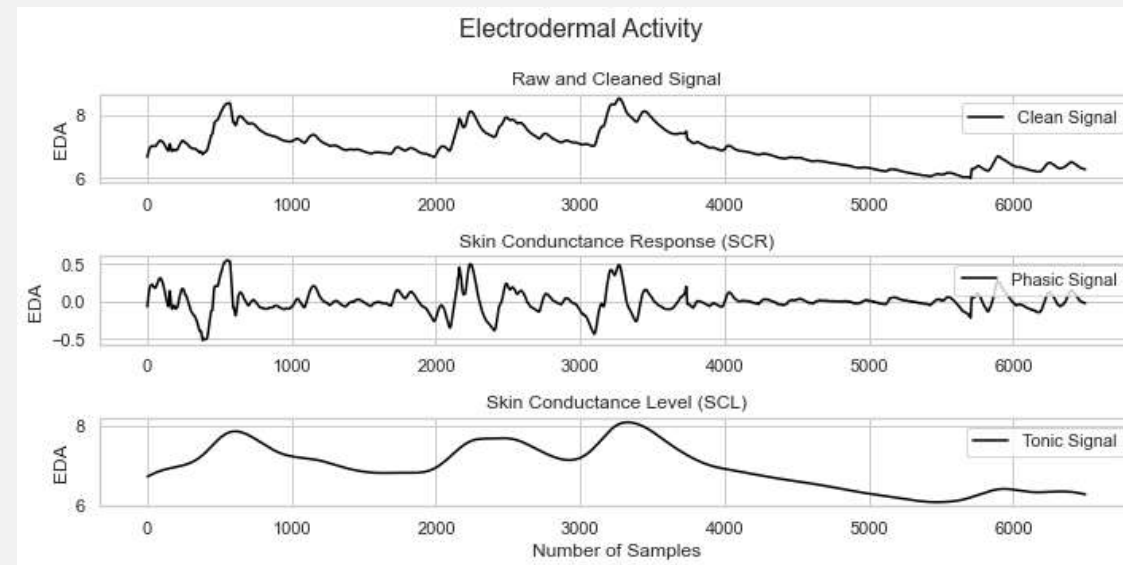
RESULTS

1) Agreement Between Viewers and Observers
