
Representing and Interpreting Affective Data

Muhammad Umair
Lancaster University
Lancaster, UK
m.umair@lancaster.ac.uk

Abstract

Affective health and well-being is a growing area of research within HCI. My research explores interactions with physiological signals capturing human affect. In particular, I develop alternative representations of affective data leveraging material properties of smart materials and actuators to create awareness and regulation of affect in daily lives.

Author Keywords

Affective Health; biofeedback; smart materials; haptics; emotion regulation

CCS Concepts

•**Human-centered computing** → **Human computer interaction (HCI)**; *Haptic devices*; User studies; Please use the 2012 Classifiers and see this link to embed them in the text: https://dl.acm.org/ccs/ccs_flat.cfm

Introduction

Emotions are vital part of our everyday lives. They have strong influence on the decisions we make and the way we interact with our surroundings but are sometimes difficult to understand and control. This is reflected in the prevalence of affective disorders e.g. depression, estimated to be the highest-ranking cause of disease in the Western world [16]. How connected are we with our own emotions? Can being aware of our emotional state help us better un-

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s).

Copyright held by the owner/author(s).
DIS'20, July 6–20, 2020, Eindhoven, Netherlands
ACM 978-1-4503-6819-3/20/04.
<https://doi.org/10.1145/3334480.XXXXXXX>

derstand ourselves or make better decisions? Despite the adaptive value of emotions for signalling events of significance, emotional awareness and regulation, i.e. knowing our emotions, and how we can control them, are complex skills that many people find difficult to acquire. But how can emotional states be best communicated to ensure that they are well understood and reflected on?

To answer these questions, increasing HCI work has focused on technologies for affective feedback in both clinical and non-clinical settings. Such work aims to invite reflection on bodily data [19, 10, 25, 21, 4, 13, 8], regulate ongoing emotions [31, 1, 11, 12, 14] or cultivate mindfulness [22, 27, 18, 34, 33, 20, 23] and relaxation [5, 9, 15, 32] by providing interactive feedback mirroring physiological signals. When representing affect, previous research used time-series graphs [6] and abstract visualizations [21, 28, 4, 25] through a variety of biosensors on mobile and desktop based interfaces. Unlike the predominant focus on screen-based displays, an emerging body of research has started to move away from traditional displays and explored feedback on affective data through different materials such as paper, clothing, shape-changing surfaces, ambient feedback and haptic actuators [1, 14, 7, 35, 24, 36]. The goal of such work is to provide real-time, subtle feedback that can be used in everyday life settings.

I draw upon the importance of materiality of different forms of digital data [3] by engaging in an exploration of such materials in supporting feedback on biosensory data and shaping people's interpretations. I employed a research through design material exploration [26] consisting of a playful and tinkering approach [17] to discover novel material properties of different materials and actuators. Due to its suitability to support imaginative exploration of novel designs, and potential emphasis on the body, research through design

has been employed in both e-textiles [2] and wearable artifacts [28]. My research advances the exploration of embodied metaphors by exploring both different materials and actuators for creating affective interfaces in both lab and everyday life settings. My aim is to create low-cost, simple prototypes to support engagement with, and understanding of real-time changes bodily signals. For this, I am exploring both the biosensors for capturing physiological parameters i.e. movement, breathing, arousal and valence, as well as different materials and actuators for metaphorical representations of biosensory data. I anticipate that symbolic self-representations based on biosensory data will not only allow people to see their bodily reactions in real-time but facilitate an embodied awareness that may motivate a better sense of self, reflection and regulation on personal affective data. Below I present some of my work on using thermochromic and haptic materials for representing skin conductance data.

Wearable Smart Materials and Actuators for Affective Chronometry in Daily Life

By exploring thermochromic materials and actuators, I developed six wrist-worn prototypes that communicate physiological arousal through slow and fast changing colors, vibrations, gentle squeeze and heat on the wrist [30]. We engaged with 12 people who wore the prototypes for 2 days. Our findings show that prototypes helped participants in paying attention to the self, identify emotional responses, identify the source and control emotional responses. Moreover, all representations supported awareness of how participants' emotional responses unfold in time, however in different ways.

A Toolkit for Prototyping Visual Representations of Physiological Arousal

Considering strong benefits from involving users in design of technologies, we developed a toolkit containing digital and physical materials for fabricating interactive thermochromic displays [29]. The toolkit was evaluated through workshops with 20 participants with limited experience of prototyping with biosensors and thermochromic materials, who created personalized representations of physiological arousal through hybrid crafting. Our findings highlight participants playfully explored the material qualities while personalizing the interfaces which helped in understanding of inner workings of the technology. We found key motivations for designing the interfaces and representation of arousal are awareness and regulation of negative arousal.

