Prototyping Emotions: A Modular Methodological Toolkit for Teaching Novice Interaction Designers

Low-Fidelity Single-Modal On-Body Affective Haptic Prototypes in Tandem Teams

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Background & Motivation

Why Affective Haptics?

- Increasing role of emotionally rich interactions in HCI [6, 7, 12, 29, 11]

Current trends:

- Haptic UX [9, 4]
- Biofeedback & Wearables [1, 26, 14, 2]
- XR applications [3]

Affective haptics -> real-world applications:

- Mental health [11, 30, 26]
- Assistive tech [11, 30]

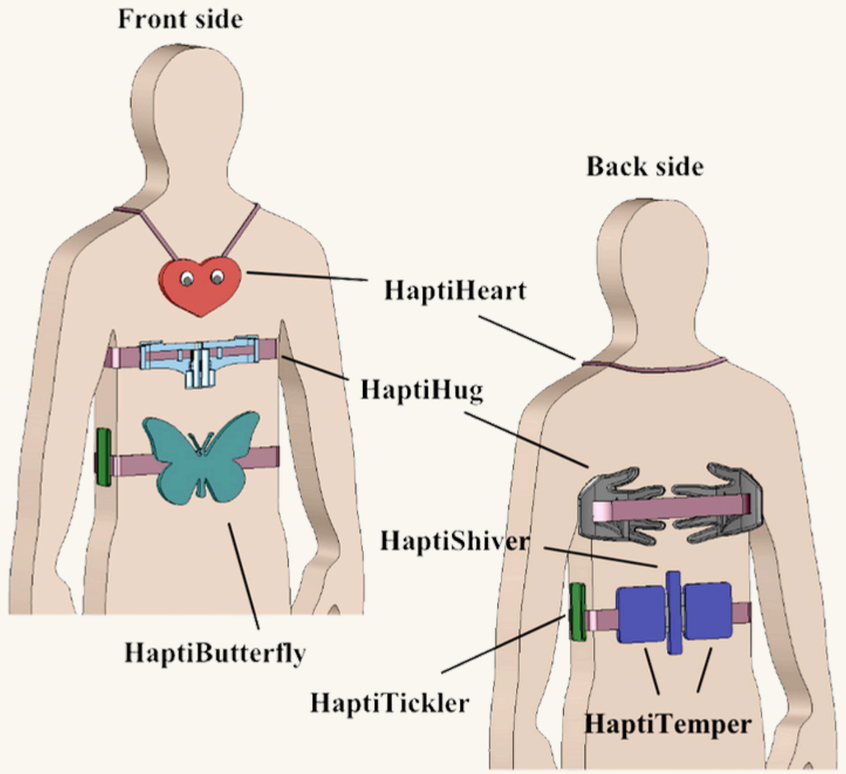


Figure 3: Affective haptic devices worn on a human body.

iFeel_IM!: sensing the **thermal property** of the object (HaptiTemper), **pressure** (HaptiHeart, HaptiHug), **vibration** frequency (HaptiButterfly, HaptiTickler, and HaptiShiver) [27]

→ **Current Gap:** Frameworks and toolkits not accessible for novice interaction designers to prototype affective haptic feedback (17, 18, 24)

[1]

Related Work

- Increasing focus on affective computing and emotional engagement in HCI + better sensor technologies and AI to shape affective UX [21,] 29, 11)
- Need for affective haptic design tools, approaches and research methodologies for novice designers (24;24 29; Eid & Osman, 2016; 17Moussette, 2012; MacLean, 2022; 18Seifi et al., 2019)

Related work

Emotions

Emotion Typology

Educating about complex emotional states [31]

Circumplex Model of Affect

Mapping emotions by valence and arousal [23, 22]

Object Baseline

Body Maps

Somatic Sensation Capturing in Interaction Design [10, 11, 6, 20, 28, 16]

Metaphor Elicitation

(Embodied/ Imaginative) Metaphor Elicitation [5, 19]

Prototyping

Experience Prototyping

- Iterative refinement of designs
- allowing users to experience haptic feedback firsthand
- provide real-time tandem design

[8, 26]

Embodied Cognition & Embodied Interaction:

- Embodied Interaction xplores how physical interactions shape cognitive and emotional processes

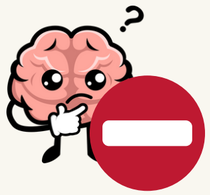
[15, 10, 5, 16)

Research Questions

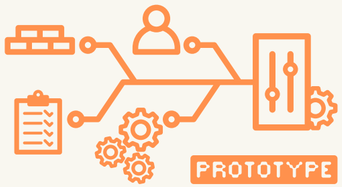
RQ1: What is the impact of using embodied metaphors in combination with body maps on the design and communication process of affective haptic feedback for novice interaction designers?

