جامعة نيويورك أبوظبي

NYU | ABU DHABI

Affective Touch: Emerging Applications and Challenges

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Affective Haptics for Enhanced XR
12 July 2021: 8:15 – 11:00 EST

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Agenda

- **Background: Affective Haptic System**
- **Affective Haptics for Pleasant Awakening**
- **Affective Haptics in VR**
- **Affective Haptics for Touchscreen Interaction**
- **Future Perspectives**

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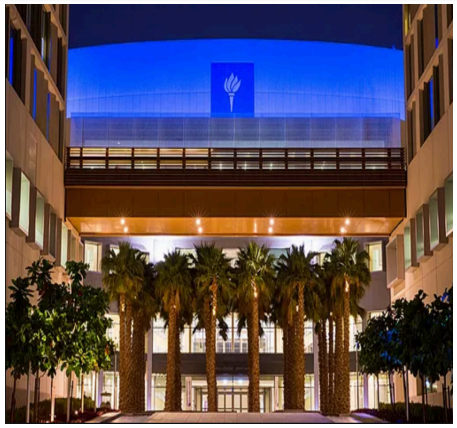
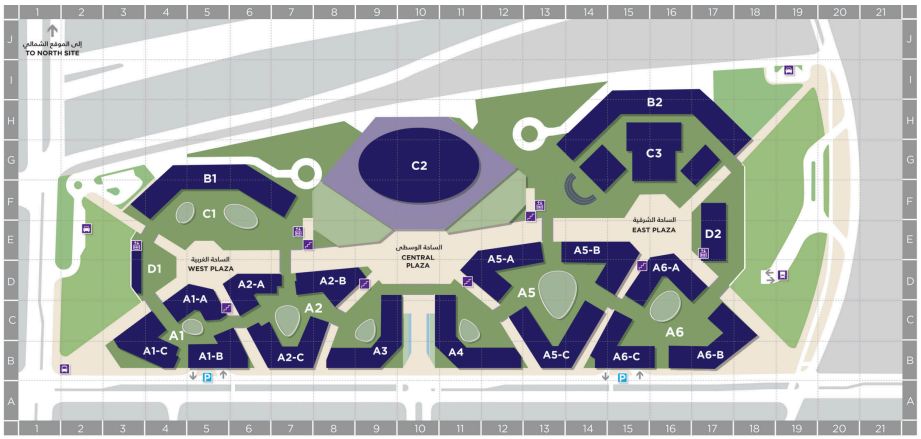
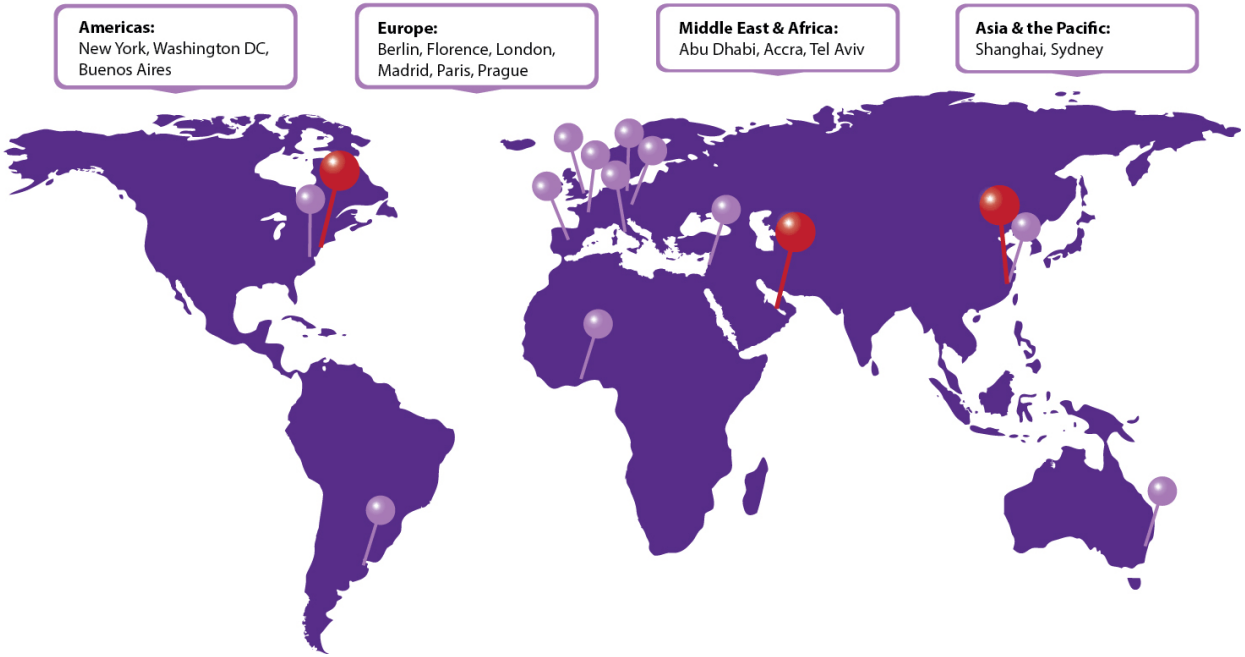
Where I come from?







6 continents, 3 Degree-Granting Campuses (NY, AD, Shanghai)
NYU – Abu Dhabi:

- 1,600+ students enrolled for Academic Year 2020-2021
- 56% Female 44% Male
- More than 120 nationalities
- More than 120 languages spoken!

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Introduction – Touch and Emotions

- To be human is to be emotional
- Touch is intrinsically emotional
- Benefits of affective touch
  - Security
  - Relaxation
  - No anxiety
  - Better sleep
  - Healthier heart
  - Deeper breathing
  - Better immune response

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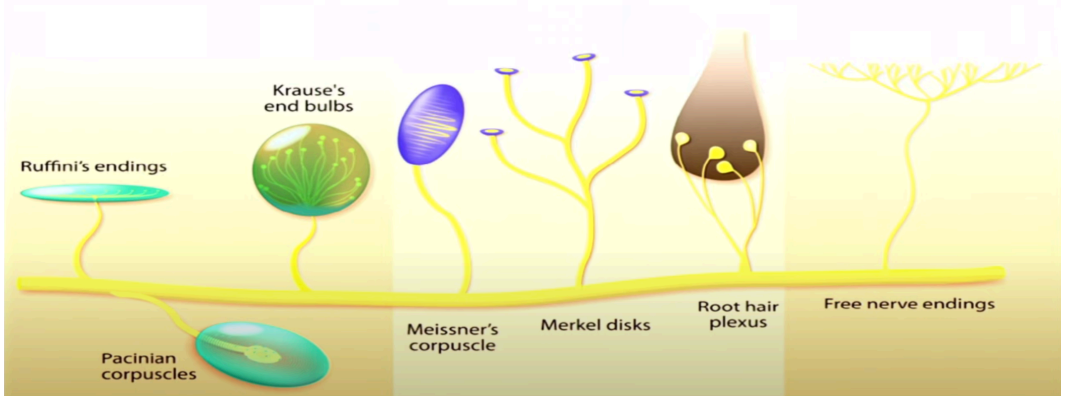
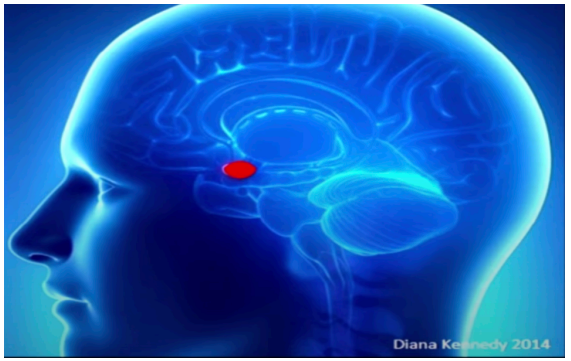
Affective Touch System

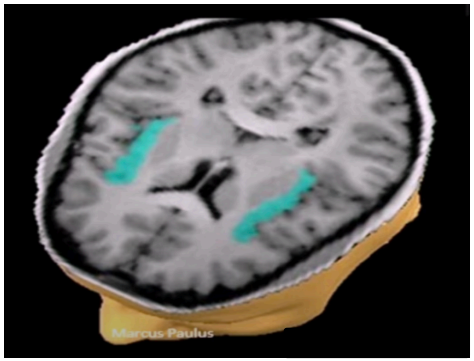
- CT-afferent System: mediates the affective properties of touch.
- Slow-conducting, unmyelinated, mechanosensitive nerve fibers
- Found in hairy skin
  - Optimal stimulation is gentle stroking
  - Show preference for a temp. of 32 ^{o}C
  - Low indentation forces (2.5-3 mN)
  - Stroking velocity of 1-10 cm/sec
  - Activate limbic cortical areas
- Oxytocin: love hormone.
- Endorphins: relieve stress and pain



Pressure | Fine touch | Pleasure



Amygdala



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Affective Haptics for Pleasant Awakening

Georgios Korres, Camilla Birgitte Falk Jensen, Wanjoo Park, Carsten Bartsch, and **Mohamad Eid**, “A Vibrotactile Alarm System For Pleasant Awakening”, IEEE Transactions on Haptics (impact factor: 2.75), Volume: 11, Issue: 3, pages: 357 – 366, 2018.

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Affective Haptics for Pleasant Awakening

- Existing sleep alarm systems are predominantly audible!