Emotion Regulation using Haptics

Currently, I am exploring haptic actuators for example, vibration, heat and cool patterns, shape changing and smart materials in addition to visual feedback. Haptic feedback patterns has ability to subtly influence users shifting their attention to the self. I am interested in using heart rate variability features to determine regulation of autonomic balance and haptic biosensory feedback coupled with visual information for regulation of affect in daily life.

Acknowledgements

This work has been supported by AffecTech: Personal Technologies for Affective Health, by the H2020 Marie Skłodowska-Curie GA No 722022.

REFERENCES

- [1] Jean Costa, Alexander T. Adams, Malte F. Jung, François Guimbretière, and Tanzeem Choudhury. 2016. EmotionCheck: Leveraging Bodily Signals and False Feedback to Regulate Our Emotions. In *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp '16)*. ACM, New York, NY, USA, 758–769. DOI : <http://dx.doi.org/10.1145/2971648.2971752>
- [2] Laura Devendorf, Joanne Lo, Noura Howell, Jung Lin Lee, Nan-Wei Gong, M. Emre Karagozler, Shiho Fukuhara, Ivan Poupyrev, Eric Paulos, and Kimiko Ryokai. 2016. "I Don'T Want to Wear a Screen": Probing Perceptions of and Possibilities for Dynamic Displays on Clothing. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*. ACM, New York, NY, USA, 6028–6039. DOI : <http://dx.doi.org/10.1145/2858036.2858192>
- [3] Paul Dourish and Melissa Mazmanian. 2011. Media as material: Information representations as material foundations for organizational practice. In *Third international symposium on process organization studies*. 92.
- [4] Pedro Ferreira, Pedro Sanches, Kristina Höök, and Tove Jaensson. 2008. License to Chill!: How to Empower Users to Cope with Stress. In *Proceedings of the 5th Nordic Conference on Human-computer Interaction: Building Bridges (NordiCHI '08)*. ACM, New York, NY, USA, 123–132. DOI : <http://dx.doi.org/10.1145/1463160.1463174>
- [5] Asma Ghandeharioun and Rosalind Picard. 2017. BrightBeat: Effortlessly Influencing Breathing for Cultivating Calmness and Focus. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '17)*. ACM, New York, NY, USA, 1624–1631. DOI : <http://dx.doi.org/10.1145/3027063.3053164>

- [6] Victoria Hollis, Artie Konrad, Aaron Springer, Matthew Antoun, Christopher Antoun, Rob Martin, and Steve Whittaker. 2017. What Does All This Data Mean for My Future Mood? Actionable Analytics and Targeted Reflection for Emotional Well-Being. *Hum.-Comput. Interact.* 32, 5-6 (Nov. 2017), 208–267. DOI : <http://dx.doi.org/10.1080/07370024.2016.1277724>
- [7] Noura Howell, Laura Devendorf, Tomás Alfonso Vega Gálvez, Rundong Tian, and Kimiko Ryokai. 2018. Tensions of Data-Driven Reflection: A Case Study of Real-Time Emotional Biosensing. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. ACM, New York, NY, USA, Article 431, 13 pages. DOI : <http://dx.doi.org/10.1145/3173574.3174005>
- [8] Ellen Isaacs, Artie Konrad, Alan Walendowski, Thomas Lennig, Victoria Hollis, and Steve Whittaker. 2013. Echoes from the Past: How Technology Mediated Reflection Improves Well-being. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '13)*. ACM, New York, NY, USA, 1071–1080. DOI : <http://dx.doi.org/10.1145/2470654.2466137>
- [9] George (Poonkhin) Khut. 2016. Designing Biofeedback Artworks for Relaxation. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '16)*. ACM, New York, NY, USA, 3859–3862. DOI : <http://dx.doi.org/10.1145/2851581.2891089>
- [10] Madelene Lindström, Anna Ståhl, Kristina Höök, Petra Sundström, Jarmo Laakso, Marco Combetto, Alex Taylor, and Roberto Bresin. 2006. Affective Diary: Designing for Bodily Expressiveness and Self-reflection. In *CHI '06 Extended Abstracts on Human Factors in Computing Systems (CHI EA '06)*. ACM, New York, NY, USA, 1037–1042. DOI : <http://dx.doi.org/10.1145/1125451.1125649>
- [11] Adam Lobel, Marientina Gotsis, Erin Reynolds, Michael Annetta, Rutger C.M.E. Engels, and Isabela Granic. 2016. Designing and Utilizing Biofeedback Games for Emotion Regulation: The Case of Nevermind. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '16)*. ACM, New York, NY, USA, 1945–1951. DOI : <http://dx.doi.org/10.1145/2851581.2892521>
- [12] Diana MacLean, Asta Roseway, and Mary Czerwinski. 2013. MoodWings: A Wearable Biofeedback Device for Real-time Stress Intervention. In *Proceedings of the 6th International Conference on Pervasive Technologies Related to Assistive Environments (PETRA '13)*. ACM, New York, NY, USA, Article 66, 8 pages. DOI : <http://dx.doi.org/10.1145/2504335.2504406>
- [13] Daniel McDuff, Amy Karlson, Ashish Kapoor, Asta Roseway, and Mary Czerwinski. 2012. AffectAura: An Intelligent System for Emotional Memory. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '12)*. ACM, New York, NY, USA, 849–858. DOI : <http://dx.doi.org/10.1145/2207676.2208525>

