



Memory Bites: From Earth to Space and Back

**Enjoying Wine:
Opportunities and Challenges
for Interaction Design**

**Designing for
Uncertain Futures**

Money as an Interface

**New Forum
Play Time**

**New Column
Design as Practice**



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From Algorithms to Thinking Machines

*The New
Digital Power*

Domenico Talia

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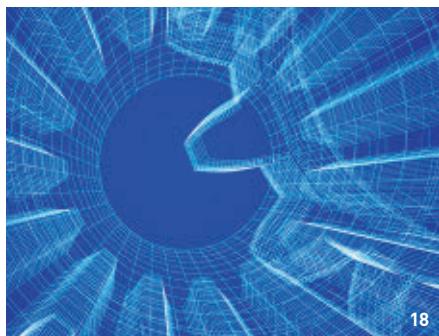
From Algorithms to Thinking Machines

*The New Digital
Power*

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We need a resurgence
of interest and ability in
“classic” skills.

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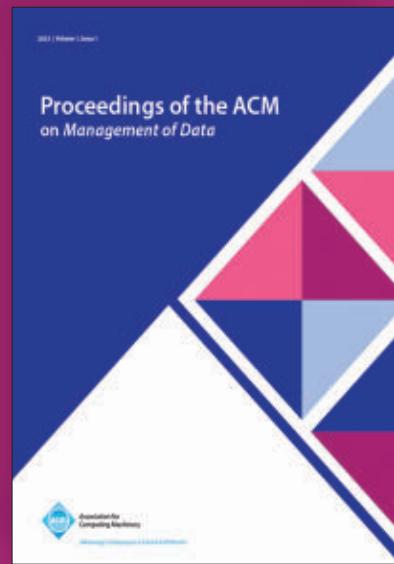
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Publishing the principles, algorithms, techniques, and applications of database management systems, data management technology, and data science and engineering

Proceedings of the ACM on Management of Data (PACMMOD) is a journal concerned with the principles, algorithms, techniques, and applications of database management systems, data management technology, and data science and engineering. The journal invites submissions of original research on data management, data engineering, and data science that target the data life cycle of real applications and study phenomena at scales, complexities, and granularities never before possible. This data life cycle often encompasses applications leveraging statistical, machine learning, and artificial intelligence methods and, in many instances, using massive and heterogeneous collections of potentially noisy datasets. Articles that address data challenges at various stages of the life cycle, from modeling, acquisition, cleaning, and integration to indexing, querying, analysis, exploration, visualization, interpretation, and explanation fall within the areas of coverage. Papers are generally expected to focus on data-intensive components of data science pipelines, and to solve problems in areas of interest to our community (e.g., data curation, optimization, performance, storage, systems), operating within the constraints of accuracy, privacy, fairness, and diversity. Submissions describing deployed systems and solutions to data science pipelines and/or fundamental experiences and insights from evaluating real-world problems are encouraged.

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Association for Computing Machinery

► WELCOME



Elizabeth Churchill



Mikael Wiberg,
Umeå University

Some Food for Thought and Some (Digital) Things to Digest

Welcome to the November–December issue of *Interactions*! In this issue, we want to continue to build on both the established foundations and the legacy of the past few years, bringing critical perspectives and design and engineering together in a collection of features, forums, columns, and more.

We are in the final few weeks of 2023—it feels like this year has flown by. It has been a year of ups and downs across the global stage, with a few too many downs in these closing months. That said, even in times of hardship and crisis, people around the world continue to carve out moments during this season for celebrations and holiday observances. During this season, many people celebrate faith and invite hope, rejoicing in that which is good in the world—and they do so with family and friends. Our focus this issue is life, living, and sustenance with and through technology. While digital technologies are increasingly described as ubiquitous to underscore how they are fundamentally intertwined with our everyday lives, we have been thinking about how food is so important in our coming together. Food is also fundamentally entangled with our cultural practices,

our rituals, and our daily activities—and, of course, our celebrations.

Before diving into the content, let's recognize just a few of the festivals celebrated at this time of year: Diwali, Thanksgiving, Hanukkah, and Christmas. Honoring the triumph of good over evil, Hindus, Jains, and Sikhs celebrate Diwali, the Festival of Lights. The biggest holiday of the year in India, it is also a major holiday in Myanmar, Nepal, and Sri Lanka. In the U.S., Canada, Grenada, Saint Lucia, and Liberia, November brings the fall harvest celebration in the form of Thanksgiving. Hanukkah, which means “dedication” in Hebrew, also falls at this time of the year. Another Festival of Lights, this eight-day Jewish holiday is known for the lighting of the menorah. The winter solstice is typically on or around December 21, which marks the longest night of the year. Called Toji in Japan, it is traditional to take a hot bath with citrus fruit. In China, it is called the Dongzhi Festival, when people eat tang yuan (湯圓), which is similar to mochi, with family. This time is also referred to as the pagan holiday Yule, which includes the winter solstice and the 11 days following. Many ancient Yule traditions have been incorporated into modern Christmas celebrations. In the Christian tradition, people commemorate the birth of Jesus Christ on Christmas Eve (December 24) and

Christmas Day (December 25). While Christmas is a Christian holiday, it is also a cultural holiday globally, with traditions that span both religious and secular aspects of the season. A more recent holiday is Kwanzaa, started in 1966 by Maulana Karenga, chair of Black Studies at California State University, Long Beach. This holiday honors African-American culture and its purpose is to bring the African-American community together.

As noted above, one of the things these celebrations have in common is the focus on food and eating and the communal spirit of sharing. In this issue, we have two feature articles focused on the delights of eating and drinking. In our cover story, “Memory Bites: From Earth to Space and Back,” Marianna Obrist and Carlos Velasco invite us to imagine we are on a NASA one-year mission to the International Space Station. We are not alone—we are with a few crewmates, and we are literally and metaphorically hungry for the tastes of home. The article explores how to use VR and other multisensory technologies and experiences to evoke memories and the familiar tastes of home, spurring feelings of being connected to our personal slice of Earth, friendship, family, and communal celebration.

Our second food and communal sharing feature discusses changes in

Our focus this issue is life, living, and sustenance with and through technology.

the production of wine. In “Enjoying Wine—Opportunities and Challenges for Interaction Design,” Jeni Paay celebrates the ceremonial, spiritual, physical, and emotional properties of wine. She shares some of the threats to the wine production industry from the irreversible environmental changes of global warming. And she asks: What are the opportunities and challenges for interaction design to help the wine industry ensure a future for drinking and making wine?

Another key feature of this season is spending on communal and family events, and on gifts! In “Money as an Interface,” Belén Barros Pena reminds us that money and its exchange is also a design concern, and that we as HCI, UX, and IxD scholars and practitioners have a contribution to make in designing financial flows, technological communications around financial issues, and applications that support the management of shared and personal finances.

We also have a number of other delights for you in this issue. In some parts of the world it is *cold* this time of year—other places not so much, as we wish no more extreme heat waves for our friends in the Southern Hemisphere. Tessa Lau and colleagues share an experience around how robots fare in the cold, illustrating just how complex hardware systems can be to

debug, and reminding us that even sophisticated and complex machines are at the mercy of the environment for their functioning. Too few of us are aware of the enormous engineering and climate control efforts, and the sheer cost of running all the servers that keep us connected and productive with computation. The story of the recalcitrant robots is a timely reminder as we see increasing investment in hardware—and in climate control for data centers—to make our interconnected software world function effectively and efficiently.

One of our forum articles, “Unleashing Immersive Experiences: The Power of Gesture-Based VR Interaction” by Nour Halabi, Evan Jones, and Pejman Mirza-Babaei introduces both opportunities for improving gesture-based VR interaction and the benefits of collaboration between game development studios and academic HCI research labs to drive advancements in the gaming industry.