- Vibrotactile stimulation to display the alarm signal:
  - Reduce sleep inertia by applied pleasant stimulation
  - Pleasant yet arousing vibrotactile stimulation
  - Confidential alarm

- Attention is divided into:
  - Endogenous attention: voluntary
  - Exogenous attention: involuntary

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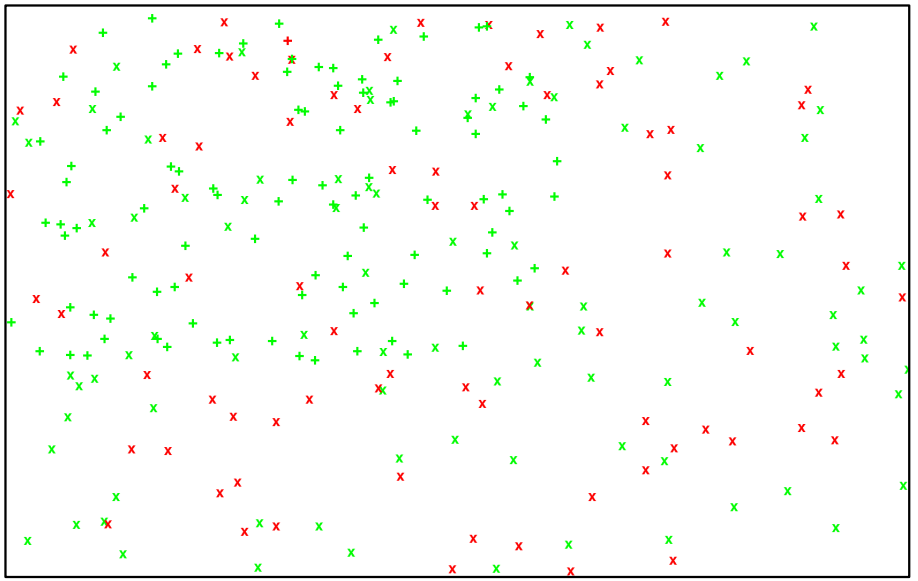
Motivating Experiment: Exogenous Attention

- Investigate the ability of vibration to orient attention and induce emotions

- Dual-task paradigm:
  - Visual search task
  - Red plus '+' is the target
  - Others are distractors
  - Apply vibrotactile feedback (40% of trials)
  - Press 'c' if target is found
  - Press 'n' if target not found
  - Press SPACE if vibrotactile stimulus



- Subjective emotional ratings of the vibrotactile patterns
  - 9-point arousal/valence scales

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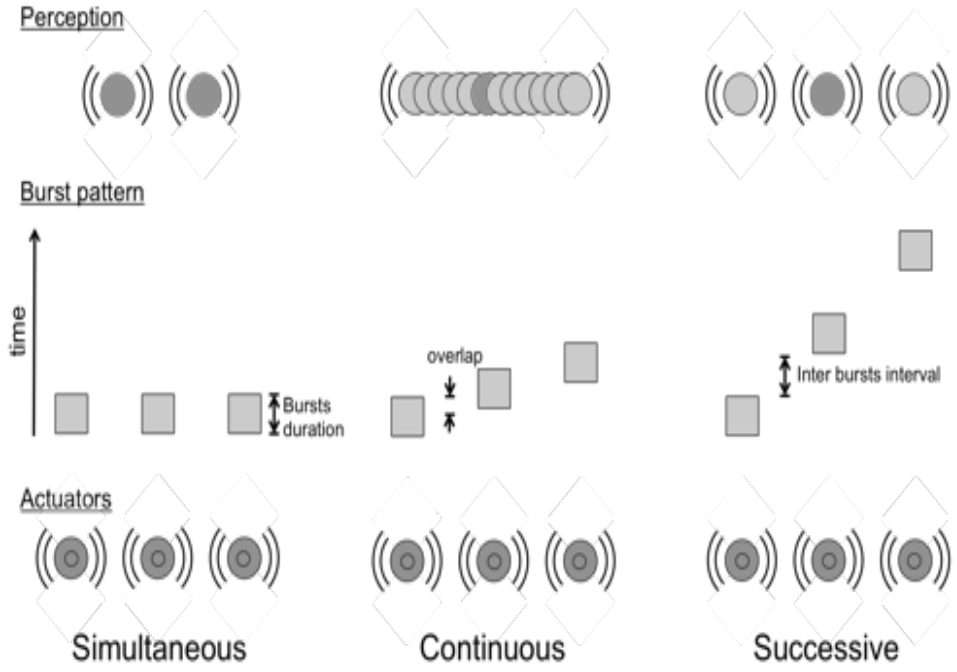
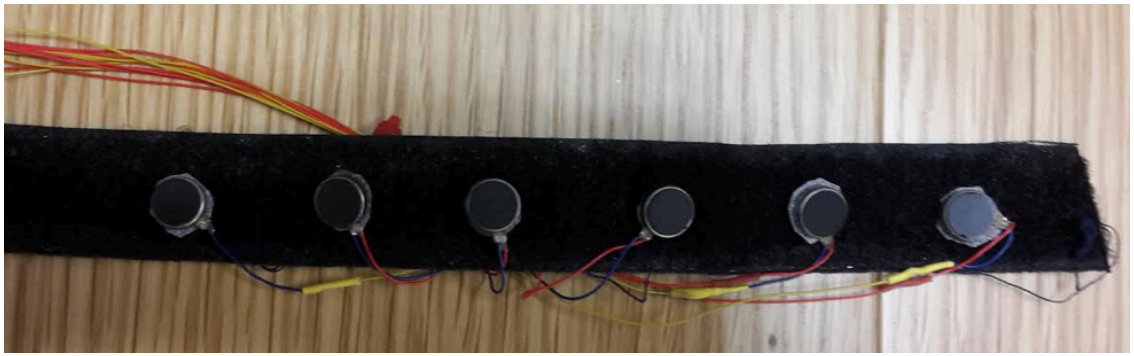
Vibrotactile Alarm Response

- Three patterns are used:





Vibrotactile motors layout

Pattern	Modulation	Feature [1]	Attributes[2]
1	Simultaneous	Int++	(1.25g, 0.25g, 10, 2s, 0, 0s)
2	Simultaneous	Int++, vel++	(1.25g, 0.25g, 10, 2s, 0, 0s)
3	Continuous	Int++	(1.25g, 0.25g, 10, 2s, 0.4, 0.5s)
4	Continuous	Int++, vel++	(1.25g, 0.25g, 10, 2s, 0.4, 0.1s)
5	Continuous	Int++, dir	(1.25g, 0.25g, 10, 2s, 0.4, 0.1s)
6	Successive	Int++	(1.25g, 0.25g, 10, 2s, 3, 0.1s)
7	Successive	Int++, vel++	(1.25g, 0.25g, 10, 2s, 3, 0.1s)
8	Successive	Int++, dir	(1.25g, 0.25g, 10, 2s, 3, 0.1s)

[1] Int++ is Intensity Increase, vel++ is Velocity Increase, dir is Direction Change

[2] Each cell is a set of (Imax, Imin, Gain, Duration, α, timeStepSize)

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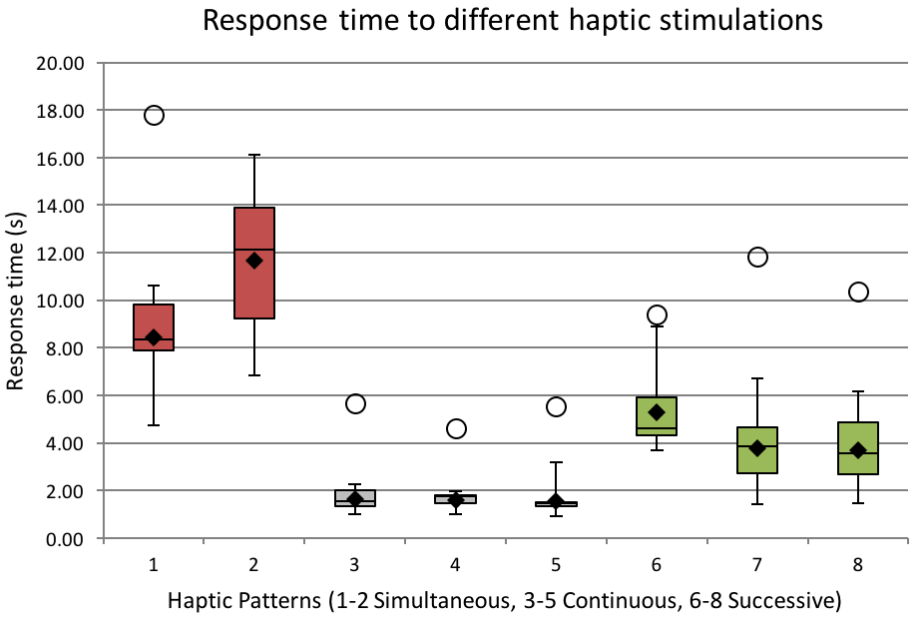
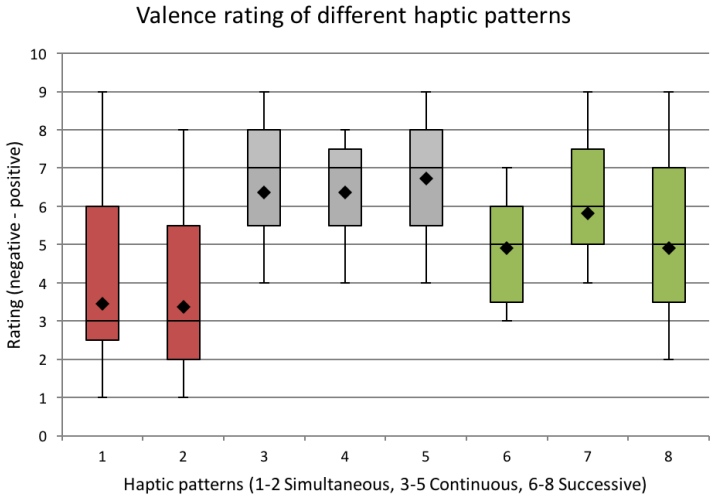
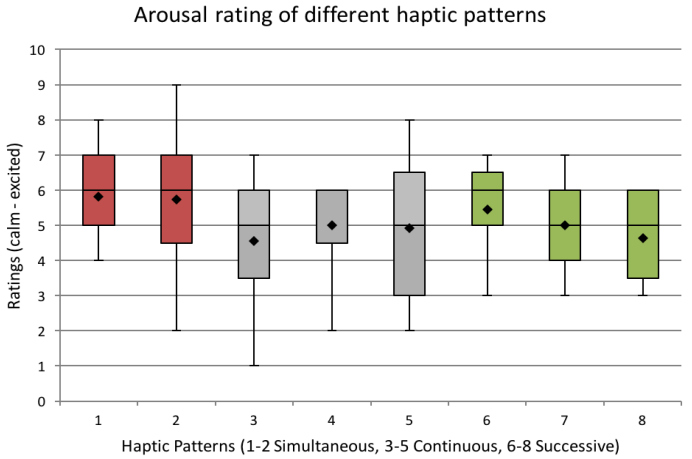
Results: Vibrotactile Patterns

