INTERACTIONS MAY–JUNE 2015 VOLUME XXII.3

Association for Computing Machinery

Beyond Interaction

BY PETER-PAUL VERBEEK

Digitizing Fashion

Fingers, Thumbs, and People

A Guitar That Tells Its Own Life Story

Sharing the Hidden Treasure in Pictorials

Photo: Andrés Lucero | Design: Andrés Lucero, Rodrigo Zuloaga

NATURE MEETS INTERACTIVE SURFACES

ITS 2015

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INTERACTIONS
VOLUME XXII.3

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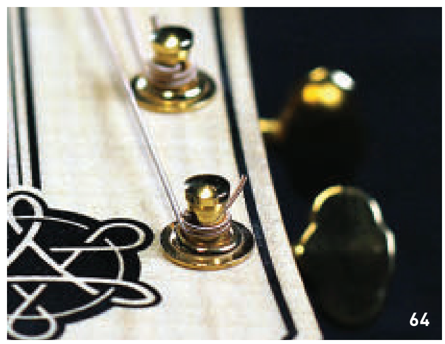
Photograph by Vita Khorzhevska

MIDDLE IMAGE BY VAL LAWLESS; RIGHT IMAGE BY VITA KHORZHEVSKA



SPECIAL TOPIC

FORUMS

DEPARTMENTS

Association for Computing Machinery

LEFT IMAGE BY LILIANA OVALLE; RIGHT IMAGE BY ZHOUXING LU

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Association for Computing Machinery

SIGCHI

Ron Wakkary

Erik Stolterman

HCI in Pictures

Does a picture say more than a thousand words? Well, there is a growing trend in HCI research toward more diverse publication formats, such as exhibitions, videos, and demonstrations. At the DIS 2014 conference, a new format was explored: pictorials. These aimed to fulfill the practice-oriented nature of design by encouraging HCI and design researchers to express and unpack their design practices and research through imagery. In this issue we extend this effort with a Special Topic on pictorials, guest edited by Eli Blevis, Sabrina Hauser, and William Odom.

We are also happy to present a cover story by one of the most recognized contemporary philosophers specializing in technology, Peter-Paul Verbeek. He has attracted a lot of attention in the past few years with his books *What Things Do: Philosophical Reflections on Technology, Agency, and Design* and *Moralizing Technology: Understanding and Designing the Morality of Things*. In "Beyond Interaction: A Short Introduction to Mediation Theory," Verbeek explores the relationship between technology and the user. He writes that "humans and technologies should not be seen as two 'poles' between which there is an interaction; rather, they are the *result* of this interaction." As a consequence, he claims that interaction design is not only the design of technological artifacts "but also the design of the human subjects who interact with these objects." Read and reflect!

In other news, following an engaging cover story in our January–February 2015 issue, Elisa Giaccardi has changed the focus and name of her forum to Connected Everyday. We wish Elisa good luck with this new direction. This is also the final issue in which Gerrit van der Veer is in charge of the Community Square column; he is retiring from his role as president of ACM SIGCHI. We thank Gerrit for his faithful reporting on SIGCHI activities over the years and look forward to working with his successor.

The *Interactions* website (interactions.acm.org/) is growing with more articles and an active community of bloggers. Take a look!

Ron Wakkary and Erik Stolterman
eic@interactions.acm.org

There is a growing trend in HCI research toward more diverse publication formats.

DOI: 10.1145/2756410

Professional UX Credentials: Are They Worth the Paper They're Printed On?

By Anna Wichansky
September–October 2014
DOI: 10.1145/2656370

UX certification is a serious and hotly debated issue. Unfounded statements like "The 'gold standard' of UX professional certification is available through the Board of Certified Professional Ergonomists (BCPE)," as noted by Anna Wichansky, are not useful.

A useful certification program has a useful website that answers all relevant questions from users. For example, it should explain who judges applicants' qualifications and what qualifications the judges possess. It should also clearly explain the various types of certifications offered, and how they differ. BCPE offers User Experience Professional certification. It is not clear—at least to me—how the UX certification differs from other types of certification offered (Human Factors Professional and Professional Ergonomist).

A precise and usable curriculum is essential. A list of 25 primary references and 23 secondary references is hardly useful.

Certification questions for UX professionals must be useful. Questions like "In designing an industrial sewing machine that will be sent to China for a female workforce to use to manufacture dresses, what is the popliteal height to accommodate 95 percent of the workforce?" are not useful. Questions addressing essential skills for UX professionals are missing from the BCPE sample test, for example, the ability to recognize leading or closed contextual interview questions, bad usability test tasks, and how to communicate usability findings in a useful way.

Certification questions must be easy to understand and the correct answer must be indisputably correct. This, of course, also applies to publicly available examples of certification questions.

Finally, a clear separation between training organizations, certification providers, and providers of curricula and certification questions is essential.

Please, let's have an unbiased article about what a 2015 state-of-the-art certification program should and should not include to help UX professionals make informed choices regarding certification programs.

Rolf Molich

Let's have an unbiased article about what a 2015 state-of-the-art certification program should and should not include to help UX professionals make informed choices about these programs.

AUTHOR'S RESPONSE:

Since this is a forum about the Business of UX, I chose to share my professional experience on the value of certification, both as a recipient and as a hiring manager. It is not a review article about all the certification programs that exist, and there are many others internationally. I referred to Arnie Lund's 2011 book for that, although Rolf's program is too new to be included.

I stand by my opinion: The BCPE certification is still the gold standard for the UX profession. That means it's the best we have today. After 25 years it's stood the test of time, across multiple generations of human-machine interfaces. Experts in human factors and subspecialties such as HCI develop BCPE tests to modern psychometric standards. It is potentially a conflict of interest to sell applicants a training program and then test to it.

In addition to testing, it also requires academic credentials, proof of work experience, and recertification over time.

To be helpful, I'd suggest applicants ask the following questions when considering certification options:

- How long has the certification program existed?
- Who are the people designing and grading the test?
- Do they have any expertise in professional certification activities?
- Are they also selling the training, potentially a conflict of interest?
- Where do the test questions come from?
- Do they have any evidence of psychometric reliability or validity for professional practice?
- How many people have applied, and how many people have been accepted?
- Are there any other requirements for certification, such as work experience and academic degrees (certification), or is it just a test (certificate)?
- Are there any employers or professions requiring or even mentioning the certification as desirable?
- Do the leaders of my field have the certification?

It's also important to remember that over the course of a career, professionals need to demonstrate a broad base of skills and knowledge to keep up with a changing world. Certifications may be used as predictors of future potential, as well as acknowledgments of past success.

I invited Carol Stuart-Buttle, Executive Director of BCPE, to comment on their 25-year-old approach to certification. Below is her response.

Anna Wichansky

RESPONSE FROM THE BOARD OF CERTIFIED PROFESSIONAL ERGONOMISTS:

BCPE provides certification for Human Factors/Ergonomics (HFE) professionals. HFE professionals contribute expertise to multidisciplinary teams in many domains with the collective goal of user-centered design, for example, in the user experience and product usability fields. Lately, in the design of medical devices, the U.S. Federal Drug Administration requires human factors testing of all devices before approval to market, which has further increased HFE involvement in product usability.

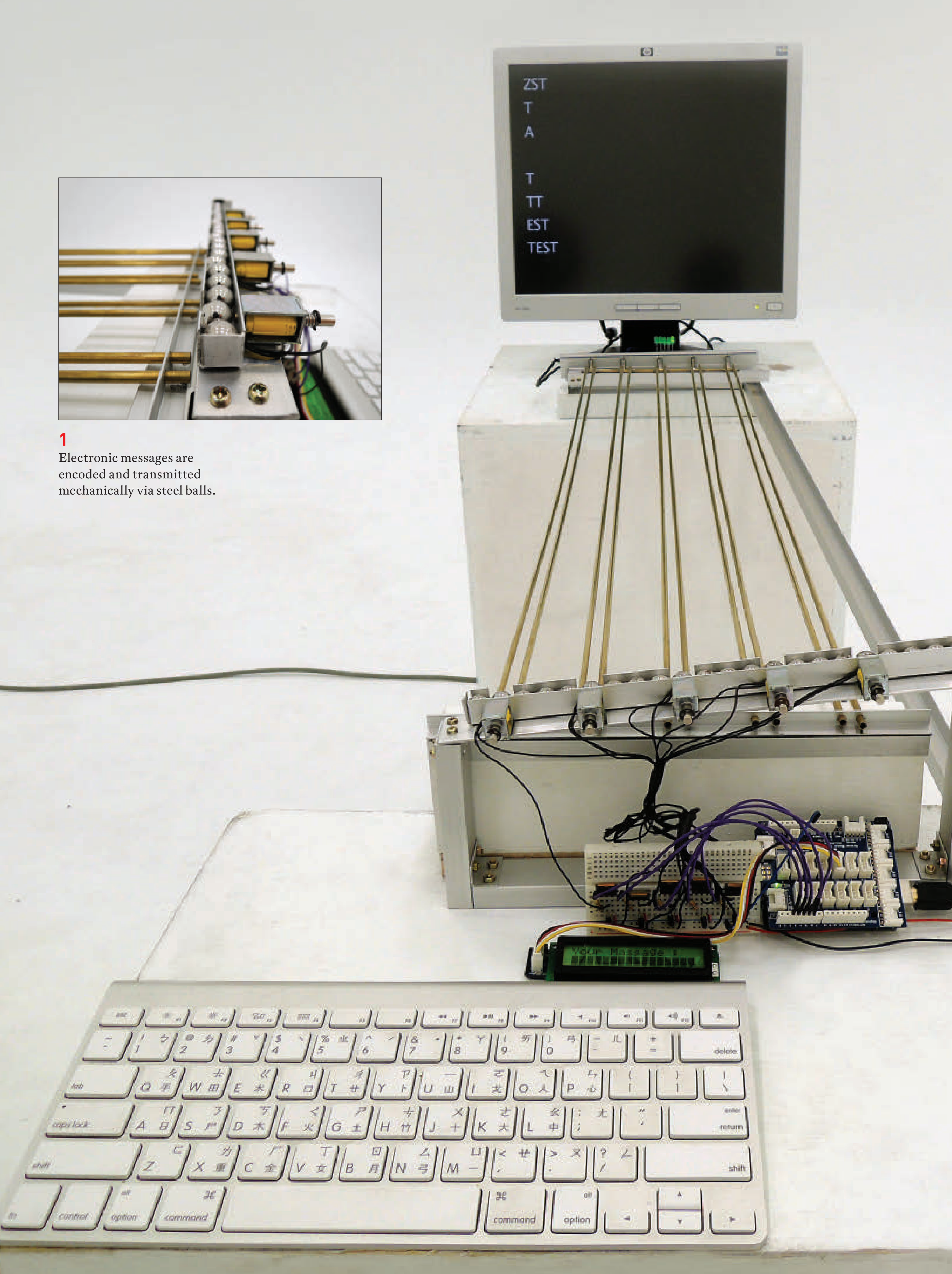
There are many other talented professionals who may seek training and credentials in domains in which HFE professionals work. While some individuals might aspire to certification by BCPE, others may wish for opportunities from other groups. The following provides context for the BCPE certification.

The BCPE, a non-profit organization established in 1990, offers a single certification with a credential that indicates a baseline breadth of knowledge, demonstration of competence in HFE, and requires adherence to a code of ethics. The certificant chooses the designation that works for their work domain, CUXP being one of the choices along with CPE and CHFP. Unlike a certificate program that tests a student's comprehension of a specific training program, professional certification attests to a minimum level of professional competence and therefore must be independent of any specific training program to avoid a conflict of interest. In addition, the certifying body is not permitted to accredit the training or educational programs.

Accreditation standards call for stringent, frequent field surveys of practice for development of core competencies, with psychometric validation of those criteria. The core competencies are the base of an exam, which also undergoes specific, rigid psychometric analysis and validation, including item validation and reliability, as well as exam equivalency. In the U.S., programs abiding by such stringent accreditation standards are often referred to as the gold standard of certification and by definition have state-of-the-art processes.

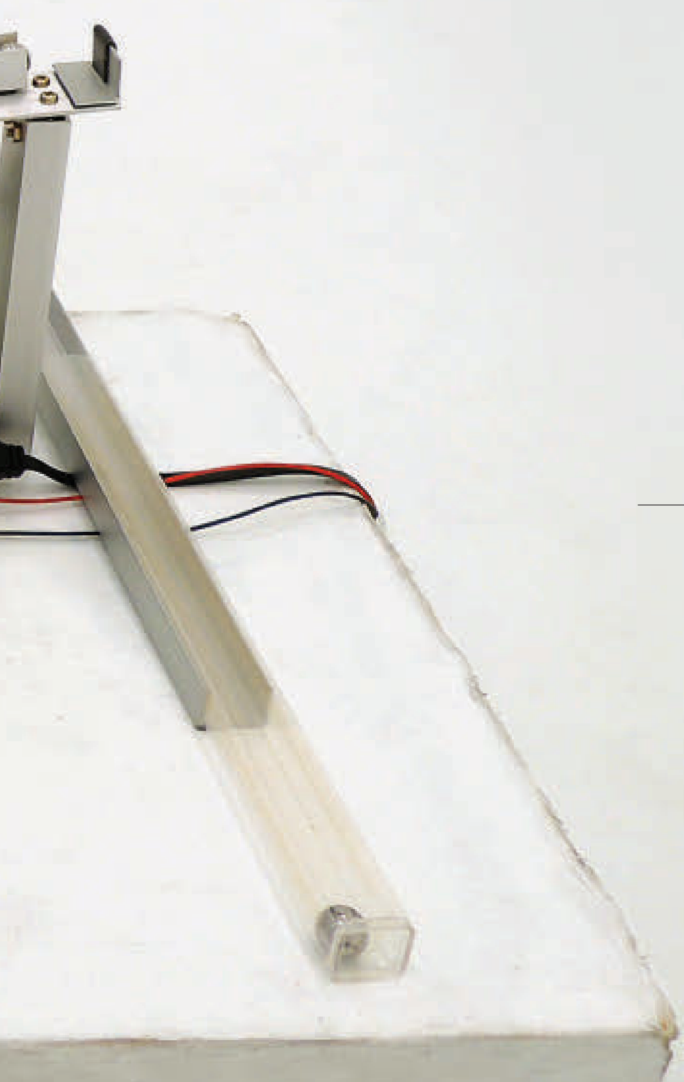
Carol Stuart-Buttle

DOI: 10.1145/2752226



1
Electronic messages are encoded and transmitted mechanically via steel balls.

ENTER



DEMO HOUR

1. The Weight of Numbers

This interactive installation transforms and sends messages via mechanical parts. Using a computer keyboard and a small LCD screen, participants first type a short message. After pressing Enter, the message is sent via steel balls to a monitor located three feet away. Every five steel balls carries an encoded five-digit signal. The balls slide on steel tubes from one side to the other to send the message. The digital signals are embodied in physical entities. They are able to roll, collide, and make sounds in the real world. Participants can thus sense speed and sound, which normally don't exist in the digital world.

http://cargocollective.com/CSH/The-Weight-of-Numbers
https://www.youtube.com/watch?v=TAEKE57M4SI
The 9th Digital Art Awards Taipei (Nominated); http://digitalartfestival.tw/daf14/數字的重量?lang=en

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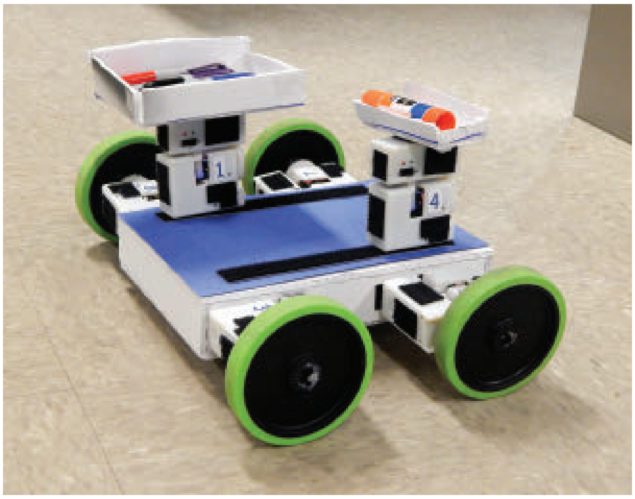
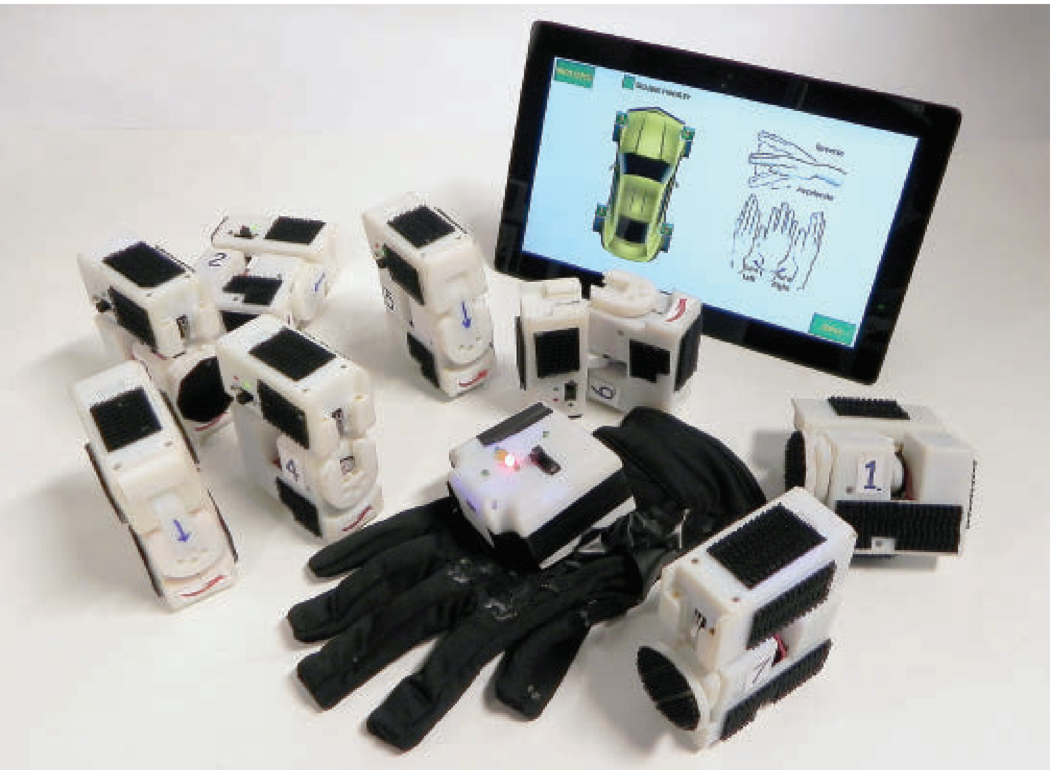


2
A user-created vehicular toy that transports objects.



2
The HandiMate system: Eight modules, a tablet interface, and a glove-based controller.

2. HandiMate

The combination of technological progress and a growing interest in design has promoted the rise of DIY (do it yourself) and craft activities. In a similar spirit, we introduce HandiMate, a platform that makes it easier to fabricate and animate electromechanical systems from everyday objects without technical expertise. Users assemble their handcrafted creations with joint modules and animate them via gestures. The joint modules are packaged with an actuator, a wireless communication device, and a micro-controller. This modularization makes quick electromechanical prototyping a matter of pressing together Velcro. Animating these constructions is made intuitive and simple by a glove-based gestural controller. We further conducted studies to evaluate the gender perception of the kit. We found that via the act of crafting, the kit appeals to both genders equally.

https://engineering.purdue.edu/cdesign/wp/?p=2504
https://www.youtube.com/watch?v=yhajVNe3O9A

Seehra, J.S., Verma, A., Peppler, K., and Ramani, K. HandiMate: Create and animate using everyday objects as material. *Proc.of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction*. ACM, New York, 2015, 117–124. DOI: 10.1145/2677199.2680570
Verma, A., Yoon, S.H., Peppler, K., and Ramani, K. HandiMate: Exploring a modular robotics kit animating crafted toys. *Proc. of Interaction Design and Children 2015*. To appear.

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We found that via the act of crafting, the kit appeals to both genders equally.

3
Transform physical riding data from your bike ride into colorful mosaics.

4
Can you extinguish the flame...with your mind?

3. CycleMosaic

Pick up your bicycle, mount your smartphone on the handlebars, get outdoors, and be art! CycleMosaic is an app that weaves your cycling trips into visual mosaics of your adventures. Vibrations travel up through the forks, stem, handlebars, and into your hands while pedaling along the road. Meanwhile, you feel the power from your legs moving into the crankset. Via the CycleMosaic app, all the accelerations and tilts are transformed into RGB and transparency presentations, forming a mosaic. These mosaics open up a new opportunity for conversation, inspiring those who see the images to try CycleMosaic for themselves.

https://www.youtube.com/watch?v=aH_Uw7oaNr4

Yun-Maw Kevin Cheng, Tatung University
→ kevin@ttu.edu.tw

Chao-Lung Lee, Tatung University
→ d9806006@ms.ttu.edu.tw

4. Trāţaka

Trāţaka is a project based on a brain-computer interface. While wearing this device, the user is invited to concentrate his attention on a flame placed in front of him. The level of attention detected by the system controls the air flow located under the flame: Higher levels correspond with more intense air flow. The goal is to extinguish the flame. In this way, the user is pushed to be aware of his ability to control his concentration, as well as it can be detected by the device.

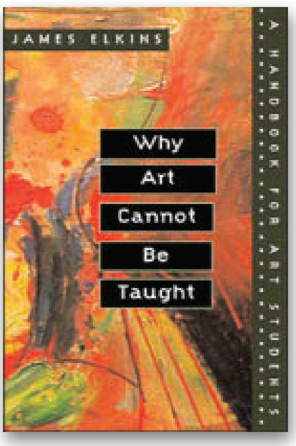
http://www.chierico.net/trataka/
https://vimeo.com/89318571

Alessio Chierico, Kunstuniversität Linz
→ alessio.chierico@ufg.at

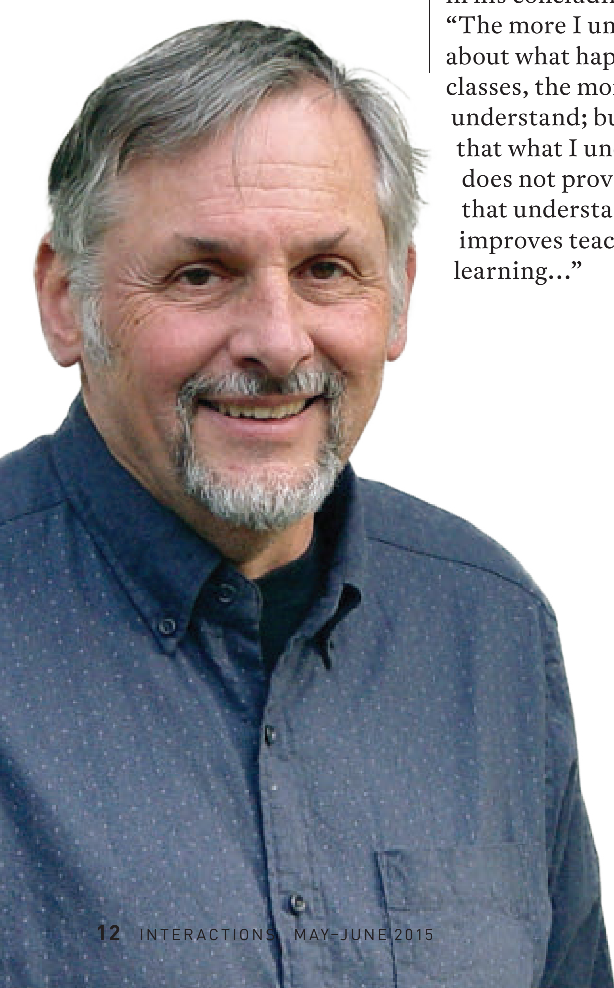
DOI: 10.1145/2748930 © 2015 ACM 1072-5520/15/05 $15.00

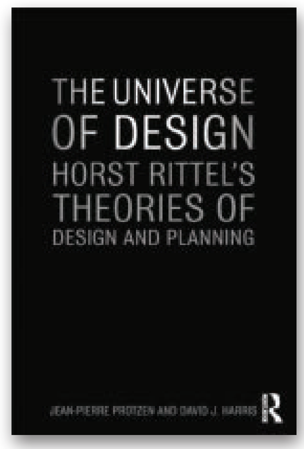
WHAT
ARE YOU
READING?

Steve Harrison

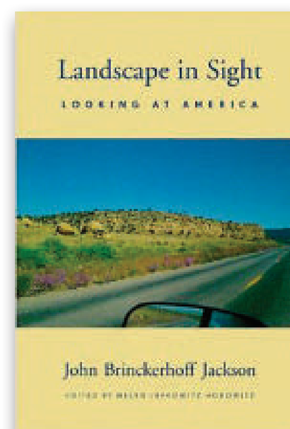


Why Art Cannot Be Taught
By James Elkins (2001)
Elkins's book was conceived and marketed as a survival guide for art students, but it is actually part critical memoir and part skill development guide for understanding and taking criticism and suggestions—that is, an inspirational guide for art instruction. The book is loaded with pragmatic methods that often have a disruptive quality: Ask the critics only to pose questions, not pass judgments; have students present their work for 10 minutes before showing it to outside critics; conduct critiques nonverbally. But he gets even more radical in his concluding chapter: "The more I understand about what happens in art classes, the more I want to understand; but I also know that what I understand does not provide evidence that understanding improves teaching or learning..."





