

---

# Tactile Band: Accessing Gaze Signals from the Sighted in Face-to-Face Communication

**Shi Qiu**

Eindhoven University of  
Technology  
P. O. Box 513  
5600 MB Eindhoven NL  
SQIU@tue.nl

**Matthias Rauterberg**

Eindhoven University of  
Technology  
P. O. Box 513  
5600 MB Eindhoven NL  
G.W.M.Rauterberg@tue.nl

**Jun Hu**

Eindhoven University of  
Technology  
P. O. Box 513  
5600 MB Eindhoven NL  
J.Hu @tue.nl

**Abstract**

Gaze signals, frequently used by the sighted in social interactions as visual cues, are hardly accessible for low-vision and blind people. A concept is proposed to help the blind people access and react to gaze signals in face-to-face communication. 20 blind and low-vision participants were interviewed to discuss the features of this concept. One feature of the concept is further developed into a prototype, namely Tactile Band, to aim at testing the hypothesis that tactile feedback can enable the blind person to feel attention (gaze signals) from the sighted, enhancing the level of engagement in face-to-face communication. We tested our hypothesis with 30 participants with a face-to-face conversation scenario, in which the blindfolded and the sighted participants talked about a given daily topic. Comments from the participants and the reflection on the experiment provided useful insights for improvements and further research.

**Author Keywords**

Accessibility; eye tracking; visual impairments

**ACM Classification Keywords**

H.5.2. [Information interfaces and presentation]: User Interface, K.4.2 [Computers and Security]: Social Issues – Assistive technologies for persons with disabilities.

Permission to make digital or hard copies of all or part 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 components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from [Permissions@acm.org](mailto:Permissions@acm.org).

TEI '16, February 14-17, 2016, Eindhoven, Netherlands

© 2016 ACM. ISBN 978-1-4503-3582-9/16/02...\$15.00

DOI: <http://dx.doi.org/10.1145/2839462.2856520>

## Introduction

In face-to-face communication, sighted people communicate smoothly through the transmission and interpretation of nonverbal signals, such as eye gaze, facial expressions and gestures. Eye gaze in particular plays an important role in conversation. A common face-to-face conversation can contain a wealth of gazes and mutual gazes, which the sighted people take for granted in their daily routines. A sighted speaker consciously or unconsciously uses gaze or eye contact to communicate with the conversation partner. Through the conversation partner's eyes, she can sense interest, engagement, happiness etc. Gaze signals are frequently used by the sighted in social interactions as visual cues. However, these signals and cues are inaccessible for the blind and hardly accessible for low-vision people. In this paper, we propose a concept to help the blind people access and react to gaze signals in face-to-face communication in user study. 20 blind and low-vision participants were interviewed to discuss the features of this concept. One feature of the concept is further developed into a prototype, namely Tactile Band, to aim at testing the hypothesis that tactile feedback can enable the blind person to feel attention (gaze signals) from the sighted, enhancing the level of engagement in face-to-face communication.

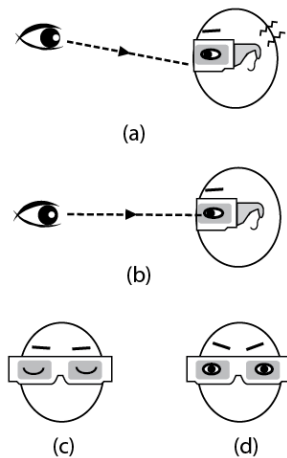
## Related Work

This research draws on theories of gaze behavior and related research on gaze based interfaces. A number of studies have investigated the importance of gaze behaviors of sighted people in social occasions. Argyle studied that in dyadic (two-person) conversations, about 75% of the time people are listening coincides with gazing at the speaker [1]. Kendon suggested that seeking or avoiding looking at the face of the

conversation partner has important functions in dyadic conversations, to regulate the flow of conversation and to communicate emotions and relationships [4]. In recent years, research on gaze based interfaces moves forward with advances in eye tracking technology. Rantala et al. introduced eyeglasses that presented haptic feedback when using gaze gestures for input. The glasses utilized vibrotactile actuators to provide gentle stimulation to three locations on the user's head [7]. Hosobori et al. developed a communication interface namely EyeChime: three participants sit around a table, and sounds were generated and played when participants looked at the other person's face or when the participants' eyes met [3].

## User Study

In our user study, we proposed a conceptual design, E-Gaze glasses, to help blind people access and react to gaze signals, which aims to enhance the engagement between the sighted and the blind people in social interactions. It has two main functions: to help access gaze signals and to react to the sighted by conveying eye gesture signals. Based on these two functions, four features of E-Gaze (Figure 1) were proposed as follows: (a) *gaze detection*, slight vibrations from E-Gaze indicate gazes from the sighted conversation partner; (b) *eye contact simulation*, when the sighted looks at E-Gaze, E-Gaze also looks back to establish "eye contact"; (c) *avoiding state*, if the sighted gazes long enough, E-Gaze looks away to avoid the long gaze; (d) *attention state*, the simulated eyes in E-Gaze opens bigger when the heartrate of the blind person increases, indicating an "attention state". We interviewed 20 blind and low-vision participants (8 females,  $M_{age} = 20.88$ ,  $SD = 1.46$ ; 12 males,  $M_{age} = 19.92$ ,  $SD = 3.42$ ) with ages ranging from 16 to 29



**Figure 1.** E-Gaze: (a) gaze detection; (b) eye contact simulation; (c) avoiding state; (d) attention state.

years old. Ten were from Yang Zhou Special Education School in Chinese mainland and the other ten were from Hong Kong Blind Union. The interviews were conducted online. In the interviews, we explained to participants features of E-Gaze using persona and scenarios. Finally, we collected in total 79 quotes of comments and suggestions about the design of E-Gaze. There were 44 positive responses and 35 negative responses. Example comments are presented as follows:

#### Gaze Detection

In general, the majority of the participants (17/20) felt gaze detection could be beneficial for the blind. One participant said: *"This idea (C1) is good, because we can easily know some people will speak to us"* (P20). However, three participants had negative comments on gaze detection. One of them argued: *"It is not necessary for knowing being looked at. The sighted could come to call your name directly"* (P18).