- [14] Pardis Miri, Robert Flory, Andero Uusberg, Helen Uusberg, James J. Gross, and Katherine Isbister. 2017. HapLand: A Scalable Robust Emotion Regulation Haptic System Testbed. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '17)*. ACM, New York, NY, USA, 1916–1923. DOI : <http://dx.doi.org/10.1145/3027063.3053147>
- [15] Angela M. Morrow, K L O Burton, Melissa M Watanabe, Benjamin H Cloyd, and George Poonkhin Khut. 2018. Developing BrightHearts: A Pediatric Biofeedback-Mediated Relaxation App to Manage Procedural Pain and Anxiety. *Pain practice : the official journal of World Institute of Pain* 18 6 (2018), 698–708.
- [16] World Health Organization. 2013. Comprehensive Mental Health Action Plan 2013-2020. *Geneva: World Health Organization* (2013).
- [17] Stefano Parisi, Valentina Rognoli, and Marieke Sonneveld. 2017. Material Tinkering. An inspirational approach for experiential learning and envisioning in product design education. *The Design Journal* 20, sup1 (2017), S1167–S1184.
- [18] Joan Sol Roo, Renaud Gervais, Jeremy Frey, and Martin Hachet. 2017. Inner Garden: Connecting Inner States to a Mixed Reality Sandbox for Mindfulness. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. ACM, New York, NY, USA, 1459–1470. DOI : <http://dx.doi.org/10.1145/3025453.3025743>
- [19] Joan Sol Roo, Renaud Gervais, and Martin Hachet. 2016. Inner Garden: An Augmented Sandbox Designed for Self-Reflection. In *Proceedings of the TEI '16: Tenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '16)*. ACM, New York, NY, USA, 570–576. DOI : <http://dx.doi.org/10.1145/2839462.2856532>
- [20] Kavous Salehzadeh Niksirat, Chaklam Silpasuwanchai, Mahmoud Mohamed Hussien Ahmed, Peng Cheng, and Xiangshi Ren. 2017. A Framework for Interactive Mindfulness Meditation Using Attention-Regulation Process. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. ACM, New York, NY, USA, 2672–2684. DOI : <http://dx.doi.org/10.1145/3025453.3025914>
- [21] Pedro Sanches, Kristina Höök, Elsa Vaara, Claus Weymann, Markus Bylund, Pedro Ferreira, Nathalie Peira, and Marie Sjölander. 2010. Mind the Body!: Designing a Mobile Stress Management Application Encouraging Personal Reflection. In *Proceedings of the 8th ACM Conference on Designing Interactive Systems (DIS '10)*. ACM, New York, NY, USA, 47–56. DOI : <http://dx.doi.org/10.1145/1858171.1858182>
- [22] Eunbi Seol, Seulki Min, Sungho Seo, Seoyeon Jung, Youngil Lee, Jaedong Lee, Gerard Kim, Chungyeon Cho, Seungmoo Lee, Chul-Hyun Cho, Seungmoon Choi, and Dooyoung Jung. 2017. "Drop the Beat": Virtual Reality Based Mindfulness and Cognitive Behavioral Therapy for Panic Disorder — a Pilot Study. In *Proceedings of the 23rd ACM Symposium on Virtual Reality Software and Technology (VRST '17)*. ACM, New York, NY, USA, Article 57, 3 pages. DOI : <http://dx.doi.org/10.1145/3139131.3141199>
- [23] Christopher D Shaw, Diane Gromala, and A Fleming Seay. 2007. The meditation chamber: Enacting autonomic senses. *Proc. of ENACTIVE/07* (2007).