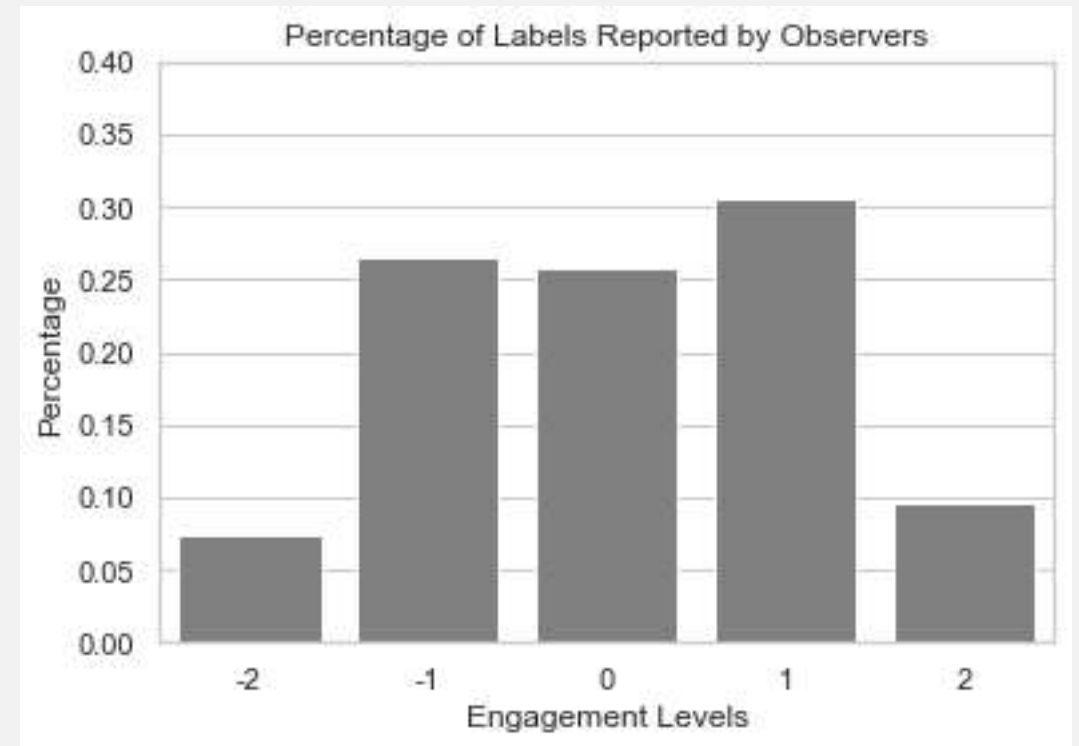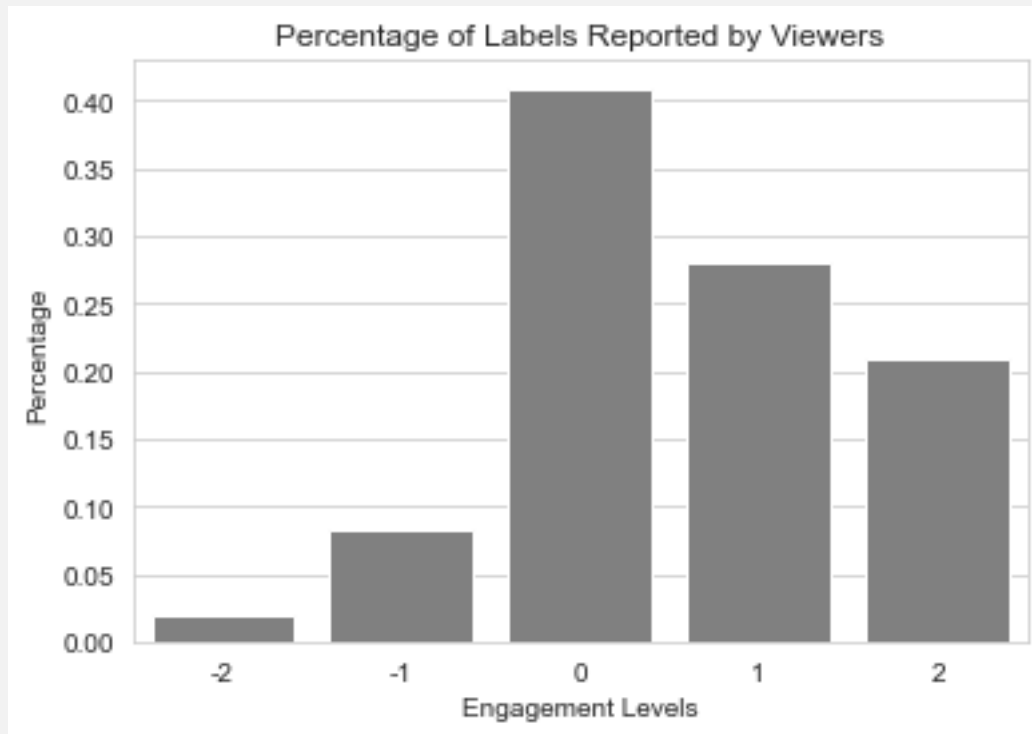
RESULTS