#### Eye Contact Simulation

Fourteen participants had positive comments on the eye contact simulation while six participants had negative ones. Example positive responses were: *"It is useful at the beginning of the conversation, when expressing the respect to your conversation partner"* (P1). *"The sighted could feel me being polite if E-Gaze has eye contact with them"* (P16). The negative responses were: *"E-Gaze can establish eye contacts with the sighted, but I cannot feel eye contacts"* (P11). *"I feel E-Gaze taking control over me and dominate my feelings. It replaces me to show eye gestures (feelings) to the sighted, which is out of my control"* (P14).

#### Avoiding State

Participants' attitudes towards avoiding state included seven positive responses and thirteen negative responses. An example positive response was: *"It (C3) can be very useful. Nobody liked being gazed at for a long time. It could be a feasible way to stop being gazed"* (P13). The example negative response was: *"The avoiding state causes misunderstanding. The sighted may consider you are not willing to communicate. If you are not patient about talking, you could tell her or change to the other topic."* (P18).

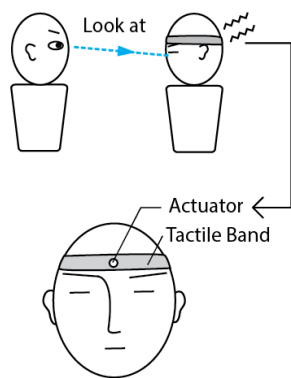
#### Attention State

We collected six positive and fourteen negative responses towards the attention state. P20 expressed his positive opinion: *"It (C4) is interesting to let the sighted talking to you know that you are interested in the topic."* But some participants thought it was unnecessary to have this function. For example: *"The attention state is too artificial and looks like cartoon figures' expression. I prefer natural expressions"* (P9). *"I feel uncomfortable if E-Gaze exposes my attention state. It is my privacy"* (P2).

Based on results of the user study, we clarified our design direction: selecting gaze detection feature for the further design as the first step. Then we developed gaze detection feature to a prototype: the Tactile Band.

#### Preliminary Experiment

The Tactile Band was designed to enable the blind person to feel attention (gaze signals) from the sighted. The hypothesis is that the tactile feedback can enhance the level of engagement in face-to-face communication. In our concept, a wearable eye tracker (SMI Eye



**Figure 2.** Design concept of the Tactile Band



**Figure 3.** The blindfolded and the sighted participants had a conversation in a test.

Tacking Glasses<sup>1</sup>), worn by the sighted, can detect her gazes to the blind person. Gaze signals are mapped to vibration signals of an actuator embedded in the Tactile Band, worn by the blind person on her forehead. The blind person perceives a slight vibration from the Tactile Band as a signal of the sighted looking at her face (Figure 2).

The Tactile Band used a Wizard-of-Oz environment in the preliminary experiment. The wizard (a human observer) observed the real-time eye tracking video from SMI eye tracker and controlled vibration actuator of the Tactile Band. If the gaze hit the facial region of the blindfolded participant, a slight vibration was triggered by the wizard. If the gaze was still in the facial region, slight vibrations with equal intervals were triggered by the wizard. The vibration stopped when gaze was out of the facial region.

A within-subject design was conducted and it included one independent variable with three levels (no Tactile Band, Tactile Band without vibrations & Tactile Band with vibrations) and one dependent variable (engagement in a conversation). The level of engagement was measured with two subjective measures: relationship quality (IMI: Intrinsic Motivation Inventory questionnaire) [5] and partner closeness (IOS: The Inclusion of Other in the Self Scale) [2]. IMI included 45 items, assigned to 7 subscales. We were particularly interested in participants' mutual relationship in conversations. Therefore, we chose one subscale: relatedness (8 items), included the item like *"It is likely that this person and I could become friends if we interacted a lot"*. IOS Scale was used to measure

<sup>1</sup> <http://www.smivision.com/>

the closeness. It included seven increasingly overlapping circle pairs, which could indicate the distance of the relationship between themselves and their conversation partners.

The participants were 30 student volunteers from Eindhoven University of Technology (11 females,  $M_{age} = 29.73$ ,  $SD = 5.69$ ; 19 males,  $M_{age} = 28.16$ ,  $SD = 2.17$ ) with ages ranging from 21 to 42. They were paired randomly to have dyadic conversations and one of them was blindfolded (Figure 3). Three conversations were taken under the following experimental conditions for the blindfolded in a random order: (I) no Tactile Band; (J) Tactile Band without vibrations; (K) Tactile Band with vibrations. Before each conversation, one topic was randomly picked from 14 daily topics from IELTS oral exams included the item like *"Describe a job you have done"*. Participants were asked to share ideas about the topic. Each conversation lasted around 10 minutes and after each conversation, participants were asked to answer a post-experimental questionnaire. After three conversations and post-experimental questionnaires, we did a short interview to collect the blindfolded participant's comments and suggestions towards the Tactile Band. Each conversation was video-taped and the interview was audio-tapped. The overall experiment lasted approximately 90-120 minutes.

## Results

We used SPSS for the data analysis. The conversation quality was analyzed using RM-ANOVA with relationship quality and partner closeness as within-subject factors. Table 1 presents mean and standard deviation of relatedness and partner closeness across three conditions. Before running RM-ANOVA, we checked the data for violations of parametric analysis: the sphericity

	I (N=30)		J (N=30)		K (N=30)	
	M	SD	M	SD	M	SD
<b>R</b>	5.58	0.86	5.71	0.71	5.59	0.87
<b>P</b>	3.07	1.14	3.17	1.15	3.17	0.87

**Table 1.** Mean and standard deviation of relatedness (R) and partner closeness (P) across three experimental conditions: (I) no Tactile Band; (J) Tactile Band with no vibration; (K) Tactile Band with vibration.

assumption was tested using Mauchly's test. There were no significant effects of relatedness  $F(2, 56) = 0.64, p = 0.53$ , and partner closeness  $F(2, 56) = 0.20, p = 0.82$  in three conditions. Since the blindfolded participants wore the Tactile Band, their comments and suggestions towards the Tactile Band were analyzed. Total 70 quotes of user comments were collected and they were merged into three categories: the modality (20 quotes), the prototype (31 quotes) and suggestions (19 quotes).