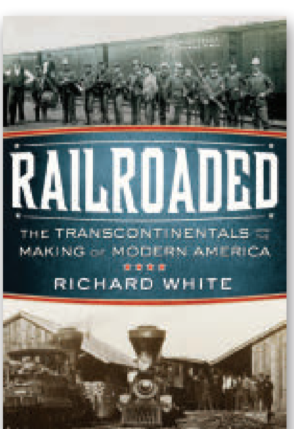
The Universe of Design: Horst Rittel's Theories of Design and Planning
By Jean-Pierre Protzen and David Harris (2010)
While a graduate student at UC Berkeley, I heard a rumor that Horst Rittel had one goal in life: to get tenure without publishing. In fact, he did get tenure, and on the basis of only a few working papers plus the oft-cited publication with planner Mel Webber that describes "tame" and "wicked" problems. But 20-plus years after he died, there is now a published book. The bulk is devoted to an edited transcript of 10 lectures he gave to the faculty of the College of Environmental Design at Berkeley shortly after his arrival in 1963. Rittel proposes abstractions of design process that not only presage the development of wicked/tame problems, but also outline a kind of design algebra that nails the iterative design process by recognizing the limits of rationality. Reading it today, it forms a useful bridge between the dominant paradigms of design in HCI, particularly Herb Simon's *Sciences of the Artificial*, and a more participatory approach. It also harkens back to a time when more of the professor's job was analysis and provocation.

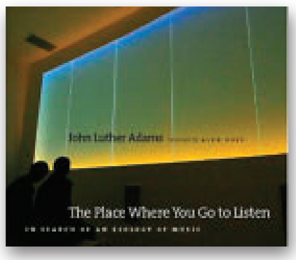


Landscape in Sight: Looking at America
By John Brinkerhoff Jackson (1999)
Seeing is essential to good design and great research. Jackson observed mid-20th-century America with great care, focusing on the built environment. I come back to these essays to understand better how he has seen and the richness of "place" *as he has seen it*. We are in need of a J.B. Jackson for the digital realm.

Specs
Focus: Design, space, and place; taking the long view
Driven by: Architecture
Base: Virginia Tech

Railroaded: The Transcontinentals and the Making of Modern America
By Richard White (2011)
Federal and state subsidies for 19th-century western railroad development set the pattern for the close ties between large capital and government, and created much of the "Gilded Age" excess. Stanford historian White argues that there really was neither an economic basis nor a technological imperative for the enterprise, but rather greed that seized opportunity and political power. Perhaps in 100 or 150 years, another historian like White will tear apart the romantic hype surrounding digital technology and consider the underlying structures that actually created it.





The Place Where You Go to Listen: In Search of an Ecology of Music
By John Luther Adams (2009)
Artist documentation as a literary form is often a combination of self-indulgent art-speak and a mechanism to recapture the original experience. This is different. The book provides documentation for the long-term sound-and-light installation, *The Place Where You Go to Listen*, at the Museum of the North at the University of Alaska, Fairbanks. Adams is a composer living in interior Alaska. The art installation—which I saw firsthand three years ago—is subtle and stunning. It abstracts elements of the greater interior Alaska environment through sensing of seismic data, aurora borealis activity, weather, sunlight, and so on, mapping those elements to sound and shades of light on a white wall in a secluded room. The book explains how the design of the installation resulted in a powerful transcendent experience. The big lessons I take from the book: Don't expect meaning and engagement without a lot of effort, and it ain't the technology, stupid.

Everything Sings: Maps for a Narrative Atlas
By Denis Wood (2010)
I am a sucker for structural analyses. I am also a sucker for maps. My graduate thesis project was an abstract thematic-map planning and design tool. This book makes thematic maps poetic. Wood documents his neighborhood, Boylan Heights, in Raleigh, North Carolina. He sees meaning not only in structure, but also in the interstices between structures and in forms of representation. I use the book with my students to illustrate the difference between visualizing data and creating meaning. I find myself rereading it and rediscovering joy in the patterns of a community.

Perhaps in 100 or 150 years, another historian like White will tear apart the romantic hype surrounding digital technology and consider the underlying structures that actually created it.

Steve Harrison is a professor in the Department of Computer Science and the School of Visual Arts at Virginia Tech, a member of the Center for Human-Computer Interaction, co-director of THIRD Lab, conference co-chair for DIS 2014, and a licensed architect.
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DOI: 10.1145/2745695

Specs

Materials: Recorded sounds, action cards

Tools: Inertial sensors, Leap Motion, microphones, screen, computer

MaD

Mapping by demonstration for continuous sonification.

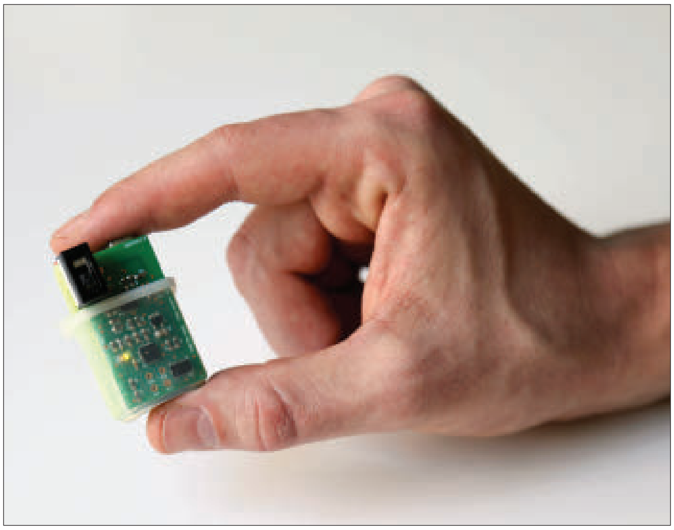
Describe what you made.
We created two installations built around a single idea: letting people choose their own arm and hand gestures to control sound synthesis. Record your own movements; the system will learn them and map them to sounds. In the first installation, people craft specific gestures to interact with environmental sounds, for example, wind, fire, birds, and water. Similar to a Foley artist, you can "play" sounds, creating a complex sound environment with your hands.

In the second installation, you use arm gestures to control vocal sounds. In this case, you record both gestures and vocalization simultaneously. To make it more challenging, we created a two-player game based on action cards, the "imitation game." Each player must follow the suggestions on the cards for both sounds and actions. Once one player records a vocalization and a gesture, the other player must imitate the gesture, which will replay the other player's voice.

The idea was to create elements with which people could engage with the systems. By brainstorming, we ended up with the idea of an imitation game and cards to guide people. We then went through several iterations to select and refine the actions and sounds, balancing between ease of execution, and challenging and playful cases. The final setup, including motion sensing, fine-tuning of the sound synthesis, and positions of each physical and graphical interface, was adapted through iterative testing with users.

What for you is the most important/interesting thing about what you made?
Our goal was to involve people in a creative process of designing gestures to control sound. Usually, designing sonic interactive systems requires programming and expertise—we wanted to make this process playful. First, you move as you feel while listening to a sound, or while vocalizing. Then you're in control of a palette of sounds that you can manipulate as you wish. The systems draw upon interactive machine learning to learn the associations from user demonstrations. The installation also teaches people about state-of-the-art adaptive gestural interfaces.

Was this a collaborative process, and if so, who was involved?
The design of the installations involved several people with complementary expertise in hardware and software development, sound design, and sonic interaction design. The software building blocks of the systems—motion analysis, sound analysis, and synthesis tools—originate from several years of research and practice at Ircam. The wireless motion sensors were designed by our colleague Emmanuel Fléty for interactive music systems, with requirements of high accuracy, low latency, and compactness. Some of the recorded sound material was designed by Roland Cahen, originally for another installation called DIRTI, the Dirty Tangible Interface project by User Studio, to which our colleague Diemo Schwarz also contributed. For the imitation game, we developed a set of action cards, associating



→ MO (modular musical interface) inertial sensors.

→ Experimenting with the motion sensors.

→ **The imitation game.**

actions and sounds that the players had to imitate. We experimented within the team to select the set of action cards that elicited the most interesting gestures and vocal imitations; the final set was designed by Riccardo Borghesi.

What was the biggest surprise in making this?

It is striking to observe how people can learn very quickly with the help of interactive sound. Imitating someone else's gestures with accuracy is difficult, especially when the task is to reproduce the precise dynamics of the movement. Interactive sonification provides rich feedback that complements the visual modality in kinesthetic empathy. We believe that continuous sonification can help improve movement accuracy and consistency, which creates possibilities for novel applications in movement learning such as sport and dance pedagogy, and rehabilitation.

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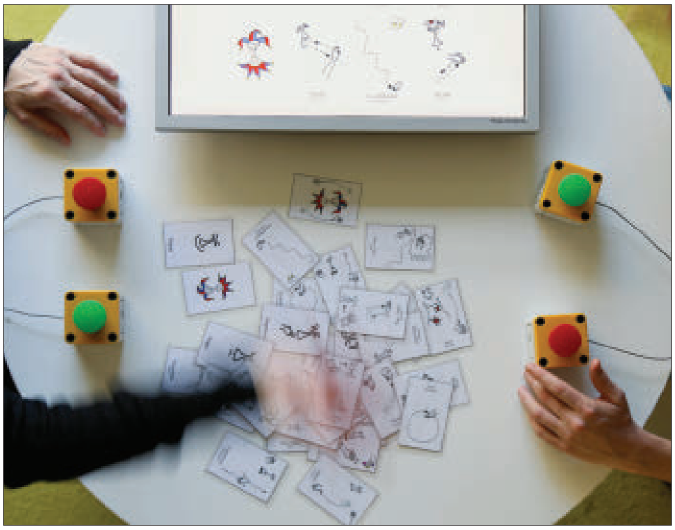
DOI: 10.1145/2754894

→ **Action cards for inspiring vocal imitations and gestures.**



→ **Testing the final setup.**

PHOTOGRAPHS BY SÉBASTIEN ROBASZKIEWICZ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NTNU Health Informatics Usability and Design Lab

As told by Dag Svanæs

How do you describe your lab to visitors? The NTNU Health Informatics Usability and Design Lab allows for full-scale clinical simulations of health IT systems with health workers and patients in realistic hospital settings. This is useful in all phases of a design process, from problem identification to co-design, prototyping, development, and evaluation. The lab is part of the National Norwegian Research Centre on Electronic Health Records (NSEP) at NTNU University Hospital campus in Trondheim, Norway.

What is a unique feature of your lab?
Electronic health record (EHR) systems have traditionally been desktop-based, but we currently see a move toward mobile EHR solutions in hospitals. Usability testing of this new generation of EHR systems makes it necessary to simulate important properties of the work environment, such as the physical setting and the social interaction in the clinic. This requires a laboratory that allows for full-scale usability tests with multiple users simultaneously. The NTNU lab has approximately 50 square meters of open space with reconfigurable recording equipment, which makes it well suited for this purpose. In addition to state-of-the-art recording equipment with roof-mounted cameras and wireless microphones, the lab also has an eye tracker that has been used extensively in usability tests.

How many people are in the lab, and what is the mix of backgrounds and roles?
The lab is managed by the computer and information science department at NTNU and has one lab engineer, Terje Røsand. The NSEP Research Centre, which hosts the lab, is a collaboration of the Schools of Computer Science, Medicine, and the Social Sciences at NTNU. The lab has been used in a number of research projects at NSEP, in most cases in close cooperation with clinics at university hospitals. Examples include full-scale simulation of new EHR systems for hospitals, role play and low-fi prototyping of new mobile EHR solutions with nurses and physicians, co-design of a social media solution for obesity patients,

DAY IN THE LAB

→ **Exploring innovative ways of utilizing digital technology through a clinical simulation.**

usability testing of full-body exergames with elderly patients, usability testing of location-based services for the hospital, usability testing of a self-reporting system for COPD patients, and prototyping and evaluation of fall sensors for the elderly.

Describe a day in the life of your lab.
A day in the lab would typically involve preparations for a usability test. A current example is a student project on sensor-based haptic feedback on walkers (rullators) for visually impaired elderly patients. The preparation consists of giving the student a helping hand with the Arduino-based prototype on the walker to ensure the ultrasound sensors will survive the usability tests, recruiting users through a clinic at the hospital, and configuring the lab to simulate a realistic situation from the user's life.

What is one feature of your lab that you could not do without?
The large space that allows us to mimic real-world use contexts.

What is one feature of your lab you want and do not have?
Eye-tracker glasses.

How would you describe how people interact in your lab?
The lab has become a melting pot, where researchers and students from computer science, industrial design, the social sciences, and medicine meet to explore potentials of digital technology for the medical domain.

What is the one thing you see as most important about the work you do there?
The most important role of the lab is to give credibility to a design and usability perspective on medical technology locally. Both in the hospital setting and at the university, a physical lab becomes a kind of totem that gives credibility to the research we do as being "scientific"—although much of the research could have been done without a physical lab.

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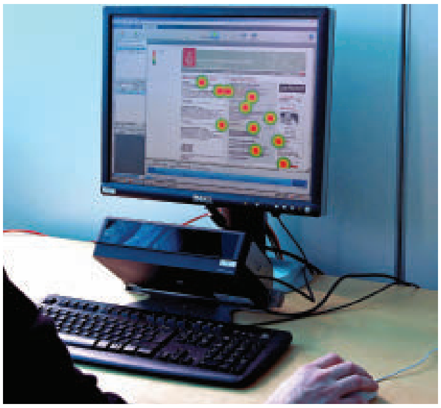
→ New technology is often evaluated with teams of health workers.

→ Analyzing eye-tracking data from a usability test.



The most important role of the lab is to give credibility to a design and usability perspective on medical technology locally.

→ Full-scale replication of a clinical setting.

Heather Wiltse,
Umeå University

On Being Turned Inside Out

In the Pulse Room of Rafael Lozano-Hemmer's "A Draft of Shadows" exhibition at Bildmuseet on the Umeå University Arts Campus, a large room is empty except for rows and rows of light bulbs hanging from the ceiling and a pair of metal rods on a stand at one end of the room. The light bulbs flash seemingly at random while a low, rumbling, whooshing sort of sound fills the room. But when a person holds onto the rods, the light bulbs start to flicker faster, and then within a few seconds the lights and sounds converge in a pulsing *thump thump… thump thump… thump thump….* The lights flash in unison, each flash further punctuated by a low, thudding sound. It is the unmistakable sound of a heartbeat, and the effect is mesmerizing.

It is also more than a little uncanny to share one's pulse with a room. A heartbeat is one of our most intimate and vital bodily processes. It distinguishes us as living beings. Along with the breath, it is what people check for when trying to determine if a person is alive. It is also at the core of our psychological and emotional being. This is why people talk about being brokenhearted, heavy hearted, or joyful hearted, having a heart that is overflowing, or wearing one's heart on one's sleeve. It is why we know what is meant when it is said that the Grinch's small heart grew three sizes that day.

Hearing someone else's heartbeat is a very particular kind of intimacy, one usually reserved for medical professionals and lovers. Yet in the Pulse Room, one's heartbeat becomes public, pulled out of the usually private confines of one's chest and turned into performative spectacle for others in the room to watch and feel. And it is very much felt: The lights and sounds are so strong that they are not just present to one's senses but rather invade them—a highly visceral, if fleeting, impression transmitted from one body to another through the mediation of the room.

This can lead to a rather unusual kind of performance anxiety: What will my heartbeat look like? Is it going to be really fast because I just climbed five flights of stairs, making it look like I'm nervous or out of shape? What if I actually am nervous by the time it's my turn, simply because of thinking about it?

When one woman in the long opening-day queue holds onto the rods and it takes an unusually long time for the room to sync with her heartbeat, looks are exchanged and there is a bit of nervous laughter. What would it mean if this contraption could find everyone's heartbeat except yours?

In reflecting on my experience in the Pulse Room, however, I realized that it was not an entirely novel sensation. I have held other metal rods that register my heartbeat, although they have been attached to exercise machines designed to raise it. I know there are now also many options for wearable devices that sense heartbeats (and myriad other things). One of the features of the Apple Watch is the ability not only to monitor one's heartbeat but also to share it with another person through the device, while the "tap" feature lets you communicate with other Watch wearers through "silent, gentle tap patterns they'll feel on the wrist" [1]. I experienced a similar feeling when realizing that, because I connected it to my Spotify account a couple years ago, my Last.fm profile has a record of over 24,000 (and counting) music tracks I have listened to, and even identifies the track I am listening to at this moment on my headphones. The headphones are private; the Last.fm profile is not. And although they are very different, this line of reflection also makes me think of the recently popular Internet quizzes designed to help you figure out (and share on Facebook) things such as which Elvis song is your anthem, which classic literary heroine you are, what city you should really live in, what your job at Downton Abbey would be, the color of your aura, or which animal you were in a past life.

In the Pulse Room, one's heartbeat becomes public, pulled out of the usually private confines of one's chest and turned into performative spectacle for others in the room to watch and feel.

What all of these things have in common is that they can give the feeling of being turned inside out: of having heretofore private aspects of bodies, everyday activities, and personalities pulled out and displayed for more public viewing and assessment.

This presents a sharp contrast to the self-conscious identity play and carefully styled performance that characterized the early days of online life. Then, it was often assumed that there was at least the possibility, if not the reality, of a nice, comfortable distance between one's presented and real selves (if such things even exist). Now it is almost as if the cognitive

Rafael Lozano-Hemmer, Pulse Room, Bildmuseet 2014. Courtesy of the artist.

PHOTOGRAPH BY MIKAEL LUNDGREN

faculties governing performance of self are being bypassed as technologies go straight to the source, collecting the data they need in order to make more definitive presentations.

For example, although I think I have a fairly good grasp on my taste in music, my Spotify "year in review" report provides another view based on the hard data of the tracks played within my account (which might challenge my own subjective description of what I like to listen to). Even silly Internet quizzes that are, it must be said, more than a little reductive and often downright ridiculous, are presented with the rhetoric of finding out who you *really* are (whether in this or a past life). The premise is that a series of carefully crafted questions that might even seem completely unrelated to the matter at hand can be used to dredge up, psychoanalysis-style, the deeper contents of one's psyche that can then be shared directly to Facebook. This allows for that most intimate confirmation of friendship: sharing the results when you have, through the help of a Playbuzz quiz, been shown the nitty-gritty details of your true self [2].

So what does all this mean? Has all the online identity play and lamenting about how our online interactions are less "real" and "authentic" perhaps created a longing for things that are incontrovertibly genuine? After spending time as disembodied avatars, do we long to hear heartbeats that remind us there is, in fact, still a crucial difference between circuits and flesh? Do we need gadgets to tell us stories about ourselves to confirm our unique presence and identity in the world, to count the things we do that might affirm that our lives count for something?

Although I don't know the answer to these questions, I do think they are worth asking. Because in designing technologies to address human needs, the needs and concerns ultimately being addressed often go far deeper than what is foregrounded by a typical use case. It might be said these deeper concerns are of the heartfelt variety.

ENDNOTES

1. Apple Watch: http://www.apple.com/watch/new-ways-to-connect/
2. Playbuzz: http://www.playbuzz.com/ondazp10/discover-your-true-self

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Patchwork Living, Rubber Duck Debugging, and the Chaos Monkey

“Patchwork living” is a good description of my life with technology.

One of the meanings of the word *patch* is to repair a tear, a breach, in a material. By extension, “patching” software or firmware means to fix something that is damaged, torn, or no longer functioning as it should. A software security patch, for example, repairs a new (or newly discovered) breach in the security capabilities of a device, service, or application.

This kind of repair work defines my patchwork-living lifestyle. I spend a lot of time being interrupted by, and then managing, the bleeping, jumping, jiggling mess of alerts that inform me of patches in need of installing, software updates desperate to be indulged, and licenses needing to be revisited….

Yesterday is a good example: An update to the operating system on my computer was strongly recommended—alert, alert, alert. I checked that everything was saved, closed documents and applications, and clicked Install. Then I waited and waited, and finally restarted my machine. Forty minutes later, I had apparently emerged from the techno-grooming tunnel. Success.

But wait…

Why did the software that I used just last week, the one I need to accomplish this morning’s task, no longer work? Why does my music no longer stream to my speakers? Why can I no longer see the media server from my computer?

Taking slow, logical steps like a good systems administrator, I sought the root cause. I crawled around on the floor plugging and unplugging devices, rebooting, restarting, and resetting. I set permissions and reconnected devices that had just hours before been happily communicating. I engaged in “rubber duck debugging”—talking out loud, stepping through settings and interconnections, unpacking the ways in which I have patched my technologies together. The search for the eureka moment, when the “thing that broke” would reveal itself, consumed all my attention. Two hours evaporated.

Field research on everyday technology management reveals I am not the only one encountering such issues. This is both a relief (who likes being alone in their struggles?) and irritating. It is indicative of an industry that is, itself, in need of repair, of “patching.” I fear for the future. My collection of notionally connected devices and services is modest compared with the predicted Internet of Things world that will have embedded, connected, computational systems and subsystems woven into the entire fabric of our lives. If we continue on this trajectory—ever more aggressive marketing and the proliferation of intertwined, intermingled services, devices, and applications coupled with a standards process that can’t keep up with the pace of technology development or with the driving force of business—we will be in even more trouble. User experience so far belies the marketing rhetoric of a seamlessly and securely supported life with assemblies of harmoniously interconnected devices and services. Rather, many user experiences suggest this could be the dawn of the Internet of Partially Connected Frustration or the Internet of Insecure Curmudgeonly Connections [1].

What can we in HCI, UX, and design engineering do?

First, let’s stop being myopic, imagining bubbled and bounded designs. Little of what we design is stand-alone. As HCI researchers and practitioners, everything we design is part of a bigger, sprawling networked system—in fact an unwieldy, unruly, and unpredictable set of complex systems. Certainly *anything* connected to the Internet is part of a very complex system that includes myriad devices, software, routers, and services. Complex systems are *open*, not closed. Their boundaries are fuzzy; one can’t tell where they start and where they end. The edges of our devices, our services, and our applications are blurry, part of a dynamic, shape-shifting world. We can predict neither who our users will be nor what use they will make of what we create. We cannot predict what computational agents and services will be interacted with, hosted, and/or destroyed as unplanned connections are engaged.

As we move deeper and deeper into the era of the Internet of Things, to borrow Sidney Dekkar’s phrase, we are “drifting into fragility.” Admittedly, Dekkar’s work focuses on complex, *safety-critical* systems; consumer devices are not typically conceived and prototyped and marketed as safety-critical systems. Rather, they are considered to be for communication and social media consumption and participation, for discretionary personal tasks and information management, for entertainment—which reflects an out-of-date conception. We know that personal devices are increasingly woven into the fabric of coordinated, collaborative, and collective work activities and patterns. They are

increasingly *becoming critical*.

Nassim Taleb claims there are three kinds of complex system: fragile, robust, and anti-fragile [2]. Fragile systems are not built to withstand volatility. Robust systems require careful predictive models of likely failures and have redundancies built in. "Anti-fragile" systems *like* deviance and volatility; they are built to create, test, debug, and *grow* from disorder. Taleb writes, "It is far easier to figure out if something is fragile, not easy to predict the occurrence of an event that may harm it. Fragility can be measured; risk is not measurable."

But risk can be understood and tested, and anti-fragile systems can be implemented. In the world of critical systems, connecting pieces of the system is not the breakthrough—keeping them running and avoiding failure at critical moments is. For that, one needs transparent, interrogable, reflective systems that allow the user to easily understand what is going on and patch and repair as needed—*before* time is running out for the critical deadline, or when the connection to the Internet is sketchy. A good example is Netflix's server systems that are designed for intentional breakage, a test and retest model [3]. Their Chaos Monkey "wreaks havoc like a wild and armed monkey set loose in a data center," working "on the principle that the best way to avoid major failures is to fail constantly." Unexpected failures always happen at the worst times, so Chaos Monkey enables simulated failures when they can be monitored and repaired. Chaos Monkey is the crash-test dummy of Web services, checking for abnormal conditions, configurations, and security issues.

So first, let's stop being self-servingly clumsy in assuming we are designing encapsulated services; let's ask responsible questions about what lies beyond the borders of what we are implementing, what the possible sources of failure may be, and what our users will need to know to do effective repair. Second, let's think about designing software agents like the Chaos Monkey that exist to test our interconnections and reveal to us any patches that may be needed *before* things go wrong. And third, let's build better debugging tools for people who don't have time and/or any interest in becoming versant in the vagaries of complex computational systems. Consumers are increasingly the system administrators of their own complex ecosystems; it would behoove us to learn from system administrators how they manage complex systems and what tools *they* have at their disposal.

The grand challenge for the Internet of Things era is not going to be how to get computation into everything. Rather, it is going to be how to build anti-fragile systems for the technological sedimentary layers of an everyday life.