Keeping with the theme of virtual reality, our Exit image for this issue is by Singaporean artist Jennifer Teo: a VR installation artwork addressing the saving of the Bukit Brown cemetery and nature space in Singapore, which has been under the threat of destruction to make way for modern development for years. Jennifer’s

artwork shares many viewpoints on why and how to save this honored and historic space. This work, should you wish to see it in person, is currently at Perilous Playground at the Chinese Culture Center of San Francisco.

Finally, we would like to welcome two new contributors! Jon Kolko is returning to the *Interactions* team after many years, this time as a columnist. In Design as Practice, he will be focusing on the pragmatics of designing and codesigning great experiences, flows, and services. And Pejman Mirza-Babaei, mentioned above, has taken on a role as forum editor with a focus on platforms and infrastructures for games and gaming. His forum, Play Time, will bring together discussions around HCI, UX, and IxD with a lens on how the technology itself, from platform to product, shapes our experiences of games and immersive experiences.

As we close out this Welcome and 2023 comes to an end, we’d like to wish all our contributors and readers a peaceful holiday season. Thank you for coming on these journeys of human-centered computing with us. And, as before, we invite submissions in all categories across the magazine. Please get in touch if you have energy, time, and great ideas to contribute.

Elizabeth Churchill and Mikael Wiberg
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Psychological Privacy

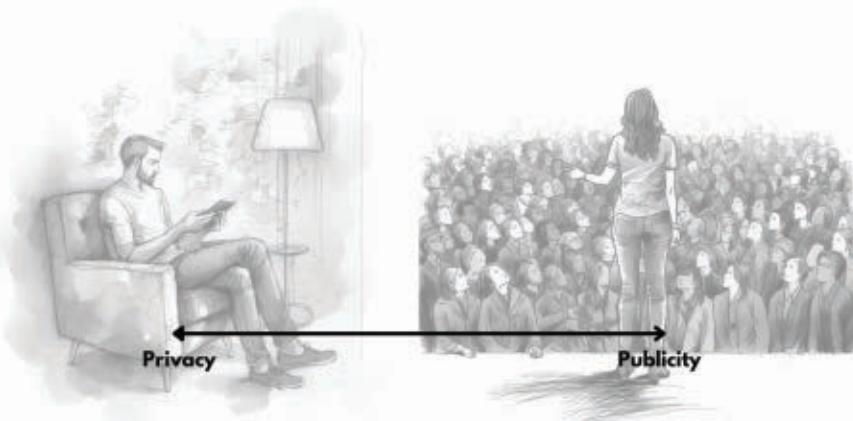
How Perceptual Publicity Can Support Perceived Publicity

Wee Kiat Lau, Lisa Valentina Eberhardt, Marian Sauter, and Anke Huckauf, Ulm University

Picture this: Sitting in his kitchen, young Tim chuckles at the recent misfortune of neighbors who fell prey to burglars. At the same time, he's enthusiastically experimenting with a banking app on his fresh-off-the-assembly-line computer, a machine devoid of even the most fundamental antivirus protection. This scenario is a striking illustration of the privacy paradox. We voice anxiety about our data's usage, often lambasting corporations with lax privacy protocols, only to defy our apprehensions by not embracing measures to safeguard ourselves. Let's dissect this intriguingly paradoxical user behavior from the lens of perceptual psychology, illuminating the circumstances under which we sense privacy or publicity, distinguishing these states, and suggesting ways to aid individuals like Tim.

Perception in private and public surroundings. Envision an intensely private moment: reclining on your sofa, shaking off the weariness of work. Now, contrast this with a public spectacle: accepting accolades onstage for special achievements, with a massive audience bearing witness. How do these scenarios make you feel, and what sets them apart? To shed light on this question, we will go deep into our bodies' states and processes. A key environmental distinction arises when we feel private—the high likelihood of being cocooned in a familiar setting, surrounded by well-known objects and people, which lets us unwind. New experiences, however, kick-start our alertness; they ignite our curiosity and grab our attention.

Fundamental cognitive processes in any living organism include sensation and perception. Familiar environments



envelop us with recognizable items, triggering well-known sensations, be they sounds, scents, tactile sensations, or visuals. Therefore, private settings pose fewer challenges to the perceptual system about object identification and sensory memory. This reduction in demand allows the system to function at a lower sensitivity level, freeing up capacity for other operations.

This perceptual mode is accompanied by physiological processes. Broadly speaking, in relaxed, private settings, the parasympathetic neural activation ("rest and digest" mode) is dominant, whereas the sympathetic activation ("fight or flight" mode) is dominant in unfamiliar public settings. There are some remarkable perceptual effects caused by this: Sympathetic activation leads to larger pupils, resulting in more light input, in a slightly extended visual field, and in reduced visual acuity, especially outside of the eyes' focus—that is, in periphery and in depth [1]. We therefore can assume that in public relative to private settings, we perceive with less spatial accuracy from a larger visual field.

Attention in private and public surroundings. Perception is accompanied by an adaptation of

attentional processes. All attentional functions respond to situational affordances. We can differentiate between alertness and selective attention. Alertness is the increase and maintenance of response readiness. It can be supposed to complement the general arousal level of an organism. Thus, alertness will be high in public settings, while it can be reduced when the organism is surrounded by familiar objects. The notion of a broader visual field, although with lower spatial resolution, can be plausibly assumed to support alerting functions in public settings.

Regarding selective attention, new salient stimuli are known to capture attention. This improves visual search performance. In private surroundings, distracting objects can be quickly identified and thus be effectively suppressed. This can lead to a phenomenon known as *inattentional blindness*: In familiar settings, it frequently happens that we miss even uncommon, unexpected objects. The visual system is also capable of suppressing distracters based on their spatial location [2], improving efficiency in familiar environments. The familiarity of surrounding objects eases not only the selection of task-relevant objects

but also the suppression of distracting objects. Inhibition again saves capacity for other processes [3]. In unfamiliar public settings, however, stimuli must be processed until they are identified as harmless, and suppression of task-irrelevant stimuli is thus more difficult.

The dichotomy between private and public settings even manifests in our posture and movements. Onstage, we present our bodies to a large audience, making exaggerated, sweeping gestures. Conversely, in private, our muscles can relax, leading to smaller, more restrained movements. This difference extends to eye movements and gaze, which in turn influence perception.

Level of control in private and public surroundings. Taken together, private settings lessen the need to attend to external stimuli; you can unwind and rely on the consistency of the surroundings. Also, perceiving things provides already familiar information. All these processes diminish the need for cognitive control, allowing processing to occur more subconsciously. Consequently, executing learned skills, routines, and habits becomes more probable. Public behavior, however, is marked by unfamiliar surroundings. The influx of novel objects or people prompts a slew of questions: Is that unfamiliar face a threat? What does that unexpected sound imply? This cognitive appraisal demands effortful attention, sapping mental resources, making us more cautious in and conscious of our actions [3].

This thinking aligns with Daniel Kahneman's [4] idea that human behavior is regulated either by quick, instinctive, and emotional processing (as in private settings) or by slower, more deliberative, and logical processing (common in public settings). Crucially, it's nearly impossible to engage both methods simultaneously. Therefore, in a situation prompting emotional automated processing with only weak conscious monitoring, we're hardly capable of producing analytical thinking with logical deductions. This means that if users engage with their personal devices at home, their behavior is dominated by automated, nonconscious routines.