#### *The modality*

Comments of the vibration feedback were gathered from the result of the question: *"What do you think about the vibration feedback, when your conversation partner looks at your face?"* Two participants (P3, P11) mentioned they could not immediately map the vibration to the gaze signal in conversations. The other participant (P10) explained in the beginning the vibration feedback helped her concentrate on the conversation partner, but after while it became just a subtle clue that she often neglected.

#### *The prototype*

We asked participants two open questions: *"Which aspects make you like /dislike the Tactile Band?"* Six participants liked the Tactile Band. The example comments were: *"The Tactile Band did not feel interfering too much. It was easy to wear and it had subtle cues."* *"It was used quite soft material, which was comfortable to the skin."* (P10, P14) Some participants also explained why they disliked the Tactile Band. The primary reason was they disliked having the Tactile Band on the head. The example comment was: *"The head feels like a scary location for such direct*

*vibrations. It might also be obtrusive for the conversation partner."* (P14)

#### *Suggestions*

We received suggestions for improving the Tactile Band in two directions: try other modalities to map gaze signals and improve the wearability of the Tactile Band. As for other modalities, two participants stated temperature changes could map to gaze signals. For example: the soft warmth on eyes indicated a kind of the close feeling (P15). Other participants mentioned cue tone, soft touch and different intensity of the vibration. For the wearability of the Tactile Band, participants gave many suggestions and the top three were: at hand, around the arm and using the mobile device, where were more invisible during the conversation.

#### **Discussion**

We get useful implications for further improvements in both the design and the experiment: improve the prototype such as the wearability, redesign the scenario in the experiment and give more time to the participants to get used to mapping between gaze signals and tactile signals.

According to the observations and user comments, we need to improve the wearability of the Tactile Band. For example, it could be worn on the wrist, which is less visible than on the forehead. The intensity of the tactile feedback could be fine-tuned. Other types of tactile feedback can also be explored besides vibration, such as a sense of pressure by changing the shape of the material.

Besides the improvements of the prototype, redesigning the scenario in our experiment is also needed. In interviews, some blindfolded participants expressed several alternative contexts in which they would find them to be more useful. For example, a slight vibration (gaze) signal from the conversation partner predicts the start of the conversation to help them be more concentrated. We also consider in turn-taking, eye gaze plays an important role as it indicates where the speaker's focus of attention is directed. An alternative scenario can be that, one sighted speaker discusses with two blindfolded participants in triadic (three-person) conversations. The sighted stops talking and gives her turn to one of two blindfolded listeners by the gaze signal.

Spending more time in learning the mapping between gaze signals and tactile signals may be helpful. The blindfolded participants knew the importance of the gazes and they had the direct and clear understanding of gaze behaviors. However, gaze is a visual cue in their perception. It will take some time, even a long-term training for them to map gaze signals to tactile signals, which is unnatural for them. As for the blind people, we found they tend to have the indirect and fuzzy understanding of eyes and gazes [6]. They knew the importance of gazes from descriptions in novels or by others. Mapping gazes with tactile signals is a new experience for them, which is likely to require more time for practicing to get used to.

### Conclusion

In the experiment, we get useful insights and design implications. The prototype needs to be improved with the wearability with fine-tuned intensity of the tactile feedback. Other feedback can also be explored such as

the cue tone or the sense of pressure caused by the shape changing of material. We also find the approach of adopting blindfolded participants have some limitations. In our future work, we will involve some blind participants in testing the prototype.

### Acknowledgements

This research is supported by the China Scholarship Council and facilitated by Eindhoven University of Technology.

### References

1. Michael Argyle. (1994). *The psychology of interpersonal behaviour*. Penguin UK.
2. Arthur Aron, Elaine N. Aron, and Danny Smollan. (1992). Inclusion of Other in the Self Scale and the structure of interpersonal closeness. *Journal of Personality and Social Psychology*, 63(4), 596.
3. Asako Hosobori and Yasuaki Kakehi. (2014). Eyefeel & EyeChime: a face to face communication environment by augmenting eye gaze information. In *Proceedings of the 5th Augmented Human International Conference (AH 2014)*, 7-10.
4. Adam Kendon. (1967). Some functions of gaze-direction in social interaction. *Acta Psychologica*, 26(1), 22-63.
5. Edward McAuley, Terry Duncan, and Vance V. Tammen. (1989). Psychometric properties of the Intrinsic Motivation Inventory in a competitive sport setting: A confirmatory factor analysis. *Research Quarterly for Exercise and Sport*, 60(1), 48-58.
6. Shi Qiu, Jun Hu, and Matthias Rauterberg. (2015). Nonverbal Signals for Face-to-Face Communication between the Blind and the Sighted. In *Proceedings of International Conference on Enabling Access for Persons with Visual Impairment (ICEAVPI 2015)*, 157-165.

7. Jussi Rantala, Jari Kangas, Deepak Akkil, Poika Isokoski, and Roope Raisamo. (2014). Glasses with haptic feedback of gaze gestures. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'14)*, 1597–1602.





**TENTH ANNIVERSARY CONFERENCE ON TANGIBLE  
EMBEDDED AND EMBODIED INTERACTION**



# **Proceedings of the Tenth Anniversary Conference on Tangible Embedded and Embodied Interaction**

14-17 February 2016, Eindhoven, the Netherlands

Conference Chairs: Saskia Bakker, Caroline Hummels, Brygg Ullmer

Program Chairs: Luc Geurts, Bart Hengeveld, Daniel Saakes

Publications Chair: Mendel Broekhuijsen

Sponsors:

Eindhoven University of Technology, Koninklijke Nederlandse Akademie van Wetenschappen,  
Fontys Eindhoven, Microsoft Research, Tangible Display





**Association for  
Computing Machinery**

**The Association for Computing Machinery**

**2 Penn Plaza, Suite 701**

**New York, New York 10121-0701**

Copyright © 2016 by the Association for Computing Machinery, Inc. (ACM). Permission to make digital or hard copies of portions 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. Copyright for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, to republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.