ENDNOTES

1. The last time I wrote about the Internet of Things was in 2009 in the March+April issue of *Interactions*. I see an uptick in hyperbole and excitement, and a huge amount of technical and design work before the dreams shown in the vision videos will come to pass. Perhaps happily, the term *Internet of Things* has peaked in terms of Gartner's "hype cycle." It is now thankfully entering the "trough of disillusionment," which hopefully will mean some deeper research will be done. Security issues are being discussed, as are interoperability standards: Gartner's Hung LeHong wrote a while back, "Standardization (data standards, wireless protocols, technologies) is still a challenge to more-rapid adoption of the IoT."

2. Taleb, N. *Antifragile: Things That Gain from Disorder.* Random House, New York, 2012.
3. https://github.com/Netflix/SimianArmy/wiki/Chaos-Monkey

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IMAGE BY VAL LAWLESS

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The Times New Roman Lie

This is not a paean to a typeface. This is about how Chrome OS lies.

On Black Friday 2014, I bought a Chromebook. I was not alone; Amazon reported that its top three notebooks of the holiday season were all Chromebooks. I've been a Mac user since I switched to a Mac SE from the Apple IIGS, where a pixelated Mavis Beacon taught me how to type, so I had some reservations, but I figured that since I was already backing up most of my work in the cloud and that most of my academic papers were coauthored using Google Docs, it wouldn't be too difficult of a transition. On top of that, my work-issued MacBook developed a serious love affair with the Spinning Beachball of Doom. After it took two minutes and 30 seconds to copy text out of a PDF and another 45 seconds to paste it into a Microsoft Word document, I spent the better part of the day knee-deep in Web forums. Finally, I gave up and dropped the computer off at the tech-support desk. The university's fantastic Mac technician couldn't figure it out, either: Neither new RAM nor a new hard-drive cable nor a new hard drive could keep the beachball away.

So when Amazon cut the price on the Chromebook by $50, I jumped. For $280, what did I have to lose?

That should have been a rhetorical question. Instead, the answer is Times New Roman.

Overall, the user interface on the Chromebook is good, though it does not surpass or even meet the standard set by Apple in the Jony Ive-Steve Jobs glory days. The first task was to wrangle the font sizes and default zoom on the computer's 1080p 13-inch "True HD" display into a state where I could read my email without a magnifying glass. That wasn't so bad: Open Settings; look for something about fonts; fail to find anything about fonts; search for fonts. Bingo: Settings for default font size and page zoom under the "Web content" subheading. Because almost everything on the screen of a Chromebook is rendered as a webpage, these controls change the size of almost everything displayed on the screen, including the text in the settings menu. Yet key UI elements, such as the tabs in the Chrome Web browser, remained just as squint-inducingly tiny as before, and there exists no mechanism to adjust their size.

Spurred on by my partial success and resigned to my reading glasses, I adventurously clicked a button titled "Customize Fonts." I was hoping to make Web pages look more familiar by changing the default fonts to Helvetica and Georgia, the same typefaces I was used to studying while the beachball made its frequent appearances on my Mac. This is when I first made acquaintance with the impostors Tinos and Arimo.

In Google's words, Tinos is "an innovative, refreshing serif design that is metrically compatible with Times New Roman" [1]. (It should not be surprising that Arimo is "an innovative, refreshing sans serif design that is metrically compatible with Arial.") Tinos, Arial, and the "innovative, refreshing" Courier New clone Cousine are the default fonts for Chrome OS. Perhaps by *innovative* and *refreshing* Google really means *thin* and *light*. On my Chromebook's 13.3-inch 1080p display, Tinos and Arimo are eye-strainingly skinny and faint, even scaled to 150 percent. I found Georgia in the list of available fonts and increased the default zoom to a level my 25-year-old self would have sneered at.

At the time of this writing, there is no workaround to generate a printed document using Times New Roman from a Chromebook.

But Tinos would return in a cunning disguise. Oddly, in Google Docs and even in Microsoft Word Online when used on a Chromebook, Times New Roman, Arial, and Courier New are listed as options in the font menu. In fact, I'm typing a draft of this column in "Times New Roman." Those quotation marks aren't a mistake, because the font displayed on my screen is not Times New Roman; it is—you guessed it—the slightly more square Tinos. The same kind of deception also happens when using Arial; the giveaway there is the shape of the lowercase *a*. Arimo's has a tail that is just a touch too long, disturbing the spacing between letters and screaming for kerning. Perhaps, I thought, saving the document to PDF would result in a file that would display the correct typeface. No dice. At the time of this writing, there is no workaround to generate a printed document using Times New Roman from a Chromebook.

The extent of this problem—which, because I have a working, if beachbally, non-Chrome OS computer, is merely an inconvenience—became apparent when I was using the Chromebook to finalize a manuscript for submission to an academic journal. Referring back to the submission guidelines, I noticed this line:

Font: 12 point, Times New Roman

Uh oh. 12 point, Times New Roman.

Not “12 point, Times New Roman or an innovative, refreshing, and metrically compatible typeface.” Now, sure, there are a lot of ways the publisher could solve this problem, for example, by translating the strict page limitation into a character limit, but the trend is to push this work onto authors, and the submission guidelines culminated in an ominous warning about the rejection of noncompliant manuscripts. I would not be able to submit my work unless I went back to a Mac or Windows machine with Times New Roman installed. I suspect that Google’s omission of the font that has become the standard for professional and educational communication has less to do with an ideological commitment to innovative and refreshing open-source fonts and more to do with the fact that Times New Roman is owned by Monotype, a business that makes money by selling and licensing fonts.

But what about the children? I’m not the only Chromebook user foiled by Times New Roman. Check out this post in the Google Product Forums:

“The Times New Roman font in Docs does not exactly match the Windows version. Teachers at my kids school are deducting points for using the ‘wrong’ font. I would have never noticed but the lowercase *e* and *w* are definitely different. Thoughts?” [2]

At first brush, I find it horrifying that teachers would deduct points for using the wrong font. But part of grade school is learning that it’s important to follow the rules, and when top academic journals are specifying that manuscripts must be submitted in Times New Roman, it’s hard to argue with the logic. So I don’t think there is a direct link. I think it is more of an emergent phenomenon that is taking some ideas created 30 years ago and amplifying them via the Internet to reach a larger demographic.

And you can’t even *buy* Times New Roman—not from Monotype, not from Google—for installation on a Chrome OS device. While there is a workaround, it involves putting the device into its less-secure developer mode, then using the Chrome OS command line to install the font after every restart. I’m having a hard time imagining that poor kid’s parent bothering with a “solution” like this on a system where the central selling point is simplicity. For my part, I’d gladly pay Monotype’s retail price of $29 to add this key piece of technology to my Chromebook.

IMAGE BY LUIS ROCA

This brings me back to the issue of interaction. When the forefront of the field is addressing wearable technology and confronting the challenge of sustainability, it might seem petty to pick on Google for omitting Times New Roman. But this is just as big of a usability issue as laggy scrolling and slow page-load times in Google Docs: To ignore Times New Roman is to ignore its role in the ecosystem of uses in which computing is embedded. If Google wants Chrome OS to be a viable replacement for Mac OS and Windows, it needs to be able to produce documents set in Times New Roman.

ENDNOTES

1. https://www.google.com/fonts/specimen/Tinos; https://www.google.com/fonts/specimen/Arimo
2. https://productforums.google.com/forum/#!topic/docs/SQbdTI6u0yo

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Beyond Interaction: A Short Introduction to Mediation Theory

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The field of interaction design is founded upon the idea that, ultimately, it is not *things* that are to be designed, but rather the *interactions* between humans and things. Still, interaction might not always be the most helpful concept for understanding the relations between humans and products, or for understanding technological artifacts in general. Recent insights from the philosophy of technology, specifically from the approach of "technological mediation," lead us to rethink the relations between humans and things, shedding new light on the field of interaction design. In fact, these insights make it possible to rethink both the interaction dimension of interaction design and the very idea of designing interactions itself.

Interaction can be translated literally as "action in-between." It indicates what is going on between a human being, on the one hand, and a technological artifact, on the other. Both entities have a relation to each other and act upon each other. The concept of interaction therefore presupposes the existence of human subjects and technological objects, *between* which there is a specific kind of *activity*. While questioning this pre-given character of subject and object might sound a little far-fetched,

Insights

- Interaction is just one of many possible relations between humans and technologies.
- Mediation theory can help designers to anticipate the impact of a product on human practices and experiences.
- Responsible design does not shy away from influencing human behavior, but rather aims to give such influences a desirable direction.

PHOTO BY VITA KHORZHEVSKA

it can actually help expand the field of interaction design.

First, from the perspective of the "mediation approach" in philosophy of technology, humans and technologies should not be seen as two "poles" between which there is an interaction; rather, they are the *result* of this interaction. As I will make clear below, they are not pre-given entities but rather ones that mutually shape each other in the relations that come about between them. And second, in many cases the relation between humans and technologies is in fact part of a larger relation, between human beings and their world, in which technologies play a mediating role. What is being designed, then, is not a thing but a human-world relation in which practices and experiences take shape.

The design of interactions therefore implies not only the design of technological objects that allow for specific interactions, but also the design of the human subjects who interact with these objects. Designing technology is designing human beings: robots, vacuum cleaners, smart watches—any technology creates specific relations between its users and their world, resulting in specific experiences and practices. Here, I will investigate how we can further conceptualize the relations between human beings and technologies and what this could imply for the practice of design.

HUMAN-TECHNOLOGY RELATIONS

In the field of design, the interactions between human beings and technological artifacts are often characterized in terms of functions and use. Products are designed to be used, after all, and therefore the quality of the interaction that people can have with a product is typically indicated in terms of functionality and usability. Yet there is a risk in this conceptualization. First, many relations we have with high-tech products cannot be characterized adequately as "use" relations. Technologies like smart lighting in shop windows that analyze people's gaze in order to highlight specific products, or electrodes implanted in the brain to influence brain activity, are not used. The configurations of users and technologies that arise here can be better characterized as *immersion* and *fusion* than as use.

Moreover, understanding human-technology interactions in terms of functionality too easily reduces the role of products to instrumentality: Human beings have their own goals and intentions, and products should help them to realize them in an optimal way. In many cases, though, these goals and intentions do not exist independently from the technologies that are used. Social media has generated new types and dimensions of social relations that were not intended in the design of the technology, but rather emerged from them. These technologies do much more than merely function—they help to shape human existence.

The relations between humans and technologies, then, are much more complicated than functionality and use. On a more conceptual level, three approaches to human-technology relations can be distinguished: Technologies can be seen as extensions of the human; there can be a dialectics between humans and technologies; and human-technology relations can be approached in terms of hybrids.

Extension. When approaching human-technology relations in terms of extensions, technologies appear primarily as tools or instruments. They enable human beings to do specific things. In this view, technologies are typically seen as neutral. As extensions, they merely facilitate human practices and experiences, rather than actively helping to shape them.

A good example of this approach is Joe Pitt's work on the neutrality of technology [1]. Pitt defends the thesis that it is highly undesirable to give up the idea of the neutrality of technology, from a moral point of view. As soon as we bestow material artifacts, rather than human beings, with agency, we dilute the idea of moral responsibility. Seeing technologies as more than neutral opens the door to arguments like "the machine made me do it" [1]. Pitt claims this view pretends that humans can share responsibilities with technologies, and therefore provides an unjustified moral excuse. Driving too fast is not the car's fault, just like a murder cannot be blamed on the weapon. Humans, not technologies, have agency and can be held responsible for their actions.

Another variant of extensionism can be found in the "extended mind theory," as defended by Andy Clark and David Chalmers [2,3]. Cognition, they claim, cannot be limited to the human mind, but rather is extended to the material artifacts people use, such as agendas, computers, and even brain implants: They help us to think, remember, and have experiences. This approach to technologies as extensions of the human being, though, is in fact a variant of the hybrid approach I will explain below. Clark and Chalmers show that technologies help to shape what it means to be human; technologies do not merely extend a pre-given human subject with a material object, but rather become part of human functioning.

Dialectics. Another approach to human-technology relations has a dialectical nature, in the sense that it sees an opposition rather than a continuity between humans and technologies. Instead of enabling people to realize their own intentions, technologies are a significant force themselves. One version of this dialectical approach is the framework of opposition versus resistance [4]. Technologies are then seen as overpowering or alienating forces, while human beings need to find ways to free themselves from them. Good examples are the Marxist critique of mechanization, in which the laborer is alienated from both the production process and the products themselves, and the current critiques of information technologies and their impact on our cognitive skills [5,6].

Another version of the dialectical approach gives the tension between humans and technologies a more productive character. It sees

The design of interactions implies not only the design of technological objects that allow for specific interactions, but also the design of the human subjects who interact with these objects.

technologies as "externalizations" of specific aspects of the human being, which make possible human development. In Ernst Kapp's philosophical-anthropological approach to technology, for instance, technologies are seen as projections of human organs [7]. A hammer is a projection of the fist, a saw of teeth, and the telegraph network—the high-tech of his day—of the human nervous system. And Wilhelm Schmid sees the development from tool to machine to automaton as an ongoing externalization of human capacities: While tools still have to be operated both physically and mentally by human beings, machines take over the physical part, and automatic machines take over the cognitive part [8]. Interacting with technologies, then, gives us a relation to ourselves as well.

Hybridity. The hybrid approach sees a fundamental problem in both the instrumental and dialectical approaches. Approaching technologies in terms of extension of or opposition to the human being implicitly locates humans and technologies in two distinct spheres: one of the human subject, the other of the technological object. And this separation fails to grasp the complex intertwining of humans and technologies. To understand this intertwining, we need to think in terms of hybrids. Technologies and human beings help to shape each other. Technologies are an element of human nature: They are part of us. Our perceptions and experiences, our actions and ways of living, all these elements of human existence take shape in close interaction with technologies.

Technological instruments, for instance, help scientists to perceive the world. The reality of a star is profoundly mediated by telescopes, brain activity by MRI scanners, and the health condition of a fetus by ultrasound devices. Such mediations are not merely neutral "intermediaries": What a star, the brain, and an unborn child are for us cannot be understood without taking into account the mediating role of technologies in our perception and understanding of them. The same can be said of human behavior. Technologies help shape the ways we behave and interact. The default settings of copy machines and printers help to determine how many double-sided prints will be made. Antenatal diagnostic technologies inform the ethical decisions we make. The quality of our social interactions and relations is mediated by social media and the built environment.

The concept of technological mediation can be helpful in investigating this hybrid character of human-technology relations. In the postphenomenological approach to technology that developed out of the work of Don Ihde [9,10], technologies are conceptualized as mediators in the relations between human beings and their world. Rather than being opposed to humans, or mere extensions of us, they need to be seen as media for our connections with the world. Technologies help shape perceptions and actions, experiences, and practices. In doing so, they help shape how human beings can be present in the world and how the world can be present for human beings.

This implies that designers, in fact, do not merely design products, but human practices and experiences as well. Products do not only have functional, interactive, and aesthetic qualities, but are in fact also mediators in the lives of human beings. Designing things is designing human existence. Dealing with this situation in a responsible way requires a thorough conceptualization of human-technology relations and the role that design can play in shaping them.

MEDIATION THEORY

In order to investigate the mediating role of technologies, it is helpful to study the relations between humans and technologies along several lines. First of all, building upon and expanding the work of Don Ihde, we can categorize various types of *relations* between humans, technologies, and the world. Second, we can identify various *points of application* from where technologies exert their influence on human beings. And third, several types of *influence* that technologies exert on human actions and decisions can be distinguished.

Types of relations. At the heart of Don Ihde's postphenomenological approach to technology is an analysis of various types of relations between human beings, technologies, and the world. Ihde investigated the ways in which technologies play a role in human-world relations, ranging from being "embodied" and being "read" to being "interacted with" and being "in the background." In *embodiment* relations, technologies form a unity with a human being, and this unity is directed at the world: We speak with other people *through* the phone, rather than speaking *to* the phone itself, and we look *through* a microscope rather than *at* it. Ihde schematizes this relation as (human - technology) → world.

Hermeneutic relations, as Ihde calls them, are relations in which human beings read how technologies represent the world, such as an MRI scan that represents brain activity or the beeping of a metal detector that represents the presence of metal. Here, technologies form a unity with the world, rather than with the human being using them. Humans are directed at the ways in which technologies represent the world. Schematically: human → (technology - world).

In a third type of human-technology-world relations, which Ihde calls the *alterity* relation, human beings interact with technologies with the world in the background of this interaction. Examples are human-robot interactions, getting money from an ATM, and operating a machine. In fact, this relation can be seen as a central domain of interaction design. It can be schematized as human → technology (world).

Fourth, Ihde distinguishes the *background* relation, in which technologies are the context for human experiences and actions. The sounds of air conditioners and fridges, the warm air from heating installations, the notification sounds from cellphones during a conversation—in all of these examples, technologies are a context for human existence, rather than being experienced themselves. Schematically: human (technology/world).

Many recent technologies, however, do not fit into one of these four categories [11]. There are configurations of humans and technologies that are even more intimate than an embodiment relation, while others have a more powerful contextual influence than the background relation. A brain implant, for instance, that is used for deep brain stimulation to treat Parkinson's disease or psychiatric disorders, is not merely embodied; rather, it merges with the human body into a new, hybrid being. I have proposed to call this a *cyborg* relation: human/technology → world.

Other technologies merge with our environment, into "smart environments" with "ambient intelligence" and sometimes even "persuasive technologies" [12]. Here, technologies are not just a background for our existence, but rather an *interactive* context: They detect if people are present or not, recognize faces, give feedback on behavior. This configuration of *immersion* can be schematized as human ⟷ technology/world.

Wearable technologies such as Google Glass give yet another human-technology configuration. They result in a bifurcation of the human-world relation: On the one hand, smart glasses can be embodied to give an experience of the world, while, on the other hand, they give a representation of the world in a parallel screen. This relation could be called *augmentation*, combining an embodiment relation and a hermeneutic relation: (human - technology) → world + human → (technology - world).

Points of contact. A second dimension of human-technology relations concerns the "contact points" between human beings and technological products. In all of the human-technology-world relations discussed above, there are specific types of connections between users and products. Steven Dorrestijn has developed a framework to categorize these contact points, using the human body as a reference [13]. He distinguishes four types of contact, corresponding to four zones around the human body: "to the hand," "before the eye," "behind the back," and "above the head."

The first two zones concern the ways in which individual human beings encounter technologies: physically (to the hand: bodily interaction with technologies, like crossing a speed bump) and cognitively (before the eye: interpreting information given by the technology, like stopping at a red traffic light). The last two zones are contextual: behind-the-back refers to the material infrastructure that has an impact on our actions and experiences (like using the train only if there are good connections between one's home and the railway station), and above-the-head refers to the role technology plays in our thinking (like having utopian or rather dystopian expectations of the social impact of technology).

Types of influence. The third and last dimension of human-technology relations concerns the character of the influence that is being exerted on human beings. Nynke Tromp et al. have distinguished two dimensions in the influence of technologies on human beings: its *visibility* and its *force*. The impact of technologies can be located somewhere on the continuum between "hidden" and "apparent," on the one hand, and between "weak" and "strong," on the other [14].

Strong, apparent influences can be called *coercive*: turnstiles that force you to buy a ticket before entering the subway, or cars that won't start when you don't wear a safety belt. Weak, apparent influences are *persuasive*. Technologies show their influence, without being overpowering: smart energy meters that give feedback on your energy consumption or e-coaching apps that help you lose weight.

The hidden types of influence are often seen as a little more creepy, but in fact they are very common. Hidden, weak influences can be called *seductive*. Their impact is non-cognitive and mild: placing a coffee machine in the hall of a company to stimulate social interaction, using material that ages beautifully to prevent people from discarding a product prematurely [10,15]. The final type of influence is both strong and hidden; it can be called *decisive* or *implicative* because it exerts influence without this influence being noticed. An example is an apartment building without an elevator, implicitly forcing people to use the stairs.

Mediation. Within these three dimensions, technologies help shape human experiences and practices. Rather than being external to human beings, they help define what it means to be human. Technologies help us develop our knowledge of the world, our moral actions and decisions, and even our metaphysical and religious frameworks: MRI scanners provide neuroscientists with a highly specific way to access the brain, while obstetric sonography informs ethical decisions about abortion, and IVF reorganizes the boundary between the given and the made, or fate and responsibility. Technological mediation is part of the human condition—we cannot be human without technologies.

This makes the design of technologies a highly responsible activity. Designing technology is designing humanity, in a sense. Any technology will help to shape human actions and experiences, and will therefore have an impact that can be understood in ethical terms. Designers materialize morality [16]. Therefore, along with functionality, interaction, and aesthetics, mediation deserves a central place in the conceptual framework that implicitly and explicitly guides design activities.

THE ETHICS OF DESIGN

How, then, can designers take mediation into account in their design work? First, designers can try to *anticipate* mediations when designing a product. Imagination can be a powerful tool for that, and the mediation framework described here can help guide one's imagination through various dimensions of the relations between humans and products.

A more invasive approach is to *design* mediations explicitly into products. Rather than preventing unintended and unanticipated mediations, the ambition is then to design products that explicitly have an impact on people's experiences and practices—like the speed bumps and double-sided printers mentioned above. The "nudge" approach defended by Richard Thaler and Cass Sunstein [17] has a similar ambition: gently influencing people's behavior in a specific direction.

Explicitly influencing people via design is a contested thing to do, though. It puts something at stake that has become one of the most sacred things in contemporary Western culture: human autonomy. For that reason, for instance, Thaler and Sunstein explicitly call their approach a form of "libertarian paternalism." It is inevitably paternalistic, in the sense that it exerts influence on human beings, but at the same time it explicitly aims to be libertarian, in the sense that it always gives people the possibility to opt out. Nudges should never be given invisibly or without the possibility of avoiding them.

From the perspective of mediation theory, though, this focus on autonomy is not very helpful. Without giving up on human freedom, to the contrary, mediation theory shows that technologies always mediate human practices and experiences. Rather than seeking to eliminate these unavoidable impacts of technologies, we should make the best of them. And rather than seeking for autonomy against the powers of technology, we should seek to develop responsible forms of mediation. Users, designers, and policymakers should be enabled to read, design, and implement technological mediations, in order to be able deal in a critical, creative, and productive way with powers that remain hidden otherwise [18]. Human freedom cannot be saved by shying away from technological mediations, but only by developing free relations to them, dealing in a responsible way with the inevitable mediating roles of technologies in our lives.

CONCLUSION

At the intersection between interaction design and philosophy of technology, a lot of interesting work is to be done. Philosophy of technology can offer conceptualizations of the relations between humans and technologies that deepen our understanding of what *interaction* can mean in interaction design. At the same time, the field of interaction design is a rich source of inspiration for philosophy of technology, as the place where new types of human-technology relations emerge, and where designer intent and use practices meet. The concept of mediation can be the bridge between the fields: Rather than seeing technologies as functional, we need to understand how they play a mediating role in human practices and experiences. Technologies-in-use help shape relations between users and their environment. Mediation theory can help us analyze the various shapes these relations can take, the points of application between a technology and its user, and the specific types of mediation at play. Designing interactions is designing relations between human beings and the world, and, ultimately, designing the character of the way in which we live our lives.

Endnotes

1. Pitt, J.C. 'Guns don't kill, people kill': Values in and/or around technologies. In *The Moral Status of Technical Artefacts*. P. Kroes, P.-P. Verbeek, eds. Springer, 2014, 89–101.
2. Clark, A. and Chalmers, D. The extended mind. *Analysis 58*, 1 (Jan. 1998), 7–19.
3. Clark, A. *Natural Born Cyborgs: Minds, Technologies, and the Future of Human Intelligence.* Oxford Univ. Press, 2003.
4. Verbeek, P.-P. Resistance is futile. *Techne: Research in Philosophy and Technology 17*, 1 (2013), 72–92.
5. Carr, N. Is Google making us stupid? What the internet is doing to our brains? *The Atlantic.* (Jul. 1, 2008).
6. Turkle, S. *Alone Together: Why We Expect More From Technology and Less From Each Other.* Basic Books, 2012.
7. Kapp, E. *Grundlinien einer Philosophie der Technik: Zur Entstehungsgeschichte der Kultur aus neuen Gesichtspunkten*. Verlag George Westermann, 1877.
8. Schmidt, H. Die entwicklung der technik als phase der wandlung des menschen. *Zeitschrift des VDI 96*, 5 (1954), 118–122.
9. Ihde, D. *Technology and the Lifeworld: From Garden to Earth.* Indiana Univ. Press, 1990.
10. Verbeek, P.-P. Artifacts and attachment—a post-script philosophy of mediation. In *Inside the Politics of Technology*. H. Harbers, ed. Amsterdam Univ. Press, Amsterdam, 2005, 125–146.
11. Verbeek, P.-P. Cyborg intentionality: Rethinking the phenomenology of human-technology relations. *Phenomenology and the Cognitive Sciences 7*, 3 (2008), 387–395.
12. Verbeek, P.-P. Ambient intelligence and persuasive technology: The blurring boundaries between human and technology. *Nanoethics 3*, 3 (2009), 231–242.
13. Dorrestijn, S. et al. Future user-product arrangements: Combining product impact and scenarios in design for multi-age success. *Technology Forecasting and Social Change 89* (2014), 284–292.
14. Tromp, N. et al. Design for socially responsible behavior: A classification of influence based on intended user experience. *Design Issues 27*, 3 (2011), 3–19.
15. Verbeek, P.-P. and P. Kockelkoren. Matter matters. In *Eternally Yours: Visions on Product Endurance*. E. van Hinte, ed. 010 Publishers, Rotterdam, 1997, 101–119.
16. Verbeek, P.-P. *Moralizing Technology: Understanding and Designing the Morality of Things*. Univ. of Chicago Press, 2011.
17. Thaler, R. and Sunstein, C. *Nudge: Improving Decisions About Health, Wealth, and Happiness.* Penguin Books, 2009.
18. Kiran, A.H and Verbeek, P.-P. Trusting our selves to technology. *Knowledge, Technology & Policy 23*, 2–4 (2010), 409–427.