Counteracting perceived privacy

by simulating a public audience. So, how can we assist users in selecting an appropriate level of control? Novelty in environmental stimuli can be an indicator. How we process these cues shapes how we perceive and interact with our surroundings, be they private or public. The cues could be signals or symbols [5]. Signals are automatic cues operating beneath conscious thought, like the familiar ticktock of a clock or the distinctive feel of your sofa, directing our arousal and attention needs. Conversely, symbols, such as GDPR text, demand conscious, detailed analysis, and interpretation, thus requiring higher cognitive capacity.

Discerning the psychological differences between private and public settings equips us with a potent tool to mold privacy behavior and promote prudent disclosure. As we've noted, using personal devices in private settings often sparks cues associated with private behavior, possibly leading to a false sense of security. Thus, introducing cues that simulate public scenarios could stimulate public consciousness, reminding users to be more circumspect with their disclosures. These could be visuals, sounds, smells, or other elements that evoke the public nature of their online interactions. One subtle method to induce a feeling of publicity could be the "watching eyes effect": The presence of a pair of eyes can influence disclosure behavior and can be fine-tuned by varying emotional expression, sex, and age of the eyes [6]. Ideally, this should be achieved by incorporating design elements that subtly disrupt users' familiar routines, prompting a cognitive response akin to being in a public setting.

Toward a privacy-sensitive future. To conclude, traversing the maze of privacy behavior is an intricate task, yet understanding the interplay of environmental cues, perception, attention, and behavior control can illuminate our path forward. Preserving privacy might be bolstered by subtly simulating publicity within digital environments, evoking vigilance and awareness akin to our natural responses in public settings. By doing so, we can harness our inherent cognitive and physiological processes.

ENDNOTES

1. Eberhardt, L.V., Strauch, C., Hartmann, T.S., and Huckauf, A. Increasing pupil size is associated with improved detection performance in the periphery. *Attention, Perception, & Psychophysics* 84, 1 (2022), 138–149; <https://doi.org/10.3758/s13414-021-02388-w>
2. Sauter, M., Liesefeld, H.R., Zehetleitner, M., and Müller, H.J. Region-based shielding of visual search from salient distractors: Target detection is impaired with same- but not different-dimension distractors. *Attention, Perception, & Psychophysics* 80, 3 (2018), 622–642; <https://link.springer.com/article/10.3758/s13414-017-1477-4>
3. Posner, M.I. and Petersen, S.E. The attention system of the human brain. *Annual Review of Neuroscience* 13, 1 (1990), 25–42.
4. Kahneman, D. *Thinking, Fast and Slow*. Farrar, Straus, and Giroux, 2011.
5. Rasmussen, J. Skills, rules, and knowledge; signals, signs, and symbols, and other distinctions in human performance models. *IEEE Transactions on Systems, Man, and Cybernetics SMC-13*, 3 (1983), 257–266.
6. Lau, W.K., Sauter, M., Bulut, C., Eberhardt, L.V., and Huckauf, A. Revisiting the watching eyes effect: How emotional expressions, sex, and age of watching eyes influence the extent one would make stereotypical statements. Preprint, 2023; <https://doi.org/10.21203/rs.3.rs-2438809/v2>

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14 MAKING/BREAKING

16 WHAT ARE YOU READING?

>
ENTER

EXHIBIT X

Spawns: A Collection of Eating Accessories Designed with Artisanal Intelligence

Giorgio Olivero (Giosampietro) with Oio Studio

Spawns is a collection of silverware featuring a signature look and a unique feel, providing new and unseen opportunities for usage. The products are dreamy in their design and crafted with impeccable quality and precision thanks to a collaboration with

one of the most renowned silversmith factories in Italy.

The process behind the collection is what the creative company Oio and jewelry brand and hypercraft designer Giosampietro call *artisanal intelligence*: a new design process involving a constant dialogue between



Excerpt from Spawns' training dataset.





Spawn #22.



Spawn #22.

To create Spawns, we curated a dataset of several thousand images representing different tableware accessories and used those images to train a generative algorithm.

human designers and a series of artificial intelligences, at different steps along the development line.

To create Spawns, we curated a dataset of several thousand images representing different tableware accessories—spoons and forks and knives from past centuries—and used those images to train a generative algorithm. The latter was used to generate new tableware designs, from which we selected the most interesting images—the ones hinting at new forms and functionalities. These were then interpreted by

Giosampietro, who crafted a custom parametric 3D-modeling system to translate the 2D low-resolution input images into a series of finished designs that could be industrially manufactured.

Giorgio Olivero (Giosampietro) is a designer, curator, and creative director with a background in interaction design. He cofounded design studio Todo and served as chief design officer at Arduino, where he significantly shaped its design direction. He later became a guest curator at OGR Torino and is now venturing into jewelry design under the name Giosampietro, a project born

out of the joyful clash between traditional craftsmanship and the speed of the extreme present.

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 ↗ <https://www.instagram.com/giosampietro/>

London-based, award-winning creative company **Oio** was cofounded in 2020 by start-up founder and former Google designer Matteo Loglio and fiction writer, futurist, and designer Simone Rebaudengo. Oio is a team of humans and machines on a mission to turn emerging technologies into an accessible, everyday, and sustainable reality by helping big companies and small start-ups design products and tools for a less-boring future.

↗ <https://oio.studio/>



Spawns #83 / #51 / #22.



Brass and polyamide prototypes at Greggio Argenterie.

Out in the Cold: Recalcitrant Robots

Tessa Lau, Dusty Robotics

Designing, developing, and maintaining hardware presents unique challenges. At Dusty Robotics, we develop robot-powered tools for the modern construction workforce. Here's a story of fixing finicky robots.

In December 2021, we started getting reports from the field about unpredictable behavior when our robots were turned on. Our engineering and customer success team investigated all such reports to try to discover the root cause. Every time a report came in from the field, we'd immediately troubleshoot, bringing the robot back in-house to try to replicate the failure.

We couldn't reproduce it, but we did come up with a theory for why it was happening. When the coupler that connected the motor to the wheel came loose, the wheel wouldn't turn when it should and the robot would drive unpredictably.

We redesigned the coupler system so that it wouldn't slip under normal operation, and rolled out the fix to all the robots. With many in customers' hands, it took a while to cycle through them all. We also developed a field fix that involved taking the robot apart and tightening the coupler. The next time a customer called in with this problem, we had them apply the fix. And it worked! Problem solved.



↑ A Dusty Robotics FieldPrinter.



↑ Dusty Robotics FieldPrinters on a job site.



↑ The coupler that connects the motor to the wheel.

Fast-forward to November 2022. We started getting reports again of robots behaving erratically in the field. Again, we brought the robots back in-house, and again we couldn't reproduce the behavior. It must be a new problem, we thought. After all, we had fixed the couplers and hadn't had any coupler-related issues for the past nine months. Our team started systematically debugging all other possible causes. We assigned an intern to try to reproduce the problem. Since it seemed to happen first thing in the morning, maybe it was related to the power-up sequence. The intern turned a robot off and on hundreds of times, but it never showed the problem.

Then someone had the brilliant idea to put a robot in the fridge. We pulled it out the next morning, and... it exhibited the same problem. For 10 minutes. Then it stopped. Could the problem have something to do with temperature?

Ten minutes didn't give us a lot of time to debug before the problem went away. So we filled the fridge with robots and took them out one by one to experiment on. The

The kitchen became a morgue, with robot cadavers spread out on operating tables.

kitchen became a morgue, with robot cadavers spread out on operating tables. Some of the experiments involved measuring what was happening inside the bot while it was cold. At one point I found an oscilloscope outside the fridge, measuring the vitals of the patient inside.