Request permission to republish from: [permissions@acm.org](mailto:permissions@acm.org) or Fax +1 (212) 869-0481.

For other copying of articles that carry a code at the bottom of the first or last page, copying is permitted provided that the per-copy fee indicated in the code is paid through [www.copyright.com](http://www.copyright.com).

**Notice to Past Authors of ACM-Published Articles**

ACM intends to create a complete electronic archive of all articles and/or other material previously published by ACM. If you have written a work that has been previously published by ACM in any journal or conference proceedings prior to 1978, or any SIG Newsletter at any time, and you do NOT want this work to appear in the ACM Digital Library, please inform [permissions@acm.org](mailto:permissions@acm.org), stating the title of the work, the author(s), and where and when published.

**ISBN:** 978-1-4503-3582-9

Additional copies may be ordered prepaid from:

**ACM Order Department**

PO Box 30777

New York, NY 10087-0777, USA

Phone: 1-800-342-6626 (USA and Canada)

+1-212-626-0500 (Global)

Fax: +1-212-944-1318

E-mail: [acmhelp@acm.org](mailto:acmhelp@acm.org)

Hours of Operation: 8:30 am – 4:30 pm ET



**SIGCHI**

# TEI'16 Chairs' Welcome

Welcome to ACM TEI'16, the 10<sup>th</sup>-anniversary edition of the International Conference on Tangible, Embedded and Embodied Interaction, hosted at Eindhoven University of Technology, the Netherlands from February 14th to February 17th, 2016.

This year's conference marks TEI's tenth anniversary. We see this as a perfect opportunity for recalling some of our founding values and complementing these with contemporary values, for reemphasizing the relationship between interactive products and systems and the body, and for learning from each other's approaches and rationales. To do this, we have established the theme '**Our Body Is Our Manual**': As the interactions we propose in our products and systems are aimed to inform our embodied selves, we should also allow ourselves to be informed by our bodies when designing and researching these interactions. Through a wide palette of work ranging from highly technical to highly artistic, and from highly applied to highly conceptual or theoretical, we wish to trigger discussion and reflection, with the aim of emphasizing what binds us.

TEI'16 hosts a four-day program, starting out with the **Graduate Student Consortium** and a series of **Studio-Workshops** that embody the essence of our community by offering intellectual and practical experiences to conference attendees with diverse skills and backgrounds. The main program is kicked off by **Takeo Igarashi**, who in his opening keynote discusses computer tools that allow end users control over the design of artifacts in their lives. After the opening keynote, the Papers track commences, in a slightly different set up than before. This year we do not include Q&As in the presentations but instead wrap up each session with a reflective discussion between the presenters. The day concludes with the **Demos, Posters** and **Work-In-Progress** exhibition. From day two until day four the **Art Exhibition** questions and frames the impact of new technologies on our lives and proposes new modes of embodiment. Following day three's Papers sessions we host a full afternoon of **Studio-Workshops**, engaging all TEI attendees in active, hands-on discussions. Day four includes three Papers sessions, a lunch lecture and panel discussion, and the closing keynote by **Tom Djajadiningrat**, who reconsiders tangible interaction by discussing new technologies, illustrated through examples by Philips Design.

This year we received 178 submissions to the Papers track, which were all equally subjected to a double-blind peer review process of at least three reviewers and a meta-reviewer. A total of 45 accepted papers makes for an acceptance rate of 25%. For the Work-in-Progress track we received 100 submissions, which were subjected to a double-blind peer review process of two reviewers each. This resulted in 40 accepted submissions, making for an acceptance rate of 40%.

Of course, organizing this conference could not have been possible without the energy and commitment of many, many people. We would like to thank everyone who contributed to TEI'16: the authors for submitting their quality work to the conference, all the organizing committee chairs for managing their part of the conference, the program committee and external reviewers for safeguarding the quality of the conference, the local organizing committee, the sponsors, supporters and partners, and the TEI steering committee.

*We wish you a great conference!*

## Conference Chairs

**Saskia Bakker**

*Eindhoven University of Technology (NL)*

**Caroline Hummels**

*Eindhoven University of Technology (NL)*

**Brygg Ullmer**

*Louisiana State University (USA)*

## Program Chairs

**Luc Geurts**

*KU Leuven (Belgium)*

**Bart Hengeveld**

*Eindhoven University of Technology (NL)*

**Daniel Saakes**

*KAIST (Korea)*

# Table of Contents

<b>TEI'16 Conference Organizers.....</b>	<b>XIII</b>
<b>TEI'16 Program Committee &amp; Reviewers.....</b>	<b>XV</b>
<b>TEI'16 Sponsors.....</b>	<b>XXII</b>

## Keynote Addresses

<b>Design Everything By Yourself. User Interfaces For Graphics, Cad Modeling, And Robots.....</b>	<b>1</b>
<i>Takeo Igarashi (University of Tokyo)</i>	
<b>Inherently Meaningful.....</b>	<b>2</b>
<i>Tom Djajadiningrat (Philips Design)</i>	

## Paper Session 1: Stuff That Works

*Session Chair: Peter Bennett*

<b>Navigation of Pitch Space on a Digital Musical Instrument with Dynamic Tactile Feedback.....</b>	<b>3</b>
<i>Robert Jack, Tony Stockman, Andrew McPherson</i>	
<b>MobiSweep: Exploring Spatial Design Ideation Using a Smartphone as a Hand-held Reference Plane .....</b>	<b>12</b>
<i>Vinayak Vinayak, Devarajan Ramanujan, Cecil Piya, Karthik Ramani</i>	
<b>TMotion: Embedded 3D Mobile Input using MagneticSensing Technique .....</b>	<b>21</b>
<i>Sang Ho Yoon, Ke Huo, Karthik Ramani</i>	
<b>DataSpoon: Overcoming Design Challenges in Tangible and Embedded Assistive Technologies.....</b>	<b>30</b>
<i>Oren Zuckerman, Tamar Gal, Tal Keren-Capelovitch, Tal Krasovsky, Ayelet Gal-Oz, Tamar Weiss</i>	
<b>T4Tags 2.0: A Tangible System for Supporting Users' Needs in the Domestic Environment.....</b>	<b>38</b>
<i>Andrea Vianello, Yves Florack, Andrea Bellucci, Giulio Jacucci</i>	