- Statistically significant effect of patterns ($p<0.001$)
- Continuous pattern provided significantly lower response time
- Emotional responses:
  - Large individual differences for valence
  - No significant differences between patterns







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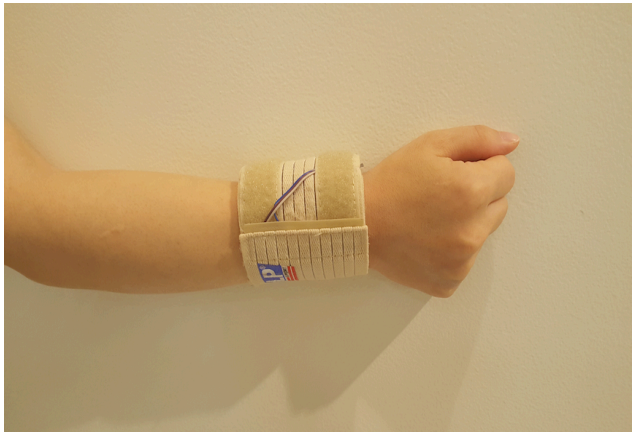
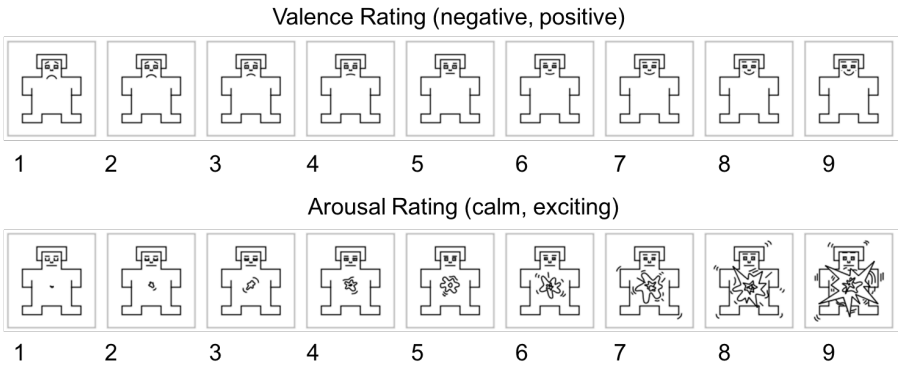
Effects of Tactile Stimulation During Sleep

- Investigate emotional reactions of vibrotactile patterns during sleep.

- Experimental Setup:
  - ❑ Ten participants (5 female), no sleep disorders
  - ❑ Use the wristband for 6 days, 2 days for each pattern
  - ❑ Complete the questionnaire with 10 min. after waking
  - ❑ Rating valence and arousal responses (9-points Likert scale).



The wristband device



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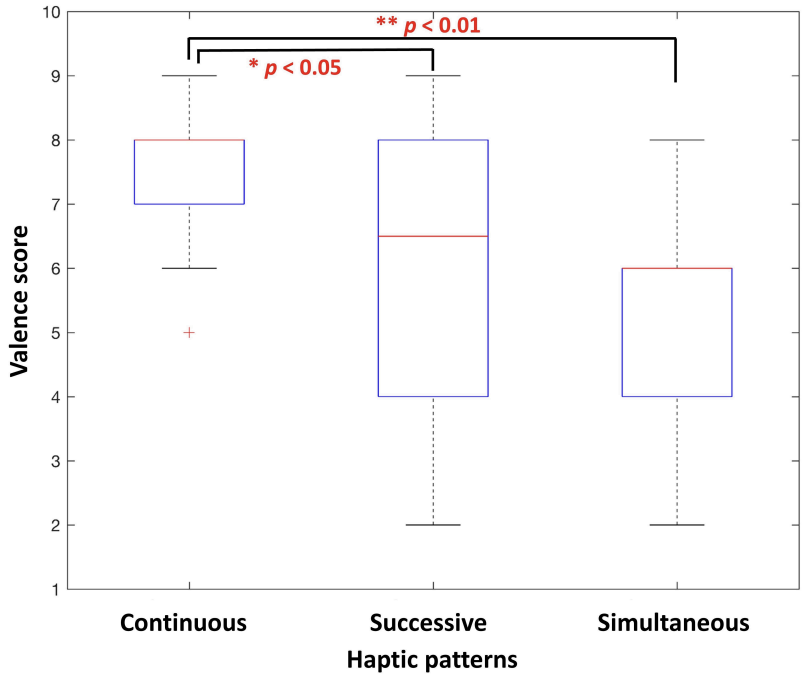
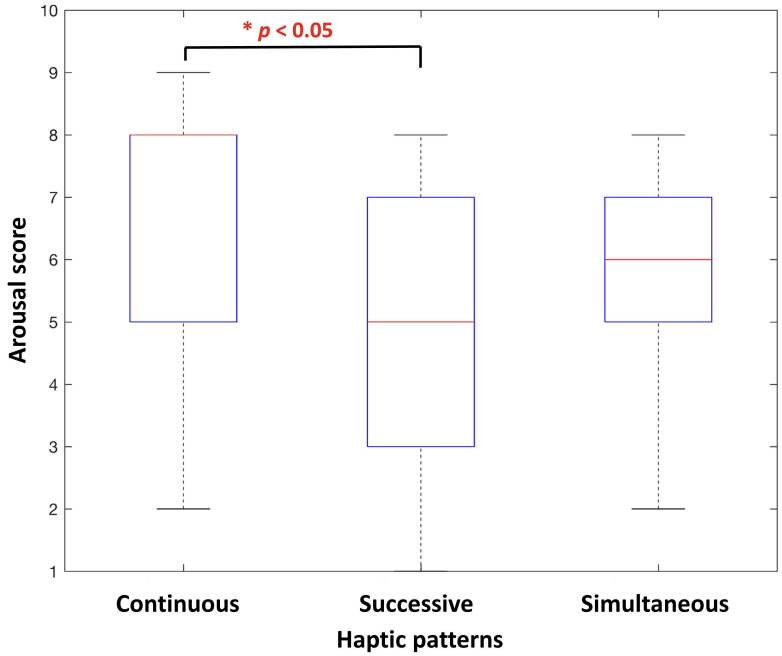
Effects of Tactile Stimulation During Sleep: Results

- Continuous tactile stimulation resulted in the highest valence rating (same as during awake)
- Continuous tactile stimulation resulted in the highest scores for arousal





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Affective Haptics in Virtual Reality

Georgios Karafotias, Georgios Korres, Akiko Teranishi, Wanjoo Park, and Mohamad Eid, “Mid-air Tactile Stimulation for Pain Distraction”, IEEE Transactions on Haptics, Volume: 11, Issue: 2, page(s): 185 – 191, 2018.

Muhammad Hassan Jamil, Wanjoo Park, and Mohamad Eid, “Emotional Responses to Watching and Touching 3D Emotional Face in a Virtual Environment”, Virtual Reality, Vol. 25, No. 2, pp. 553-564, 2021.

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Virtual Reality (VR)

- Computer generated worlds (real or imagined) for people to interact with.
- VR recreates sensory experience through interfaces simulating multiple senses such as vision, audition, touch, olfaction, and taste.
- Several applications, including entertainment, health care, interpersonal communication, etc.