2) Viewers' Selected Action Units:
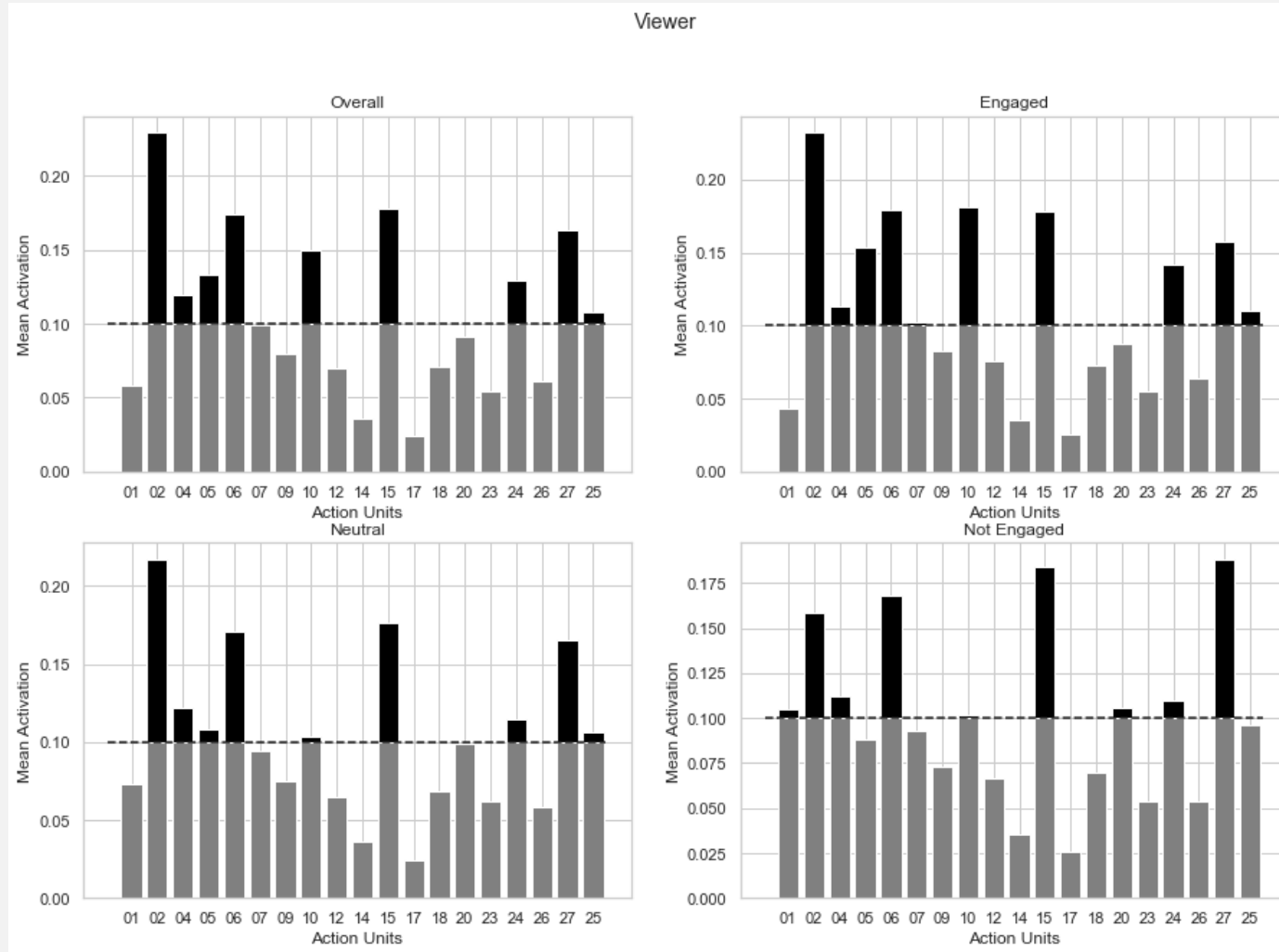
Action Units	χ^2	p
Action Unit 2	0.44	.801
Action Unit 4	1.33	.512
Action Unit 5	9.33	.009**
Action Unit 6	0.77	.678
Action Unit 10	9.33	.009**
Action Unit 15	1.00	.607
Action Unit 24	0.38	.827
Action Unit 27	1.33	.513

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.
Post Hoc test results for Action Unit 5.

		Mean Difference	SE	t	p_{bonf}
Engaged	Neutral	0.047	0.016	2.934	0.018*
	Not Engaged	0.050	0.016	3.119	0.011*
Neutral	Not Engaged	0.003	0.016	0.185	0.855

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.
Post Hoc test results for Action Unit 10.

		Mean Difference	SE	t	p_{bonf}
Engaged	Neutral	0.077	0.024	3.228	0.008**
	Not Engaged	0.071	0.024	2.976	0.016*
Neutral	Not Engaged	-0.006	0.024	-0.252	1.000

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

RESULTS

3) Head Movement:

4) Pupil Size:

4) Electrodermal Activity:

5) Duration and Number of Saccades and Fixations:

Post hoc results for duration of saccades and engagement.

		Mean Difference	SE	t	p_{holm}
Engaged	Neutral	-0.937	1.008	-0.930	0.360
	Not Engaged	1.717	1.008	1.704	0.197
Neutral	Not Engaged	2.654	1.008	2.634	0.040 *

Note. * p < .05, ** p < .01, *** p < .001.

RESULTS

6) Engagement Recognition Using Action Units:

Accuracy, F1, and Area Under Curve Score for Decision Tree, Logistic Regression and Linear Support Vector Machine algorithms.