## Paper Session 2: Share, Show And Tell

*Session Chair: Vero Vanden Abeele*

<b>Interactive Jewellery: a design exploration .....</b>	<b>44</b>
<i>Maarten Versteeg, Elise van den Hoven, Caroline Hummels</i>	
<b>Technologies for Everyday Life Reflection: Illustrating a Design Space.....</b>	<b>53</b>
<i>Ine Mols, Elise van den Hoven, Berry Eggen</i>	

<b>Towards a Framework for Tangible Narratives .....</b>	<b>62</b>
<i>Daniel Harley, Jean Ho Chu, Jamie Kwan, Ali Mazalek</i>	

<b>Designing the Behavior of Interactive Objects.....</b>	<b>70</b>
<i>Marco Spadafora, Victor Chahunea, Nikolas Martelaro, David Sirkin, Wendy Ju</i>	

<b>Ideating in Skills: Developing tools for embodied co-design .....</b>	<b>78</b>
<i>Dorothe Smit, Doenja Oogjes, Bruna Goveia de Rocha, Ambra Trotto, Yeup Hur, Caroline Hummels</i>	

### **Paper Session 3: What Your Body Can Do For You**

*Session Chair: Katrin Wolf*

<b>Modifying Gesture Elicitation: Do Kinaesthetic Priming and Increased Production Reduce Legacy Bias?.....</b>	<b>86</b>
<i>Lynn Hoff, Eva Hornecker, Sven Bertel</i>	

<b>If Your Mind Can Grasp It, Your Hands Will Help .....</b>	<b>92</b>
<i>Simon Stusak, Moritz Hobe, Andreas Butz</i>	

<b>Exploring the Aesthetic of Tangible Interaction: Experiments on the Perception of Hybrid Objects.....</b>	<b>100</b>
<i>Daniela Petrelli, Alessandro Soranzo, Luigina Ciolfi, John Reidy</i>	

<b>The Aesthetics of Heat: Guiding Awareness with Thermal Stimuli .....</b>	<b>109</b>
<i>Martin Jonsson, Anna Ståhl, Johanna Mercurio, Anna Karlsson, Naveen Ramani, Kristina Höök</i>	

<b>Substituting Color for Haptic Attributes in Conceptual Metaphors for Tangible Interaction Design .....</b>	<b>118</b>
<i>Diana Löffler, Lennart Arlt, Takashi Toriizuka, Robert Tscharn, Joern Hurtienne</i>	

### **Paper Session 4: When Learning Is Tough**

*Session Chair: Patrizia Marti*

<b>It Could Just as Well Have Been in Greek: Experiences from Introducing Code as a Design Material to Exhibition Design Students .....</b>	<b>126</b>
<i>Jennie Schaeffer, Rikard Lindell</i>	

<b>A Tangible Embedded Programming System to Convey Event-Handling Concept .....</b>	<b>133</b>
<i>Danli Wang, Lan Zhang, Chao Xu, Haichen Hu, Yunfeng Qi</i>	

<b>SynFlo: A Tangible Museum Exhibit for Exploring Bio-Design.....</b>	<b>141</b>
<i>Johanna Okerlund, Evan Segreto, Casey Grote, Lauren Westendorf, Anja Scholze, Romie Littrell, Orit Shaer</i>	

<b>Engaging 'At-Risk' Students through Maker Culture Activities.....</b>	<b>150</b>
<i>Sowmya Somanath, Laura Morrison, Janette Hughes, Ehud Sharlin, Mario Costa Sousa</i>	

<b>Using Tangible Smart Replicas as Controls for an Interactive Museum Exhibition .....</b>	<b>159</b>
<i>Mark Marshall, Nick Dulake, Luigina Ciolfi, Daniele Duranti, Hub Kockelkorn, Daniela Petrelli</i>	

## Paper Session 5: Keep In Shape

Session Chair: Tek Jin Nam

<b>LivingSurface: Biofeedback through Shape-changing Display .....</b>	<b>168</b>
<i>Bin Yu, Nienke Bongers, Alissa van Asseldonk, Jun Hu, Mathias Funk, Loe Feijs</i>	
<b>Tangible Viewports: Getting Out of Flatland in Desktop Environments.....</b>	<b>176</b>
<i>Renaud Gervais, Joan Sol Roo, Martin Hachet</i>	
<b>ReFlex: A Flexible Smartphone with Active Haptic Feedback for Bend Input.....</b>	<b>185</b>
<i>Paul Strohmeier, Jesse Burstyn, Juan Pablo Carrascal, Vincent Levesque, Roel Vertegaal</i>	
<b>A basic form language for shape-changing interfaces .....</b>	<b>193</b>
<i>Morten Winther, Anna Vallgård</i>	
<b>Balancing user and system control in shape-changing interfaces: a designerly exploration .....</b>	<b>202</b>
<i>Majken Kirkegaard Rasmussen, Timothy Merritt, Miguel Bruns Alonso, Mariane Graves Petersen</i>	

## Paper Session 6: With All Your Forces

Session Chair: Ellen Do

<b>On the Other Hand: Embodied Metaphors for Interactions with Mnemonic Objects in Live Presentations.....</b>	<b>211</b>
<i>Fabian Hemmert, Gesche Joost</i>	
<b>Snake Charmer: Physically Enabling Virtual Objects.....</b>	<b>218</b>
<i>Bruno Araujo, Ricardo Jota, Varum Chadalavada, Jia Xian Yao, Karan Singh, Daniel Wigdor</i>	
<b>TOBE: Tangible Out-of-Body Experience .....</b>	<b>227</b>
<i>Renaud Gervais, J��r��my Frey, Alexis Gay, Fabien Lotte, Martin Hachet</i>	