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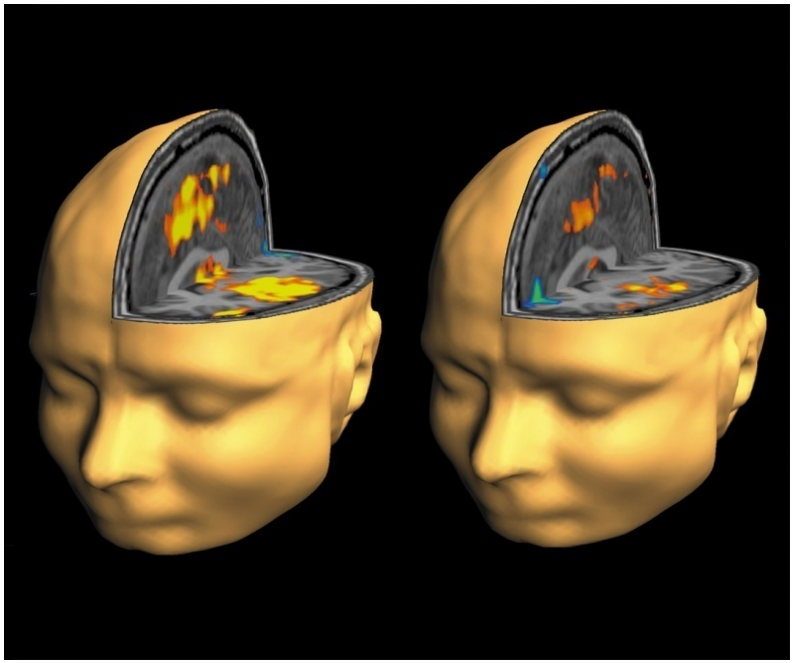
Affective Haptics in Health Care – Pain Distraction

- Pain can be controlled by a number of therapies including drugs, surgery, acupuncture, exercise, hypnosis, and even thought distraction.



Todd Richards and Aric Vills, U.W.
©Hunter Hoffman, www.vrpain.com

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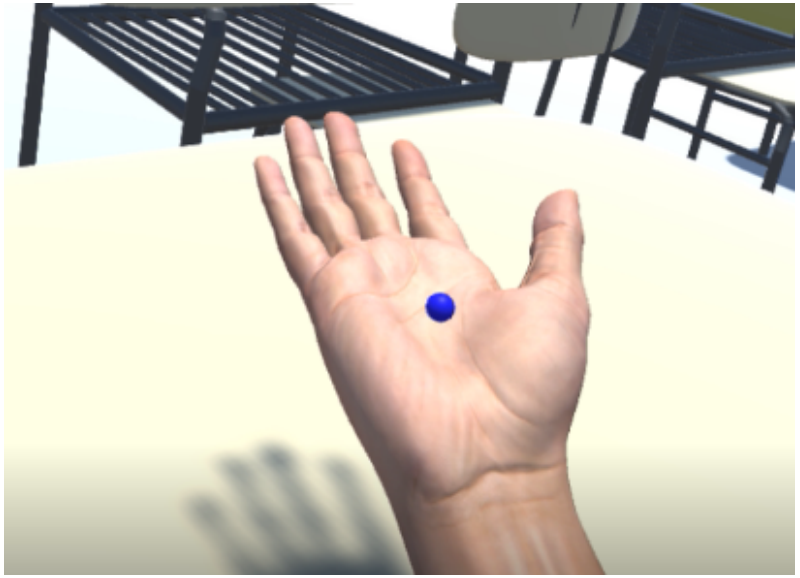
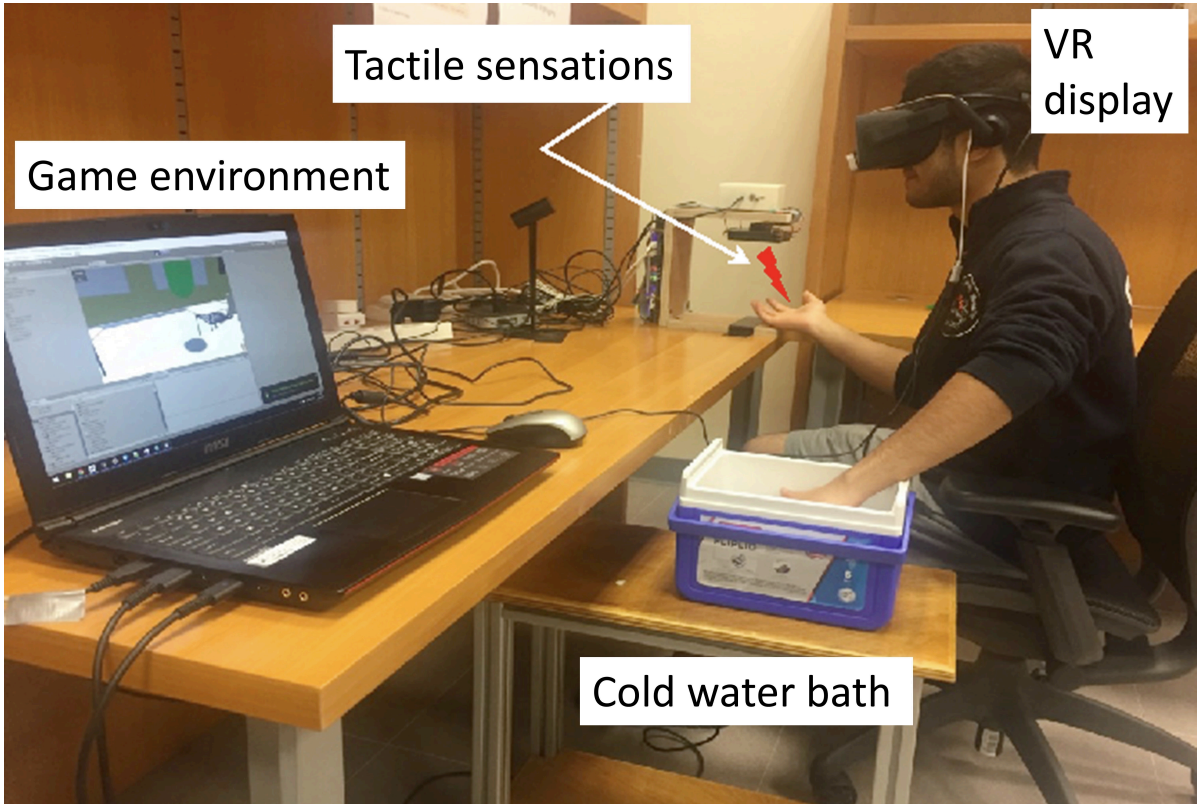
Pain Distraction: Experimental Setup/Protocol





- 50 participants (23 females and 27 males)
- Pain simulation with cold pressor test
- Control 1: no distraction
- Group 2: VR distraction
- Group 3: VR+Tactile distraction

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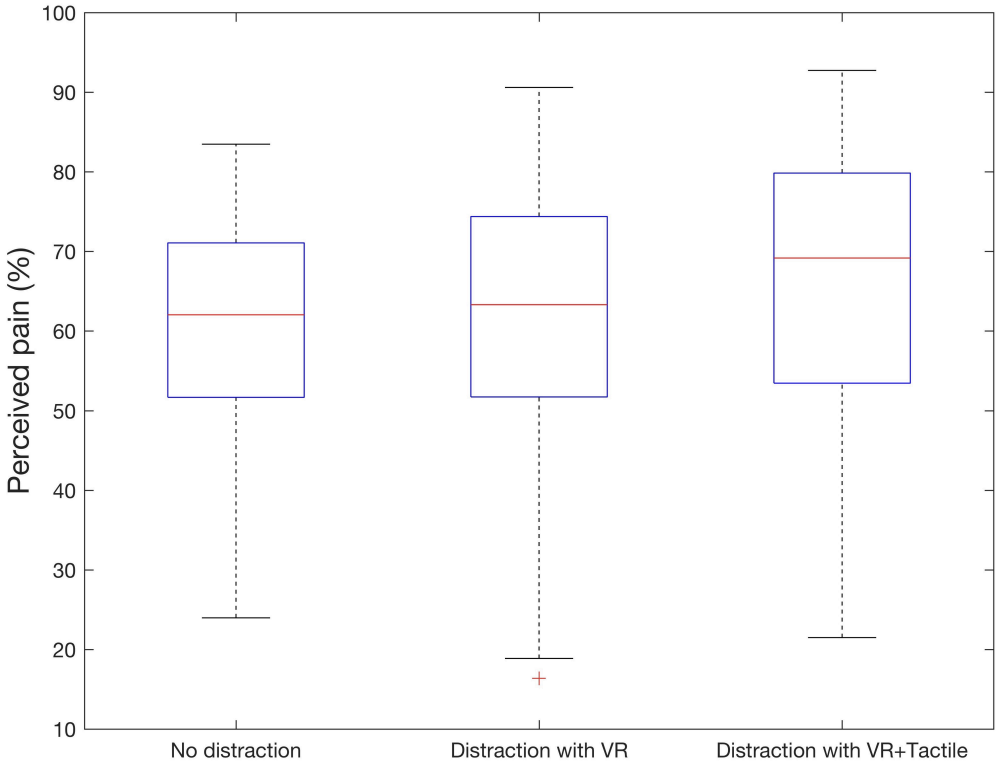
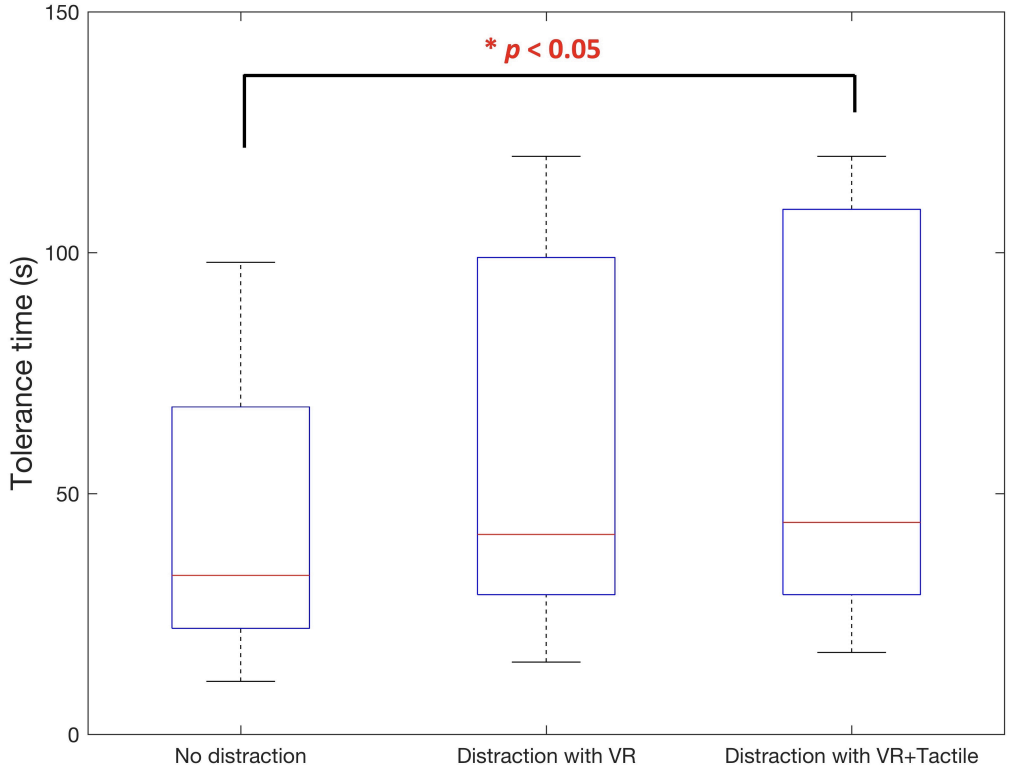
Pain Distraction - Results