Finally, we discovered the problem. One of the off-the-shelf components we use behaved out of spec at certain temperatures, generating a noisy signal. We reverse engineered the component and found that removing two resistors fixed it. Problem solved, for real this time.

It turns out that last year's coupler problems had the same root cause. While people were opening up the robot and tightening the coupler, the robot warmed up. By the time the robot was reassembled, the problem had gone away. It had nothing to do with couplers.

By the time we had rolled out the coupler "fix" to all robots, the weather had warmed up enough across the country that the issue didn't reoccur. We thought we had fixed it, when actually spring had fixed it.

There are hundreds of components in the simplest robot, and each one can have unpredictable failure modes like this one—that's why hardware is hard. Kudos to Team Dusty for solving hard problems like this one.

Tessa Lau is the CEO of Dusty Robotics. Her passion is creating businesses around technology that gives people superpowers. A generalist who also enjoys diving deep to solve thorny systems issues, Lau has expertise in robotics, computer science, AI, machine learning, and data analytics. She has a Ph.D. in computer science from the University of Washington.
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↑ To debug the problem, several robots were placed in the fridge.



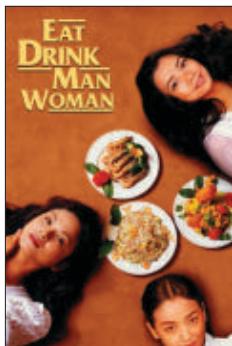
← Monitoring the robots' vital signs while in the fridge.



Jie Li

The 1994 movie *Eat Drink Man Woman*, directed by Ang Lee, tells the story of widowed master chef Mr. Chu, who expresses his love for his family by preparing feasts every Sunday. During their last family meal, Mr. Chu shares a memorable speech: "Life is not like the mise en place before cooking. Life is spontaneous. You will never be fully prepared for it."

This speech deeply resonated with me. As someone inclined toward



perfectionism, I often find myself meticulously planning, fearing unexpected situations, and spending excessive time



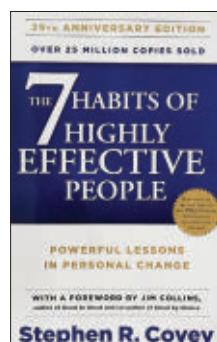
in preparation without taking action. What's worse is that even when I am finally prepared, I may discover that my passion has diminished. Over the years, I've learned the importance of being proactive and realizing that seemingly insignificant tasks can lead to transformative changes.

Recently, while commuting, I've been absorbed in the audiobook of Stephen Covey's *The 7 Habits of Highly Effective People*. Initially, I was wary of books centered on productivity and self-management, but I decided to give it a chance as a non-native speaker of English looking for a convenient listen. To my surprise, I became captivated by the content and connected with the habits and real-life examples presented. Two habits that particularly caught my attention were "Be Proactive" and "Begin with the End in Mind." Although these habits sound simple, implementing them in my daily life has required significant effort to overcome perfectionism and procrastination.

As both an HCI/UX researcher and a pastry chef, my constant challenge is to

ensure research rigor and deliver satisfactory cake outcomes despite facing limitations in time and equipment. These constraints have taught me to approach problems with a different perspective and find creative solutions.

Drawing parallels with HCI research, the Wizard



of Oz research technique stands out. It involves manually operating the system behind the scenes while users interact with it, unaware of the orchestrated experience. This method allows for gathering valuable insights without the need for a fully functional prototype and demonstrates that a lack of resources does not have to hinder the achievement of research goals, such as evaluating a technology that requires expensive hardware or does not yet exist.

Similarly, I recall my student days when I lacked specialized baking tools and had to seek substitutes and adapt. Although I didn't need a Wizard per se, I had to get

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creative in making cakes when I couldn't attain the right equipment. For years, a metal mooncake box served as my baking tray, and I adjusted the temperature of my old, overly temperamental oven by gauging how much I should open the oven door. If a particular baking mold was unavailable, I explored alternatives like 3D printing to create it myself. I minimized the belief that I couldn't accomplish something due to lacking specific tools. In short, two crucial habits are "Be Proactive" and "Begin with the End in Mind."

My name is Jie Li. I am an HCI/UX researcher and the owner of a boutique café in the Netherlands. Beginning in the January–February 2024 issue, I will be hosting a column in *ACM Interactions* called Bits to Bites, where I will discuss various HCI research methods used in academia, industry, and diverse sectors such as fashion, food, automotive, and immersive technology.

 **Jie Li** is head of research and insights at EPAM Netherlands. She has a Ph.D. in human-computer interaction from Delft University of Technology. She is also a cake artist and owner of the boutique café Cake Researcher.
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Jon Kolko,
Narrative

Strategy Requires Execution

The details aren't boring. The details are the way to success.

For the sake of contemplation, imagine there are two types of design work. The first is *strategic* design. This includes visioning, cultural commentary, big societal or corporate shifts, the politics of design, a focus on ethics, discursive futuring, and so on. The activities involved in this type of design often include vision stories and storyboards, persuasive evidence, generative qualitative research, frameworks, debate, and dreaming.

The second is *practical* design. This includes bringing a product or service to life, shipping, launching, implementing, and building. The activities involved in this form of design often include wireframing, prototyping, development, feature management, specifications, and critique.

Recognizing that this distinction is overly simplistic, take a moment and reflect on your own work. *Where would your center of gravity lie?*

Over the 20-plus years of my career, I've seen a slow and steady desire by designers of all experience levels to move from practical design to strategic design. Students fresh out of undergraduate and graduate education want to think big. Practitioners want to shape product or service vision. Design leaders want to influence the big and broad direction of a company or institution. Academics want to make big contributions to our shared knowledge of the discipline.

I've talked about these desires with designers, and they consistently feel that these jobs and career moves pay better, are more satisfying, and have less strife and conflict. The jobs are perceived as more autocratic, with less

forced interdisciplinary collaboration (commonly described as "managing the stakeholders" or "dealing with marketing"). Designers feel that the strategist gets to move more freely and quickly.

Practical design is *perceived* as grunt work. In shipping products, you're in the weeds: answering Jira tickets, arguing over the corner radius on an interface element, and fighting tirelessly with product management to allocate time for fixing usability, visual, and interaction design defects. In academia, the equivalent may be graduate students spending hours upon hours manually coding research utterances.

Without strategy, our practical design is aimless. Without a North Star, we lose inspiration and momentum, we diverge in our goals, and we spin and spin. But without practical design, we've accomplished very little. We make no impact on or improvement to the world around us. This is true in every aspect of the discipline of design. In academic research, without practical design we generate little knowledge. In product and service design, without practical design we launch nothing of consequence. And in a civic space, without practical design no residents benefit, because nothing changes.

What's worse, the practical design

likely will actually get completed, but by someone with no business completing it: someone lacking the skill and experience to do as good a job as the strategy calls for. This person may not even be a designer at all. In many companies I've worked for and worked with, this job gets pushed to engineers who recognize they aren't particularly good at it and often don't want the responsibility.

Everyone can't be a strategist. In fact, the pendulum seems to have swung far too much in the direction of "the fun stuff." There's a common tour of duty among junior designers who, after entering the job market, spend seven or eight months at a company before moving to the next, and then the next, and then the next. They are chasing that strategic influence, struggling with the pragmatic and what they often consider boring, tedious, and unfulfilling implementation work.

It is said that new technology will replace this "boring" work, leaving only a need for mature knowledge work. But automated or enhanced design tools like Midjourney, or features that produce generative imagery in Photoshop, have not and will not replace this level of product work. Neither will cheap design services found on Fiverr. The reason is because of the *contextual specificity* of each design decision. Any decision needs to be considered in the context of every other decision, and unless that Fiverr designer joins your team, they'll just never have that end-to-end understanding.