## Paper Session 7: Not For Kids Only

Session Chair: Panos Markopoulos

<b>From Patchwork to Appliqu��: Reflections from an Interaction Design Remake .....</b>	<b>236</b>
<i>Moa Bergsm��rk, Ylva Fern��us</i>	
<b>Embodied Companion Technologies for Autistic Children.....</b>	<b>245</b>
<i>Katharina Spiel, Julia Makhaeva, Christopher Frauenberger</i>	
<b>SmallTalk: Using Tangible Interactions to Gather Feedback from Children.....</b>	<b>253</b>
<i>Sarah Gallacher, Connie Golsteijn, Yvonne Rogers, Licia Capra, Sophie Eustace</i>	
<b>Tangible Play Objects: Influence of Different Combinations of Feedback Modalities .....</b>	<b>262</b>
<i>Hanneke Hooft van Huysduynen, Linda de Valk, Tilde Bekker</i>	
<b>ChillFish: A Respiration Game for Children with ADHD .....</b>	<b>271</b>
<i>Tobias Sonne, Mads M��ller Jensen</i>	

## Papers: Demos and Posters

<b>Comparing Tangible and Multi-touch Interaction for Interactive Data Visualization Tasks</b> .....	279
<i>Shiroq Al-Megren, Roy A. Ruddle</i>	
<b>Sparse Tangibles: Collaborative Exploration of Gene Networks using Active Tangibles and Interactive Tabletops</b> .....	287
<i>Ahmed Sabbir Arif, Roozbeh Manshaei, Sean Delong, Brien East, Matthew Kyan, Ali Mazalek</i>	
<b>Designing the Vertigo Experience: Vertigo as a Design Resource for Digital Bodily Play</b> .....	296
<i>Richard Byrne, Joe Marshall, Florian 'Floyd' Mueller</i>	
<b>Gleamy: An Ambient Display Lamp with a Transparency-Controllable Shade</b> .....	304
<i>Seijin Cha, Moon-Hwan Lee, Tek-Jin Nam</i>	
<b>Pneumatibles – Exploring Soft Robotic Actuators for the Design of User Interfaces with Pneumotactile Feedback</b> .....	308
<i>Kristian Gohlke, Eva Hornecker, Wolfgang Sattler</i>	
<b>DoDoc: a Composite Interface that Supports Reflection-in-Action</b> .....	316
<i>Pauline Gourlet, Sarah Garcin, Louis Eveillard, Ferdinand Dervieux</i>	
<b>Soft Pillows and the Near and Dear: Physical-to-Abstract Mappings with Image-Schematic Metaphors</b> .....	324
<i>Jörn Hurtienne, Oliver Meschke</i>	
<b>Experience as an Object to Think with: from Sensing-in-action to Making-Sense of action in Full-Body Interaction Learning Environments</b> .....	332
<i>Laura Malinverni, Edith Ackermann, Narcis Pares</i>	
<b>Crafting Mechatronic Percussion with Everyday Materials</b> .....	340
<i>Hyunjoo Oh, Jiffer Harriman, Abhishek Narula, Mark D. Gross, Michael Eisenberg, Sherry Hsi</i>	
<b>Engagement Through Embodiment: A Case For Mindful Interaction</b> .....	349
<i>Vincent van Rheden, Bart Hengeveld</i>	
<b>miMic: The Microphone as a Pencil</b> .....	357
<i>Davide Rocchesso, Davide A. Mauro, and Stefano Delle Monache</i>	
<b>MOR4R: How to Create 3D Objects Using a Microwave Oven</b> .....	365
<i>Kentaro Yasu</i>	

## Work-in-Progress

<b>EmotiPlant: Human-Plant Interaction for Older Adults</b> .....	373
<i>Leonardo Angelini, Stefania Caparrotta, Omar Abou Khaled, Elena Mugellini</i>	
<b>Maketec: A Makerspace as a Third Place for Children</b> .....	380
<i>David Bar-El, Oren Zuckerman</i>	

<b>Functional Demonstrators to Support Understanding of Smart Materials</b> .....	386
<i>Bahareh Barati, Elvin Karana, Kaspar Jansen, Paul Hekkert</i>	
<b>IrukaTact: Submersible Haptic Search Glove</b> .....	392
<i>Aisen C. Chacin, Takeshi Oozu, Hiroo Iwata</i>	
<b>Penseive Box: Themes for Digital Memorialization Practices</b> .....	398
<i>Charu Chaudhari, Anjanakshi Prakash, A.M. Tsaasan, Jed R. Brubaker, Joshua Tanenbaum</i>	
<b>Embodying Alternate Attitudes: Design Opportunities for Physical Interfaces in Persuasive Gaming Experiences</b> .....	404
<i>Emily S Cramer, Brendan B Matkin, Alissa N Antle</i>	
<b>Exploring the Potential of Realtime Haptic Feedback during Social Interactions</b> .....	410
<i>Ionut Damian, Elisabeth André</i>	
<b>Comparing bare-hand-in-air Gesture and Object-in-hand Tangible User Interaction for Navigation of 3D Objects in Modeling</b> .....	417
<i>Sanmathi Dangeti, Yingjie (Victor) Chen, Chunhui Zheng</i>	
<b>Storytime with Hue: An Innovative Approach to Storytelling Where Storytellers Control a Dynamic Lighting Environment</b> .....	422
<i>Catherine Downey, Sherin W. Kamel</i>	
<b>InfoPhys: Direct Manipulation of Information Visualisation through a Force-Feedback Pointing Device</b> .....	428
<i>Christian Frisson, Bruno Dumas</i>	
<b>Making Communication Frequency Tangible: How Green Is My Tree?</b> .....	434
<i>Carolina Fuentes, Iyubanit Rodriguez, Valeria Herskovic</i>	
<b>Code Bits: An Inexpensive Tangible Computational Thinking Toolkit For K-12 Curriculum</b> .....	441
<i>Sidhant Goyal, Rohan S Vijay, Charu Monga, Pratul Kalita</i>	
<b>TASK: Introducing The Interactive Audience Sensor Kit</b> .....	448
<i>Florian Güldenpfennig, Oliver Hödl, Peter Reichl, Christian Löw, Andreas Gartus, Matthew Pelowski</i>	
<b>Toward Thingy Oriented Programming: Recording Marcos With Tangibles</b> .....	455
<i>Florian Güldenpfennig, Daniel Dudo, Peter Purgathofer</i>	
<b>Exploring the Use of Shape Change in Home Appliances</b> .....	462
<i>Frederik Lund Jakobsen, Stefan Michael Pedersen, Jacob Albæk Schnedler, Nikolai Houlberg Øllegaard</i>	
<b>MARCut: Marker-based Laser Cutting for Personal Fabrication on Existing Objects</b> .....	468
<i>Takashi Kikuchi, Yuichi Hiroi, Ross Smith, Bruce Thomas, Maki Sugimoto</i>	