- Tactile stimulation plays a significant role in pain distraction
- Perceived pain remained unchanged

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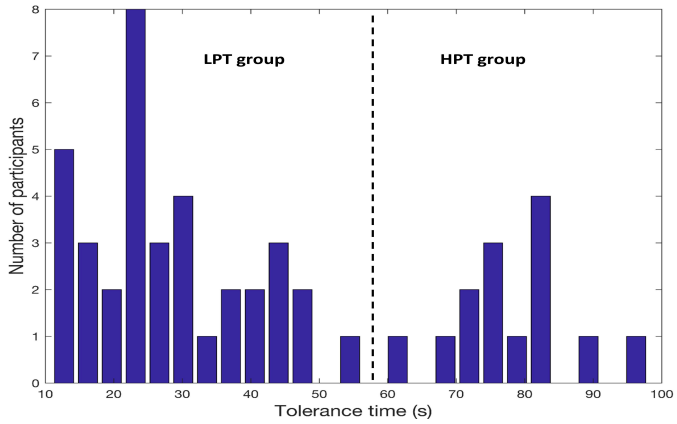
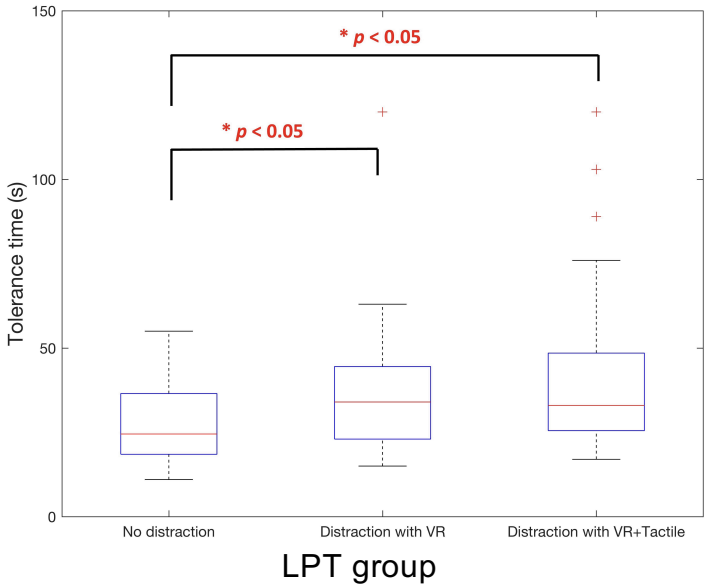
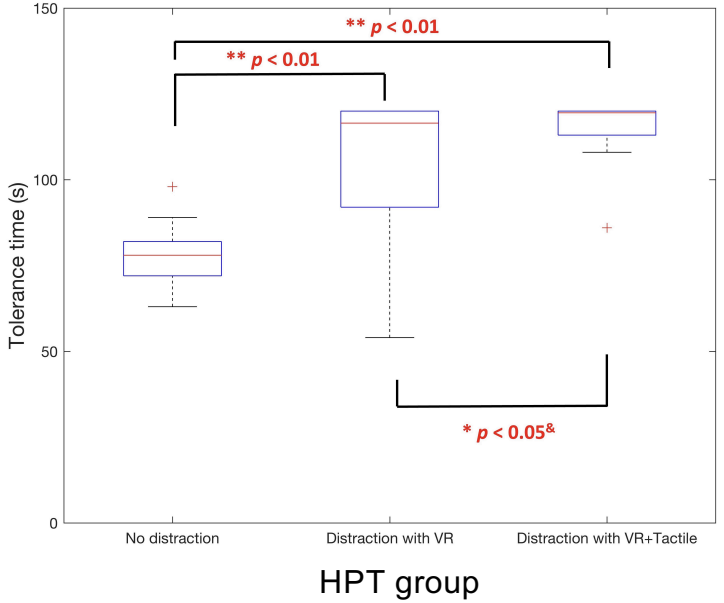
Low Pain Tolerance vs High Pain Tolerance

- Tactile stimulation is more effective with individuals who can tolerate higher pain compared to those with low pain tolerance.
- There are significant differences in tolerance time







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Affective Haptics: Interpersonal Communication in VR

- Investigate the influence of viewing and touching a virtual face displaying emotional expressions on emotional responses of viewer/toucher in a virtual environment.
- Neutral as well as the 6 universal emotions (happiness, sadness, anger, disgust, fear, and surprise) are developed.
- Stiffness/texture properties are considered

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Pre-experimental Analysis

Neutrality

Anger

Fear

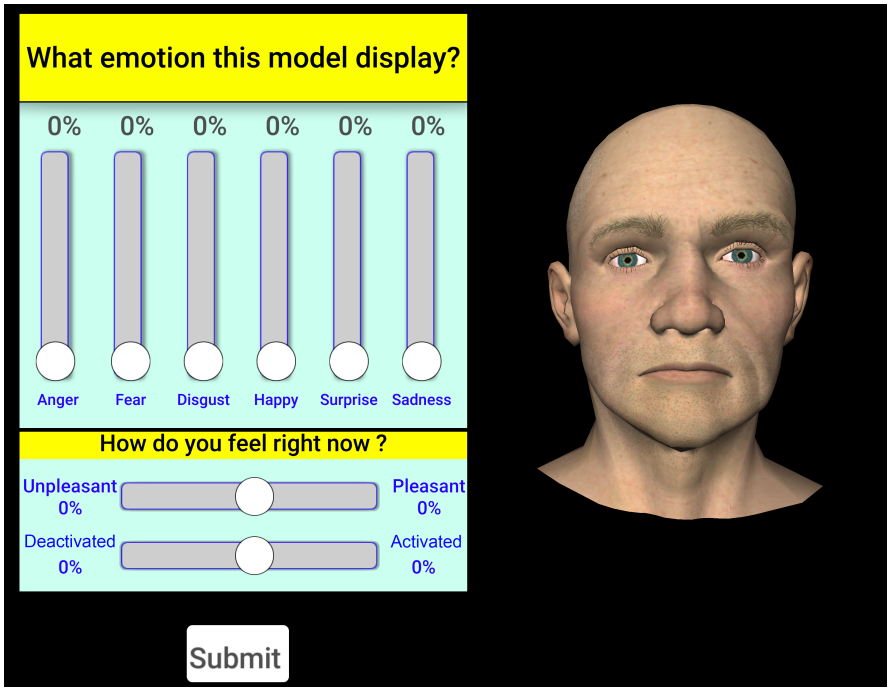
Disgust

Happiness

Surprise

Sadness

Neutral and Emotional Expressions



Self-reporting GUI

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Results: Perceived Emotions

- All emotional facial expressions were perceived as intended with statistical significance (Wilcoxon signed rank test corrected by Bonferroni)
- Fear/surprise and anger/disgust were confused

Perceived Emotion \ Facial Model		Anger	Fear	Disgust	Happiness	Surprise	Sadness
Anger	M	84.9	16.0	44.3	-0.8	-0.8	0.1
	SD	16.1	33.2	23.8	3.1	3.1	0.5
	p	***0.0005	1.0000	0.1250	1.0000	1.0000	1.0000
Fear	M	-0.9	56.7	0.0	0.5	14.5	4.1
	SD	3.6	31.8	5.3	6.2	23.3	14.2
	p	1.0000	**0.0020	0.7500	1.0000	**0.0078	1.0000
Disgust	M	19.3	11.1	40.0	4.3	2.7	4.9
	SD	29.8	19.3	32.1	8.6	8.4	13.2
	p	***0.0010	1.0000	**0.0039	1.0000	1.0000	1.0000
Happiness	M	0.0	4.1	0.0	35.2	1.6	0.0
	SD	0.0	16.0	0.0	23.7	6.2	0.0
	p	1.0000	1.0000	1.0000	***0.0005	1.0000	1.0000
Surprise	M	0.0	45.6	0.8	0.0	79.1	0.0
	SD	0.0	35.3	3.1	0.0	16.6	0.0
	p	1.0000	0.1250	1.0000	1.0000	***0.0005	1.0000
Sadness	M	-14.8	-14.8	-11.3	-11.7	-10.9	40.1
	SD	22.7	22.7	24.3	24.0	27.4	22.0
	p	0.5000	1.0000	0.5000	0.5000	0.5000	***0.0005
Valence	M	-46.0	-18.0	-40.4	16.0	-0.5	-21.7
	SD	38.9	49.4	36.1	27.1	34.8	26.8
	p	**0.0020	0.8594	**0.0098	0.4805	1.0000	0.0742
Arousal	M	-5.6	9.6	-5.7	24.7	25.3	-6.4
	SD	46.3	49.5	48.0	38.8	50.3	29.2
	p	1.0000	1.0000	1.0000	0.1211	0.5391	1.0000