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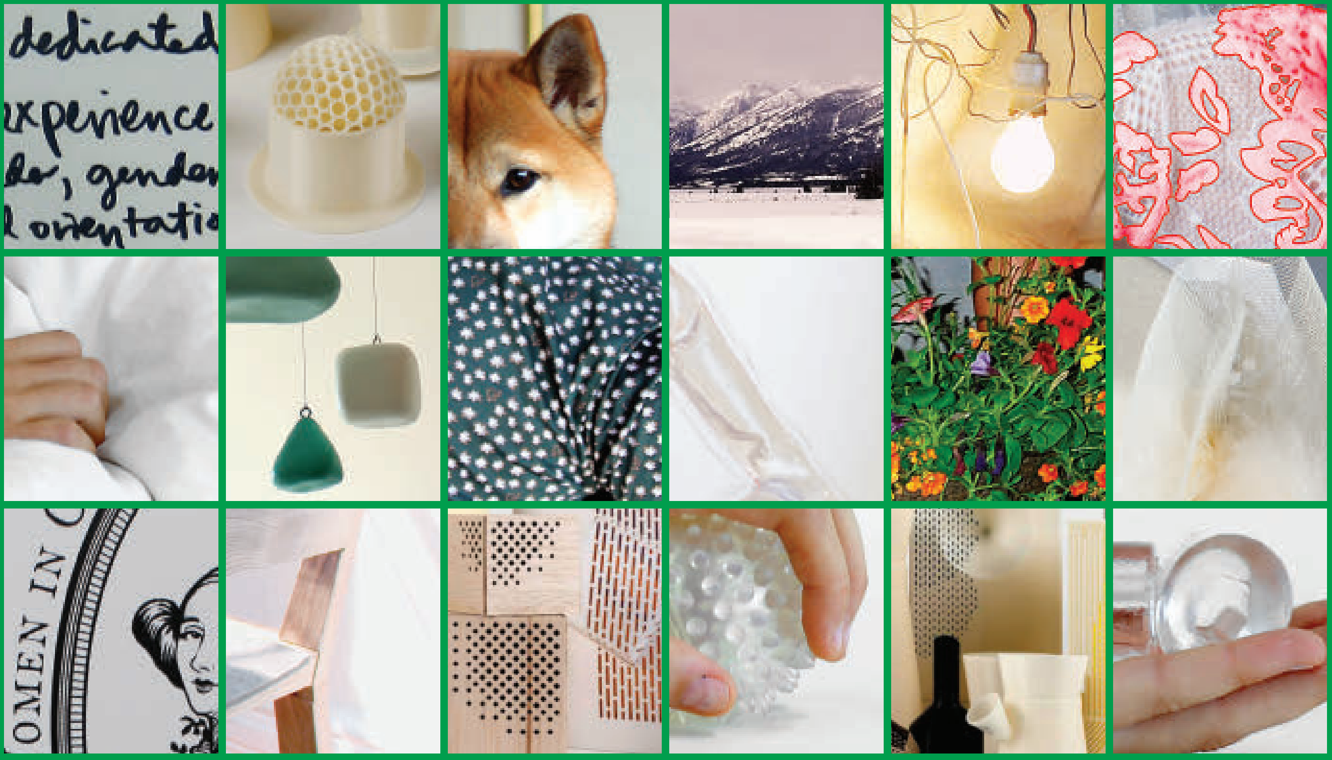
SHARING THE HIDDEN TREASURE IN PICTORIALS

The idea of images as a foundational mode of creating and articulating knowledge about interactivity has been gaining traction in HCI and interaction design. The use of photography and imagery has long been foundational in traditional schools of design. Inventories of "the best" such schools—however subjective—can be found in many business press sources [1]. Here, we privilege two design schools as exemplars of these traditions, owing to their associations with two key figures, László Moholy-Nagy and William Gaver. Famous for its history in connecting photography and design, the Institute of Design in Chicago was founded some 75 years ago by painter and photographer László Moholy-Nagy from the German Bauhaus [2]. In HCI the centrality of visual form has been advanced notably by Goldsmiths at the University of London under the stewardship of William Gaver [3]. Privileging these two institutions here must be accompanied by the awareness that many other fine schools and distinguished figures in the design tradition were equally important in establishing this foundational role for photography and imagery.

In HCI specifically, the importance of images, per se—in a sense that includes but also extends beyond the recording of design process or presentation of concepts—has a more nascent history. The Visual Thinking Gallery that has appeared on >>>>

SPECIAL TOPIC



>>>> the inside back page of each issue of *Interactions* since September 2011 [4] presents a photograph relating in some way to digital interactivity and design with only very limited text indicating a title, contributor, genre or type of connection, and caption. The core idea of the Visual Thinking Gallery is that the photograph—and its quality as a photograph *in and of itself*—is an important form of knowledge articulation, more important than the text for this form of contribution. A workshop on visual thinking was held at CHI 2012 [5]. In 2013, a primarily visual, image-oriented paper was accepted into the technical program at NordiChi—possibly the first accepted archival paper in a SIGCHI technical program to foreground images over text in articulating its core contribution [6]. And at DIS 2014, a new pictorials track [7] was introduced in which submitted pictorial essays were reviewed according to standards similar to those of other papers in the technical program; a number of them appeared as archival work.

Among the pictorials submitted to DIS 2014 are a treasure trove of images worth sharing. Here, we present a curated selection of the images that appeared in the submitted pictorials with some brief textual descriptions—just enough to state the importance of each image, but not so much as to preclude the images from speaking for themselves. The images combine to form a collection showing a range of different ways in which images serve as first-class exemplars of interaction design, including but not limited to:

- images as a record of making
- images as a form of making
- images as a record of process
- images as design ethnography
- images as commentary on interaction design
- images as purely aesthetic reflection on interactivity
- images as social commentary in the perspective of interaction design
- images as a record of inspiration
- images for reflection to inform a process
- images as a record of contexts and environments
- images as a record of concepts
- images as a record of aesthetic property (i.e., materiality).

In curating these images, we have endeavored to select images that are both interesting in their implications for interaction design and also fine images in their own right.

INVITATION

We believe that everyone can participate in making images a foundational mode of creating and articulating knowledge about interactivity. Our goal is to invite and encourage our community to consider the quality of the images they use and the roles images play in interaction design in HCI practice, education, research, scholarship, and creative activity. Visual thinking belongs to and in our community.

ACKNOWLEDGMENTS

In the American context, we must recognize the Institute of Design for its foundational role in the link between photography and design. We also especially thank Nadine Jarvis and David Cameron for their important role in the DIS 2014 Pictorials track, and indeed the Interaction Research Studio, Goldsmiths, University of London for its role in promoting visuality in HCI. We also thank especially Elizabeth Churchill, James Pierce, David Roedl, and Ron Wakkary for their roles in advancing visual thinking in HCI. We also thank the many participants of the CHI 2012 workshop [5] as well as everyone involved in the DIS 2014 Pictorials track.

Endnotes

1. See for example: images.businessweek.com/ss/09/09/0930_worlds_best_design_schools or www.businessinsider.com/the-worlds-25-best-design-schools-2012-11
2. www.id.iit.edu
3. www.gold.ac.uk/interaction
4. The Visual Thinking Gallery and its motivations are first introduced—with the very kind encouragement of Ron Wakkary—in Blevis, E. Digital imagery as meaning and form in HCI and design: An introduction to the Visual Thinking Backpage Gallery. *Interactions 18*, 5 (Sept.–Oct. 2011), 60–65.
5. Blevis, E., Churchill, E., Odom, W., Pierce, J., Roedl, D., and Wakkary, R. Visual thinking and digital imagery. *CHI'12 Extended Abstracts on Human Factors in Computing Systems.* ACM, New York, 2012, 2715–2718.
6. Jarvis, N., Cameron, D., and Boucher, A. 2012. Attention to detail: Annotations of a design process. *Proc. of the 7th Nordic Conference on Human-Computer Interaction.* ACM, New York, 2012, 11–20.
7. Cameron, D., Hauser, S., Jarvis, N., and Odom, W., eds. Pictorials. *Proc. of the 2014 Conference on Designing Interactive Systems.* ACM, New York, 2014, 121–160 and 473–502.

The DIS 2014 pictorials are: Lorenzo Davoli and Johan Redström. Materializing infrastructures for participatory hacking; James Pierce and Eric Paulos. Some variations on a counterfunctional digital camera; Stephan Wensveen, Oscar Tomico, Martijn ten Bhömer, and Kristi Kuusk. Growth plan for an inspirational test-bed of smart textile services; Ron Wakkary, Audrey Desjardins, William Odom, Sabrina Hauser, and Leila Aflatoony. Eclipse: eliciting the subjective qualities of public places; Elisa Giaccardi, Elvin Karana, Holly Robbins, and Patrizia D'Olivo. Growing traces on objects of daily use: a product design perspective for HCI; Michael Shorter, Jon Rogers, and John McGhee. Practical notes on paper circuits; Eli Blevis. Stillness and motion, meaning and form; Diego Trujillo-Pisanty, Abigail Durrant, Sarah Martindale, Stuart James, and John Collomosse. Admixed portrait: reflections on being online as a new parent; William Odom, John Zimmerman, Jodi Forlizzi, Hajin Choi, Stephanie Meier, and Angela Park. Unpacking the thinking and making behind a user enactments project.

About the Curators

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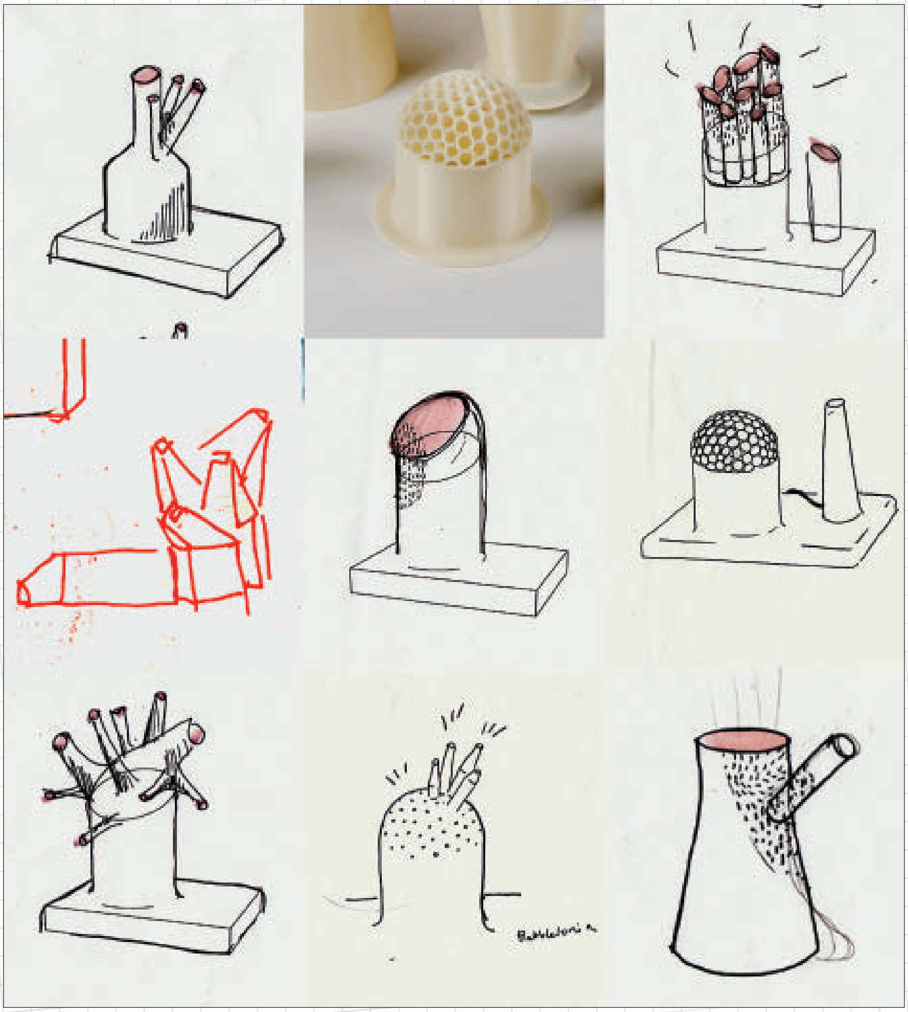


1A

1B

1

Image 1A. Sketches exploring multiple and single audio outputs.

Image 1B. Prototypes of different aesthetic explorations.

These two images were contributed by Liliana Ovalle (Interaction Design Research Studio, Goldsmith's, London), used here with permission. The soft organic forms of the prototype sketches in 1A take shape as Dieter Rams-inspired physical prototypes in 1B. The sketches in 1A are exercises in embodiment during the development of the Energy Babble audio device. The forms in 1B are prototypes exploring different aesthetics during the development of the Energy Babble audio device. As a post-hoc reflective observation on the part of the curators of this article, one could note that the forms in 1B appear to be artfully arranged as in a cubist landscape, in both the pastel color palette and primary shapes. Here, the images play the roles of *record of making* and *record of inspiration of form*.

2A

2B

2

Image 2A. Portraits of people and their dogs.

Image 2B. Flat-coated retriever society of America.

The triptych in image 2A by Max Mollon (PSL Research University, Paris) shows three dog owners interacting with their dogs of various breeds in very similar living-room contexts and poses, with soft indoor lighting. The images are a reflection on different human-canine communication styles for a project to design for interactivity between dogs and humans. As surreal as these portraits and their serendipitous notions of interactivity are, image 2B (photographer unknown) is even more surreal. It shows curator Sabrina Hauser (SFU, Vancouver) with her dog, who is receiving an award “First Place 7–9 Years Bitch” at a dog show. The deliberate poses and seemingly amateur bright flash add to the surrealism. Here, these images play the roles of *photo-ethnography both directly and indirectly as informant of interaction design* as well as *images as serendipitous, fun, or humorous inspiration for design*.

3

Image 3A. Portraits of craftspeople.

Image 3B. Handcraft Paper Museum, Tengchong Village.

These images by Haodan Tan (Indiana University Bloomington) show rural Chinese craftspeople engaged in culturally rich heritage craft (3A) and the Handcraft Paper Museum (3B), which makes these crafts available. The images serve the role of *ethnophotographic reflection on making*, interesting because the implications of craft orientations for interaction design are currently a matter of specific interest.

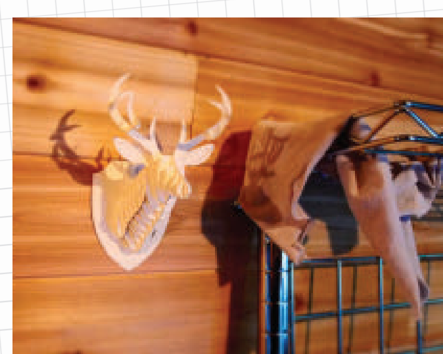
3A

3B

4

Image 4. Camper van prototype.

These images by Audrey Desjardins, Léandre Bérubé LeBrun, and Ron Wakkary (SFU, Vancouver) show a van that has been converted to a camper van. In the first image, the temporally mobile built artifact merges with and contrasts with the timeless, natural snow-covered landscape, at once both cold and warm. Before and after images show the van's transformation from a cold metal container to a warm wood-lined living space. With respect to interactivity, design images play the roles of *record of DIY culture* and *illustration of the synthesis of artisanal craft with technological affordance* (of the modern vehicle design).



5

Image 5. Stakeholder panoramas.

These images by Martijn ten Bhömer, Oscar Tomico, and Stephan Wensveen (TU/e, Eindhoven) show different stakeholder environments in the production of smart textiles and associated services. The panoramic technique and parallelism among the three environments are interesting photographically as a means of highlighting context rather than editorial focus. The roles of the images are *records of stakeholder environments* and *comparison of contexts*.

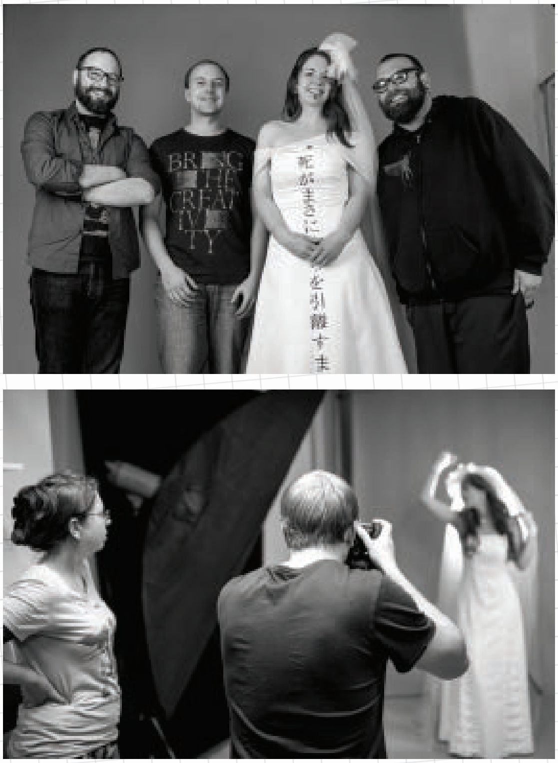
Prototyping facilities of technology partner

Knitting facilities of textile producer

Social environment of service provider

6A

6B



6

Image 6A. Design sketching with high-quality photographs.

Image 6B. The photo studio as a material of design process.

These images by Nicholas True (Umeå University), Shad Gross (Indiana University Bloomington), and Daniel Fallman (Umeå University) show high-quality photography used as a basis for sketching the design—in this case—of wedding-ceremony wearable-technology fashion. 6A shows how the design details are highlighted by their contrast in realism with the photographic background that serves as context. 6B shows the production of these background images. The images serve the role of *a material in a technique of concept sketching.*

7

Image 7. Remote presence prototypes.

These images by Jackson McConnell (OCA, Toronto) photographically illustrate his designs for mechanisms of ambient awareness and presence based on sound, visual sculpture, light, video, and even smell (not pictured). The role of images in this work is *a record of prototyping concepts*.

Quantum B

Media Mobile

Knock-Knock

Peep Show

Image 8. Crafting material properties.

This ennead of images by Ingrid Pohl (University of Technology Graz, Austria) and Lian Loke (University of Sydney) provide an inventory of material interactions. The images very economically show interactivity through the use of materials and the hands of a model. The role of the images here is as *inventory of design materiality*.

Soft

Warm

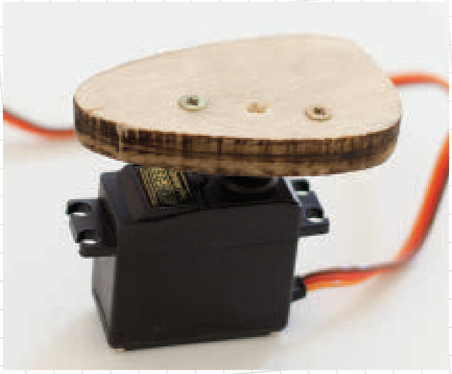
Cold

Vibration

Shape Change

Surface Roughness

Air Flow



Dynamic Movement

Water Flow

9A

9B

9

Image 9A. Scenes from feminist hackerspaces field research.

Image 9B. Anti-harassment policy in a feminist hackerspace.

Image 9A by Sarah Fox, Rachel Rose Ulgado, and Daniela Rosner (University of Washington, Seattle) and image 9B by Liz Henry chronicle the reading material in feminist hackerspaces in Portland, San Francisco, and Seattle. Here, the identities of the people who use these spaces are not in portraits, but rather in artifacts that tell a story about sociopolitical orientations. The images serve the role of *revealing identity through recording of context*.

Oskar Juhlin, Stockholm University

Digitizing Fashion—Software for Wearable Devices

Insights

- Many wearable devices provide public visual surfaces with possibilities for endless variation of aesthetic expression.
- To leverage these new expressive possibilities, fashion designers should be included in the making of software and services.
- Fashionable wearable services and software could one day interact with people's clothing ensembles.

There is an ongoing trend of digital devices being used in close physical proximity to our bodies, in the same position as our clothes. It started with the success of mobile phones, continues with the emergent use of smart watches and smart eyewear, and is leading to a future of smart textiles and organic user interfaces. These devices provide public visual surfaces with possibilities for endless variation of visual expression. With the emergence of wearable hardware, we foresee the need to develop fashion-oriented software, services, and applications. The question then arises of how, specifically, these devices should vary in their expression.

This trend started with the phenomenal success of mobile phones. The complex relationship between the use of mobile devices and the consumption of fashionable clothing has been identified and discussed in sociology and HCI [1]. Since we interact with mobile phones in close physical proximity to our bodies and clothes, we have a similar interest in their beautification. That relationship is likely to increase, given the growing interest in manufacturing and commercializing smart watches.

This interest is visible among global technology companies such as Samsung, Sony, Apple, and Motorola, as well as small start-ups such as Hyetis, Pebble, and Martian.

On a general level, researchers in HCI have argued for a long time that we need to account for social contexts in understanding and designing computer use. For example, when the computer was placed on the desktop, the field of computer-supported cooperative work (CSCW) grew out of the insight that the design needs to account for not only an individual and a computer, but also people and physical objects in their surroundings. The concern with understanding computers in context has widened even further with the growing interest in understanding users' experiences beyond how efficiently they handle tasks.

Now, with hardware increasingly worn on the body, we foresee a similar need to attend to a very different context of use. The physical proximity of mobile and wearable devices to other artifacts needs to be recognized as a new context. In close proximity to wearable computers we find the clothes we wear as well as those looking at our outfits. Mobile and wearable devices share their location with handbags, gloves, wristwatches, sunglasses, shirts, jackets, trousers, and other items. The mobile phone might be held in the same glove-covered hand that also bears a handbag. The smart watch competes with wristwatches for the position in between the arm and the hand, and is often covered by the sleeve of a blouse or a shirt. In the same way, smart glasses compete with traditional eyewear but are also situated millimeters away from cosmetic products and hairdos. The physical proximity between, on the one hand, mobile phones and wearable devices, and on the other hand, clothes, accessories, and shoes, underscores the need to understand new forms of computer experiences as being influenced by, or resembling, those in clothing and fashion.

That said, the fashion phenomenon is itself hard to grasp. It is a general term we use for the items we wear as well as a concept denoting social practices related to our experiences of clothes. HCI is not alone in the quest to unpack its meaning. In recent years, we have seen an escalation of humanistic research within "fashion studies" that engages with people's experiences and relationships with clothes. We learn that people relate to visual appeal and to the beauty of their clothes [2]. They do it in such a way that individual items are experienced as part of a complete look or outfit, and account for their selections and display as a message sent to co-present audiences. Fashion scholar Yuniya Kawamura argues that we should not confuse fashion with garments, since not all clothing items are fashionable [3]. Fashion is rather the social and cultural institutions that make particular items or textiles desired. In a similar way, Elizabeth Wilson argues that fashion is an important driver of taste and that it molds our concept of what is considered beautiful [4]. Fashion is a form of visual art with the "visible self as its medium." Like many other scholars in this area, she discusses the most salient feature in fashion: the continuous drive for change and variation. She does this by pinpointing its dissonances. The changing expression of what is seen as fashionable has to do with the evolution of aesthetic style, which reflects discords in society. Aesthetic styles are in themselves ambiguous and rooted partly in the continual change of expressions, where one style draws on the one before it, and in a sense provide a pattern in which one step reflects the previous step. But fashion aesthetics is also molecular and disconnected:

"Fashion, with its constant change and pursuit of glamour, enacts symbolically the most hallucinatory aspects of our culture, the confusions between the real and the not-real, the aesthetic obsessions, the vein of morbidity without tragedy, of irony without merriment, and the nihilistic critical stance towards authority, empty rebellion almost without political content" [4].

Fashion expressions sit uncomfortably between the private territories of our biological bodies and our selves as social and public beings. They are linked to change derived from a complex and modern society. In this sense, the connection between the self and the world, as expressed with clothes, is always ambiguous. Fashion is a means to express individual desires for independence or wishes to belong to a group, but it also becomes a social pressure for conformity, often formulated in feministic critiques of the beautification of the self.

When digital devices are wearable, we should not confuse making the device look "pretty" with the need to design for fashion. Nor should we look for quick-and-easy rules and guidelines in aesthetics (e.g., those provided by pragmatics philosopher John Dewey [5]), since fashion is fleeting and ambiguous. We suggest providing technologies that expose the design of digital devices to the institutional practices that currently mold our taste for clothes, handbags, eyewear, and so on.