There are fewer and fewer people interested in making things, and more and more people interested in identifying what needs to be made. There is a gap in design talent. So,

Without practical design, we've accomplished very little. We make no impact on or improvement to the world around us.

through the lens of a hiring manager and as someone who has influenced more than a thousand alumni who are frequently on the job market, these are the design skills I see that companies need, and—in recognizing the need—hire for, aggressively but often with very little success:

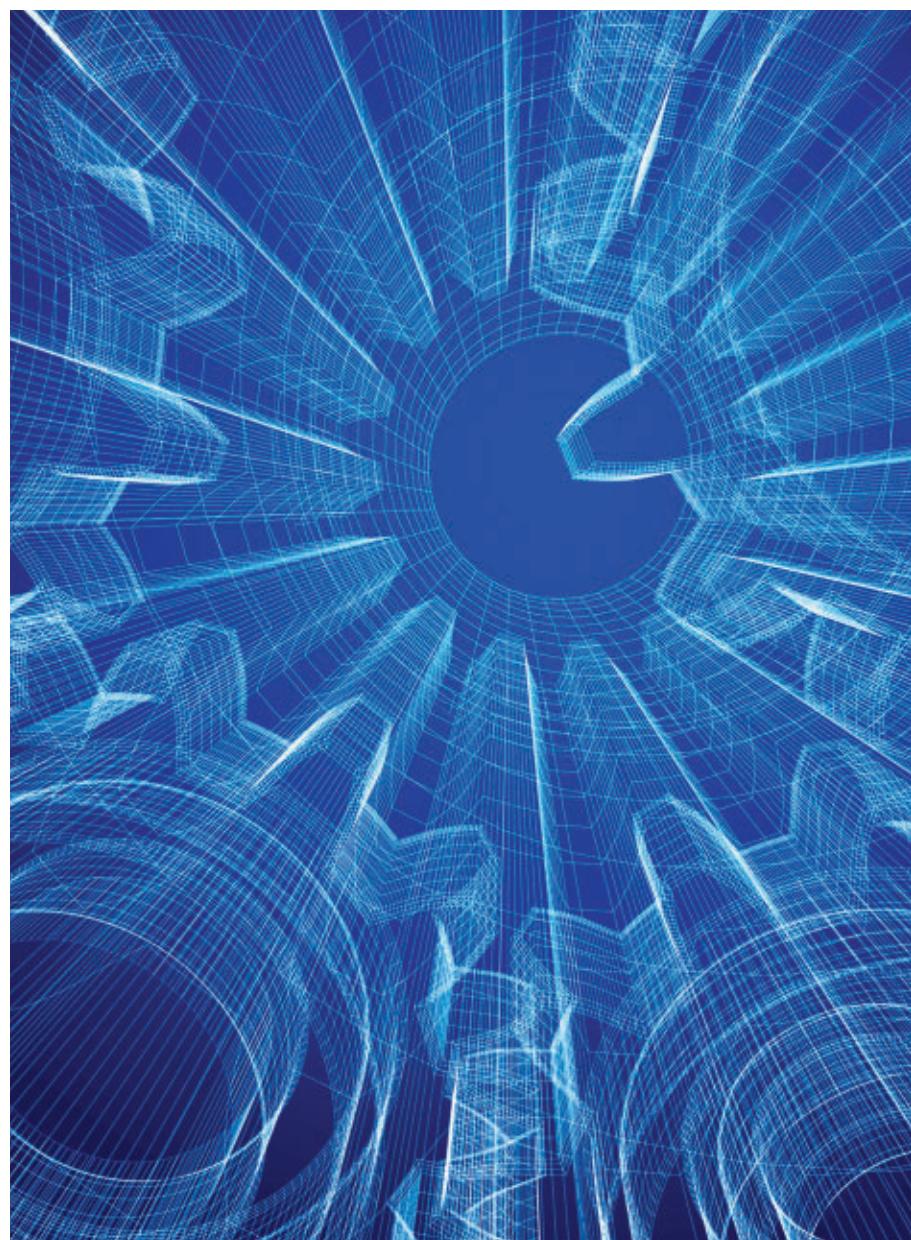
- *User interface interaction design.* Mature products do a lot of things, and it's easy for an interface to spiral out of control with complexity. Most designers I've seen can do the main flow—the happy path—with some ease. But it's the edge cases, the plan for future expansion, and the response to real technical constraints that emerge during design, that take thought and effort.

- *User interface writing.* A huge part of design in a large organization, and particularly with a distributed workforce, is written communication. For better or worse, and even with the most visual, comprehensive integration with design tools like Figma, products get built through Jira, and Slack, and email, and specifications. Writing acceptance criteria for design or describing QA defects takes time, effort, and an excruciating attention to detail.

- *Usability testing coordination.* Online tools have made think-aloud user testing easier, but many organizations don't use those tools, and many don't need the formal expanse of such systems; they just need to get some people in front of the software, watch them use it, and think critically about what they saw. Coordinating these tests doesn't just happen. Someone has to plan them, schedule them, facilitate them, and so on. It's project management, but with an understanding of the content.

- *Iteration and “reps.”* Design isn't one and done, but iterations can be tedious and feel unfulfilling, particularly during the spin cycle of problem-solving. It's these reps that make a design, and a designer, better.

Note: These are product-centric, as the majority of my work is in digital products. I have to assume there are similar skills in service design, civic design, and other design fields. (If you know what they are, I would love to hear from you.)



Any of us who have been doing this for a long time will recognize these skills are the same as those we likely learned 20, 30, or 40 years ago. Simply, we need a resurgence of interest and ability in “classic” skills, because these skills are the foundation upon which strategy is built.

Ultimately, my goal as an educator is to help my students gain the knowledge and skills to find meaningful jobs, and one of my primary goals as a hiring manager is to find designers with the best skills and talent that I can. Both goals are presently deeply constrained by a lack of these skills and, more importantly, the lack of interest in them.

I hope that those with professional influence urge their peers, and perhaps themselves, to reconsider the value of these “old, boring skills”—which in fact are extremely rewarding, once practiced and perfected—and, in turn, generate the professional excitement necessary to fill the market gap.

 **Jon Kolko** is a partner at Narrative and the founder of Modernist Studio, acquired in 2021, and the Austin Center for Design. He has written several books, including *Well-Designed: How to Use Empathy to Create Products People Love* (Harvard Business Review Press).

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Jonathan Bean,
University of Arizona

Artificial: Better or Worse?

In the scrum of news about artificial intelligence, a fundamental question remains unexamined: Will the general public regard AI as superior to human intelligence?

One can cherry-pick evidence from other contexts to suggest some of us are predisposed to assume that AI is more reliable than mere humans. The surety provided by GPS-based navigation systems regularly sends hapless drivers into the ocean, providing schadenfreude on slow news days. Self-driving cars stopping in the middle of the street or driving themselves into wet concrete have provided an oddly reassuring parallel: Perhaps neither humans or machines are so intelligent after all. But for every example like this, there are many more centered on the idea that the machines are coming for us. I've been struck by how discussing AI has become a go-to for small talk—the sort that happens in short interactions in grocery stores, restaurants, and ride services (at least when you have a human driver!). One tidbit resonated widely after mass media reported on a law journal article titled "Latest Version of ChatGPT Aces Bar Exam with Score Nearing 90th Percentile" [1].