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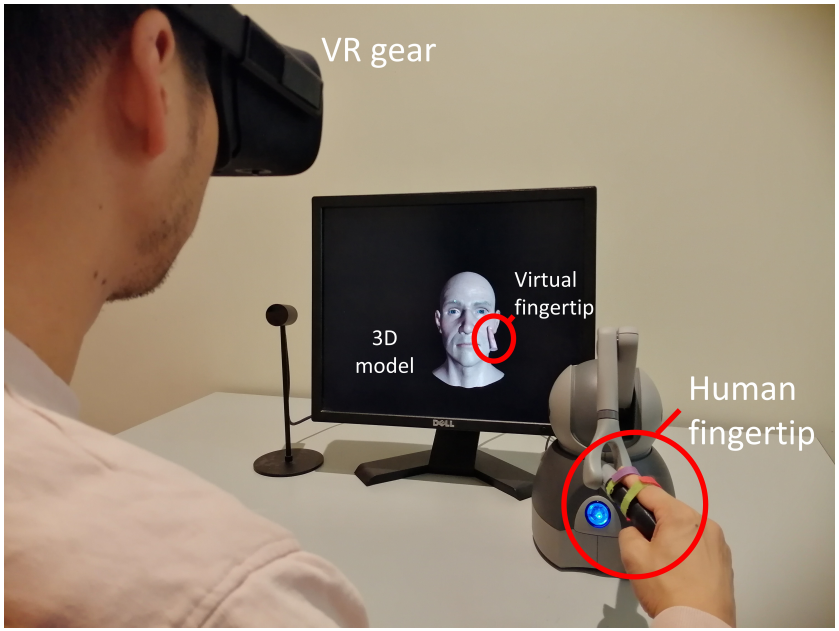
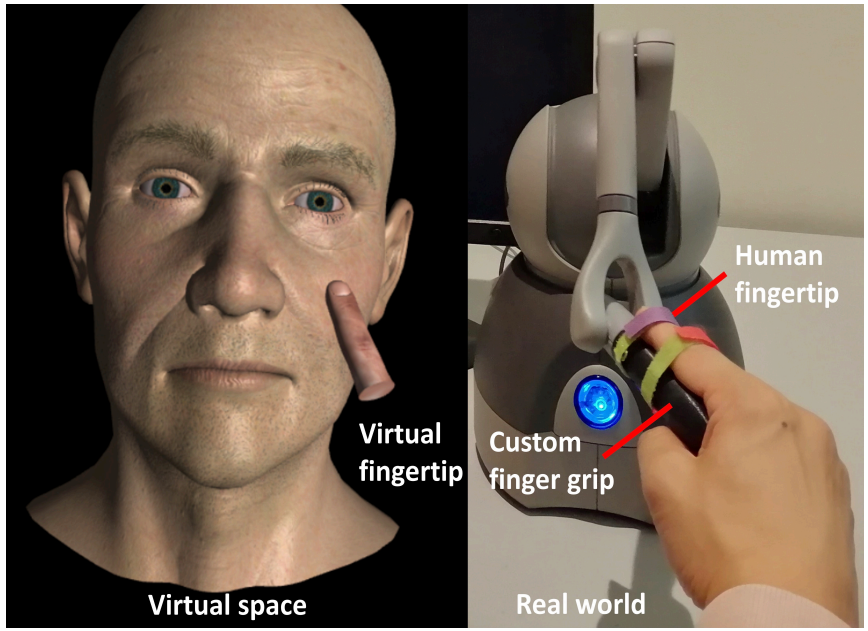
** $p < 0.01$
*** $p < 0.001$

Experimental Setup/Protocol

- A training session
- Watching neutral face
- Watching emotional face
- Touching the neutral face with varying stiffness/texture properties
- Touching emotional face with varying stiffness/texture properties





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Results: Response to Watching Emotional Face

- Watching emotional face in VR influences the viewer's emotions similarly as in real world.
- Examples: watching an angry face in a virtual environment influenced anger in the viewer

Emotional Responses \ Facial Model		Anger	Fear	Disgust	Happiness	Surprise	Sadness
Anger	M	14.2	0.7	4	1	0.3	0.9
	SD	19.3	2.6	14.8	10	7	7.5
	p	**0.0039	1.0000	1.0000	1.0000	1.0000	1.0000
Fear	M	12.8	1.6	-3	-8.7	-5.9	-7.8
	SD	21.7	23.7	21.6	16.8	19.6	17.4
	p	0.0845	1.0000	1.0000	0.0938	1.0000	0.2734
Disgust	M	10	2.2	11.2	-0.6	-2.6	-2.4
	SD	18.4	10.1	23.3	17.1	9.2	11.1
	p	0.0508	1.0000	0.0966	1.0000	1.0000	1.0000
Happiness	M	-8	3.1	-8.4	23.3	4.9	-8.8
	SD	16.7	23.4	18.2	19.6	23.4	17.8
	p	0.1250	1.0000	0.1875	**0.0012	1.0000	0.1250
Surprise	M	7.4	18.3	-6.3	-1.7	21.3	-9.1
	SD	19.6	27.3	16.2	18.4	32.8	16.5
	p	0.6972	*0.0331	0.4448	1.0000	*0.0486	*0.0400
Sadness	M	1.5	-3.1	8.4	-1.7	-3.4	26.7
	SD	10.5	8.3	19.6	10.9	8.1	22.9
	p	1.0000	1.0000	0.3594	1.000	1.0000	**0.0002
Valence	M	-36.2	-9.8	-30.9	22	-3.8	-28
	SD	39.9	44.4	41.2	41.7	35.2	39.9
	p	**0.0009	1.0000	**0.0074	0.0685	1.0000	*0.0250
Arousal	M	7.6	11	-8.7	13.1	15.8	-4.5
	SD	39.9	44.9	28	30.1	38.8	40.8
	p	1.0000	1.0000	1.0000	0.3078	0.3498	1.0000

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Results: Response to Touching Emotional Face

- A significant decrease in the surprise level was found when touching the angry model (Wilcoxon rank-sum test, $p < 0.05$, corrected by Bonferroni)

Emotional Responses \ Facial Model		Anger	Fear	Disgust	Happiness	Surprise	Sadness
Anger	M	9.6	1.0	7.7	-1.5	0.5	1.8
	SD	28.5	7.8	18.2	8.1	8.2	9.7
	p	1.0000	1.0000	0.0707	1.0000	1.0000	1.0000
Fear	M	-8.1	-2.4	1.2	-0.2	6.3	1.2
	SD	19.4	22.7	15.4	8.2	19.6	10.5
	p	0.5807	1.0000	1.0000	1.0000	1.0000	1.0000
Disgust	M	0.3	1.8	2.1	2.7	5.5	3.4
	SD	24.8	15.8	23.7	14.2	16.2	13.3
	p	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Happiness	M	0.4	-6.0	0.1	-2.4	-8.3	0.9
	SD	6.7	18.5	4.5	20.9	17.3	4.3
	p	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Surprise	M	-12.8	-10.8	0.8	-5.2	-8.7	0.0
	SD	19.1	25.8	13.2	14.2	26.1	10.9
	p	*0.0215	0.4843	1.0000	1.0000	1.0000	1.0000
Sadness	M	-0.9	2.0	-4.0	-1.5	2.4	-0.9
	SD	12.2	7.1	19.7	6.6	8.5	21.0
	p	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Valence	M	-4.7	-2.3	-0.5	-8.1	-10.1	6.7
	SD	49.1	35.4	34.4	39.6	34.8	27.0
	p	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Arousal	M	-7.4	-6.4	6.7	-6.5	-9.5	-1.4
	SD	44.9	35.3	37.0	30.6	31.7	30.2
	p	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