- [24] Jaime Snyder, Mark Matthews, Jacqueline Chien, Pamara F Chang, Emily Sun, Saeed Abdullah, and Geri Gay. 2015. Moodlight: Exploring personal and social implications of ambient display of biosensor data. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*. ACM, 143–153.
- [25] Anna Ståhl, Kristina Höök, Martin Svensson, Alex S. Taylor, and Marco Combetto. 2009. Experiencing the Affective Diary. *Personal Ubiquitous Comput.* 13, 5 (June 2009), 365–378. DOI : <http://dx.doi.org/10.1007/s00779-008-0202-7>
- [26] Petra Sundström, Elsa Vaara, Jordi Solsona, Niklas Wirström, Marcus Lundén, Jarmo Laaksohata, Annika Waern, and Kristina Höök. 2011. Experiential artifacts as a design method for somaesthetic service development. In *2011 ACM Symposium on Ubiquitous Computing, UbiComp 2011-The Role of Design on UbiComp Research and Practice, RDURP'11, 18 September 2011 through 18 September 2011, Beijing*. 33–36.
- [27] Anja Thieme, Jayne Wallace, Paula Johnson, John McCarthy, Siân Lindley, Peter Wright, Patrick Olivier, and Thomas D. Meyer. 2013. Design to Promote Mindfulness Practice and Sense of Self for Vulnerable Women in Secure Hospital Services. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '13)*. ACM, New York, NY, USA, 2647–2656. DOI : <http://dx.doi.org/10.1145/2470654.2481366>
- [28] Muhammad Umair, Muhammad Hamza Latif, and Corina Sas. 2018. Dynamic Displays at Wrist for Real Time Visualization of Affective Data. In *Proceedings of the DIS 2018 Companion Publication of the 2018 Designing Interactive Systems Conference*. ACM, 201–205.
- [29] Muhammad Umair, Corina Sas, and Miquel Alfaras. 2020. ThermoPixels: Toolkit for Personalizing Arousal-based Interfaces through Hybrid Crafting. In *Proceedings of the 2020 on Designing Interactive Systems Conference (DIS '20)*. Association for Computing Machinery, New York, NY, USA. DOI : <http://dx.doi.org/10.1145/3357236.3395512>
- [30] Muhammad Umair, Corina Sas, and Muhammad Hamza Latif. 2019. Towards Affective Chronometry: Exploring Smart Materials and Actuators for Real-Time Representations of Changes in Arousal. In *Proceedings of the 2019 on Designing Interactive Systems Conference (DIS '19)*. Association for Computing Machinery, New York, NY, USA, 1479–1494. DOI : <http://dx.doi.org/10.1145/3322276.3322367>
- [31] Marieke van Rooij, Adam Lobel, Owen Harris, Niki Smit, and Isabela Granic. 2016. DEEP: A Biofeedback Virtual Reality Game for Children At-risk for Anxiety. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '16)*. ACM, New York, NY, USA, 1989–1997. DOI : <http://dx.doi.org/10.1145/2851581.2892452>
- [32] Chi Thanh Vi and Peng Cheng. Validation of the SWAY app's effects using Electroencephalography. (????).
- [33] Jay Vidyarthi and Bernhard E. Riecke. 2013. Mediated Meditation: Cultivating Mindfulness with Sonic Cradle. In *CHI '13 Extended Abstracts on Human Factors in Computing Systems (CHI EA '13)*. ACM, New York, NY, USA, 2305–2314. DOI : <http://dx.doi.org/10.1145/2468356.2468753>

- [34] Jay Vidyarthi, Bernhard E. Riecke, and Diane Gromala. 2012. Sonic Cradle: Designing for an Immersive Experience of Meditation by Connecting Respiration to Music. In *Proceedings of the Designing Interactive Systems Conference (DIS '12)*. ACM, New York, NY, USA, 408–417. DOI: <http://dx.doi.org/10.1145/2317956.2318017>
- [35] Bin Yu, Rogier Arents, Mathias Funk, Jun Hu, and Loe M.G. Feijs. 2016a. HeartPlotter: Visualizing Bio-data by Drawing on Paper. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '16)*. ACM, New York, NY, USA, 1794–1799. DOI: <http://dx.doi.org/10.1145/2851581.2892289>
- [36] Bin Yu, Nienke Bongers, Alissa Van Asseldonk, Jun Hu, Mathias Funk, and Loe Feijs. 2016b. LivingSurface: biofeedback through shape-changing display. In *Proceedings of the TEI'16: Tenth International Conference on Tangible, Embedded, and Embodied Interaction*. ACM, 168–175.