RQ2: How can Lo-Fi on-body tandem prototyping sessions with haptic feedback be structured to elicit valuable insights into emotional responses from users?

RQ3: What challenges do novice interaction designers encounter when translating haptic feedback designs into Lo-Fi on-body prototypes?



RQ4: What tools and methodologies are needed to make on-body affective haptic prototyping accessible to novice interaction designers?



Methodology Overview

Research Approach

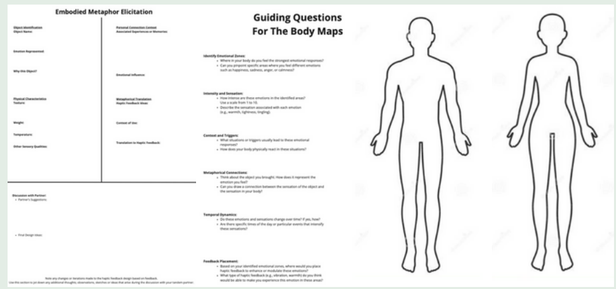
- Modular affective haptic tandem design toolkit approach
- Affective haptic prototyping workshop with novice interaction designers

Toolkit Components

1. **Hardware** → Hapticlabs DevKit (ERM, LRA, Piezo actuators)
2. **Software** → Hapticlabs Studio (No-coding prototyping for tactile haptics)
3. **Methodological Framework** → Embodied metaphor elicitation & body maps

1.Hardware
https://www.hapticlabs.io/

2.Software
https://www.hapticlabs.io/



3.Methodological Framework
Body maps, guiding questions, embodied metaphor elicitation

Evaluation:

Mixed Methods →

1. Demographic survey
2. Haptic patterns (export & audio)
3. HapticLabs project files
4. Reflections in discussions
5. Concluding Survey
6. Miro Workspace (Link here)

Workshop Procedure

Phase 1: Understanding Emotional Frameworks

Emotional Frameworks:

1. Emotion Typology: Categorizing complex emotional states for prototyping [31]
2. Circumplex Model of Affect: Mapping emotions by valence and arousal [22; 23]

Participants explored...