First Method				Second Method			
Model	Accuracy	F1 Score	AUC	Model	Accuracy	F1 Score	AUC
Decision Tree	98 %	98 %	99 %	Decision Tree	45 %	35 %	51 %
Logistic Regression	49 %	49 %	70 %	Logistic Regression	49 %	33 %	51 %
Linear SVM	48 %	48 %	70 %	Linear SVM	42 %	42 %	49 %
Observers	22 %	17 %		Observers	22 %	17 %	

RESULTS

6) Spearman Correlation Analysis Between Action Units and Engagement Level:

Spearman Correlation between Facial Action Units and Behavior for Each Video.

Action Units	Certain is Better	Back to School	Little Baby Ice Cream	Nature
Action Unit 01 - Inner Brow Raiser	-0.02***	-0.05***	-0.04***	-0.21***
Action Unit 02 - Outer Brow Raiser	0.11***	-0.06***	0.38***	0.28***
Action Unit 04 - Brow Lowerer	0.0	-0.16***	0.17***	0.04***
Action Unit 05 - Upper Lid Raiser	0.12***	0.1***	0.18***	0.26***
Action Unit 06 - Cheek Raiser	0.08***	-0.18***	-0.08***	0.16***
Action Unit 07 - Lid Tightener	0.12***	-0.02***	0.24***	0.05***
Action Unit 09 - Nose Wrinkler	0.2***	0.14***	0.28***	0.25***
Action Unit 10 - Upper Lip Raiser	0.15***	0.29***	0.18***	0.13***
Action Unit 12 - Lip Corner Puller	0.2***	-0.06***	-0.08***	0.16***
Action Unit 14 - Dimpler	0.02***	-0.29***	0.0	0.07***
Action Unit 15 - Lip Corner Depressor	0.14***	-0.05***	0.17***	0.22***
Action Unit 17 - Chin Raiser	0.06***	0.12***	-0.03***	-0.25***
Action Unit 18 - Lip Pucker	0.26***	-0.02***	0.05***	0.22***
Action Unit 20 - Lip Stretcher	0.13***	-0.36***	-0.08***	0.2***
Action Unit 23 - Lip Tightener	0.0	-0.3***	-0.18***	0.12***
Action Unit 24 - Lip Pressor	0.1***	-0.25***	0.08***	0.0
Action Unit 26 - Jaw Drop	0.16***	0.17***	0.25***	-0.04***
Action Unit 27 - Mouth Stretch	-0.15***	-0.29***	-0.15***	-0.09***

*Note. . * $p < .05$, ** $p < .01$, *** $p < .001$.*

RESULTS

6) Correlation and Regression Analysis for Engagement Questionnaire:

Pearson Correlation between questions in the engagement questionnaire (Appendix C).

Variable		I was distracted while watching video.	Video got my full attention.	I felt motivated to watch video until the end.	Video was interesting.	I felt bored while watching the video	How engaged were you while watching the video
1. I was distracted while watching video.	Pearson's r	—					
	p-value	—					
2. Video got my full attention.	Pearson's r	-0.714 ***	—				
	p-value	< .001	—				
3. I felt motivated to watch video until the end.	Pearson's r	-0.569 ***	0.581 ***	—			
	p-value	< .001	< .001	—			
4. Video was interesting.	Pearson's r	-0.447 ***	0.542 ***	0.597 ***	—		
	p-value	< .001	< .001	< .001	—		
5. I felt bored while watching the video	Pearson's r	0.469 ***	-0.654 ***	-0.563 ***	-0.641 ***	—	
	p-value	< .001	< .001	< .001	< .001	—	
6. How engaged were you while watching the video	Pearson's r	-0.452 ***	0.569 ***	0.579 ***	0.611 ***	-0.603 ***	—
	p-value	< .001	< .001	< .001	< .001	< .001	—

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

DISCUSSION

- We were unable to show an effect of engagement level on the activation of action units. One interpretation of these findings is that there is no existing specific facial expression for engagement, or changes in the facial muscles are so subtle to detect.
- Correlation difference between action units and videos show the effect of the videos on the responses of engagement and activation of Action Units when someone is engaged may vary significantly based on the content. This indicates the importance of stimulus when investigating engagement, changes in the stimuli could change the participants' responses.

- Differences in the performance of the machine learning models could be explained by facial micromovements. Cohn et al. (2002) showed that there were differences in the activation of facial action units for facial expressions between individuals, and these differences were stable over time.
- The results from engagement questionnaire and Whitehill (2014) shows that it is hard for observers and viewers to report engagement continuously.

Thank You for Your Attention!

Any Questions?