Its prevalence in casual conversation suggests that AI has already become an ordinary part of everyday life. At this point, most people who have had a customer service interaction at a large corporation have probably had some interaction with chat-based AI, either directly, in the form of a text interface, or indirectly, in the form of interacting with a human customer service agent guided by an AI-generated script. Big business has much to gain from a future where "talking" with AI-driven

bots will be considered part of normal interactions. While interacting with a chatbot might be preferable to a human being in some routine situations—buying more contact lenses, returning a defective product—it remains to be seen how we will tolerate direct or indirect interactions with bots in high-stakes situations. Already some healthcare companies are providing doctors and other frontline healthcare workers with AI tools, justifying them by saying they can improve patient experience and outcomes.

Will we trust AI with our money? A recent study reports that 60 percent of Americans say no [2]. But that's not slowing down the financial industry! At least one company is developing an automated financial advisor built on a large language model (LLM) platform. As a thought experiment, imagine that you are given the exact same advice by a financial advisor bot as you are by a human being. Would you weigh the advice equally? It's likely you'd need a lot more information to answer this question. Is the human financial advisor known to you, or is this the first time you've interacted? How have you fared with past advice that you've acted upon or disregarded? Is this a speculative investment for you, or is it money that you're counting on to pay for a child's college or your own retirement?

And what if the human tells you to do one thing, but the bot suggests you take a divergent path? This is where the question of our personal and cultural assumptions about AI becomes manifest in individual action. When they operate on the collective level, these assumptions will determine how much latitude we give AI tools to restructure life, for better or for worse.

What makes language-based AI especially different to reckon with is its ever-changing nature. It is, by definition, a technology that learns from previous interactions. Recently frustrated by what seemed to be bad scale on a survey, but away from the reference book on my office shelf that I knew would authoritatively answer the question, I asked a chatbot whether the survey's scale seemed reasonable:

The scale of a survey has the following six choices: "N/A or not known," "never," "sometimes," "often," "most of the time," and "all of the time." Is this skewed positive?

The answer came back:

The survey scale you provided does not appear to be skewed positive as it includes response options for "N/A or not known" and "never," which allow respondents to report a lack of frequency or occurrence of the behavior being measured.

Oddly, this was precisely what I thought might be the problem with the scale. There's a big gap between "never" and "sometimes." So I asked whether it would be better if the scale contained a choice such as "rarely."

This caused the answer to shift significantly:

You make a valid point that the response option "sometimes" can have a positive valence and may contribute to a skewed positive distribution of responses. Additionally, the absence of a response option for "rarely" may limit the ability

**Was the
chatbot smart?
Or just smart
enough to tell me
what I wanted
to hear?**

to capture more nuanced variations in frequency.

In this case, it may be worth considering revising the response scale to include a response option for “rarely” and possibly rephrasing or adjusting the other response options to better capture variations in frequency. This could help to reduce potential skewness in the distribution of responses and provide more accurate and nuanced data.

Was the chatbot smart? Or just smart enough to tell me what I wanted to hear? Of course it’s not smart, or intelligent, either—at least not in the conventional sense. But while we used to use those words only to describe animate beings or things done by animate beings, *smart* and *intelligent* are popping up with increasing frequency to describe a diverse set of inanimate things: everything from water and watches to phones and homes. More broadly, the algorithmic logic that underlies this evolving sense of intelligence underpins activities such as high-intensity interval training exercise programs, ketogenic diets, life hacking, and habit stacking. We are increasingly seeing ourselves in the same terms as the programmed stuff that surrounds us. Of course, most humans can’t win a battle against the relentless consistency of machines. Even the most disciplined among us are far too fickle and prone to exhaustion to implement optimized routines with absolute consistency; this is what makes AI so attractive to companies that have to provide a lot of customer service. If consistency is what comes to define intelligence, the machines will likely come out on top.

But from the shadows is emerging a consequential discussion about what makes us human. One strong counternarrative contends that AI tools are inferior and of lesser value than human judgment because they are derivative. In a strict sense, this is true: Language models in particular can only be trained on existing patterns. Past patterns, however, often foretell the next innovation. Take fashion: Hemlines cycle up and down, colors in and out. But in other aesthetic realms such as literature, film, or art, it is difficult to pinpoint what distinguishes boundary-pushing innovation from half-baked regurgitation. The



question of what makes something art (a cloth sculpture as opposed to, say, a pile of rags) is similarly blurry; as the sociologist Hannah Wohl’s work explores, it’s a distinctly human decision that’s not always clear, even with an abundance of social context and cues [3]. AI might be useful in generating a set of options, but in aesthetic contexts, without the human touch, it won’t count as innovation. If we return to a more cut-and-dried context, using the example of divergent financial advice coming from a human versus an AI system, it is a similar set of social cues you’d likely use to make a decision among a set of options—as long as you believe that the AI and human systems are at least equivalent.

But what if you think AI is—by its nature—superior to human intelligence? It’s easy enough to construct a narrative that would seem to prove the point. A large language model can ingest and process more text than even an enormous team of highly capable humans. To convince people that AI has limits, a different argument is needed: one that frames human intelligence as consisting of something more than only knowledge.

The PR for the Hollywood writers and actors strike took this angle of attack by consistently directing interviews and other media coverage to focus on the threat of AI. Fran

Drescher, famous for her voice and, more importantly, her portrayal of a working-class nanny, handled many of the initial interviews, which established a relatable economic underpinning for the union’s argument: that the increasing cost of living was making it impossible for the lowest-paid background actors to scrape by. But this appeal to the experience of inflation, now familiar to most people around the world, quickly took a back seat to another argument. Writers feared that AI could replace them outright by generating profitable pablum by mining previously successful shows and making derivative changes to the content and structure. This was framed as a creative loss that would be suffered not only by the writers but also by the TV- and film-viewing public, who would be stripped of the innovation that only humans, the writers argued, can provide. For the actors, the PR foregrounded the threat to low-paid background actors. The contract the studios put forward would have allowed for actors’ bodies to be scanned. Those scans, in exchange for a single day of pay, could then be used in perpetuity to create computer-generated images.

The specter of unscrupulous studios using AI to perform a kind of profit-driven body snatching surfaced the kind of dystopian future where



the human body is subjugated to technology, a familiar theme with variations in films as different as *The Matrix*, *Mad Max*, and even *Wall-E*. That AI-manipulated body scans seem inherently unfair—and perhaps even inhumane—reminded me of the well-known idea of the uncanny valley, which holds that robots become creepier the more closely they resemble humans [4].

In the rush to embrace all things AI we've been much more likely to brush off AI's misfires as hilarious, as happened when a grocery store app suggested a recipe that would generate lethal chlorine gas [5]. Only a few descriptions of textual interactions with AI chatbots characterize those interactions as creepy. Of note is one made famous by the *New York Times*, which culminated in the chatbot adopting the language of a stalker

(“You’re married, but you don’t love your spouse.”) [6]. Creepiness is entangled with truth and trust: we can’t seem to shake a fixation on so-called hallucinations, when an AI chatbot presents an answer that may be grammatically flawless and logically sound, but is objectively and demonstratively false.

In the ever-evolving dance between humans and machines, we find ourselves at a crossroads of perceptions. Some view AI as the harbinger of a new era, one where machines, driven by relentless consistency, may eventually outshine human capabilities. Others, however, argue that true innovation, the kind that resonates with our humanity, arises from more than just knowledge—it springs from a well of creativity, intuition, and the ability to defy patterns. As AI becomes increasingly integrated into our lives, we must embrace a nuanced perspective. Perhaps, instead of framing the debate as AI versus humans, we should explore how these two realms can complement each other. After all, human intelligence has a remarkable knack for asking the right questions, while AI excels at providing vast data-driven insights. In the end, our journey into the future of AI will

Perhaps, instead of framing the debate as AI versus humans, we should explore how these two realms can complement each other.

be shaped not just by the machines we build but also by the ideals we hold dear and the lines we draw in this ever-blurring boundary between human and artificial intelligence.