...Emotion typology -> **emotion overview and definitions**

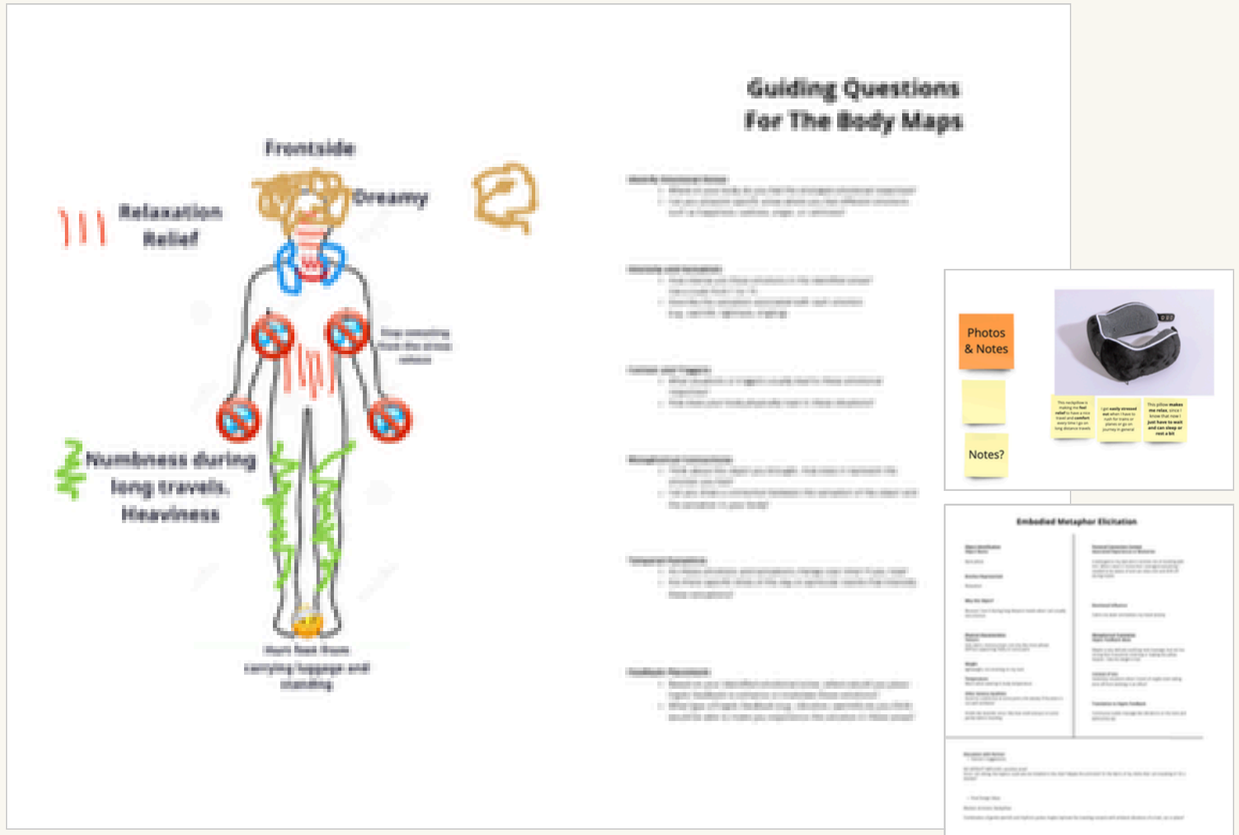
...**Mapping of emotions** onto the circumplex model of affect

...**“Haptic feedback”*** introduction

...Identification of emotional connections to **personal objects**

Workshop Procedure

Phase 2: Embodied Metaphors and Body Mapping



Workspace - Phase 2: Miroboard work space for applying the steps for their personal object brought by the participants

Body Frameworks:

Embodied Metaphors:

- Allows designers to bridge emotional experiences with tactile sensations, reinforcing affective engagement [5, 19]

Body Mapping:

- Localization of emotions on the body for effective actuator placement [28,10, 20]

Participants...

...Examined objects for sensory qualities and haptic properties

...Worked on a tailored workshop Miro board

...Were provided with **guided reflection** on the object's emotional & sensory qualities (embodied metaphor sheets)

...Used **body maps** to identify where emotions are felt

...Conceptualized **actuator placement** (Guiding body map questions)

...Created a documented **baseline** of their emotional impact with their object

Workshop Procedure

Phase 3: Low-Fidelity On-Body Tandem Prototyping

2 rounds

PROTOTYPE

Tandem Design Approach:

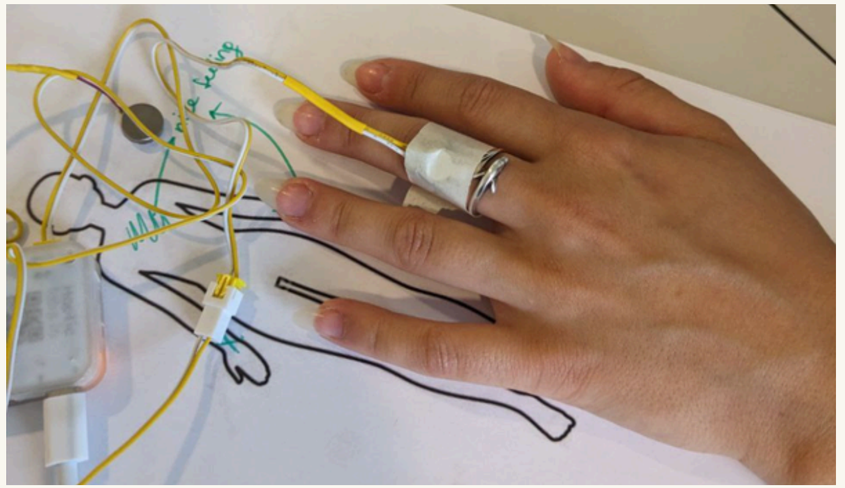
Participants alternate between designer and user roles