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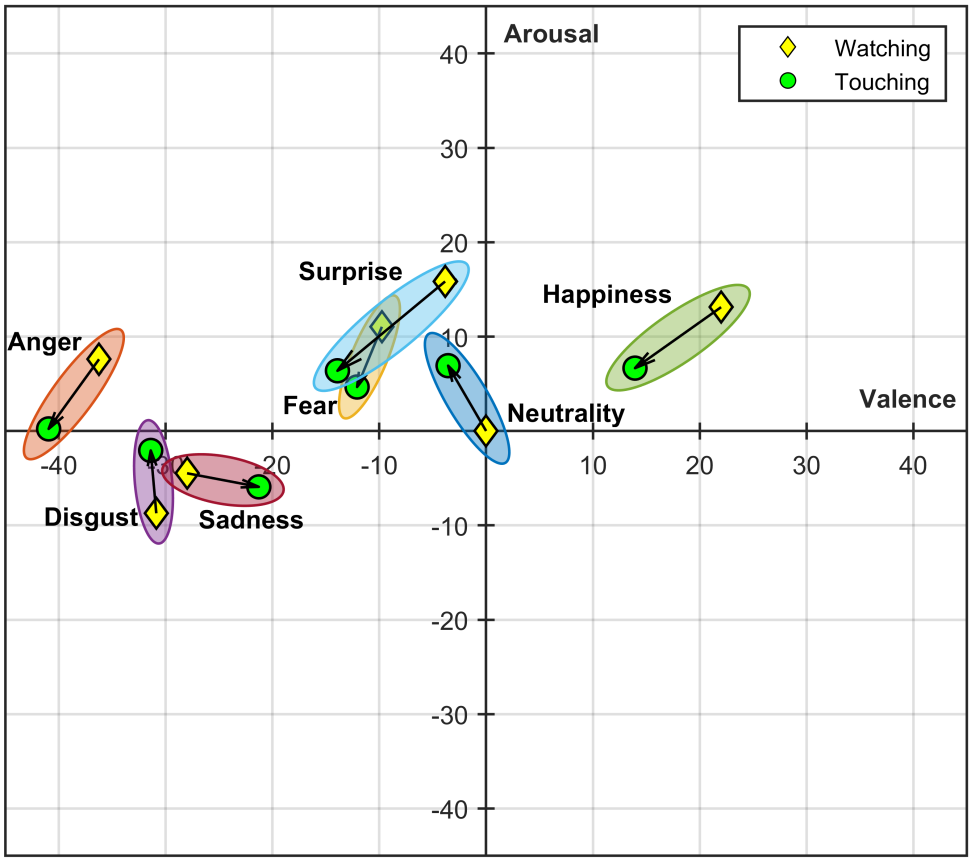
Results: Response to Touching Emotional Face

- The valence ratings for the happiness, surprise, and anger expressions decreased, while the valence ratings for sadness expression increased.
- Touching the angry, happy, surprise, and fear facial models resulted in a decrease in the arousal ratings, while neutrality and disgust expressions resulted in an increase in the arousal ratings.



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Results: Effects of Physical Properties

Physical properties were significant to modulate sadness while touching a disgusted face

Facial Model / Emotional Responses	Anger	Fear	Disgust	Happiness	Surprise	Sadness
Anger	0.8996	0.1765	0.8894	0.6732	0.4648	0.8435
Fear	0.9839	0.8679	0.9676	0.9987	0.5868	0.7479
Disgust	0.7506	0.8576	0.4158	0.5121	0.8616	0.6125
Happiness	0.9221	0.7920	0.9384	0.6444	0.7228	0.8630
Surprise	0.8166	0.7677	0.2801	0.7000	0.8904	0.9351
Sadness	0.6168	0.9323	**0.0077	1.0000	0.9342	0.9486
Valence	0.8111	0.7800	0.5843	0.6240	0.7049	0.8804
Arousal	0.7416	0.2069	0.8325	0.7467	0.7506	0.9046

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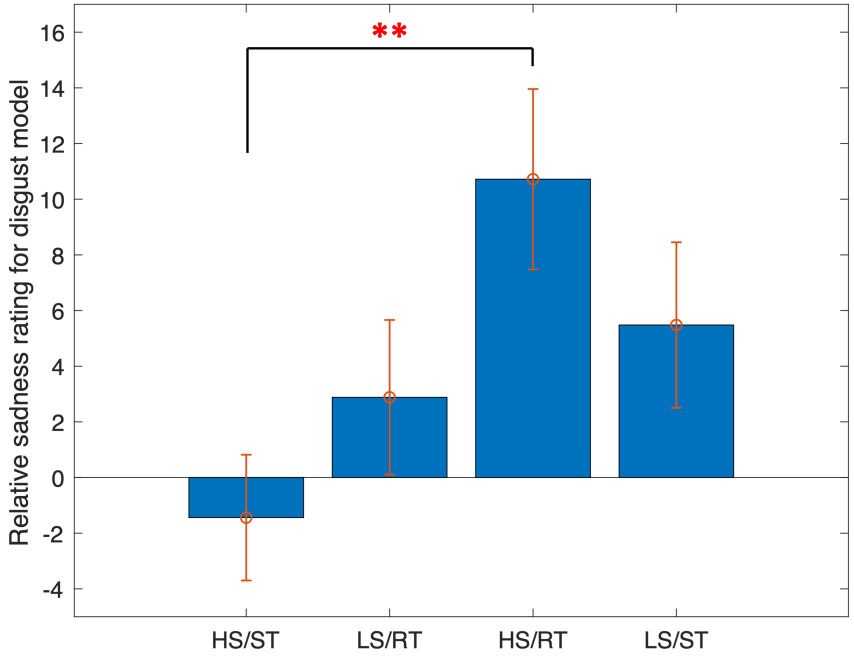
Results: Effects of Physical Properties

- A significant increase in sadness rating when touching the disgusted model with high stiffness/rough texture compared to touching the disgusted model with high stiffness/smooth texture (Kruskal-Wallis test, $p < 0.01$; Ad-hoc, Bonferroni correction).
- The combination of rough texture and hardness further modulated negative emotions in the form of sadness.



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Affective Haptics for Touchscreen Interaction

Wanjoo Park, Mohammed Hassan Jamil, Ruth Ghidey Gebremedhin, and Mohamad Eid, “Effects of Tactile Textures on Preference in Visuo-Tactile Exploration”, ACM Transactions on Applied Perception (impact factor: 1.02), Vol. 18, Issue 2, pp. 1-11, 2021.

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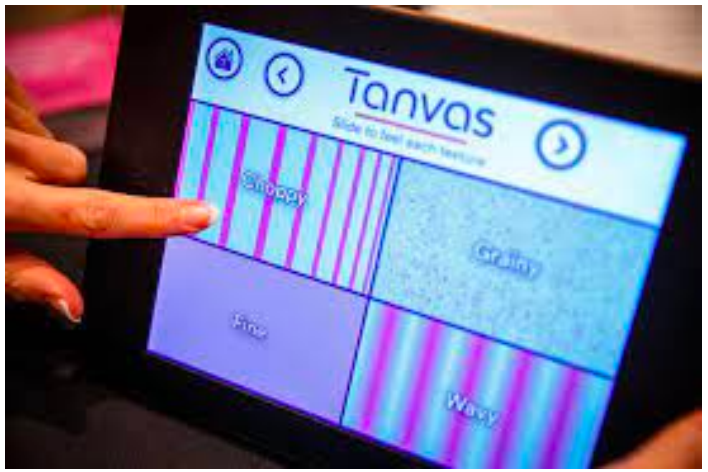
Tactile Texture for Touchscreen Exploration

- Surface haptics brings tactile feedback to touchscreen devices
- Study the preference of 2D images:
  - Effects of the presence of tactile feedback
  - Effects of the quality of tactile feedback
  - Effects of the accuracy of tactile feedback
- Using the TanvasTouch device