As a way to explore fashion-oriented design of wearables, we conducted a study of fashion bloggers' comments on mobile phones [2]. Even though such posts were few, those we found show that bloggers appreciate public visual aesthetics, accessories that combine with an outfit to create a look, and possibilities for variation in-between looks. Their limited interest in mobile devices might be explained by these devices' restricted opportunities to create and vary visual aesthetics on surfaces other than the screen, which is normally turned toward the user and invisible to people nearby. The back of a device offers a look that cannot be altered, except by adding a cover. Similar to garments and other fashion objects, the backside of each item has a fixed color and shape, but with garments, variation is easily achieved by switching between different items. Garments and accessories are then easily combined and re-combined to create publicly visible codes that are transmitted

Figure 1. A display of switching options for an imagined singular device with an organic interface.

In order to generate fashionable wearables and the supporting software, we need to link design to both fashion thinking and its specific supporting institutions.

as messages to surrounding people. The study points to the possibility of designing interfaces that extend social and visual interaction and to the way people vary their outfits beyond their current decorations.

As a next step, we investigated the possibility of creating desire by drawing on cultural institutions and practices that are common in fashion, specifically, by addressing a particular style [6]. The result was the concept of a shape-switching digital device whose shape could be changed in 22 different ways when selecting a new clothing ensemble. The shapes that the imaginary device could provide were presented as a series of 22 mock-up samples that are in themselves hard to the touch, and that vary in color and shape (Figure 1). It's important to note that this exercise is a step prior to exploring the actual shape-switching device, in which we would focus more on digital functionality and usability issues. The concept was inspired by the emerging opportunities with organic interfaces, where the interface is conceived as being capable of transforming into a variety of shapes, either by manual selection or by some sort of automatic feature. The set was designed based on further studies of fashion-conscious people in Stockholm, emphasizing a local and historically dependent visual aesthetic. The shapes are visible both to their owner and to people in the vicinity. The making of prêt-à-porter samples by a designer is important since it accounts for the fashion design process.

We conducted a user study with five women, all with an aesthetic orientation toward the identified dressing style. They mostly participated in their homes by experimenting with selecting among the samples to see how they fit with ensembles chosen from their wardrobes. Their use reflects the intention of our design concept to change the shape of a device to fit with a person's variation in dress. It also shows the importance of providing different ways to attach them to the body, since participants found various ways to carry the device, including attaching it to necklaces, shoelaces, brooches, and belts, as well as holding it in their hand.

Our design exercise was intended to draw on previous attempts to account for fashion practices in hardware design, and then point to the need to consider fashionable software and services. In mobile design, there have been explicit attempts to create designs that target a fashion-conscious market, people who are interested in their physical attractiveness and in their image. The industry has provided accessories and hardware designed for them and has marketed devices on fashion runways and in fashion magazines. With the advent of wearable computing, attempts to vary the aesthetics in hardware design are likely to multiply, such as with Intel's recent collaboration with the fashion retail firm Opening Ceremony or the current increase in smart watch releases. Although the visual expression of such hardware is as fixed as that of a mobile phone, the position of its wearable screen points to a new type of software and services that account for fashion values.

The generation of such software demands new orientations and new collaborations between the field of human-computer interaction and fashion designers embedded in fashion institutions. We do not suggest a turn to design in general, product design, or interaction design. If design is defined as human shaping of the environment in ways without precAwedent in nature in order to serve our needs and give meaning to our lives [7], then obviously the design of fashionable wearables could be done by any designer. However, our challenge is more precise: to understand the use of wearables in the context of clothing and accessories. It has been argued that fashion design focuses on aesthetics, creativity, and innovation in the domain of appearances, and differs from product-design thinking, which emphasizes problem solving and a user-centered method to framing problems [8,9]. More important, fashion design is nested into institutional arrangements that as a whole create desire, beautification, and variation [3,4]. From an institutional perspective, fashion design and interaction design differ because they are dependent on different organizational arrangements. Fashion design has a long tradition and is based on rather stable organizations, such as those involved in coordinating color selection. In sum, in order to generate fashionable wearables and the supporting software, we need to link design to both fashion thinking and its specific supporting institutions.

We envision that future wearable computers will account for a consumer understanding of fashion when it comes to both hardware and software. Our computer interfaces and our garments are literally touching each other through the introduction of technology we wear on our bodies. It is time to unpack how to combine these areas of design in order to create desirable wearables. If we do not take on this challenge, wearable human computer interaction risks being dismissed altogether or marginalized as being too unstylish.

Endnotes

1. Fortunati, L., Katz,J., Riccini, R., Eds. *Mediating the Human Body: Technology, Communication and Fashion*. Erlbaun, Mahwah, U.S., 2003.
2. Juhlin, O. and Zhang, Y. Unpacking social interaction that make us adore—On the aesthetics of mobile phones as fashion items. *Proc. Mobile HCI 2011*. ACM Press, 2011, 241–250.
3. Kawamura, Y. *Fashion-ology: An Introduction to Fashion Studies*. Berg, Oxford, U.K., 2005.
4. Wilson, E. *Adorned in Dreams: Fashion and Modernity*. Rutgers Uni. Press, New Jersey, U.S., 2003.
5. Dewey, J. *Art as Experience*. Perigee Trade, New York, 2005.
6. Juhlin, O., Zhang, Y., Sundbom C., and Fernaeus Y. Fashionable shape switching: Explorations in outfit-centric design. *Proc. of CHI 2013*. ACM, 2013, 1353–1362.
7. Heskett, J. *Design: A Very Short Introduction*. Oxford University Press, 2005.
8. Martin, R. *The Design of Business: Why Design Thinking Is the Next Competitive Advantage*. Harvard University Press, Boston, MA, 2009.
9. Pacione, C. Evolution of the mind: The case for design literacy. *Interactions 17, 2* (2010), 6–11.

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LESSONS LEARNED

FINGERS, THUMBS, AND PEOPLE

Designing for the way users really hold and touch their phones and tablets

Steven Hoober, 4ourth Mobile

IMAGE BY ANDRIJ BORYS ASSOCIATES / SHUTTERSTOCK.COM

The ubiquity of smartphones has made many of us excited to work on mobile. But in important ways, it has also actually hindered the development of good heuristics. Principles of "natural UI" have been taken to heart, and we believe our experiences are representative of the experiences and preferences of everyone.

All too often we make decisions based on anecdote, opinion, personal bias, hearsay, and rumor. We malign others, and even discount user preferences and patterns that oppose our own. As just one common example, I have encountered many designers who automatically assume that only iPhone users are worth building for, often with no data to back up that assumption.

More frustratingly, much of the foundational research cannot be applied completely or uniformly to modern devices. The devices have changed enough in use, form, and technology just since the 1990s that care must be taken even with international standards on ergonomics and human factors.

For the past two years, I have been looking closely at the existing body of research and have filled in the gaps with several studies I performed myself or in coordination with others. I have found much of our knowledge to be outdated or grounded in poor assumptions but have come to useful, actionable conclusions about how people really hold and touch their phones and tablets.

There are a handful of interrelated interactions, ergonomics considerations, and human behaviors that can be thought of as 10 distinct guidelines for touchscreen design.

1. ***Your users are not like you.*** It's easy to make assumptions and confuse empathy with your own point of view. Your users are not like you—or your friends—but rather work in myriad ways, changing the way they work and regularly shifting their grip.

People are very comfortable changing their hand position as they change tasks and contexts, touching the screen in different ways to do different things with their devices, as shown in Figure 1.

2. ***People prefer to touch the center of the screen.*** Regardless of whether the behavior is innate or learned, users prefer to touch the center of the viewport on a handset, phablet, or tablet, and will do so when given a choice.

For example, people will naturally move a list of content to the center of the screen before selecting it. When you account for content position and different devices, you find that most taps are in about the center half to two-thirds of the screen.

3. ***People prefer to view the center of the screen.*** Conveniently, this behavior extends to viewing as well. When given a chance, people will scroll content to the middle to read it.

Follow the classic mobile pattern of list views and put your main content and interaction in the middle of the page. Provide padding to scroll the end of content toward the middle, and make sure menu bars, tabs, status displays, and action items on the top or bottom are secondary.

4. ***Fingers get in the way.*** Fingers, hands, and thumbs are opaque and can get in the way. Because we shift our grip and use different devices, where our fingers and thumbs are varies, so it's hard to plan that specifically.

This also influences how we gesture. Users will scroll by dragging along the middle of the screen, but only when they will not cover content. When your selectable list has long labels, people scroll to the far right to get to the most-empty area they can. And for Arabic or Hebrew, right-to-left languages, the opposite is true.

Always provide room to make sure touch targets can be seen—enough room to see the clicked state when the target is selected—and try to provide empty space for users to feel comfortable scrolling.

5. ***Different devices are used in different ways.*** Respect user choice instead of complaining about fragmentation. Large tablets like the 10-inch iPads are used almost as computer replacements, about two-thirds of the time in a stand and a quarter of the time with physical keyboards.

As devices get larger, they are less and less handheld. And the smaller the device is, the more it is used on the move, while walking around the house or office, instead of finding time to place it on a table or sit and type at a computer on a desk.

The larger devices get, the farther away from the eye they are used. Due to angular resolution, minimum text sizes vary from 4 point for small handsets to 10 point for devices set on tables or in stands. These are minimum sizes, so use much larger text for most content of course.

6. ***Touch is imprecise.*** Capacitive touchscreens detect only the centroid (or geometric center) of the part of your finger that gets flattened against the screen.

The phone can't sense how big your finger is, how hard you pressed, how big the contact area is, which way it is facing, or anything. All it gets is a point that it assigns to be the touched coordinates. And that point is never, ever perfectly aligned. Some example tap-accuracy data is shown in Figure 2.

When we accept everything is imprecise, we stop calling these errors and refer instead to tolerances. We need to plan for imprecision and problems as

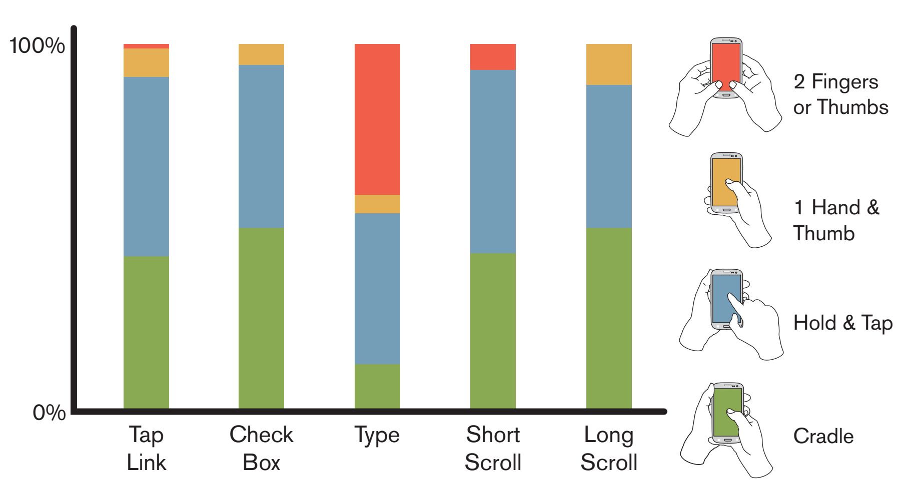

Figure 1. How people hold and touch with their phones varies by the interactive context and its needs.

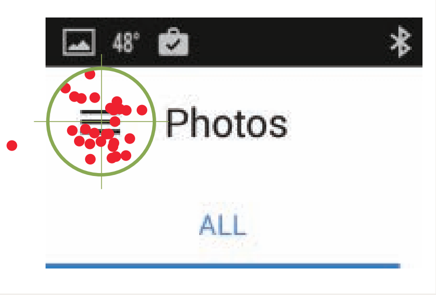

Figure 2. Red dots are the actual positions people tapped when trying to select a menu icon.

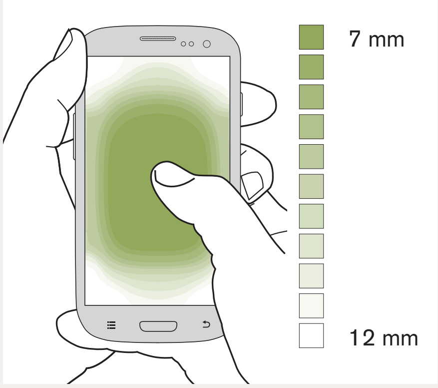

Figure 3. Accuracy varies consistently across all users by the position on the screen they are trying to tap or scroll.

part of the process. Be sure to provide the largest practical touch targets and don't just code the word or icon as a link inside a non-selectable box.

Look around and you'll see this is a known best practice. The Google drawer menu or back arrow icon—at least before 5.0—isn't as small as it appears, and it also opens when you select the icon or title next to it. Lots of hybrid apps and websites don't notice this and code it wrong, giving the "hamburger menu" a bad reputation for being too small.

7. ***Touch is inconsistent.*** The largest variable in inaccuracy is not environmental conditions, familiarity with touchscreens, or age but the position on the screen your users are trying to tap. People are more accurate when tapping the middle of the screen on all mobile devices, as shown in Figure 3. They are also more confident at the center, so they will slow down to tap corner or edge targets.

The sides are a little worse than the center, but the top and bottom require much more room, and corners require about twice the space between targets as the center to avoid accidental taps.

Be sure to provide plenty of space for any menus and controls along the top and bottom edges of the screen, and place unrecoverable or annoying-to-exit items far from others to avoid frustrating accidents.

8. ***People click only what they see.*** Make sure selectable items are clearly selectable. If it doesn't look clickable, people don't know it is. Underlines aren't bad for text inline, but especially for apps, you mostly need to bound items, being sure not to bound non-clickable items.

Visual targets, whether words, icons, or some other shape or UI widget, must:

- attract the user's eye
- be drawn so the user understands they are actionable elements
- be readable, so the user understands what action they will perform
- be large and clear enough so people are confident they can be tapped.

Clickable items need to not just afford their action (making it clear what they do) but do so consistently. If most items in your design are whole selectable rows or buttons, don't have one row suddenly be an underlined link.

9. ***Phones are not flat.*** People use their phone in real environments, so we must set aside the assumption that the interaction is entirely with a flat glass screen to which users are paying rapt attention. The way people hold and tap changes with their grip, and that changes because they are carrying items, talking to others, or opening doors.

All people are, as Robin Christopherson says, temporarily disabled, and designing like this can assure your mobile device works for every user all the time. We work in loud environments, in places with glare and rain, where we cannot touch the device, or where we are distracted. Subtle cues may not work, so be sure to multi-encode indicators and responses to interaction.

10. ***Work at human scales.*** Start your UI design at scale. There are many templates you can print that allow you to sketch at the scale of your device, or many devices.

Check your work on real devices in real environments. Get off the computer and try the interface and interaction on the actual device, outdoors, walking around, in loud places, and however else you think people will use it.

Classes of display sizes and device pixel ratios mean your intended design may be 20 percent smaller or larger on any particular device. Make no assumptions about what it will look and act like in the real world; instead, check for yourself.

DESIGN FOR PEOPLE

Most of all, within what you can control: Always design for hands, fingers, and thumbs.

And remember: You don't design for iPhone or Android, for cars or kiosks, for Web or apps, but for people. Have empathy for users and respect their choices, their ways of working. Account for the limits of their lives, their environments and their abilities.

Even when your implementation is constrained by technology, avoid designing for pixels or code; always consider what effects your work will have in the real world, when people look at, hold, and touch the screen.

ACKNOWLEDGMENTS

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MORE READING

Want more details on how people hold and touch their phones, phablets, and tablets? For the latest version of any data and guidelines, and a complete listing of annotated references, please visit 4ourth.com/Touch.

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This forum is dedicated to personal health in all its many facets: decision-making, goal setting, celebration, discovery, reflection, and coordination, among others. We look at innovations in interactive technologies and how they help address current critical healthcare challenges. **— Gillian R. Hayes, Editor**

Discouraging Sedentary Behaviors Using Interactive Play

Regan L. Mandryk, University of Saskatchewan
Kathrin M. Gerling, University of Lincoln

Regular physical activity has many benefits, including to a person's physical, emotional, and cognitive well-being [1]. Although adults should achieve 150 minutes of moderate- to vigorous-intensity physical activity per week, only 15 percent of adults meet these guidelines in at least 10-minute bouts, and only 5 percent of adults meet these guidelines in at least 30-minute bouts on five or more days per week (see [2]). For children, the statistics are even more discouraging. Although kids should get 60 minutes of activity per day, only 7 percent of Canadian youth accumulate 60 minutes per day six days a week (see [2]). The exercise habits adopted by children and pre-teens during this critical period can have lifelong consequences in physical health and self esteem. To encourage physical activity, researchers and developers in HCI have created a variety of "exergames," which encourage people to exercise by integrating exertion into the game mechanics (e.g., [3]). Many exergames have focused on providing intense physical activity for players and have been shown to yield sufficient exertion to obtain the aforementioned benefits to a player's well-being.

However, recent work among health researchers has shown that there are also negative physiological consequences associated with sedentary behavior and that these consequences are distinct from those that result from a lack of physical activity [1]. Although this may seem surprising, physical activity and sedentary behavior are not mutually exclusive. Even if a person is physically active (e.g., biking to work in the morning), she can also be sedentary (e.g., by primarily sitting for the remaining waking hours); the effects of too much sitting are physiologically distinct from too little exercise [1]. The potential negative health outcomes are of particular relevance to populations who spend large parts of the day sitting, for example, schoolchildren who spend many hours a day sitting at their desks, and groups that struggle to gain access to opportunities for regular physical activity, for example, people with mobility impairments and older adults in long-term care.

Because of the potential negative effects on health, researchers are now exploring the need for anti-sedentary guidelines to exist alongside guidelines for physical activity (see [2]). As researchers who design digital game-based interventions to promote health, we have been focused on designing games to promote physical activity; however, these exergames may or may not also work to combat sedentary behaviors. For example, a game designed to encourage a jogger to commit to and follow through with a daily jog will help a player meet the physical activity guidelines but will not help to combat sedentary behavior over the remaining waking hours. There has been little research into how the design of anti-sedentary exergames should differ from exergames that promote vigorous physical activity.

Insights

- → Even people who are physically active can suffer the negative effects of sedentary behaviors.
- → We use the motivational pull of games and principles of energame design to break up sedentary time.
- → This work has implications for specific populations, including people with mobility impairments, schoolchildren, and older adults in long-term care.

In a recent book chapter [2], we presented and contrasted the medical guidelines for physical activity and those for sedentary behaviors. We identified five design principles that need to be considered for anti-sedentary game design (see next section). We dub these anti-sedentary games *energames*—games that reduce sedentary time by requiring frequent bursts of light physical activity throughout the day. Here, we revisit the design principles for energames and show examples of how they have been used to design games that combat sedentary behavior in three at-risk populations: schoolchildren, people who use wheelchairs, and institutionalized older adults. Our work in this area is distinct in both intention and execution from much of the work on exergame design. Rather than designing for exertion experiences (e.g., [3]), our goal is to use the motivational pull of games alongside interaction design to decrease sedentary time throughout the day.

ANTI-SEDENTARY ENERGAME DESIGN

Design principles for integrating physical activity into games while fostering player motivation include aspects such as the importance of providing feedback on activity levels, drawing awareness to past and current activity levels, providing feedback on goal achievement, leveraging social sharing, and integrating activity into a user's lifestyle. Based on these and other exergame design principles, we identified the following five design principles to foster energame design [2]:

• *Providing an easy entry into play*. Lowering the barrier to foster physical activity can be accomplished by offering players an easy entry into play using accessible core game mechanics and controls.

• *Implementing achievable short-term challenges to foster long-term motivation*. To engage players over a longer period of time, achievable short-term goals can build self-efficacy and foster long-term player motivation.

• *Providing users with appropriate feedback on their exercise effort*. Providing players the opportunity to review their exercise efforts after play or through in-game feedback can improve performance and foster motivation.

• *Implementing individual skill-matching to keep players engaged*. Adapting in-game challenges to match players' individual skill levels is one of the most important aspects of energame design, and is applicable both for player-versus-system and player-versus-player games.

• *Supporting social play to foster interaction and increase exercise motivation*. Supporting social play and fostering interaction between players is a core component when trying to increase long-term exercise motivation.

Here, we present some energame examples that follow these guidelines to help reduce sedentary lifestyles in three vulnerable populations.

BUILDING ENERGAMES THAT INTERRUPT SEDENTARY BEHAVIORS

The goal of energames is to encourage people to break up sedentary time with movement. Three populations who are at risk of the negative consequences of sedentary lifestyles are schoolchildren who sit in desks for much of the day, people who use wheelchairs, and the elderly who reside in nursing homes. We have developed energames for each of these populations, and discuss their design and evaluation.

Figure 1. Screenshot of GrabApple.

GrabApple. We initially developed GrabApple to explore the space of casual exergames—that is, computer games that players can learn easily and access quickly, using simple rules and special game mechanics, to motivate them to exercise at a moderate intensity for short periods of play (see [4]). Evaluated originally with young adults, we found that players were able to increase their heart rate during play, which helped them improve their performance on tests of attention and focus (see [4]). This led us to consider the use of GrabApple for schoolchildren who could gain the acute cognitive benefits of breaking up sedentary time by playing a motion-based game.

Gameplay. The goal of GrabApple is to pick up falling apples and avoid touching the falling bombs (Figure 1). The avatar is controlled through the movement of the player's body, and the game uses the player's body weight as resistance to generate exercise through jumping, ducking, and movement. Score multipliers and game mechanics encouraged jumping, ducking, and periodically dashing to the keyboard.

Researchers are now exploring the need for anti-sedentary guidelines to exist alongside guidelines for physical activity.

Game input. The game used the Microsoft Kinect sensor to detect users' body movements. In the Kinect version, the player's position in space controlled the x and y location of the player's avatar. In a mouse-based version, avatar position was controlled using the mouse cursor.

User experience. We compared the physical exertion, affective state, and player experience of children playing GrabApple with a sedentary version of the game and traditional physical exercise used for activity breaks to interrupt sedentary time at school [4]. Our energame raised heart rates and perceived exertion levels significantly more than sedentary play, but not as much as traditional physical exercise. Players rated their arousal as higher after playing the energame (compared to sedentary play), and rated the game as more enjoyable than traditional exercise. Students also identified benefits to concentration from light exercise during a short break during the day and were interested in using a game to engage in movement-based activities during breaks.

Although GrabApple was successful as an energame, it is not accessible to players who use mobility aids such as wheelchairs. To address this design space, we implemented and evaluated Wheelchair Revolution, a game for people who use wheelchairs.

Wheelchair Revolution. We designed Wheelchair Revolution [5] with two goals in mind: First, we wanted to design a motion-based game accessible for people who use wheelchairs, and second, we wanted to support parallel competition between players who use wheelchairs and able-bodied players.

Gameplay. Wheelchair Revolution is a dancing game similar to Dance Dance Revolution, a popular motion-based game. The gameplay consists of performing steps (indicated by falling arrows) synchronously to the beat of a song (Figure 2). The player aims to perform the move indicated by each arrow at the moment the arrow is in line with a target at the bottom of the screen and is awarded points based on how well each step is executed.

Game input. Players could use a dance mat, a game pad, or a wheelchair as input. The wheelchair mode emulates dancing by requiring players to move around with the wheelchair (forward, backward, and turning the wheelchair to the left and right). Wheelchair movements are captured by a Microsoft Kinect sensor. We implemented a variety of player-balancing mechanisms to ensure fair competition between various input types.

User experience. We had dyads of players (one able-bodied person, one person using a wheelchair) play the game in conjunction with the Canadian Paraplegic Association's wheelchair relay, an annual family sports event. Participants provided feedback on the game and their player experience. Our findings showed that players using wheelchair input showed heightened satisfaction of needs (e.g., competence, autonomy, and relatedness) compared with a neutral response; satisfaction of needs during play ultimately predicts a player's motivation and is indicative of a positive user experience. Players rated their enjoyment of our game significantly higher than a neutral response, and their comments demonstrated that they enjoyed how the game integrated the wheelchair (e.g., "It is nice to see my wheelchair in the game instead of being an object that stands between me and the world"). Although our balancing mechanisms helped equalize the playing field between the different types of input, able-bodied players still outscored their opponents using wheelchairs, suggesting that better balancing approaches need to be investigated and implemented.

Our work on Wheelchair Revolution demonstrates how the wheelchair can be integrated into a game as an input device. This game was targeted at younger adults; however, we were curious to see whether motion-based play could also provide physical stimulation for older adults experiencing age-related changes. We conducted several studies, exploring the space of motion-based game design for the elderly.