- On-body prototyping using Hapticlabs DevKit
- Iterative refinement based on real-time feedback
- Documenting insights & design improvements

Challenges:

- **Technical complexity:** Limited actuators and connectivity issues
- **Emotional subjectivity:** Difficulty translating someone else's emotions and somatic experiences into haptics

e.g. Participants found that chest actuator placement evoked unintended eerie sensations, highlighting ethical design challenges



Findings & Insights

Questions are abbreviated

RQ1: Impact of using embodied metaphors in combination with body maps on design & communication process of affective haptic feedback?

- Enhanced emotional articulation & reflection
- Guided actuator placement

➡**Established emotional baseline**

RQ2: How can Lo-Fi on-body tandem prototyping sessions with haptic feedback be structured?

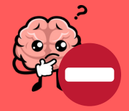
- Circumplex Model of Affect improved emotional categorization
- Tandem prototyping fostered empathy & collaboration
- Multi-day workshops recommended

➡ **Separated vs. codmbined activities?**

RQ3: What challenges do novice interaction designers encounter during Lo-Fi prototyping?

⚠ Software usability issues
⚠ Limited actuator diversity
⚠ Emotional subjectivity & consistency

➡ **Solution: Refine low-entry prototyping tools (e.g., preset & template-based systems)**

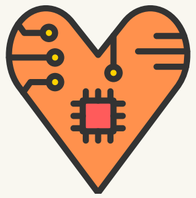


RQ4: What tools and methodologies are needed to make on-body affective haptic prototyping accessible?

- Predefined haptic patterns
- Wireless actuators

➡**Team size comparison – Future studies should compare teams to assess collaborative impact**

Scientific Criticism & Ethical Considerations



Scientific Reflection

- **Subjectivity** of emotional responses limits generalizability
- **Small sample size** (6 participants) affects statistical reliability
- **Technical limitations** constrained design exploration (limited actuators, software usability)
- Need for longitudinal studies to assess the toolkits **impact over time** for building affective haptic prototypes

Ethical Considerations: [21, 29, 11]

Human Touch Sensitivity: Risk of misinterpretation and discomfort (context, cultural differences in perception)

Autonomy, Consent, and User Control: Always option to opt-out of an affective haptic experience (modify or disable)

Consent & Emotional Safety: Participants' emotional well-being during affective haptic interaction (dependency?)

Data Privacy & Surveillance: Ethical concerns regarding personal emotional data and body mapping (biofeedback?)

Conclusion

Key Takeaways

Developed a Structured Methodology for Affective Haptic Design

- Integrated **embodied metaphors, body maps, and tandem prototyping**
- Provided a **guided framework** to help novice designers translate emotions into haptic feedback

Enabled Participants to Create Affective Haptic Prototypes

- Demonstrated how **emotions can be mapped to haptic sensations** through low-fidelity on-body prototyping
- Identified how **single-modal haptic feedback can create personalized user experience** and interaction design

Uncovered Design Challenges & Ethical Considerations

- **Subjectivity in emotional interpretation** → Haptic actuator placements complex
- **Hardware & software limitations**
- **Cultural and ethical considerations** [29, 11, 21]