<b>UnicrePaint: Digital Painting through Physical Objects for Unique Creative Experiences .....</b>	<b>475</b>
<i>Mami Kosaka, Kaori Fujinami</i>	
<b>Grasping Cultural Context through Multisensory Interactions.....</b>	<b>482</b>
<i>Jamie Kwan, Jean Ho Chu, Daniel Harley, Melanie McBride, Ali Mazalek</i>	
<b>Exploring SCI as Means of Interaction through the Design Case of Vacuum Cleaning.....</b>	<b>488</b>
<i>Lasse Legaard, Christian Hannesbo Lorentzen, Josephine Raun Thomsen, Jonas Techen</i>	
<b>Four Stories About Feeling Close Over A Distance.....</b>	<b>494</b>
<i>Eva Lenz, Marc Hassenzahl, Wasili Adamow, Patrick Beedgen, Kirstin Kohler, Thies Schneider</i>	
<b>Click: Using Smart Devices For Physical Collaborative Coding Education.....</b>	<b>500</b>
<i>Dixon Lo, Austin Lee</i>	
<b>HandyFeet: Social Bodily Play Via Split Control of a Human Puppet's Limbs.....</b>	<b>506</b>
<i>Robb Mitchell, Andreas Fender, Florian 'Floyd' Mueller</i>	
<b>HydroMorph: Shape Changing Water Membrane for Display and Interaction.....</b>	<b>512</b>
<i>Ken Nakagaki, Pasquale Totaro, Jim Peraino, Thariq Shihpar, Chantane Akiyama, Yin Shuang, Hiroshi Ishii</i>	
<b>Tangible Modeling Methods for Faster Rapid Prototyping .....</b>	<b>518</b>
<i>Satoshi Nakamaru, Jakob Bak, Dhruv Saxena</i>	
<b>Expressing Intent: An Exploration of Rich Interactions .....</b>	<b>524</b>
<i>Rachel Ng, Raghavendra Kandala, Sarah-Marie Foley, Dixon Lo, Molly Steenson and Austin Lee</i>	
<b>Interactive Jewellery as Memory Cue: Designing a Sound Locket for Individual Reminiscence .....</b>	<b>532</b>
<i>Karin Niemantsverdriet, Maarten Versteeg</i>	
<b>Designing a Multi-user Interactive Simulation Using AR Glasses .....</b>	<b>539</b>
<i>Seungjae Oh, Kyudong Park, Soonmo Kwon, Hyo-Jeong So</i>	
<b>MoCap Tango: Traces Of Complexity .....</b>	<b>545</b>
<i>Jeroen Peeters, Ambra Trotto, Stoffel Kuenen</i>	
<b>Functional Interactive Tatting - Bringing Together a Traditional Handicraft and Electronics.....</b>	<b>551</b>
<i>Alan Poole, Anne Poole</i>	
<b>Tactile Band: Accessing Gaze Signals from the Sighted in Face-to-Face Communication .....</b>	<b>556</b>
<i>Shi Qiu, Matthias Rauterberg, Jun Hu</i>	
<b>E-Gaze Glasses: Simulating Natural Gazes for Blind People.....</b>	<b>563</b>
<i>Shi Qiu, Siti Aisyah Anas, Hirotaka Osawa, Matthias Rauterberg, Jun Hu</i>	

<b>Inner Garden: an Augmented Sandbox Designed for Self-Reflection .....</b>	<b>570</b>
<i>Joan Sol Roo, Renaud Gervais, Martin Hachet</i>	
<b>A Tangible Tool for Visual Impaired Users to Learn Geometry .....</b>	<b>577</b>
<i>Lisa Marie Rühmann, Nuno Otero, Ian Oakley</i>	
<b>Cubio: A Low-Budget Platform for Exploring Stackable Interactions .....</b>	<b>584</b>
<i>Marc Teyssier, Pattie Maes, Lucas Silva, Pattie Maes</i>	
<b>The Speaker's Staff: Supporting Remote Multidisciplinary Team Meetings in Hospitals .....</b>	<b>591</b>
<i>Bert Vandenberghe, David Geerts</i>	
<b>MagnetoWear: A Magnetic Wearable Device to Interact With the Smartphone to Perform Personalized Actions .....</b>	<b>597</b>
<i>Rohan S Vijay, Sidhant Goyal</i>	
<b>Present-at-Body Self-Awareness in Equestrians: Exploring Embodied 'Feel' through Tactile Wearables .....</b>	<b>603</b>
<i>Jillian L. Warren, Brendan B. Matkin, Alissa N. Antle</i>	
<b>Designing Sculpting Light Systems for Information Decoration .....</b>	<b>609</b>
<i>Jiang Wu, Harm van Essen, Berry Eggen</i>	
<b>DrawForming: An Interactive Fabrication Method for Vacuum Forming .....</b>	<b>615</b>
<i>Junichi Yamaoka, Yasuaki Kakehi</i>	
<b>KIP3: Robotic Companion as an External Cue to Students with ADHD .....</b>	<b>621</b>
<i>Oren Zuckerman, Guy Hoffman, Daphne Kopelman-Rubin, Anat Brunstein Klomek, Noa Shitrit, Yahav Amsalem, Yaron Shlomi</i>	