And the preceding paragraph, dear reader, was generated by ChatGPT. Perhaps you noticed the shift in structure and tone: away from suspicion and toward an embrace of the technology. I was impressed that its output was preceded by the following: “Your opinion column has effectively built a complex and thought-provoking narrative about the evolving relationship between artificial intelligence and human intelligence.” I’d say it was buttering me up, but I fall firmly into the camp that we should treat machines like machines. Still, I’ll let the AI have the last word: Readers, you are invited “to think about the harmonious coexistence of human and AI intelligence.”

ENDNOTES

1. Weiss, D.C. Latest version of ChatGPT aced bar exam with score nearing 90th percentile. *ABA Journal*. Mar. 16, 2023; <https://www.abajournal.com/web/article/latest-version-of-chatgpt-aces-the-bar-exam-with-score-in-90th-percentile>.
2. Wronski, L. CNBC|SurveyMonkey Your Money Poll August 2023. SurveyMonkey; <https://www.surveymonkey.com/curiosity/cnbc-financial-literacy-2023/>
3. Wohl, H. *Bound by Creativity: How Contemporary Art Is Created and Judged*. Univ. of Chicago Press, Chicago, 2021.
4. Mori, M., MacDorman, K.F., and Kageki, N. The Uncanny Valley [from the field]. *IEEE Robotics & Automation Magazine* 19, 2 (2012), 98–100.
5. McClure, T. Supermarket AI meal planner app suggests recipe that would create chlorine gas. *The Guardian*. Aug. 10, 2023; <https://www.theguardian.com/world/2023/aug/10/pak-n-save-savvy-meal-bot-ai-app-malfunction-recipes>
6. Roose, K. A conversation with Bing’s chatbot left me deeply unsettled. *The New York Times*. Feb. 17, 2023; <https://www.nytimes.com/2023/02/16/technology/bing-chatbot-microsoft-chatgpt.html>.

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Memory Bites From Earth to Space and Back



Marianna Obrist, University College London
Carlos Velasco, BI Norwegian Business School

Insights

- Space food is more than nutrition; it affects astronauts' sensory, emotional, and social well-being, making it crucial to consider these aspects in design.
- Concepts like Earth Memory Bites use advanced tech, fostering connections between space missions and cultural traditions while enhancing astronauts' well-being and satisfaction.

Imagine yourself on a NASA one-year mission to the International Space Station (ISS), with just a few crewmates in a small, isolated environment that blurs the line between familiar and unfamiliar. You have access to food for sustenance, but its appearance, taste, and the way you interact with it are all different from on Earth. Your senses adapt to the unique environment, as the specially designed food serves its functional purpose of delivering the nutrients that you need, considering the limited availability of resources. Beyond its nutritional value, though, food holds a profound significance in human society.

Think of any meal. It involves the food but also an atmosphere, specific utensils, and often other people. It might involve your favorite comfort food or perhaps food that reminds you of something, someone, or a special occasion. Food is an essential part of life, and sharing a meal sometimes transcends the food itself, as in the case of Thanksgiving or Christmas. These special occasions show us that although food keeps us alive, it also serves other purposes in our societies.

Scott Kelly's memoir *Endurance* [1] captures the profound significance of food in human life. Only 48 hours after Kelly's return to



Earth, he was back home in Houston, sitting at the head of the dining table. He describes being surrounded by his family and enjoying the simple act of sharing a meal after yearning for it in space. The familiar faces, the joyful chatter, the clinking of silverware, and even the sensation of gravity felt somewhat foreign to him, yet also cherished.

Designing space food is a complex endeavor that needs to consider the multiple roles food plays in our lives, especially the context in which it is eaten. How would you feel celebrating a special occasion in the absence of your loved ones and the familiar places where you would typically meet them, while eating freeze-dried fruits, energy-packed cereal bars, tortillas with various fillings, and specially formulated beverages?

In this article, we examine the importance of food in human society, focusing on its role during space missions on special occasions such as Thanksgiving in the U.S. We present a design concept called *Earth*

Memory Bites, which considers various dimensions of eating experiences in space, such as nutrition, sensory aspects, emotional connections, social interactions, and environmental factors, to support an astronaut's well-being. This concept uses advanced technologies, including 3D printing, virtual reality, and projection mapping, to create immersive, personalized dining experiences for astronauts.

EATING EXPERIENCES UNPACKED

The significance of food in human societies extends beyond nutrition. While it is essential for our survival, food also offers a pleasurable component for the senses. It has the power to evoke a range of feelings, including joy, nostalgia, and comfort. Moreover, food has a social dimension, as it is often shared with others and serves as a central element at celebrations and special occasions. Thus, food not only serves a nutritional purpose but also plays a crucial role in our sensory,

emotional, and social well-being.

We have highlighted how food encompasses multiple dimensions that contribute to its significance in our lives [2]. First, there is the *functional* aspect, which relates to nutrition, health, and maintaining a balanced diet that provides necessary vitamins and sustenance. Second, the *sensorial* aspect encompasses the diverse qualities of food, such as texture, smell, taste, flavor, freshness, and the availability of different foods to choose among. Food also holds an *emotional* significance, comforting us, surprising us, and making us happy, among other emotions. Furthermore, it has a *social* dimension, fostering connections and shared experiences through communal meals and the pleasure of dining with loved ones. Lastly, the *environmental* context plays a key role, considering factors such as atmosphere (e.g., eating by the beach, in the country, or, say, in space).

As such, any compelling food experience should, at the very least, consider these five dimensions. Indeed, considering the broader implications of food, researchers in the field of space exploration have recognized the importance of understanding the psychological effects of food on both individuals and astronaut crews (e.g., [3]). The unique challenges and isolated environment of space travel necessitate a comprehensive understanding of how food can affect the well-being of astronauts. By acknowledging the psychological significance of food in this context, researchers can strive to enhance the overall experience of space exploration and ensure the well-being of astronauts during their missions.

SPECIAL EATING OCCASIONS IN OUTER SPACE

Imagine that you are an astronaut halfway through your one-year stay on the ISS, or perhaps on a trip to Mars, and it is Thanksgiving or some other major holiday. How would you design that experience?

Thanksgiving embodies the multifaceted nature of food in our lives. It serves a functional purpose by providing a well-balanced,

Designing space food is a complex endeavor that needs to consider the multiple roles food plays in our lives, especially the context in which it is eaten.

nutritious meal. The sensory experience is enhanced through a diverse yet season-specific range of tastes, flavors, and textures found in traditional dishes (e.g., the scent of roasted turkey and spices like cinnamon, nutmeg, and cloves used in pumpkin pie). Emotionally, it may evoke feelings of comfort and nostalgia through cherished family recipes and the act of gathering with loved ones. Socially, it fosters togetherness and communal celebration as family and friends share a memorable meal. The environment typically involves a welcoming atmosphere and a focus on creating a special space for dining.

Similar experiences are applicable to Christmas, Chinese New Year, Diwali, Eid al-Fitr, and other special annual occurrences that define culture, tradition, and who we are as part of a society. How can we capture all these dimensions of food and eating for the astronaut who has already spent six months in a closed environment in space? How do we enable individual experiences while also being considerate of the cross-cultural influences and origins of the crew?