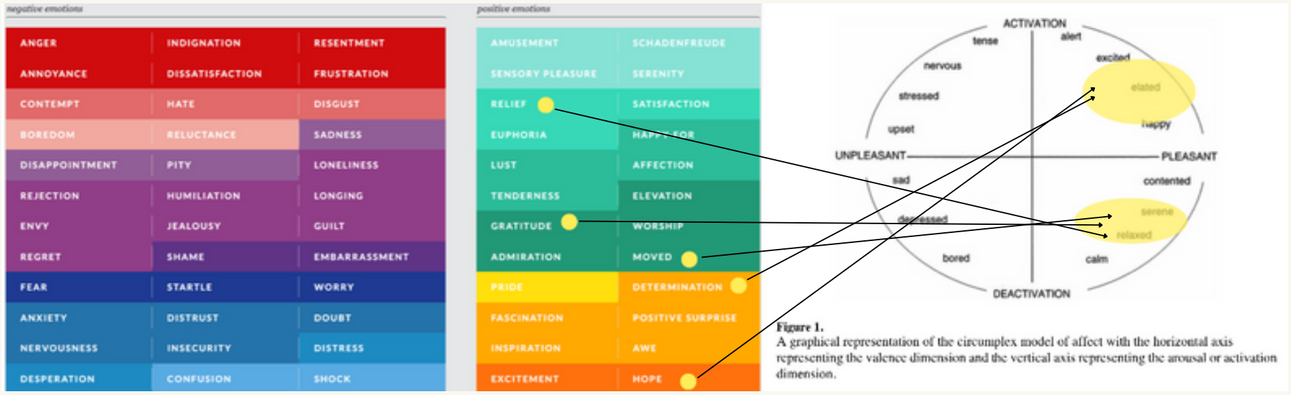
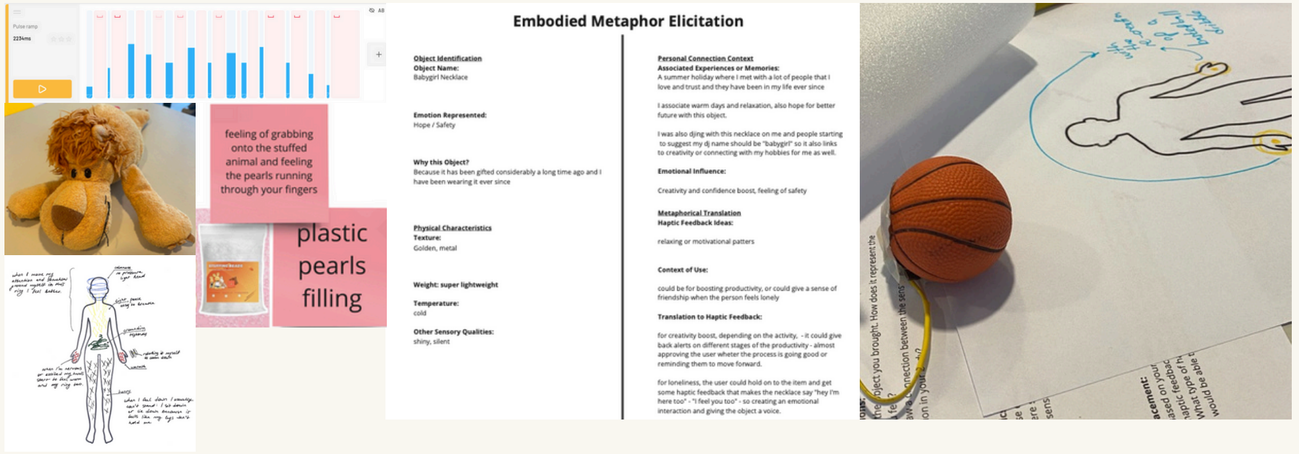


Figure 1.
A graphical representation of the circumplex model of affect with the horizontal axis representing the valence dimension and the vertical axis representing the arousal or activation dimension.

Mapping emotions: Object emotion, map it into the 2D circumplex model of affect (fokkinger, posner, russel),



Miroboard documentations: Annotations and metaphors for interacting (Bakker), prototyping on their object, prototyping based on their object's properties or interaction(buchner), etc.

Future Work

Toolkit & Methodology Enhancements:

Toolkit Refinements

- Introduce **diverse haptic modalities** (vibrotactile, thermal, kinesthetic)
- Develop **predefined haptic pattern libraries** to simplify design for novice interaction designers
- Conduct **quantitative emotional affect impact measures**

Methodology & Workshop Improvements

- Structure workshops over **multiple sessions** (e.g., 2–3 meetings) to **gradually introduce software & hardware**
- **Test single methodologies** (body maps, metaphor elicitation) separately before combining them
- Introduce **exploratory techniques** (e.g., body-storming, haptic context assessment) for more creative freedom

Research Extensions & Broader Implications:

Scaling Up & Testing in Broader Affective Haptic Contexts

- Expand participant diversity for **cross-cultural validation**
- Compare **team-based vs. individual** affective haptic design approaches (single-person vs. tandem vs. 3+ designer teams)
- Develop or utilize **multi-actuator hardware** to support richer, layered haptic feedback