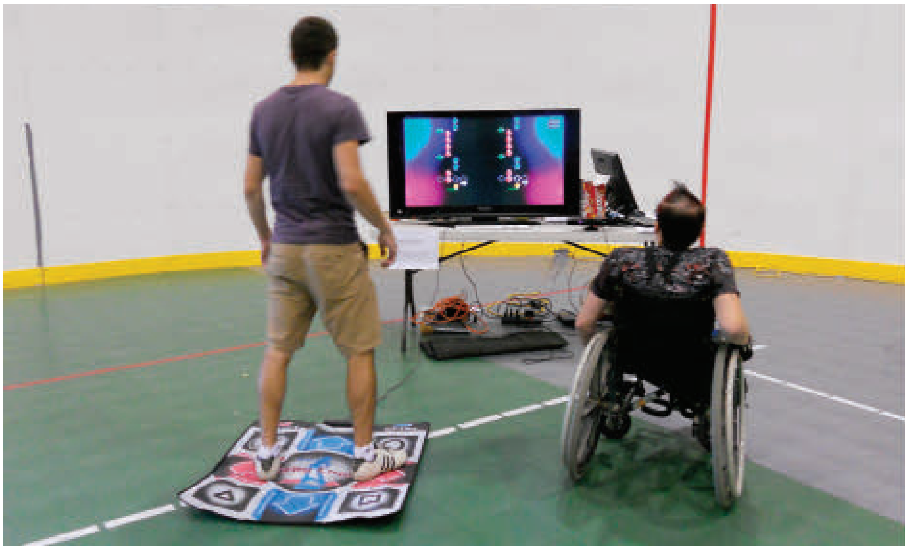

Figure 2. Wheelchair Revolution being played by a person in a wheelchair and an able-bodied player.

Hunting, cooking, and candy. Our work on motion-based game design for the elderly has investigated various input controls, including wheelchair-based control, and the use of motion-based games to foster relationships with caregivers. These research projects led to the design of a suite of motion-based games for use by the elderly, which we deployed in a long-term evaluation with seniors who lived in a care home (long-term care) and in a senior residence (assisted living) [6].

Gameplay. In Candy Kids, candy moved across the screen and could be fed to a child by moving the player avatar (represented by a virtual hand) over the scrolling candy. Prairie Hunter invited players to hunt virtual animals by moving crosshairs over the animal using the motion of their hand. In Cooking Challenge, players prepared a salad by chopping, arranging, and mixing ingredients. Harvest Time invited players to cut down apples from a tree and hand the apple to a girl (Figure 3).

Our work on Wheelchair Revolution demonstrates how the wheelchair can be integrated into a game as an input device.

Game input. Both Candy Kids and Prairie Hunter used pointing input, where the player's hand was tracked using Microsoft Kinect to control an avatar within the game. Cooking Challenge and Harvest Time implemented gesture-based input that mimicked the real-world actions associated with the content of the games. Players used their strong hand to perform gestures and pointing actions. All games could be played in single-player or multiplayer mode.

User experience. A four-month deployment of the games in the two care facilities provided insights into the use of the games by the residents. Focusing on qualitative analysis of interview and observational data, we found that playing video games in the context of a weekly activity is enjoyable and empowering for independent older adults in a senior residence, but difficult when people experience complex age-related changes and impairments—as in the care home, for example—if these changes influence how older adults view the social context of play and how much assistance they require.

REFLECTIONS ON ENERGAME DESIGN

We have presented three examples of how energames designed according to a set of guidelines can motivate movement through playful interaction

Figure 3. Screenshots of the four games designed for older adults (clockwise from top left): Harvest Time, Prairie Hunter, Cooking Challenge, and Candy Kids.

design. Our games were designed for three specific populations who are vulnerable to long periods of sedentary behavior. GrabApple was deployed in schools to break up long periods of sitting. In addition to raising heart rate and being an enjoyable experience, it also met the guidelines for energame design. The simple-to-learn game mechanics offered an easy entry into play, the in-game challenges were achievable in a short time, players received immediate feedback related to their exerted effort, the game difficulty adjusted to the player's skill through increasing challenge, and we provided a class-based aggregate leaderboard to provide motivation through social play without identifying individual players.

Wheelchair Revolution was designed to provide wheelchair-accessible motion-based play. By integrating the wheelchair as an input device, we gave players a way to break up sedentary periods of the day, and use the wheelchair as a tool to interact with a game while promoting movement. The guidelines for energame design guided development: The game provides easy entry into play by using accessible mechanics and controls; it provides short-term challenges to build self-efficacy; it provides users with feedback about how well they performed—which is directly tied to their physical effort; it balances play for players with different abilities and skills; and it allows players with different physical abilities to directly compete, offering a social play experience with other people who use wheelchairs or able-bodied players.

Finally, our suite of games for institutionalized older adults was created using the guidelines for energame design in combination with design recommendations for games for older adults. As such, we focused on energame design within the context of accessibility of games for older adults experiencing age-related changes and impairments. Our results show that the nature of energames (easy entry into play, combination of short- and long-term challenges, playability in a social setting) makes them particularly suited for deployment in care-home settings, where sessions of play often need to fit in with other scheduled activities, but that their successful integration and older adults' engagement with them ultimately depends on their individual abilities and interests. However, if older adults do take ownership of energame play, our findings demonstrate that such games can be a valuable opportunity to provide mental and physical stimulation to combat sedentary behavior in late life, encouraging older adults to reintroduce challenge and competition into their leisure activities.

Our results suggest that energames can promote movement among very different populations— from schoolchildren to older adults living in care homes. Motivating physical activity in short bursts throughout the day can help to break up long periods of sedentary behavior; interactive play is a fun way of achieving this goal.

Endnotes

1. Tremblay, M.S., Colley, R., Saunders, T.J., Healy, G.N., and Owen, N. Physiological and health implications of a sedentary lifestyle. *Applied Physiology, Nutrition, and Metabolism 35*, 6 (2010), 725–740.
2. Mandryk, R.L., Gerling, K.M., and Stanley, K.S. Designing games to discourage sedentary behavior. *In Playful User Interfaces, Gaming Media and Social Effects*. A. Nijholt, ed. Springer, 2014, 253–274.
3. Mueller, F., Vetere, F., Gibbs, M.R., Agamanolis, S., and Sheridan, J. Jogging over a distance: The influence of design in parallel exertion games. *Proc. of the SIGGRAPH Sandbox*. 2010, 63–68.
4. Gao, Y., Gerling, K.M., Mandryk, R.L., and Stanley, K.S. Decreasing sedentary behavior among pre-adolescents using casual exergames at school. *Proc. of CHI PLAY 2014*.
5. Gerling, K.M., Miller, M.K., Mandryk, R.L., Birk, M., and Smeddinck, J. Effects of balancing for physical abilities on player performance, experience and self-esteem in exergames. *Proc. of the CHI Conference on Human Factors in Computing Systems*. 2014, 2201–2210.
6. Gerling, K.M., Mandryk, R.L., Linehan, C. Long-term use of motion-based video games in care home settings. *Proc. of CHI 2015*. To appear.

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In this forum we highlight innovative thought, design, and research in the area of interaction design and sustainability, illustrating the diversity of approaches across HCI communities. **— Lisa Nathan and Samuel Mann, Editors**

Designing for Transitions to Sustainable Lifestyles

Adrian K. Clear, Kirstie O'Neill, and Adrian Friday, Lancaster University

Despite the significant risks for human and non-human life posed by the so-called Anthropocene, greenhouse-gas emissions are still rising. In such a context, how do we as citizen-consumers attempt to transition toward sustainability? The ways in which people currently practice activities such as cooking, eating, traveling, and keeping warm can all be changed to be more, or less, sustainable. To realistically have any chance at mitigating harmful climate-change effects, the changes required are significant, suggesting ways of living that might be difficult to comprehend within existing norms and expectations of consumption.

If we want to facilitate such "profound changes" [1], we need to think creatively about what these may be and how we might encourage their development. As Elizabeth Shove argues, it may be that existing sociotechnical contexts close down spaces for alternative approaches, thus making it more difficult to envisage and realize radically different spaces and practices [2]. Are there ways we can make profound shifts to more sustainable practices more conceivable, comfortable, and agreeable?

In our recent studies of food consumption and thermal comfort, we have identified points when daily practices go through significant transitions—sometimes to more sustainable forms. Over a number of projects, our inquiries have accrued convincing evidence in support of Frank Trentmann's observation that "disruption is normal" and reveals "the flexible side of habits and routines so often imagined as stable and stubborn" [3]. So we now ask the following questions: How can we support the development of more sustainable daily practices during life transitions? How might life-transition periods become opportunities for the intentional (re)design of practices? How might we focus our design work to make life transitions more supportive of sustainable practices? What are the implications of designing for (sustainable) life transitions?

TRANSITIONS IN EVERYDAY LIFE

Challenging mainstream practices and bringing about contextually appropriate, more sustainable ways of living requires changes much more significant than simply doing the things we currently do, but more efficiently. Across research projects we became intrigued by significant changes in practice that occurred during life transitions. In the following sections, we use examples drawn from recent research where we considered everyday life scenarios in which we already deal with reconfigurations of how we live our lives. By life transitions, we are referring to situations such as changing residences, having children, or retirement, where ways of doing things are developed anew, or broken down and rebuilt over time.

We discuss two recent case studies. In the first, we interviewed people to understand their food consumption practices and how these came to be. Our aim was to highlight opportunities for digital interventions to reshape food practices in more sustainable ways. What we found was that daily food consumption is often routine and unremarkable, but there appeared to be critical points in life that can influence our daily food practices, what we eat, and how we prepare it. In the second case study, we engaged university students negotiating the heating systems in their new housing.

Insights

- → Radical changes to our lifestyles are required to mitigate harmful climate-change effects.
- → Life transitions represent an opportunity to design for more sustainable everyday practices.
- → Designing for sustainable transitions is to design for longer-term and more fundamental processes of change that include challenging norms and developing new competences.

CASE STUDY: FOOD AND RETIREMENT

We spoke to a number of people about how their food practices had changed following retirement from work. The extra time that this transition allowed sometimes created space for practices that might be considered more sustainable. Many participants began to grow their own food in an allotment or their gardens:

IMAGE BY ELSPETH BRISCOE / FLICKR

My wife, she's very green-fingered and she really enjoys it... last year we had some fantastic produce. (Cyril)

Retirement provided the time for growing (perhaps in place of other, less sustainable practices), but also for developing the requisite skills and knowledge. Likewise, for trying new recipes and new ways of cooking. For one participant, the installation of solar panels instigated a new regime of household practices, in particular, shifting the performance of energy-intensive meal preparations to daylight hours:

It's nearly three years since the solar panels went on the roof. So since then we changed our eating habits...all the cooking is done during daylight hours... anything that takes up electricity is usually done within daylight hours, you know washing, ironing, drying clothes... (Rita)

However, the directions that food practices take in retirement can also be less environmentally sustainable. For some, food shopping had transformed from a weekly supermarket trip into a leisure activity, requiring more car journeys to nearby towns and villages:

Well I've nothing else to do... I haven't a job to do, I'm not trying to fit it in and so I devote what I want to devote to it. (Dorothy)

Bringing about more sustainable ways of living requires changes much more significant than simply doing the things we currently do, but more efficiently.

We've made our shopping a relaxing experience. We've gone away from the big shop... our aim is every day to get out somewhere nice if we can. (Steven)

Sometimes the significance of food diminished as a result of children leaving home or the loss of a partner. In practice, this led to less cooking, less fresh produce used, and more consumption of convenience and "ready meals," which often contain higher-impact ingredients:

I do quite enjoy cooking. But there is only the two of us, so there's no point getting too excited over it. It's just a meal, unfortunately. (Rita)

CASE STUDY: MOVING HOME AND THERMAL COMFORT EXPECTATIONS

In other ongoing work, we wanted to influence how people keep themselves warm in their homes, introducing a system to reduce their reliance on the infrastructure provision of heat, in the spirit of *adaptive thermal comfort* [4]. We set out to understand the thermal comfort practices of students moving into shared accommodations at university. In our interviews we found that in spite of generally low expectations for heating in university accommodations, students quickly realized that heat was plentifully available. We saw radiators set to "max" and windows used to regulate the temperature instead of thermostatic radiator valves.

The next year, we recruited participants in the same accommodations to live with a system that, among other things, didn't allow the radiator to be switched on continuously. We were interested in learning how they coped with this attempt to shift their comfort practices.

We saw various ways in which the system was appropriated, and everyday life renegotiated. Some felt their thermal comfort had improved, whereas others felt our system was frustrating and required extra effort to use as they tried to fit it into their existing practices, such as wearing light clothes indoors and keeping the radiator on as much as possible:

Sometimes…you just want to come home and…be in a cozy home. If I've been in the library for quite a few hours it can be a bit of a pain in the butt if it's not warm-warm. (Stephanie)

For another participant who did not really engage with the system initially, the impact of having no direct heating for several days was that she found a lower temperature was perfectly acceptable and discovered other alternative ways to keep comfortable indoors:

I think it's sort of made me realize how it doesn't actually bother me as much when it's colder… I don't need to have it that *warm.*

Our case studies suggest that life transitions (retirements, moving house, and so on) provide ready opportunities for changes to one's expectations and practices. The key question here is, how can we design to ensure such changes are both comfortable and sustainable?

Our case studies suggest that life transitions provide ready opportunities for changes to one's expectations and practices.

SUSTAINABLE TRANSITIONS

What does it mean to make sustainability transitions in practice? We propose that it's not about driving to work in higher gears to reduce the emissions of our commute, but rather leaving the car at home, cycling, or even reconsidering the need to be physically present at the workplace. We must make a metaphorical U-turn: We must throw our lives out of kilter, renegotiate and explore more sustainable ways of being. Purposefully designing to support or even instigate breakthroughs and tipping points may result in (sustainable) niche innovations being mainstreamed.

Our case studies point to the opportunities and limitations of taking a material-centric approach, leading us toward considering design in terms of shifting *practices*: While we provided a new tool for keeping warm, existing norms and expectations (e.g., of what a "cozy" room is, and notions of appropriate indoor clothing) and competencies and materials (e.g., using means other than the radiator to keep warm) shaped how thermal comfort was ultimately done. Additionally, our retirees point to the importance of developing skills and knowledge not only for doing food differently (e.g., growing, cooking) but also for accounting for people's images of what a fulfilling life of retirement is (e.g., getting out and doing something fun, relaxing and slowing down).

A promising route for design, then, is to support transitions as longer-term and more fundamental processes of change. This involves designing interactions that support the development of necessary elements of practice—related to materials, competencies, and meanings [2]—that help guide or even instigate transitions in practice in a sustainable direction. Doing so opens up interesting questions for HCI in terms of realizing systems and interfaces that evolve with users as they engage in a course of practice and life transitions, and how an "ecology" of interactions might work together to support change in a number of interrelated areas of everyday life.

Endnotes

1. Tomlinson, B., Six Silberman, M., Patterson, D., Pan, Y., and Blevis, E. Collapse informatics: Augmenting the sustainability & ICT4D discourse in HCI. *Proc. of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, New York, 2012, 655–664.
2. Shove, E., Pantzar, M., and Watson, M. *The Dynamics of Social Practice: Everyday Life and How It Changes*. SAGE, 2012.
3. Trentmann, F. Disruption is normal: Blackouts, breakdowns and the elasticity of everyday life. In *Time, Consumption and Everyday Life: Practice, Materiality and Culture*. E. Shove, F. Trentmann, and R.R. Wilk, eds. Berg, Oxford, 2009, 67–84.
4. Clear, A., Friday, A., Hazas, M., and Lord, C. Catch my drift? Achieving comfort more sustainably in conventionally heated buildings. *Proc. of the 2014 Conference on Designing Interactive Systems*. ACM, New York, 2014, 1015–1024.

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Public policy plays an influential role in the work we do as HCI researchers, interaction designers, and practitioners. *Public policy*, a broad term, includes both government policy and policy within non-governmental organizations. This forum focuses on topics at the intersection of human-computer interaction and public policy. **— Jonathan Lazar, Editor**

The Role of Tool Support in Public Policies and Accessibility

Fabio Paternò, CNR-ISTI, **Antonio Giovanni Schiavone,** CNR-ISTI

Since the late 1990s, several countries have begun to enact laws addressing computer-system accessibility for technology funded or provided by the government. One of the first countries was the U.S., where in 1998 Congress approved and the president signed into law Section 508 of the Rehabilitation Act, with the goals of eliminating barriers in information technology, making new opportunities available to people with disabilities, and encouraging the development of relevant technologies.

Two years later, the European Council also began to address the issue, in 2000 approving the eEurope political initiative, whose aim was to support and promote the creation of a society based on knowledge, open and accessible to all—especially to all European citizens with disabilities. In the following years, several action plans (such as eEurope 2002, eEurope 2005, and eAccessibility) were made operational, with the aim of ensuring that all citizens have access to ICT services, removing the technical, legal, and other barriers that some people encounter when using them.

As a result of these initiatives, several European countries have begun to enact national laws on the accessibility of information systems (to name a few: Germany – BITV 2002, Italy – Stanca Act 2004, France – Loi Handicap 2005, Spain – *Reglamento sobre las condiciones básicas para el acceso de las personas con discapacidad a lastecnologías* 2007). The common purpose of these laws was to require that IT-based services provided by public administrations are presented in such a way as to enable people with disabilities to access the information and take full advantage of the opportunities offered.

The European Union's efforts in promoting accessibility continued even after the end of the eEurope initiative with the launch of a new program named Digital Agenda for Europe (DAE). This active program is one of the seven flagship initiatives of the Europe 2020 Strategy.

In the same period of time, other countries enacted accessibility laws (to name a few: Canada – Common Look and Feel 2000, Japan – JISX8341 2004, Brazil – e-MAG 2007). The existence of this set of laws shows that Web accessibility is an issue of global concern. Despite these legislative endeavors, many public organizations' websites are still poorly designed and have accessibility barriers. In 2011, Goodwin et al. published an accessibility analysis of national government portals and ministry websites of several U.N. member states [1]. This study revealed accessibility issues on government websites around the world. In particular, the analysis showed that non-accessible websites are more common in countries with poorly developed economies and low per capita GNI, and where only a small percentage of the population has access to the Internet.

Insights

- → Despite numerous efforts by various governments, universal Web accessibility is still a global issue.
- → As indicated by recent experiences, modern automatic validators can play a useful role in ensuring the accessibility of public administrations' websites.
- → Public policies for Web accessibility should take account of such tools, regulating and promoting their use.

INTRODUCING AUTOMATED ACCESSIBILITY TOOLS

Many accessibility experts agree that accessibility validation is a process that cannot be fully automated. The W3C itself, in a preparatory document for the development of its WCAG 2.0 guidelines [2], discussed accessibility criteria that are "machine testable," compared with others that are "reliably human testable," thus suggesting that not all accessibility audits were automatable. Moreover, it is easy to imagine how difficult it is for an automated tool to assess guidelines such as "text requires reading ability more advanced than the lower secondary education level after removal of proper names and titles, supplemental content" (WCAG 2.0 – Guideline 3.1.5 "Reading Level").

Despite these inherent limitations, automated tools still play an important role in ensuring the accessibility of websites. Indeed, following the adoption of accessibility laws, various government organizations started paying more attention to accessibility guidelines, but Web accessibility requires constant monitoring of many details across many pages. Thus, in order to simplify the monitoring, analysis, detection, and correction of website accessibility problems, several automatic and semi-automatic tools were developed. A typical category of software tools used for this purpose is the so-called accessibility validators, software programs or online services that help determine if a website meets accessibility criteria, which are usually encoded in "accessibility guidelines."

The first accessibility validator, Bobby (named for British policemen), was developed in the mid-1990s by the Center for Applied Special Technology (CAST). In general, the first generation of validators had a number of limitations: First, most of these tools allowed validating at any one time only a single webpage, or in rare cases, a single website. In the real world it is more useful to evaluate the accessibility of collections of websites grouped by topic or territory and to monitor the evolution of their accessibility over time, providing a high-level view of whether progress is being made. A number of other issues exist in the use of automated accessibility tools:

• *Expandability and upgradeability.* Newer technical guidelines get released, and while there is one international standard (WCAG, currently 2.0), some countries make modifications to it. For the developers of accessibility validators, extending the set of guidelines supported by their tools or upgrading the existing ones can be a major undertaking: In general, it may be necessary to rewrite a significant portion of the validator's source code, with notable costs in terms of time and resources.

• *Alignment with the latest technology.* New versions of languages for describing webpages' layout and structure have been released, introducing new features such as semantic tags. Mobile browsing has become increasingly widespread, affecting the technical design and development of websites, which nowadays must be able to be viewed on a variety of devices and different screen resolutions. Websites are becoming more and more dynamic and include interactive content. In this ever-changing panorama of technologies, the first generation of validators often appears to be unable to effectively validate websites made with the most modern technologies.

• *Limited effectiveness of the reports.* Automated tools provide reports that are sometimes difficult to interpret since they show so many details; it is difficult to identify the main problems and how to address them. One aspect that must be taken into account is that such reports can be accessed by people with different roles (developers, designers, public officers) who need different levels of information for improving the site.

IMAGE BY POGONICI / SHUTTERSTOCK.COM

TOOLS DESIGNED FOR GOVERNMENTAL USE

In recent years, a new generation of accessibility validators has been developed to overcome the limitations outlined here. For example, AMA [3], an application promoted by the University of Bologna (Italy) as part of the Vamolà project, gathers the accessibility status of large collections of Italian government websites according to different aspects. This tool has been used by the public administration of the Emilia-Romagna region to monitor the accessibility of 380 websites of public institutions that reside in this region (nine provinces, 330 municipalities, and 40 other public organizations). The data collected has been used to elaborate the annual report about the usage of Web technologies in Emilia-Romagna [4].

For the developers of accessibility validators, extending the set of guidelines supported by their tools or upgrading the existing ones can be a major undertaking.

In terms of expandability and upgradeability, some researchers have developed accessibility validators that separate the validation engine from the guidelines-specification phase. With this approach, the guidelines are codified through specifically designed formalization languages and specified in external files; updating or expanding the available guidelines involves simply recoding existing guidelines or codifying new ones. An example of this approach is EvalAccess, an accessibility validation tool developed by the University of the Basque Country (Spain) that uses a guidelines language formalization named Unified Guidelines Language (UGL) [5] to express the requirements of several guidelines sets.

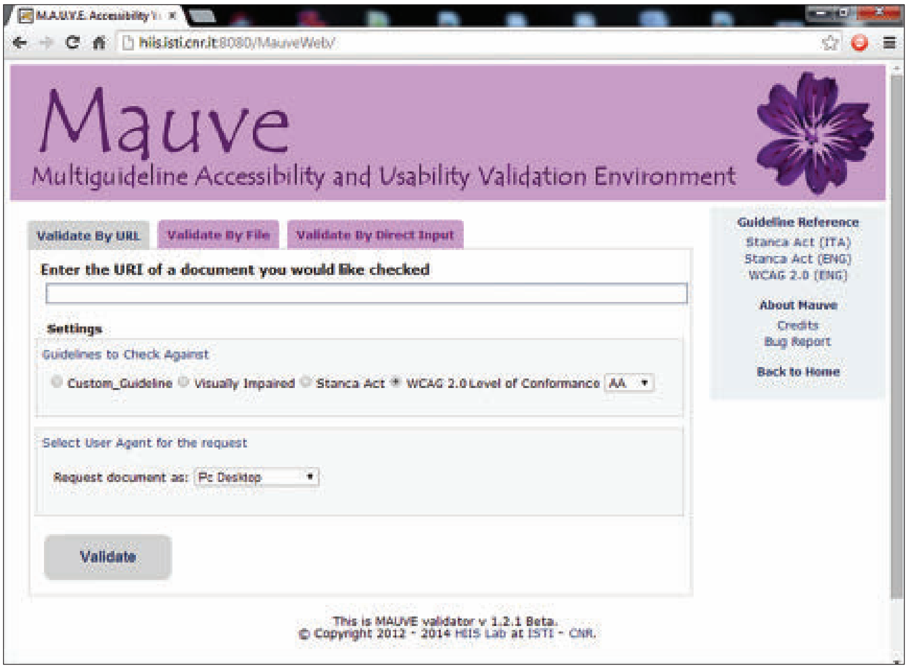

Figure 1. The MAUVE homepage.

The issue of alignment with the latest technology is particularly important, but also the most difficult to solve, for at least two reasons. The first difficulty lies in the fact that for each site, there may be versions specific to a given type of device (e.g., mobile and desktop versions) or a single version of the site that adapts its user interface according to the resolution of the device (responsive layout). In both cases, an accessibility validator must be able to analyze in a single run the set of all possible user interfaces for that page on all possible devices and screen resolutions. The second and greatest difficulty is determined by the fact that modern websites are dynamic, meaning they utilize technologies (e.g., Ajax scripts) that can change both the webpage's user interface and content automatically or in response to user interaction. Furthermore, it is increasingly common to come across websites that combine these two latter problems. For example, it is easy to find dynamic websites with responsive design. Nevertheless, researchers from around the world are proposing technological solutions to overcome these difficulties. One example is MAUVE [6] (Figure 1), proposed by the CNR of Pisa (Italy), which is a validation environment that can recover and validate versions of a webpage specific to certain categories of devices, and through the use of some browser plugins, capture and then validate the actual version of a dynamic page in a given time.