## Art Exhibition

<b>The BIODress: A Body-worn Interface for Environmental Embodiment .....</b>	<b>627</b>
<i>Sara Adhitya, Beck Davis, Raune Frankjaer, Patricia Flanagan and Zoe Mahony</i>	
<b>POEME: A Poetry Engine Powered by Your Movement .....</b>	<b>635</b>
<i>Shannon Cuykendall, Ethan Soutar-Rau and Thecla Schiphorst</i>	
<b>Functionality in Wearable Tech: Device, as Jewelry, as Body Mediator .....</b>	<b>641</b>
<i>Alexandra Ju</i>	
<b>Dividual Plays Experimental Lab - An installation derived from Dividual Plays .....</b>	<b>647</b>
<i>Keina Konno, Richi Owaki, Yoshito Onishi, Ryo Kanda, Sheep, Akiko Takeshita, Tsubasa Nishi, Naoko Shiomi, Kyle McDonald, Satoru Higa, Motoi Shimizu, Yosuke Sakai, Yasuaki Kakehi, Kazuhiro Jo, Yoko Ando, Kazunao Abe and Takayuki Ito</i>	
<b>A Flying Pantograph: Interleaving Expressivity of Human and Machine .....</b>	<b>653</b>
<i>Sang-Won Leigh, Harshit Agrawal and Pattie Maes</i>	
<b>What We Have Lost / What We Have Gained: Tangible Interactions between Physical and Digital Bodies .....</b>	<b>658</b>
<i>Matthew Mosher and David Tinapple</i>	

<b>Exploring Bodies, Mediation and Points of View using a Robotic Avatar</b> .....	663
<i>Paul Strohmeier</i>	
<b>Tangible Scores</b> .....	669
<i>Enrique Tomàs</i>	
<b>Heart Calligraphy: an Abstract Portrait Inside the Body</b> .....	675
<i>Bin Yu, Rogier Arents, Jun Hu, Mathias Funk and Loe Feijs</i>	

## Graduate Student Consortium

<b>Crafting Tangible Interaction to Prompt Visitors' Engagement in House Museums</b> .....	681
<i>Caroline Claisse</i>	
<b>Towards Self-Aware Materials</b> .....	685
<i>Artem Dementyev</i>	
<b>Exploring the Design Space of Tangible Systems Supported for Early Reading Acquisition in Children with Dyslexia</b> .....	689
<i>Min Fan, Alissa N. Antle, Emily S. Cramer</i>	
<b>Embodied Spatial Thinking in Tangible Computing</b> .....	693
<i>Brendan Alexander Harmon</i>	
<b>Performance-Led Design of Computationally Generated Audio for Interactive Applications</b> .....	697
<i>Christian Heinrichs, Andrew McPherson</i>	
<b>Designing for the Mindbody in Technology-Mediated Music-Making</b> .....	701
<i>Aura Pon</i>	
<b>Exploring 3D Printed Interaction</b> .....	705
<i>Martin Schmitz</i>	
<b>Designing Posture Monitoring Garments to Support Rehabilitation</b> .....	709
<i>Qi Wang</i>	

## Student Design Challenge

<b>BrainstORB</b> .....	713
<i>Conor Byrne, Evan Healy, Nigel Frahill, Rebecca Power</i>	
<b>Sensole: An Insole-Based Tickle Tactile Interface</b> .....	717
<i>Eric Geißler, Andreas Mühlenberend, Klaus Harnack</i>	
<b>Inflatibits – A Modular Soft Robotic Construction Kit for Children</b> .....	723
<i>Christopher Kopic, Kristian Gohlke</i>	
<b>Whoosh Gloves: Interactive Tool to Form a Dialog Between Dancer and Choreographer</b> .....	729
<i>Svetlana Mironcika, Joanne Pek, Jochem Franse, Ya Shu</i>	

<b>Hulagram: Inspiring Creativity Through Human Movement .....</b>	<b>733</b>
<i>Megan Dalton Rafferty, Danielle Daly, Anthony O'Brien and Craig Fleming</i>	
<b>Tommy Blocks: a modern redesign of the classical children's building blocks .....</b>	<b>738</b>
<i>Riccardo Rigo, Charlotte Kortbeek, Cristian Grama, Denis Laure</i>	
<b>MuSme: A Tangible Skin Suit for Music Creation.....</b>	<b>743</b>
<i>Amal Tidjani, Eileen Cho, Priscilla Lee</i>	

## Studio-Workshops

<b>Designing Tangibles for Children: One Day Hands-on Workshop.....</b>	<b>749</b>
<i>Alissa N. Antle, Jillian L. Warren, Brendan B. Matkin, Min Fan, Emily S. Cramer</i>	
<b>Tangible Data, explorations in data Physicalization.....</b>	<b>753</b>
<i>Trevor Hogan, Eva Hornecker, Simon Stusak, Yvonne Jansen, Jason Alexander, Andrew Vande Moere, Uta Hinrichs, Kieran Nolan</i>	
<b>MeMod: A Modular Hacking And Programming Toolkit For Everyday Objects.....</b>	<b>757</b>
<i>Austin S. Lee, Dhairya Dand</i>	
<b>The Interaction Engine: Tools for Prototyping Connected Devices.....</b>	<b>762</b>
<i>Nikolas Martelaro, Michael Shiloh, Wendy Ju</i>	
<b>TEI 2016 Studio: Inflated Curiosity .....</b>	<b>766</b>
<i>Jifei Ou, Felix Heibeck, Hiroshi Ishii</i>	
<b>Bodily Sketching With Sensable Stretchables .....</b>	<b>770</b>
<i>Alan Poole, Robb Mitchell, Katrin Wolf, Rahimullah Sarban</i>	
<b>Embodying Soft Wearables Research.....</b>	<b>774</b>
<i>Oscar Tomico, Danielle Wilde</i>	
<b>Stereo Haptics: Designing Haptic Interactions using Audio Tools .....</b>	<b>778</b>
<i>Siyan Zhao, Zachary Schwemler, Adam Fritz, Ali Israr</i>	
<b>Developing Responsive and Interactive Environments with the ROSS Toolkit.....</b>	<b>782</b>
<i>Andrea Bellucci, Aneesh P. Tarun, Ahmed Sabbir Arif, Ali Mazalek</i>	
<b>GaussStudio: Designing Seamless Tangible Interactions on Portable Displays.....</b>	<b>786</b>
<i>Rong-Hao Liang, Han-Chih Kuo, Miguel Bruns Alonso, Bing-Yu Chen</i>	
<b>Second Workshop on Full-Body and Multisensory Experience .....</b>	<b>790</b>
<i>Assunta Matassa, Leonardo Angelini, Maurizio Caon, Marianna Obrist, Elena Mugellini</i>	