Long-Term Impact & New Application Domains

- Conduct **longitudinal studies** to assess skill retention & design evolution over time.
- **Investigate applications** in healthcare, mental well-being, assistive technology, and VR/AR experiences
- Explore **multi-modal affective feedback** (haptic + visual + auditory) for holistic emotional interactions of various contexts

References 1

[1]
Arfan Ahmed, Sarah Aziz, Mahmood Alzubaidi, Jens Schneider, Sara Irshaidat, Hashem Abu Serhan, Alaa A Abd-alrazaq, Barry Solaiman, and Mowafa Househ. 2023. Wearable devices for anxiety & depression: A scoping review. Comput Methods Programs Biomed Update 3, (2023), 100095. https://doi.org/10.1016/j.cmpbup.2023.100095

[2]
R. Alhejaili. 2023. Wearable Technology for Mental Wellness Monitoring and Feedback. Thesis. Queen Mary University of London. Retrieved December 31, 2023 from https://qmro.qmul.ac.uk/xmlui/handle/123456789/92960

[3]
Sang-Gyun An, Yongkwan Kim, Joon Hyub Lee, and Seok-Hyung Bae. 2017. Collaborative Experience Prototyping of Automotive Interior in VR with 3D Sketching and Haptic Helpers. In Proceedings of the 9th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '17), September 24, 2017. Association for Computing Machinery, New York, NY, USA, 183–192. https://doi.org/10.1145/3122986.3123002

[4]
Ahmed Anwar, Tianzheng Shi, and Oliver Schneider. 203. Factors of Haptic Experience across Multiple Haptic Modalities. In Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23), April 19, 2023. Association for Computing Machinery, New York, NY, USA, 1–12. https://doi.org/10.1145/3544548.3581514

[5]
Saskia Bakker, Alissa N. Antle, and Elise van den Hoven. 2012. Embodied metaphors in tangible interaction design. Pers Ubiquit Comput 16, 4 (April 2012), 433–449. https://doi.org/10.1007/s00779-011-0410-4

[6]
Susanne Bødker. 2006. When second wave HCI meets third wave challenges. In Proceedings of the 4th Nordic conference on Human-computer interaction: changing roles (NordiCHI '06), October 14, 2006. Association for Computing Machinery, New York, NY, USA, 1–8. https://doi.org/10.1145/1182475.1182476

[7]
Susanne Bødker. 2015. Third-wave HCI, 10 years later---participation and sharing. interactions 22, 5 (August 2015), 24–31. https://doi.org/10.1145/2804405

[8]
Marion Buchenau and Jane Fulton Suri. 2000. Experience prototyping. In Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques (DIS '00), August 01, 2000. Association for Computing Machinery, New York, NY, USA, 424–433. https://doi.org/10.1145/347642.347802

[9]
Antoinette Bumatay and Jinsil Seo. 2017. Investigating the Role of Biofeedback and Haptic Stimulation in Mobile Paced Breathing Tools. May 18, 2017. 287–303. https://doi.org/10.1007/978-3-319-58628-1_23

[10]
Karen Cochrane, Kristina Mah, Anna Ståhl, Claudia Núñez-Pacheco, Madeline Balaam, Naseem Ahmadpour, and Lian Loke. 2022. Body Maps: A Generative Tool for Soma-based Design. https://doi.org/10.1145/3490149.3502262

[11]
Mohamad A. Eid and Hussein Al Osman. 2016. Affective Haptics: Current Research and Future Directions. IEEE Access 4, (2016), 26–40. https://doi.org/10.1109/ACCESS.2015.2497316

[12]
Christopher Frauenberger. 2019. Entanglement HCI The Next Wave? ACM Trans. Comput.-Hum. Interact. 27, 1 (November 2019), 2:1-2:27. https://doi.org/10.1145/3364998

[13]
Maria Luisa González Ramírez, Juan Pablo García Vázquez, Marcela D. Rodríguez, Luis Alfredo Padilla-López, Gilberto Manuel Galindo-Aldana, and Daniel Cuevas-González. 2023. Wearables for Stress Management: A Scoping Review. Healthcare (Basel) 11, 17 (August 2023), 2369. https://doi.org/10.3390/healthcare11172369