AUTOMATED VALIDATORS IN PUBLIC POLICIES

While automated validators are important tools for ensuring compliance with accessibility laws, the laws themselves, as well as associated regulations, often do not make explicit reference to such tools or describe how the tools should be utilized in implementing public policies (for instance, the Italian "Implementation Regulations for Law 4/2004" associated with the Stanca Act does not mention automated tools, but the document [7] associated with the Stanca Act does). Laws and regulations typically mention evaluation by experts and usability testing by people with disabilities as appropriate methodologies for validation. Specific guidance is rarely mentioned. Examples of organizations that have successfully adopted automated testing include some government agencies in Sweden, where results of automated accessibility testing are publicly posted monthly [8], and the U.S. Census Bureau, where 90 percent of webpages receive a monthly review from an automated accessibility inspection (although results are not posted publicly) [9]. Guidance and best practices could be very helpful to guide the appropriate use of automated accessibility validators in implementing public policies.

In our opinion, there are several reasons why public policies should go a step further and provide clear and well-documented advice for adopting automatic tools in supporting accessibility validation, taking into account recent experiences and research in this field:

• Although the consensus is that automatic validation has limits, even validation performed by human beings has critical issues related to human limits. For instance, experts are certainly able to perform more accurate analyses, but they also require a long time to validate sites containing a large number of pages. Automated tools can help experts analyze large numbers of webpages, detecting the most common and frequent accessibility errors, thus reducing their workload and allowing them to focus on the most sensitive aspects of the accessibility assessment.

• Usability testing helps uncover problems related to an individual's specific disability. Automatic validators are able to evaluate accessibility problems related to multiple disabilities, at least for those types of checks that are automatable.

• Public policies generally give little guidance on methods to follow to ensure that the accessibility of a site is maintained over time. As it is quite unrealistic to assume that a public administration will continually make use of an expert to perform usability testing, it is possible that validators can be used as a system of "warning lights," able to perform periodic validation of a site's accessibility (either triggered manually or via timed automated systems) in order to monitor the site's accessibility over time. In this regard, it is interesting to think about how often a website should be validated. There is no single answer to this question—it depends on the characteristics of the site. A site that has already been made accessible and whose structure, user interface, and content have not changed over time does not need to be validated weekly. On the other hand, a site that is updated daily or several times a day should be validated with greater frequency. In the real world, these two extremes rarely represent a concrete case. The most common case is a site where the structure and user interface are modified over several years. Regarding the content, usually a subset of the site's pages are updated infrequently (e.g., the contact page), while others have frequently updated content (e.g., the news page). The best strategy is therefore to validate different sections of the site at different frequencies, calculated on the basis of update frequency. In general, the frequency of validation should be equal to, or slightly lower than, the update frequency.

CONCLUSION

It has been years since the appearance of the first automated accessibility validators, but their adoption has not been fully addressed in public policies. Even if they do not provide a complete analysis of accessibility and can sometimes provide confusing results, accessibility validators can significantly reduce the time and effort to evaluate websites, making the validation process more efficient, consistent, and reliable.

Public policy stakeholders should consider the progress in this field of research for at least three reasons. First, according to several national laws on Web accessibility, public officials are obliged to ensure accessibility in online communications. Further, pushed by the recent economic crisis, many public authorities are moving their services to the Web to speed up processes, reduce costs, and optimize document management. It is important that these e-government services be accessible. Finally, for ethical reasons, public administrations have the duty to support all citizens, giving everyone the same quality of services. Automated accessibility testing tools can play an important role in making public websites more accessible.

Endnotes

1. Goodwin, M., Susar, D., Nietzio, A., Snaprud, M., and Jensen, C.S. Global Web accessibility analysis of national government portals and ministry Web sites. *Journal of Information Technology & Politics 8*, 1 (2011), 41–67.
2. W3C's "Requirements for WCAG 2.0 Checklists, Techniques, and Test Files"; http://www.w3.org/WAI/GL/WCAG20/WD-wcag2-tech-req-20050125.html
3. Mirri, S., Muratori, L.A. and Salomoni, P. Monitoring accessibility: large scale evaluations at a Geo political level. *Proc. of the 13th International ACM SIGACCESS Conference on Computers and Accessibility*. ACM, New York, 2011, 163–170.
4. Benchmarking della società dell'informazione in Emilia Romagna, 2013 (available only in Italian); http://digitale.regione.emilia-romagna.it/entra-in-regione/pubblicazioni/collana-e-r-digitale/benchmarking-della-societa-dellinformazione-in-emilia-romagna-2013
5. Arrue, M., Vigo, M., and Abascal, J. Including heterogeneous Web accessibility guidelines in the development process. *Engineering Interactive Systems Lecture Notes in Computer Science 4940* (2008), 620–637.
6. Paternò, F. and Schiavone, A.G. An extensible environment for guideline-based accessibility evaluation of dynamic Web-applications. *Universal Access in the Information Society 14*, 1 (Mar. 2015), 111–132.
7. Guidelines containing the technical requirements, the definitions of the different accessibility levels and the technical methodologies for the testing of Web site accessibility; http://www.pubbliaccesso.gov.it/biblioteca/documentazione/guidelines_study/index.htm
8. Gulliksen, J., vonAxelson, H., Persson, H. and Göransson, H. Accessibility and public policy in Sweden. *Interactions 17*, 3 (2010), 26–29.
9. Lazar, J. and Olalere, A. Investigation of best practices for maintaining Section 508 compliance in U.S. federal Web sites. *Proc. of the 2011 Human Computer Interaction International Conference*. 2011, 498–506.

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We live in a world where everyday objects, digital services, and human beings are increasingly interconnected. This forum aims to offer and promote a rich discussion on the challenges of designing for a broader ecology of materials, artifacts, and practices. **— Elisa Giaccardi, Editor**

The Carolan Guitar: A Thing That Tells Its Own Life Story

Steve Benford, Adrian Hazzard, and Liming Xu, University of Nottingham

Turlough O'Carolan was the last of the great Irish harpers, an itinerant musician who traveled through Ireland around the turn of the 18th century, staying with and composing tunes for his many patrons. He has also been the inspiration for the Carolan Guitar, a prototype acoustic guitar whose digital augmentations enable it to tell its life story as it passes among players, audiences, and venues.

Our choice of an acoustic guitar to become an example of an Internet-enabled thing is a deliberately provocative one. Acoustic guitars are highly traditional and often valuable, especially when made by hand through the crafting of expensive, delicate tonewoods by a highly skilled luthier. Guitars also tend to be long-lived, existing for decades—sometimes even centuries—and are consequently passed down among owners, quite often outliving them. This makes them an especially challenging target for rapidly evolving and somewhat unstable Internet of Things (IoT) technologies that may well be "here today and gone tomorrow" by comparison. Does it really make sense to digitally augment these venerable instruments?

And yet it is the inherent value and longevity of these guitars that also makes them an ideal target for the IoT. Guitars gather rich stories throughout their lifetimes that enhance their provenance and value. From the sustainable sourcing of the tonewoods used to construct them, through the processes of construction, to the history of their ownership, to the tunes they have played, guitars are replete with stories. These stories can add great value to guitars, with "celebrity" instruments being sold for millions of dollars. Mind you, everyday guitars may also be extremely valuable to their owners, being associated with very unique personal memories and sometimes being handed down from generation to generation.

So we are all agreed that we should augment acoustic guitars with the ability to capture and tell their rich life stories. The next question is, how might we do this? Again, we have opted for what might prove to be a provocative approach. We rejected the idea of embedding sensors, actuators, and displays within these objects (even though there is plenty of room inside them) in favor of covering them with interactive surface decorations. Part of the craft of luthiery is to decorate the instrument with beautiful inlay, typically on the headstock and in the rosette around the soundhole, but sometimes extending to the bindings and on occasion to other places too.

We have chosen to work with a technology called Aestheticodes [1] that enables people to draw their own interactive patterns from scratch. By following a simple set of topological drawing rules that concern the numbers and arrangements of solid "blobs" and "regions" embedded within a drawing, designers are able to create beautiful patterns that may contain multiple points of interaction hidden within them. Viewers can then locate these codes within a wider pattern and scan them with their phone or tablet to trigger digital interactions such as viewing some media, visiting a website, or leaving a comment. This topological approach was previously explored by Enrico Constanza and implemented in a system called D-Touch [2]. We have since built on his pioneering work to extend the technique and implement it within a mobile app that you download for free (www.aestheticodes.com).

Our initial experience of working with skilled designers to create interactive bowls, menus, and placemats for a restaurant revealed that the relative simplicity and openness of the "recognition rules" matched well with their valued drawing skills and enabled them to create rich interactive patterns [3]. We therefore were determined to apply the same approach to decorating a handmade acoustic guitar.

We brought together an interdisciplinary team comprising a luthier, a graphic designer with experience with Aestheticodes, and HCI researchers. This team set about designing and building a guitar over a period of six months. We are documenting our progress on the guitar's blog (www.carolanguitar.com), including reports of where it has been and who has played it since it was released into the wild. We'll quickly

Insights

→ We developed an acoustic guitar that records its social history as it passes from player to player.
→ Players access this history by scanning the decorative inlay, which contains embedded codes.
→ Our approach is an example of hybrid physical-digital crafting.

summarize a few key points here.

Inspired by the O'Carolan theme, our designer began by creating some Celtic knotwork Aestheticode patterns. Our luthier then took us through the process of choosing the guitar's woods, shape, and size. We elected for a combination of spruce for the soundboard and flamed maple for the back and sides, and chose a basic dreadnought shape for the body, subtly extending some of the bouts to accommodate more extensive patterns. Perhaps the most interesting aspect of the design—at least for this readership—lay in deciding where on the guitar to place the interactive patterns and which interaction each might trigger. While this mapping can, and no doubt will, evolve over time, several ideas emerged from our early discussions:

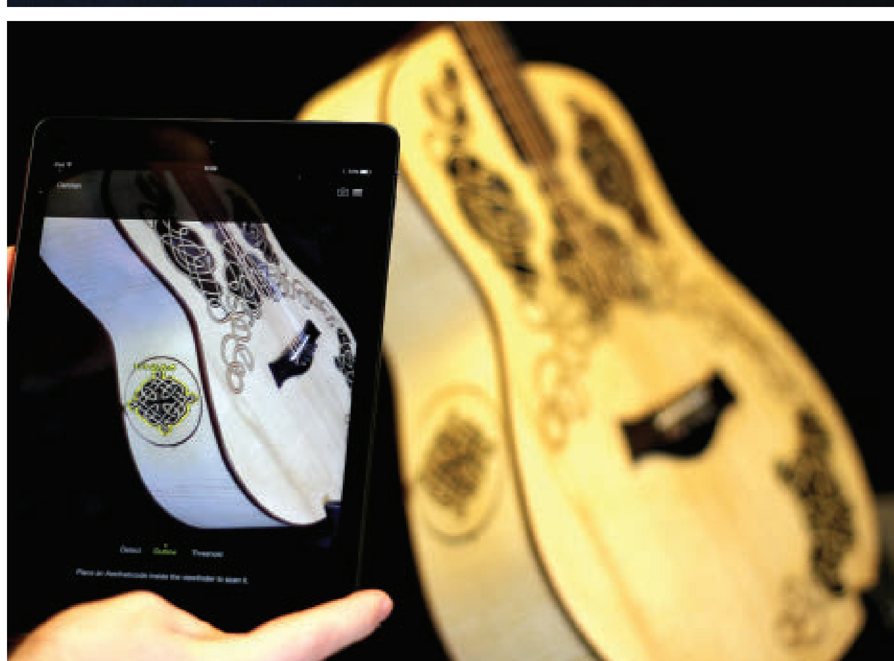
• The headstock would carry a logo that would link to official provenance.

• The public areas on the front soundboard would link to videos of performances with the guitar.

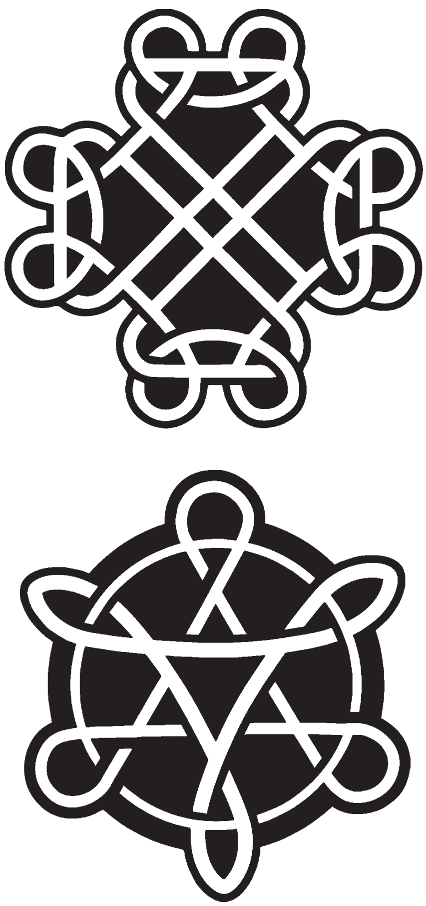
• The largest area of real estate on the instrument, the back, would be decorated with a large code that might be scanned from some distance so audiences could learn about its current player as well as the history of previous players.

• The areas under the strings would be reserved for patterns that linked to technical documentation describing construction and maintenance that only someone who removed the strings would be able to access.

By far the most complicated part of the design was the soundboard, as this involved adapting the patterns to meet several constraints, which ultimately led us to some unusual construction techniques. The soundboard is an especially sensitive part of the guitar that contributes greatly to its voice. It is made from an expensive and thinly carved piece of wood that is placed under great tension by the strings so it must be supported by underlying braces, the positions of which are part of the luthier's art. The soundboard must also have holes, with sufficient total area to project the instrument's voice, but not in the sensitive area of the lower bout, as this would compromise structural integrity. Finally, the player's arms tend to obscure parts of the soundboard.



Scanning an Aestheticode on the Carolan Guitar.



Liz Jeal's Celtic knot designs.

The resulting pattern was carefully designed to meet all of these constraints while also containing two distinct interactive codes, one on the areas visible to the public and a second one running under the strings. This pattern was realized using a combination of laser etching to mark out the pattern and laser cutting to make the soundholes and also cut out the inlay from darker rosewood and mahogany, with the inlay then being applied by hand. The codes in the final design comprise a mixture of inlay and holes (which appear dark) to produce a pattern that is scannable but that also functions as a soundhole.

Since its completion, our guitar has found its way into the wider world and into the hands of players who have told us their stories of guitars and their thoughts about the project, and who have recorded tunes and songs [4,5].

While it's lovely to talk in detail about building guitars, we should also consider what this project might tell us about the IoT. We suggest there are three broad possibilities here.

First, constructing the Carolan guitar has already revealed something about the complex nature of digitally augmenting physical artifacts. Applying interactive surface decoration has required us to become intimately familiar with the material properties arising from the quality and nature of wood and of techniques for etching, cutting, and inlaying it, mirroring the observations of Tsaknak, Fernaeus, and Schaub on their experience of crafting digital interactions into leather [6]. Crafting interactivity into a complex real-world artifact has also required us to take account of its structural qualities, including understanding good and bad places to apply patterns as well as functional properties, such as how its voice is produced, how players will hold it, and even how one removes its strings. In short, there would appear to be far more to augmenting a thing than "slapping" a QR code somewhere onto its surface (or electronics into it).

As we move forward into the next phase of the project, we hope the Carolan will help us answer two further questions with implications for the wider IoT.

One key question concerns how to augment everyday objects in a sustainable way. Guitars can have long lifetimes and typically evolve slowly in comparison with digital technologies. How can we mitigate the challenges of our digital technologies becoming obsolete long before our instrument reaches the end of its active life? Is it more sustainable to integrate electronics into a traditional artifact, or to connect it to digital media through interactive surface decoration, as in the case of the Carolan?

Another major question concerns the kinds of stories that might become associated with our guitar and the various ways in which these might enhance its value. Previous IoT research has begun to explore how stories can enhance the value of everyday things [7]. We intend for the Carolan to help us understand the wide range of stories that can be associated with an object from the moment of its conception and birth, through its ongoing use as it passes among many different owners, to its ultimate archiving. Even at this early stage, we have seen plenty of evidence that our guitar will acquire a rich digital footprint encompassing the details of its construction, videos of performances, and the wider stories and reflections it elicits from players.

We look forward to being able to answer these questions as our project progresses. We hope you will follow our progress at www.carolan.com and perhaps even get to meet and play the Carolan as it continues its journey.

Endnotes

1. An introduction to Aestheticodes; https://www.youtube.com/watch?v=kW39Mt5kscQ
2. Costanza, E. and Huang, J. Designable visual markers. *Proc. CHI 2009*. ACM, 2009.
3. Meese, R., Ali, S., Thorne, E.C., Benford, S., Quinn, A., Mortier, R., Koleva, B., Pridmore, T., and Baurley, S. From codes to patterns: Designing interactive decoration for tableware. *Proc. CHI 2013*. ACM, 2013.
4. The Carolan guitar being played by Gypsy Jazz guitarist Lulo Reinhardt; https://www.youtube.com/watch?v=M6ctCMUwx70.
5. Lulo Reinhardt recounts his experience of decorating guitars; https://www.youtube.com/watch?v=j6IGA4A34WA
6. Tsaknaki, V., Fernaeus, Y., and Schaub, M. Leather as a material for crafting interactive and physical artifacts. *Proc. DIS 2014*. ACM, 2014.
7. Barthel, R., Hudson-Smith, A., De Jode, M., and Blundell, B. Tales of Things–The Internet of 'Old' Things: Collecting stories of objects, places and spaces. *Proc. Internet of Things 2010*.

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This forum is dedicated to maximizing the success of HCI practitioners within the frenetic world of product and service design. It focuses on UX strategy approaches, leadership, management techniques, and above all the challenge of bringing HCI to peer-level status with longstanding business disciplines such as marketing and engineering. **— Daniel Rosenberg, Editor**

Blending Market Research and User Research Activities

Pallavi Kutty, Move Inc.

As the definition of UX becomes more and more holistic, there is an increasing opportunity to merge market and user research activities into an integrated process. However, there is no one-size-fits-all answer for whether this is a good or bad practice; it depends on the individual project context and goals.

Merging the two methods helps create a complete story for the product, but doing so requires a good understanding of what the disciplines accomplish on their own, and when one research type is needed over the other throughout the product lifecycle.

For user research professionals, it is important to understand the strengths of market research and what kinds of insights it brings to the table. This will help user researchers see how their field complements market research so they can determine when to use market research insights to further plan user research activities. Furthermore, being aware of prior market research studies within a company and utilizing insights from them can help user researchers narrate a more comprehensive story of user behaviors, needs, and motivations.

An important fact to keep in mind is that neither method is better than the other: They are complementary approaches. They are not and should not be competing with each other from either a content or political perspective.

It does not make business sense to launch a well-designed product to a market that has no use for the function or service it provides. Nor does it make sense to launch a badly designed product into a market for which the user needs have not been thoroughly validated in advance.

MARKET RESEARCH

Market research helps answer the questions *what* and *who*—what will people buy, and who or which groups of people will buy it?

Market research provides insights to help solve marketing challenges. Business questions regarding market segmentation (identifying groups within a population), product differentiation (how is this product different from my competitors'), product positioning, and industry trends are impossible to answer without market research data.

Typical business questions that market research helps answer include:

• Identifying a potential market for a product/service

• Determining the acceptance criteria of the product/service, including pricing

• Determining buying patterns—what population will buy a product/service based on different variables like age, gender, income level, location, etc.

• Identifying who the competitors are and what their key success factors are.

Market research broadly splits into two types: primary and secondary.

Primary research compiles insights based on research conducted in-house or by hiring a market research firm.

Primary research helps you investigate specific business questions, such as demand for a particular product/service your company has in mind or the reaction to how a particular product/service should be packaged or priced.

Secondary research uses insights compiled by outside sources such as government agencies, industry and trade associations, and media sources. This is easy to find, and much of it is available for free or at low cost. Secondary research helps you keep up with changing industry trends and how a large section of the population both behaves and spends money. The downside of secondary research is that it is not specific to the business problem your company is trying to solve. For example, secondary market research will tell you how much money consumers spent buying electronic gadgets last year. It won't tell you how much they are willing to pay for the new electronic gadget your company is planning to invent.

Both kinds of research are important for any business. Secondary research lays the foundation and

Insights

→ Blending market and user research helps narrate a more comprehensive story of user behaviors, needs, and motivations.

→ Both market and user research employ similar qualitative methodologies, but what they uncover can be radically different and/or complementary.

→ Collaboration between market and user researchers ensures you both "build the right product" and "build the product right."

primary research helps you fill in the gaps specific to your business-planning process. For example, the owner of a restaurant would want to know all about a neighborhood before opening his restaurant. Secondary research will give him or her the needed demographic information, income data, and spending patterns of that particular neighborhood. The owner can then fill in the gaps by conducting primary research to find out how often the households in that neighborhood are willing to go to the kind of restaurant he or she plans to open. This will further inform their business plan to more specifically fit the location demographics.

USER RESEARCH

User research helps answer the questions *why* and *how*—why is the user doing this and not some other thing? What is the overall context that this design will fit into? How does the user go about accomplishing the goals?

It focuses on understanding user behaviors, needs, and pain points through observation, task analysis, and other feedback methodologies.

User research focuses on employing techniques and methodologies to create and improve user experience at the individual consumer level.

Typical user research questions include:

- What goals are the users trying to accomplish?
- Do any of the concepts, functions, and designs being presented in the product fail to meet the users' expectations?
- Does this design allow the user to accomplish their goals/tasks effectively and efficiently?
- Do the use cases and scenarios considered in the design need to be modified?
- Who are the primary and secondary personas for this product?
- What are the critical success points for each task?

User research helps validate assumptions and hypotheses, analyze competition, understand user goals, and develop user stories and scenarios in the analysis phase of product development. During the design phase, user research validates interaction design, information architecture, and task analysis. Finally, when the product is deployed, user research conducts benchmark studies to evaluate the product against those of competitors and establish a usability baseline to compare with further releases.

WHAT DO THEY HAVE IN COMMON?

The most common misconception about market research is that it is always quantitative and that it requires large sample sizes. Like user research, market research utilizes qualitative methodologies that can be conducted on a sample size of 10 or less. While both disciplines can practice similar qualitative methodologies, what they uncover can be radically different and/or complementary.

Contextual inquiry (or ethnographic study) is an example of a qualitative methodology that both disciplines employ. This methodology is used to observe actual user behavior. It is a hybrid form of research that involves interviewing the subjects as well as just observing them work (or play) in their natural environment.

Market research conducts ethnographic studies in the very early stages of product development, the opportunity/needs discovery phase, and the product-definition phase. The focus of the study is exploration of individual motivations and attitudinal aspects underlying the consumers' actions. The insights uncovered help reveal the consumer attitudes and behavior relevant to the new product development. They also help with the decision of whether to invest in the product space at all.

User researchers conduct ethnographic studies after the product concept is solidified but before the design process starts. The aim of the study at this point in time is to gain insights into the consumers' goals and tasks, and the influence that social, technical, and physical environments have on consumer goals. The insights help clarify the users' roles and responsibilities, primary and secondary tasks, as well as workspace social dynamics, all of which influence the product design itself.

User interviews (in-depth interviews) are another example of a qualitative methodology used by both disciplines. This consists of one-on-one interviews conducted in person or through remote technology (phone or video). The format is usually an unstructured interview in which the researcher has a skeleton outline to make sure all the key points are covered.

Market researchers conduct user interviews as a precursor to a quantitative survey to investigate motivations and feelings, usually in the opportunity discovery phase. These are typically conducted when there is insufficient knowledge about a target population. These early interviews provide a preliminary idea of what's going on. In turn, they are used to design quantitative surveys that will follow. Market researchers also use this methodology to dig deeper, to understand the motivations behind the acceptance or rejection of a product or service concept.

User researchers conduct user interviews to get a deeper understanding of the target users identified via market research. The focus of this activity is to investigate their feelings around needs and pain points, and the perception of the end-to-end experience with the product. This methodology can be used as a precursor to a deeper contextual inquiry, or to other user research-only methods.

Other qualitative methodologies such as focus groups and diary studies also blur the lines between market and user research. In this case, the main differences are the specific phase of product development in which the activities are conducted and the focus of the research. Market research activities are conducted during the audience definition, opportunity/needs discovery, and product concept phases. The focus of market research studies is on perception and attitudinal aspects. User research activities are mostly in the pre-design and post-design phase, and center on how work is actually done. However, with changing roles and a better understanding of what user research can do, in many companies user research teams have also been conducting studies earlier, during the opportunity/needs discovery and product concept phases.

Due to the overlap in the product phase, when both disciplines conduct their activities, it is possible that insights gathered from both disciplines have a significant overlap. This makes it all the more important that the two disciplines collaborate on research activities to ensure that you both "build the right product" and "build the product right." In cases where it matters, it also makes sense to blend both activities so one research activity can be designed based on the findings of the other.

Neither method is better than the other: They are complementary approaches. They are not and should not be competing with each other from either a content or political perspective.

BLENDING RESEARCH ACTIVITIES

Time crunch and budget constraints are the two factors that work in favor of blending market and research activities into one activity.