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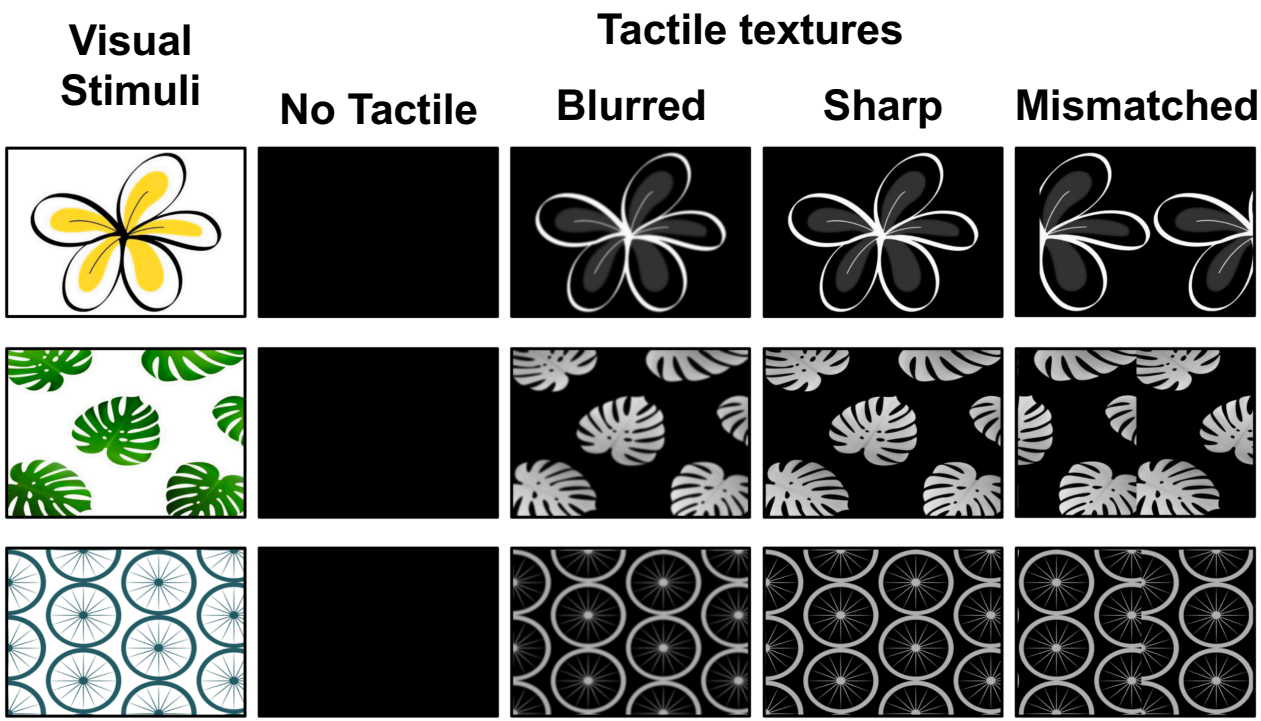
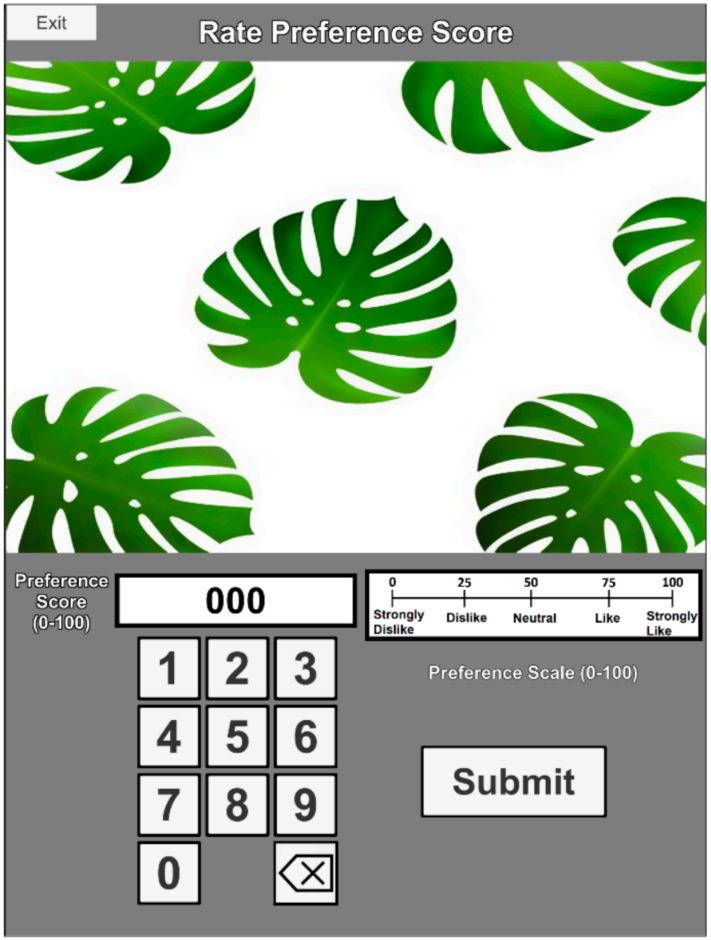
Tactile Texture for Touchscreen Exploration



Color, shape, and regularity and roughness of texture



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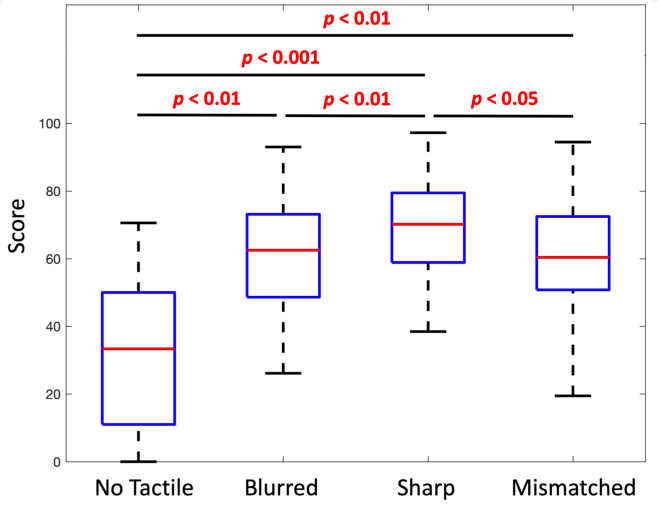
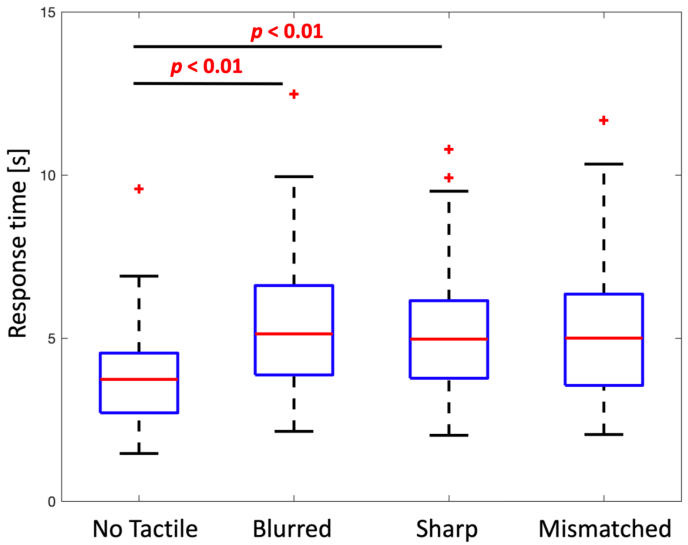
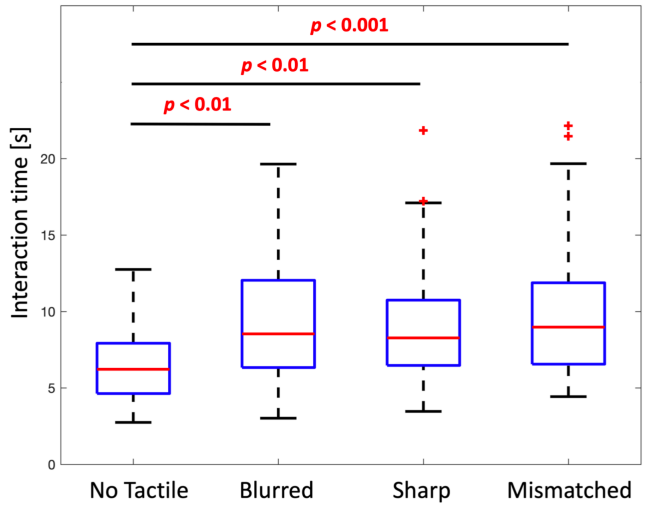
Tactile Texture Preference – Results

- Score: preferred tactile feedback regardless of the quality/correctness of tactile information.
- Interaction time: Users spent more time with tactile feedback, regardless of tactile condition.
- Response time: Users took more time with correct multimodal feedback







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Affective Haptics: Lessons Learned

- There is no touch that goes without emotions!
  - Positive or negative!
- Affective touch is a (very) personal experience
  - Personalized affective haptic technologies?
- Affective touch is highly contextual
  - Time, location, body part, relationship/gender, etc.?

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Affective Haptics: Challenges

- Better understand the human affective haptic system
- Quantitatively capturing emotional responses
  - Physiological measures?
  - Brain imaging?
- Human-like haptic interaction
  - Soft haptics?
  - Thermal feedback?
- Use cases

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Recent Publications

- Wanjoo Park, Mohammed Hassan Jamil, Ruth Ghidey Gebremedhin, and Mohamad Eid, “Effects of Tactile Textures on Preference in Visuo-Tactile Exploration”, ACM Transactions on Applied Perception, Vol. 18, Issue 2, pp. 1-11, 2021.
- Muhammad Hassan Jamil, Wanjoo Park, and Mohamad Eid, “Emotional Responses to Watching and Touching 3D Emotional Face in a Virtual Environment”, Virtual Reality (impact factor: 3.634), Vol. 25, No. 2, pp. 553-564, 2021.
- Georgios Korres, Camilla Birgitte Falk Jensen, Wanjoo Park, Carsten Bartsch, and Mohamad Eid, “A Vibrotactile Alarm System For Pleasant Awakening”, IEEE Transactions on Haptics (impact factor: 2.75), Volume: 11, Issue: 3, pages: 357 – 366, 2018.
- Georgios Karafotias, Georgios Korres, Akiko Teranishi, Wanjoo Park, and Mohamad Eid, “Mid-air Tactile Stimulation for Pain Distraction”, IEEE Transactions on Haptics (impact factor: 2.75), Volume: 11, Issue: 2, page(s): 185 – 191, 2018.
- Rodrigo Ceballos, Beatrice Ionascu, Wanjoo Park, and Mohamad Eid, “Implicit Emotion Communication: EEG Classification and Haptic Feedback”, ACM Transactions on Multimedia Computing Communications and Applications (TOMM) (impact factor: 2.25), Volume 14, Issue 1, January 2018.
- Georgios Karafotias, Akiko Teranishi, Georgios Korres, Friederike Eyssel, Scandar Copti, and Mohamad Eid, “Intensifying Emotional Reactions via Tactile Gestures in Immersive Films”, ACM Transactions on Multimedia Computing Communications and Applications (TOMM) (impact factor: 2.25), Volume 13, Issue 3, 2017.

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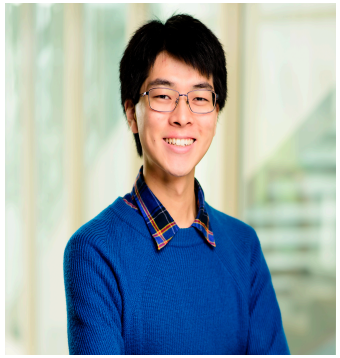
Acknowledgment



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Thank you very much!

Questions?

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