[14]
Blake Anthony Hickey, Taryn Chalmers, Phillip Newton, Chin-Teng Lin, David Sibbritt, Craig S. McLachlan, Roderick Clifton-Bligh, John Morley, and Sara Lal. 2021. Smart Devices and Wearable Technologies to Detect and Monitor Mental Health Conditions and Stress: A Systematic Review. Sensors 21, 10 (January 2021), 3461. https://doi.org/10.3390/s21103461

[15]
James Hollan, Edwin Hutchins, and David Kirsh. 2000. Distributed cognition: toward a new foundation for human-computer interaction research. ACM Trans. Comput.-Hum. Interact. 7, 2 (June 2000), 174–196. https://doi.org/10.1145/353485.353487

[16]
Kristina Höök. 2018. Designing with the Body: Somaesthetic Interaction Design. https://doi.org/10.7551/mitpress/11481.001.0001

References 2

[17]
Karon E MacLean. 2022. Designing affective haptic experience for wellness and social communication: where designers need affective neuroscience and psychology. Current Opinion in Behavioral Sciences 45, (June 2022), 101113. https://doi.org/10.1016/j.cobeha.2022.101113
[18]
Camille Moussette. 2012. Simple haptics: Sketching perspectives for the design of haptic interactions. (2012). https://doi.org/10.1007/978-3-642-31401-8_22
[19]
Luciara Nardon and Amrita Hari. 2021. Sensemaking Through Metaphors: The Role of Imaginative Metaphor Elicitation in Constructing New Understandings. International Journal of Qualitative Methods 20, (January 2021). https://doi.org/10.1177/16094069211019589
[20]
Lauri Nummenmaa, Enrico Glerean, Riitta Hari, and Jari K. Hietanen. 2014. Bodily maps of emotions. Proceedings of the National Academy of Sciences 111, 2 (January 2014), 646–651. https://doi.org/10.1073/pnas.1321664111
[21]
Jimmy Or (Ed.). 2008. Affective Computing. IntechOpen. https://doi.org/10.5772/71
[22]
Jonathan Posner, James A. Russell, and Bradley S. Peterson. 2005. The circumplex model of affect: An integrative approach to affective neuroscience, cognitive development, and psychopathology. Dev Psychopathol 17, 3 (2005), 715–734. https://doi.org/10.1017/S0954579405050340
[23]
James A. Russell. 1980. A circumplex model of affect. Journal of Personality and Social Psychology 39, 6 (1980), 1161–1178. https://doi.org/10.1037/h0077714
[24]
Hasti Seifi, Farimah Fazlollahi, Michael Oppermann, John Sastrillo, Jessica Ip, Ashutosh Agrawal, Gunhyuk Park, Katherine Kuchenbecker, and Karon Maclean. 2019. Haptipedia: Accelerating Haptic Device Discovery to Support Interaction & Engineering Design. https://doi.org/10.1145/3290605.3300788
[25]
Daniel Shor, Bryan Zaaijer, Laura Ahsmann, Simon Immerzeel, Max Weetzel, Daniël Eikelenboom, Jess Hartcher-O'Brien, and Doris Aschenbrenner. 2018. Designing Haptics: Comparing Two Virtual Reality Gloves with Respect to Realism, Performance and Comfort. In 2018 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct), October 2018. 318–323. https://doi.org/10.1109/ISMAR-Adjunct.2018.00095
[26]
Clay Spinuzzi. 2005. The Methodology of Participatory Design. Technical Communication 52, (May 2005), 163–174.
[27]
Dzmitry Tsetserukou, Alena Neviarouskaya, Helmut Prendinger, Naoki Kawakami, and Susumu Tachi. 2009. Affective haptics in emotional communication. In 2009 3rd International Conference on Affective Computing and Intelligent Interaction and Workshops, September 2009. 1–6. https://doi.org/10.1109/ACII.2009.5349516
[28]
Laia Turmo Vidal, Yinchu Li, Martin Stojanov, Karin Johansson, Beatrice Tylstedt, and Lina Eklund. 2023. Towards Advancing Body Maps as Research Tool in Interaction Design. (February 2023). https://doi.org/10.1145/3569009.3573838
[29]
Preeti Vyas, Unma Mayur Desai, Karin Yamakawa, and Karon Maclean. 2023. A Descriptive Analysis of a Formative Decade of Research in Affective Haptic System Design. In Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23), April 19, 2023. Association for Computing Machinery, New York, NY, USA, 1–23. https://doi.org/10.1145/3544548.3580735
[30]
Ju-Yu Wu, Congo Tak-Shing Ching, Hui-Min David Wang, and Lun-De Liao. 2022. Emerging Wearable Biosensor Technologies for Stress Monitoring and Their Real-World Applications. Biosensors 12, 12 (December 2022), 1097. https://doi.org/10.3390/bios12121097
[31]
2022. Emotion Typology. Retrieved from https://emotiontypology.com/