At Move Inc., a subsidiary of News Corp (www.realtor.com), the product team was in a time crunch to deploy a product that would enhance the experience of home search for the buyers. The interaction and visual designs were completed and ready to go. There was no time to conduct a comprehensive market research study followed by a usability study. The tight timeline provided a chance for both disciplines to come together in one study.

The market research team and I planned a study combining both activities. Each session started with 30 minutes dedicated to a market researcher introducing the concept and probing on perception and attitudes. The market researcher also uncovered the perceptions of homebuyers toward Move Inc. offering the product in question. Here are some of the questions asked by the market researcher:

- Describe the concept in your own words.
- If this type of information were available to you, would it be useful? Why or why not?
- When would you use it in your home search process?
- Does it matter to you to be able to get this type of information?
- How do you feel about realtor.com offering this information?

The next 60 minutes were dedicated to a user researcher discussing the usability of the design. The result of this combined study helped inform the product team about brand perceptions around the product, the attitude around the product concept, and the utility of the product features. It also helped inform the UX design team on how to improve the interaction and information architecture of the product.

Apart from saving time and being able to provide a quick detailed research report, blending the two activities also saved a considerable amount of money. The total cost of the project ended up being 1.5x as opposed to being 3x; 1x for user research plus 2x for market research.

The most important takeaway from this case study was that we could uncover both the perceived value of the product (by presenting the concept first) and the actual value (by investigating the usability of the product) in a single study. This provided the product team with solid context regarding what to fix in the product as well as how to fix it.

Going forward, at Move Inc., we established a process for small product enhancements and product releases with time crunch to combine qualitative market and user research in a single study. The value for the product and design teams has been immense, since they have been getting both attitudinal and behavioral insights from the same study. It's become easier to make the leap from making changes to the product definition to making changes to the design of the product.

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Envisioning, designing, and implementing the user interface require a comprehensive understanding of interaction technologies. In this forum we scout trends and discuss new technologies with the potential to influence interaction design. **— Albrecht Schmidt, Editor**

Printed Electronics for Human-Computer Interaction

Jürgen Steimle, Max Planck Institute for Informatics and Saarland University

A technology revolution is happening. For a long time, electronic components were accepted as being rigid, rectangular, and somewhat bulky. As a consequence, today's computing devices are typically flat, rectangular, and have a fixed shape. But a new technology is challenging this established view. Printed electronics offers a new way to realize fundamentally different electronic components that are paper-thin and deformable, that can cover large areas, and that can be deeply embedded within various materials and geometries.

These new possibilities have already been influencing HCI research and consumer electronics through flexible OLED and e-paper displays. Research such as Gummi, Nokia Kinetic, PaperPhone, and Flexpad has investigated new interactions for handheld devices that can be physically deformed.

Now printed electronics itself is becoming accessible as a tool for HCI researchers, makers, and even interested laypeople. Recent work in printed electronics is enabling non-experts to print their own functional devices and interactive surfaces in a way that's very similar to printing graphics on paper. Ready-to-use printing techniques are available to produce your own customized sensors and displays easily, rapidly, and at low cost. The hardware can be controlled with common DIY hardware platforms such as Arduino.

This is opening up exciting new possibilities for HCI, as it is now possible to realize interfaces that so far designers might have conceptualized but would not have been able to implement. For instance, radically new types of mobile and wearable interfaces can be implemented by printing touch-sensitive display surfaces of custom shape that are very thin, lightweight, and deformable. These can be handheld, worn right on the human body, or integrated within clothing, interactive jewelry, and accessories. Printed on paper, electronic components can realize smart packaging and interactive paper solutions for new interfaces in education, knowledge work, communication, and play.

Furthermore, new geometries and new materials make it possible to deeply embed user interfaces within the physical environment. Printing on very large surfaces enables interactive floors or interactive wallpaper. Printing on curved surfaces enables smart objects and applications in the car. And printing electronics on wood can realize aesthetically pleasing, calm interfaces that are embedded within furniture.

Insights

- Printed electronics enables HCI researchers, makers, and end users to print their own customized user interfaces.
- Recent research in HCI has contributed platforms and toolkits for easy, rapid, and inexpensive printing of electronics.
- The technology can enable radically novel interfaces and interactions in mobile, wearable, tangible, and embedded computing.

PRINTED ELECTRONICS IN A NUTSHELL

Printed electronics involves leveraging conventional printing methods together with new types of inks to fabricate electrical devices. It benefits from the long history of graphic printing, which over the years has led to a wide range of printing methods that produce very high-quality prints, are extremely cost-efficient, and can print in low to high volume. And of course they are compatible with all kinds of flexible and rigid substrates, including inexpensive paper or transparent polymer films, but also more unconventional materials such as wood, stainless steel, ceramics, fabric, and leather. Pretty much any established printing method for graphical printing has been successfully used for printing electronic components. This includes roll-to-roll mass printing methods, very versatile screen printing, and fully digital inkjet printing, which is very well suited for low-volume printing. Thus far, the field is mostly focusing on 2D printing on thin-film substrates. However, promising work is emerging that allows us to 3D-print electronics within objects, such as the 3D printer of the Harvard spin off Voxel8.

The key to printed electronics is the electrically active inks and pastes, a very dynamic research

Figure 1. Using a consumer-grade inkjet printer to print a conductive circuit on photo paper [1]. (Courtesy of Yoshihiro Kawahara)

area. Already a wide range of inks with various electrical properties are commercially available. Depending on the material, a printed structure can act as conductor, semi-conductor, isolator, or dielectric. It can also exhibit other functional properties, such as actively emitting light. Commonly used materials include dispersions of metallic or carbon particles (e.g., silver nanoparticles) and conductive and semi-conductive polymers (e.g., PEDOT:PSS and pentacene).

The functional behavior is defined by not only the material, but also the geometry in which one or multiple materials are printed. A conductive structure printed on a single layer can act as a flexible circuit board, as well as a resistor, capacitor, inductor, or antenna. By printing various materials on multiple layers, active components can be realized such as displays, more complex sensors, actuators, transistors, and batteries.

Will the next generation of microprocessors be printed? Will printed electronics replace conventional silicon-based electronics? No. Rather, printed electronics will coexist with them. Printed electronics is limited by a much lower integration density due to the lower resolution of printing. It also offers considerably lower switching times than in conventional electronics because of the low mobility of printed semi-conductors. Therefore, we will see continued use of conventional electronics for high-performance applications, while printed electronics will open up new markets and applications for thin, lightweight, large-area, deformable, and extremely low-cost electronics.

PRINT YOUR OWN FUNCTIONAL USER INTERFACE

So why not use printing to prototype your new mobile, wearable, tangible, or embedded user interface? In ground-laying work, Kawahara et al. [1] have demonstrated that highly conductive structures can be printed in high resolution with a consumer-grade inkjet printer, which is as cheap as $100. The approach replaces the standard inks in the cartridge with commercially available conductive ink, which is made of silver nanoparticles. The user designs the conductive traces and electrodes in any graphics application and then prints them within a few seconds on a specific type of photo paper (Figure 1). Despite its limitation to single-layer printing, the method can be used for a wide variety of purposes. Among other scenarios, the authors have demonstrated its efficacy in the rapid prototyping of deformable electronic circuits and for printing capacitive touch sensors and RFID antennas.

If the prototype requires more complex functionality that cannot be printed, conventional electronics components can be attached onto the printout by using CircuitStickers, which the authors have presented in follow-up work. The team has also contributed an improved multimodal sensing technique [2]. It allows for single-layer printing of sensors that are capable of sensing multi-touch and proximity input, several levels of touch pressure, and deformation. Last but not least, printed sensors can be visually appealing, as shown in Figure 2.

Other conductive inkjet printers can realize much larger circuits by printing onto material dispensed

Figure 2. Printed circuits can be both functional and aesthetic. This is a capacitive sensor for music control on an electric ukulele, adapted from an artwork by Evgeny Kiselev. (Courtesy of Nan-Wei Gong)

Figure 3. This multi-touch sensor sheet is cuttable into various shapes and remains functional. This enables physical prototyping of electronic components [4].

from a roll. This enables new kinds of large-scale interfaces, for instance, smart wallpapers and floors that offer embedded sensing and output capabilities. Gong et al. have contributed a large-scale sensor floor, which was realized on a several meter long flexible substrate [3]. The sensor can be deployed on or under a floor to detect the presence and whereabouts of people.

In addition to deformability and large sizes, printed electronics offers new affordances that can be leveraged for interaction. One such affordance is that thin sheets are cuttable. This allows for very direct and instant physical customization. Why not simply cut a sensor film to a desired shape in order to augment a physical object or surface with touch-sensing capability? Olberding et al. [4] have contributed a cuttable multi-touch sensor that remains functional after it is cut into a new shape (Figure 3). The printed sensor ensures resilience to cutting by new geometric layouts in which the individual electrodes of the sensor are connected to the controlling unit. Given the low cost of printed electronics, it's conceivable that it will be possible to buy touch-enabled materials that can be used pretty much as if they were conventional materials, supporting rapid and hands-on prototyping of electronics.

More complex sensors can be realized using multi-layered printing and additional functional materials. PyzoFlex [5] is a thin pressure-sensing foil that exhibits a very linear response and therefore allows for continuous measurement of normal force. The sensor is screen printed in several layers. Its functional layer is made of a new pyro- and piezo-electric material, which is not yet commercially available. In follow-up work called FlexSense, the authors have used the same functional material to realize a mostly transparent and very accurate deformation sensor.

While most prior work on printed electronics in HCI has investigated sensors for capturing user input, new work is addressing the output side. PrintScreen [6] is a platform that enables non-expert users to design and fabricate light-emitting and touch-sensitive displays (Figure 4). The approach leverages commercially available electroluminescent ink, which emits light when a current is applied. This is closely related to OLEDs, the difference being that electroluminescent displays require a higher voltage but can be fabricated in ambient environments without the need for a cleanroom. PrintScreen displays can be printed either with conductive inkjet printing, which is very fast, or using hobbyist-level screen printing, which supports more complex displays. The displays are around 0.1 mm thin, deformable, and highly customizable, not only in terms of content but also in terms of shapes and materials. Among other materials, displays can be printed on paper, transparent polymer film, wood, leather, ceramics, and steel. PrintScreen enables the prototyping of new kinds of mobile, wearable,

Figure 4. Some examples of deformable touch-sensitive displays fabricated with PrintScreen [6].

and ubiquitous computing interfaces, including customized interactive print products, smart packaging and objects, personalized body-worn interactive accessories, and crafts with embedded displays.

All approaches presented here realize the input/output surfaces with printed electronics, while the controlling unit and battery are still conventional components. Paper Generators [7] presents a way to realize flexible interactive surfaces with a self-contained energy supply. Paper Generators harvest energy from the user's interaction with the interface. For instance, when tapping on a button, the user unconsciously generates the energy required for the interface.

WHAT IS DOWN THE ROAD?

The fabrication approaches presented here are affordable for most any HCI lab, maker space, or even private hobbyists. This opens up new creative ways of exploring electronics and new types of user interfaces, new interaction modalities, and applications. However, using consumer-grade printers and simple controlling electronics comes at a cost: limited resolution of sensors and displays as well as continued need for rigid electronic components.

These current limitations are fully acceptable for the purposes of prototyping and even for a wide range of commercial applications. But the good news is that printed electronics can already offer much more than what has been explored in HCI thus far. The state-of-the-art in printed electronics is rapidly advancing through contributions in chemistry, material science, and printing technology. It is also a very dynamic market; the first commercial products have already been released, and many more are waiting in the wings. A good overview of the state-of-the-art is provided in [8].

In terms of displays, high-resolution flexible displays are entering the market. Curved OLED displays have already been deployed in consumer electronics, for instance, in curved smartphones and curved TVs. Deformable displays, including foldable and even rollable ones, are predicted to be commercialized in the near future. The most recent trend in printed displays looks beyond just deformable displays into displays that can be stretched, for instance, when printed onto textiles and other elastic substrates.

In terms of sensors, many more modalities than touch, pressure, or deformation can be realized using printed electronics. This includes environmental sensors for temperature, pressure, and humidity, sensors for chemical analyses, light sensors, as well as biosensors. These sensors will enable a wide range of applications in areas such as health, environmental monitoring, and quality checking. First products, such as printed glucose test strips, have become commercially available.

To make the entire device thin and flexible, and not just the input/output surface, additional components need to be printed: logic, memory, and battery. The first printed flexible batteries have become commercially available, and so have flexible solar cells, which could charge mobile devices and one day even cover the roofs of cars. Also, simple logic circuits and printed memory have been successfully demonstrated as prototypes. While they are still very far from having the processing power of conventional electronics, they could soon enable specialized applications such as smart packaging, fully printed RFID tags, or smartcards that incorporate processing and some display output.

These few examples show that a user interface prototyped using the methods described here can be brought to a whole different technical level when it is mass-produced with commercial high-end fabrication techniques. These recent advances also make it very likely that in the near future an increasing variety of components can be printed in do-it-yourself setups and through specialized low-volume print services.

Even though it is challenging to predict the market in this young and disruptive field, one thing is clear: Printed electronics empowers us to realize applications of electronics that were unthinkable before. Let's embrace this new technology to realize a new generation of user interfaces that are thin, lightweight, expressive and aesthetic, and deeply embedded in our physical environment.

Endnotes

1. Kawahara, Y., Hodges, S., Cook, B.S., Zhang, C., and Abowd, G.D. Instant inkjet circuits: Lab-based inkjet printing to support rapid prototyping of ubicomp devices. *Proc. of the 2013 ACM International Joint Conference on Pervasive and Ubiquitous Computing*. ACM, 2013, 363–372.
2. Gong, N.-W., Steimle, J., Olberding, S., Hodges, S., Gillian, N.E., Kawahara, Y., and Paradiso, J.A. PrintSense: A versatile sensing technique to support multimodal flexible surface interaction. *Proc. of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2014, 1407–1410.
3. Gong, N.-W., Hodges, S., and Paradiso, J.A. Leveraging conductive inkjet technology to build a scalable and versatile surface for ubiquitous sensing. *Proc. of the 13th International Conference on Ubiquitous Computing*. ACM, 2011, 45–54.
4. Olberding, S., Gong, N.-W., Tiab, J., Paradiso, J.A., and Steimle, J. A cuttable multi-touch sensor. *Proc. of the 26th Annual ACM Symposium on User Interface Software and Technology*. ACM, 2013, 245–254.
5. Rendl, C., Greindl, P., Haller, M., Zirkl, M., Stadlober, B., and Hartmann, P. PyzoFlex: Printed piezoelectric pressure sensing foil. *Proc. of the 25th Annual ACM Symposium on User Interface Software and Technology*. ACM, 2012, 509–518.
6. Olberding, S., Wessely, M., and Steimle, J. PrintScreen: Fabricating highly customizable thin-film touch-displays. *Proc. of the 27th Annual ACM Symposium on User Interface Software and Technology*. ACM, 2014, 281–290.
7. Karagozler, M.E., Poupyrev, I., Fedder, G.K., and Suzuki, Y. Paper Generators: Harvesting energy from touching, rubbing and sliding. *Proc. of the 26th Annual ACM Symposium on User Interface Software and Technology*. ACM, 2013, 23–30.
8. Cantatore, E., ed. *Applications of Organic and Printed Electronics: A Technology-Enabled Revolution*. Springer, 2013.

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Gerrit C. van der Veer,
President, ACM SIGCHI

SIGCHI

Thanks to Our Volunteers and Friends

It is election time for the SIGCHI Executive Committee (EC). I hope you will all vote, before May 31, for the six officers who will be leading SIGCHI for three years starting July 1. Your vote is needed and will count.

Voting alone, however, is not enough to make SIGCHI run. In fact, it takes many dedicated volunteers to perform the diverse activities of SIGCHI. The EC is supported by appointed vice presidents (for publications, conferences, chapters, and operations) and appointed adjunct chairs whenever needed for pursuing visions of the EC (currently for specialized conferences, developing worlds, public policy, education, mentoring, awards, liaising with other societies, communities, and media and branding).

The vice president for conferences and the adjunct chair for specialized conferences lead the Conference Management Committee (CMC), which includes a core of nine people specializing in surveys, video captures, conference archives, reviews, and the submission process. In addition, steering committee leaders of our sponsored conferences are members and meet with the CMC to work on transferring information and improving the planning and management of our 18 conferences. And each of these conferences is run by a conference committee, reviewers, session chairs, student volunteers, and so on.

We also have a growing international public policy committee, a publications board and journal and magazine editors, and leaders for our 18 communities and 42 local chapters (the numbers are growing).

Many SIGCHI activities can only be successful if our volunteers manage to get support from groups, organizations, and individuals outside our organization. Let me provide a recent example:

Bringing CHI, our flagship conference, to Asia is an enterprise we considered and discussed for many years. It was only through the support of the Korean HCI Society that we managed to make it happen. It's worth noting that most of the 2,000 members of the Korean group are not (yet?) members of SIGCHI. The Korean HCI Society and SIGCHI have been coordinating to make it happen, and our Korean colleagues are extremely happy about CHI 2015 taking place in Asia.

However, in many ways, holding CHI in Korea competes with the existing annual Korean HCI conference: The Korean conference is normally held in February each year, only about two months before CHI in April!

The Korean HCI Society has worked aggressively to support CHI in Korea, navigating many disruptions to its own conference and practices. Indeed, it moved its 2015 conference three months earlier, to December 2014. This resulted in their having two conferences in the same year, and no Korean HCI Society conference in calendar year 2015.

CHI 2015 chose to hold the planning committee (PC) meeting in Seoul to begin the CHI 2015 cross-pollination. To entice PC members to make such a long trip, the Korean HCI Society moved its conference to Seoul, which cost double the amount of the usual location; scheduled the conference for just prior to the PC meeting; held a special track, called Premier CHI, on the final day in which CHI PC members presented their work; and provided lodging and food for PC members who participated in that special track.

In hosting 250 volunteers, logistics for the CHI PC meeting are equivalent to a small conference. Korean volunteers arranged to hold the PC meeting at Yonsei University, which helped keep costs manageable, and the Korean HCI Society submitted and managed grant requests to the Korean government to offset some costs at the PC meeting.

Even though the Korean HCI Society expended tremendous time and effort to hold a successful PC meeting, it provided even more support for the even greater challenges of organizing and running CHI 2015.

This is only one example. It shows how the success of many SIGCHI activities depends on SIGCHI volunteers and many others (our friends) contributing their time, their creativity, their expertise, and their resources. Representing the six SIGCHI officers that you elected three years ago, I acknowledge these contributions and thank our volunteers and friends.

—Gerrit C. van der Veer
President, ACM SIGCHI

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acm Inroads

PAVING THE WAY TOWARD EXCELLENCE IN COMPUTING EDUCATION

Association for Computing Machinery

ACM/SIGCSE Seek
New Editor for *ACM Inroads*

ACM and the Special Interest Group on Computer Science Education (SIGCSE) seek a volunteer editor-in-chief for its quarterly magazine *ACM Inroads*.

ACM Inroads serves professionals interested in advancing computing education on a global scale. The magazine—written *by* computing educators *for* computing educators—presents an array of thought-provoking commentaries from luminaries in the field together with a diverse collection of articles that examine current research and practices within the computing community. For more about *ACM Inroads*, see **http://inroads.acm.org/**

Job Description

The editor-in-chief is responsible for soliciting all editorial content for every issue. These responsibilities include: soliciting articles from prospective authors; managing the magazine's editorial board and contributors; creating new editorial features, special sections, columns and much more. For more information, see ***http://inroads.acm.org/eic-search.cfm***

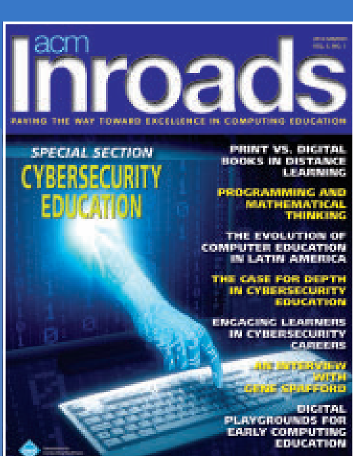
Eligibility Requirements

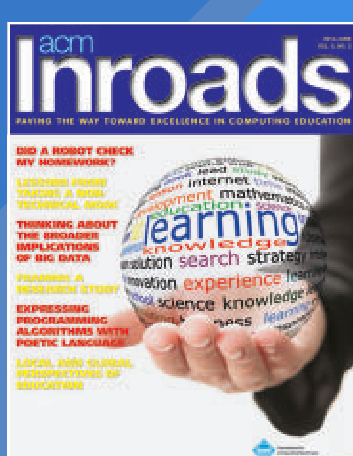
The EiC search is open to applicants worldwide. Experience in and knowledge about the issues, challenges, and advances in computing education a must.

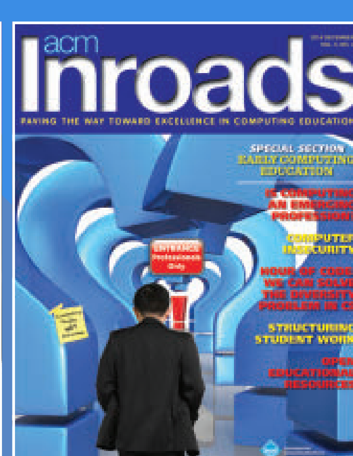
This editorship commences on September 1, 2015. You must be willing and able to make a three-year commitment to this post.

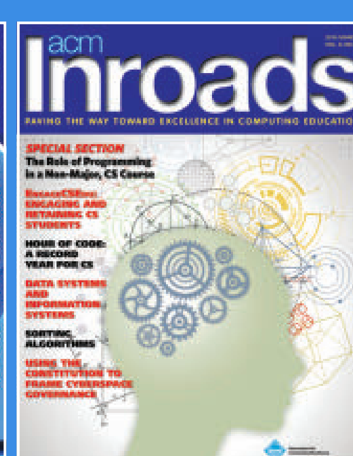
Please send your CV and vision statement expressing the reasons for your interest in the position and your goals for *Inroads* to: ***eicsearch@inroads.acm.org***

The ACM Publications Board will review all candidates.









May – August 2015

May

Smart Greens 2015 – 4th International Conference on Smart Cities and Green ICT Systems (Lisbon, Portugal)
Conference Dates: May 20–22, 2015
→ http://www.smartgreens.org/

CAADRIA 2015 – 20th Annual Conference on Computer-Aided Architectural Design Research in Asia (Daegu, Korea)
Conference Dates: May 20–23, 2015
→ http://www.caadria2015.org/

June

TVX 2015 – ACM International Conference on Interactive Experiences for Television and Online Video (Brussels, Belgium)
Conference Dates: June 3–5, 2015
→ http://tvx2015.com/

Persuasive 2015 – 10th International Conference on Persuasive Technology (Chicago, USA)
Conference Dates: June 3–5, 2015
→ http://trex.id.iit.edu/persuasive2015/

PerDis 2015 – 4th International Symposium on Pervasive Displays (Saarbrücken, Germany)
Conference Dates: June 10–12, 2015
→ http://pervasivedisplays.org/2015/

IDC 2015 – ACM SIGCHI Interaction Design and Children (Boston, USA)
Conference Dates: June 21–24, 2015
→ http://idc2015boston.org/

C&C 2015 – ACM Creativity and Cognition (Glasgow, UK)
Conference Dates: June 22–25, 2015
→ http://www.creativityandcognition.com/cc15

UXPA 2015 – User Experience Professionals' Association International Conference (San Diego, USA)
Conference Dates: June 22–25, 2015
→ http://uxpa2015.org/

EICS 2015 – 7th ACM SIGCHI Symposium on Engineering Interactive Computing Systems (Duisburg, Germany)
Conference Dates: June 23–26, 2015
→ http://eics2015.org/

July

UMAP 2015 – 23rd Conference on User Modelling, Adaptation and Personalization (Dublin, Ireland)
Conference Dates: June 29–July 3, 2015
→ http://umap2015.com/

EVA London 2015 – Electronic Visualisation and the Arts (London, UK)
Conference Dates: July 7–9, 2015
→ http://www.eva-london.org/

SOUPS 2015 – Symposium on Usable Privacy and Security (Ottawa, Canada)
Conference Dates: July 22–24, 2015
→ http://cups.cs.cmu.edu/soups/2015/

August

HCI 2015 – 17th International Conference on Human-Computer Interaction (Los Angeles, USA)
Conference Dates: August 2–7, 2015
→ http://2015.hci.international/

Aarhus 2015 – Critical Alternatives, 5th Decennial Aarhus Conference (Aarhus, Denmark)
Conference Dates: August 17–21, 2015
→ http://aarhus2015.org/

MobileHCI 2015 – 17th International Conference on Human-Computer Interaction with Mobile Devices and Services (Copenhagen, Denmark)
Conference Dates: August 24–27, 2015
→ http://mobilehci.acm.org/2015/

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VISUAL THINKING GALLERY

Self-Portraits

- Contributor: Zhouxing (Jason) Lu
- Curator/Editor: Eli Blevis
- → Genre: Reflections on social dynamics in design contexts and, more generally, constructed images

This triptych of self-portraits reflects on (top) cultural misunderstandings and sense of self, (middle) team dynamics and hidden self, and (bottom) outward confidence and inner fears.

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