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Thank you for listening

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Q&A

"How could the toolkit be adapted for different cultural contexts to ensure meaningful affective haptic interactions?"

Questions:

1. **What are the key limitations in affective haptics research as identified by Eid and Al Osman (2016)?**
   - Answer: Key limitations include insufficient research on haptic-based affect detection compared to affect display, limited exploration of emotions like disgust and surprise, and the high contextual dependency of interpreting haptic stimuli [Eid and Al Osman - 2016….]
2. How does the interpretation of haptic stimuli differ based on context, as discussed by Eid and Al Osman (2016)?
   - Answer: Haptic stimuli interpretation is highly contextual; emotions like anger or sadness can vary based on cultural, situational, and individual factors. This contextual variability challenges the development of universal haptic communication systems [Eid and Al Osman - 2016….]
3. What is a significant finding about multimodal affective communication according to Christensen (2015)?
   - Answer: Christensen found that multimodal signals (e.g., combining audio and haptic feedback) are more effective in conveying public emotions like happiness compared to unimodal signals, but private emotions like sadness may show less clear interactions with multimodal stimuli [Christensen - 2015 - Em….]
4. What are the potential applications of affective haptics in emotional communication highlighted by Tsetserukou et al. (2009)?
   - Answer: Applications include enhancing emotional intimacy during online communication through systems like iFeel_IM!, which uses haptic devices (e.g., HaptiHug, HaptiButterfly) to convey emotions like joy, fear, and sadness in real time [Tsetserukou et al. - 20….]
5. What challenges were identified in developing haptic devices for emotional communication as discussed by Vyas et al. (2023)?
   - Answer: Challenges include integrating interdisciplinary approaches, designing scalable and adaptable systems for diverse user needs, and addressing ethical concerns like data privacy in emotion-sensing technologies [Vyas et al. - 2023 - A ….]

1. What are some implications for the future development of affective haptic systems as suggested by MacLean (2022)?
   - Answer: Future systems should prioritize the seamless integration of affective neuroscience with haptic technology, focusing on personalized user experiences and bridging the gap between theoretical knowledge and practical design applications [MacLean - 2022 - Design….]
2. How does the concept of “pseudo-haptic touch” enhance emotional communication in virtual environments?
   a. Answer: Pseudo-haptic touch, as implemented in systems like iFeel_IM!, uses haptic feedback synchronized with virtual animations (e.g., hugging in Second Life) to create immersive emotional experiences, enhancing users' perception of physical presence and emotional connection [Tsetserukou et al. - 20….]
3. What future research ambitions are discussed in affective haptics for improving user experience?
   a. Answer: Future ambitions include developing more nuanced and personalized haptic feedback systems, exploring under-researched emotional states like disgust, and integrating AI-driven models for adaptive emotional response [Eid and Al Osman - 2016…MacLean - 2022 - Design….]
4. How does the study of multimodal affective stimuli inform the design of haptic systems?
   a. Answer: Insights from multimodal studies, such as those exploring the synergy between auditory and haptic signals, suggest that combining sensory modalities can create more immersive and emotionally resonant systems, especially for public emotions [Christensen - 2015 - Em…Eid and Al Osman - 2016….]
5. What ethical considerations should guide future research in affective haptics?
   a. Answer: Ethical considerations include ensuring user privacy, obtaining informed consent for emotion data collection, minimizing potential emotional manipulation, and addressing biases in emotional recognition algorithms [Vyas et al. - 2023 - A …Eid and Al Osman - 2016….]