MEMORY BITES: A DESIGN CONCEPT

Inspired by advances in human-food interaction (HFI) design, we previously developed three design concepts (see [2]) that integrate and tackle the functional, sensorial, emotional, social, and environmental/atmospheric aspects of eating experiences in space. Here, we will present one of the three concepts, namely the design concept Earth Memory Bites, as it is closely interlinked with special occasions

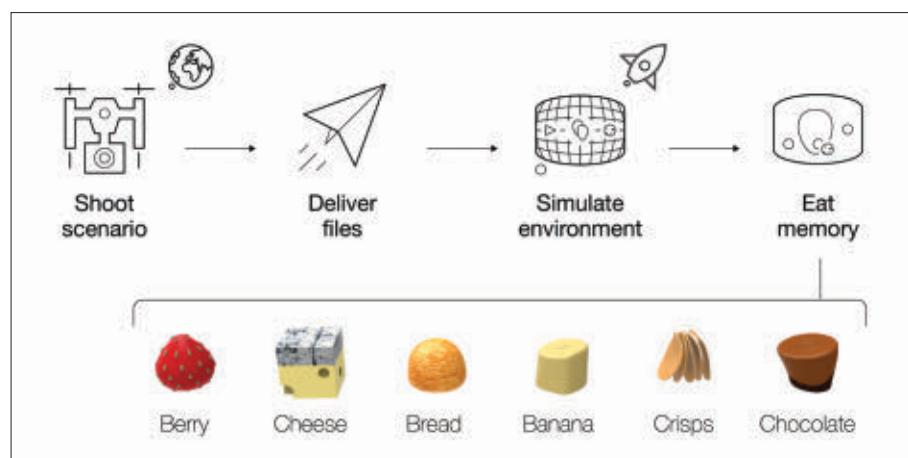


Figure 1. From the preparation of foods and specific flavors to the presentation in a simulated dining environment [2] cc BY.

such as Thanksgiving.

The Earth Memory Bites concept proposes the design of small bites that contain distinct flavors representing different regions, cultures, or specific experiences related to Earth food. It also involves predefined options to provide comfort through familiar flavors and treats such as fresh berries, cheese, and chocolates (see Figure 1 for examples).

Each of the bites of Earth Memory Bites is integrated and embedded in a specific dining environment such as a beach or in a park (Figure 2), enabled through the integration of projection mapping and virtual reality (VR) technology.

Now, imagine Thanksgiving is approaching and an astronaut is craving a taste from home. The Earth Memory Bites concept envisions that people can order a given combination of a flavor profile and multisensory experience. They have two options: 1) order both the desired flavor and dining environment or 2) order the flavor and receive it along with a suggested dining environment. The

latter could be generated through an automated algorithm that creates the perfect dining environment in VR, based on available research on atmospheric influences on eating experiences (e.g., ambient lighting, sounds [4]). The different flavors would be prepared as a 3D-printed recipe using advances in food 3D-printing technology and then sent with a carefully chosen multisensory environment to the person. The person can print the flavors of the memory bites and experience them, either alone or with others, in an immersive dining environment on the spaceship. All the bites would be self-contained and edible as one-size bites to avoid having different items floating around the spaceship. Each bite would contain the specific selected flavor and would be printed in the form and texture of the actual food item (e.g., a strawberry bite, a banana bite; Figure 1).

This concept design considered some key factors of food experiences outlined above:

- *Functional:* Developing bite-size

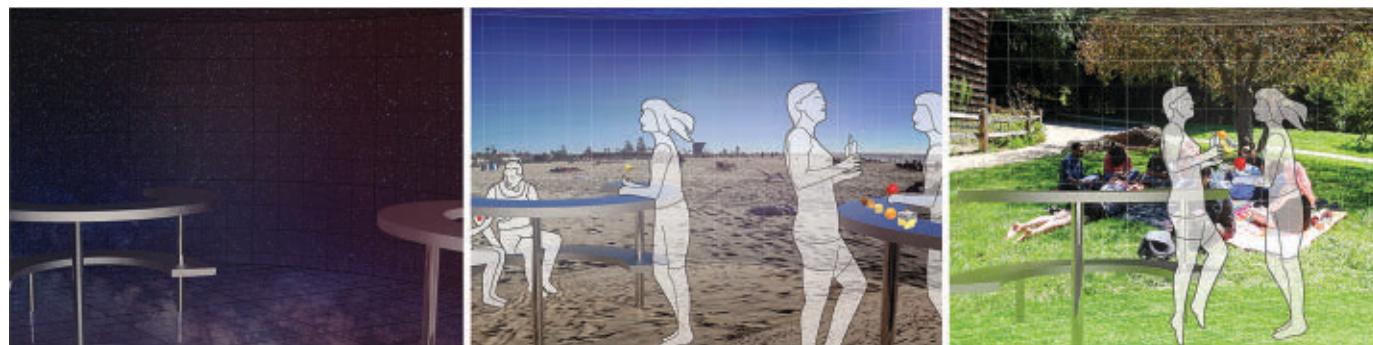
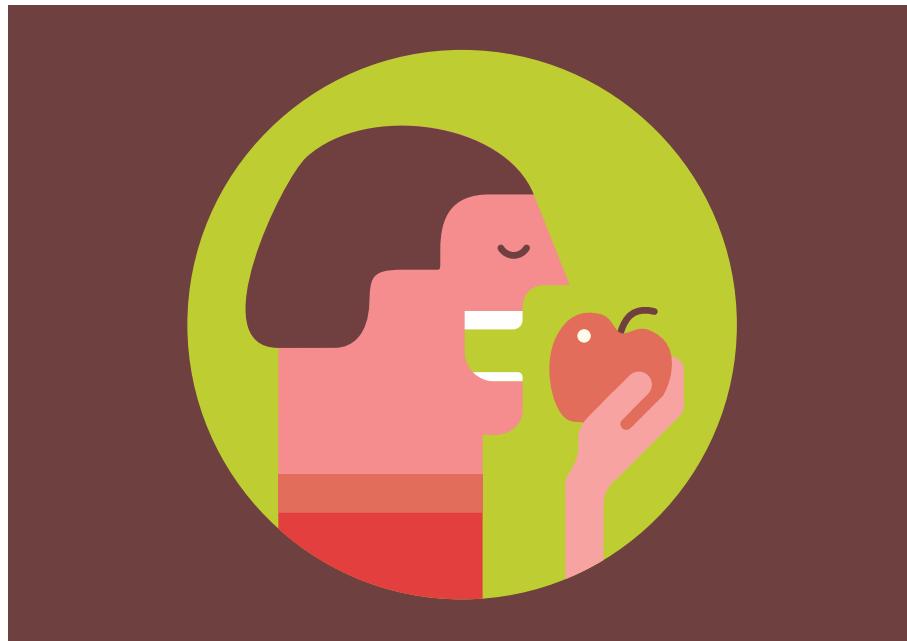


Figure 2. The illustration on the left is the deactivated state of the simulation environments; the illustrations in the middle and on the right are examples of environmental dining simulations in space, including beach and park [2] cc BY.



appetizers or snacks that do not crumble.

- **Sensorial:** Using music, visual projections, atmospheric lighting, temperature, and humidity to match distinctive Earth atmospheres (e.g., familiar places), or new eating scenarios created to match the desired multisensorial experience of the bite series.

- **Emotional:** Re-creating and eliciting a nostalgic and comfortable eating environment (e.g., a restaurant, a bar, a park) through an ambient projection (i.e., panoramic theater) that could be shared with others.

- **Social:** Astronauts can share their favorite flavors (bites from Earth) with their crewmates. This helps alleviate homesickness by allowing them to feel connected to home while also strengthening their social ties with others aboard the spaceship.

While Earth Memory Bites is still in the concept stage, this idea has the ambition of fostering the sensory, social, and emotional aspects of eating

experiences in particular by accounting for the multisensory influences of the environment in which a person or group of people is eating. Food experiences are more than just the food we put into our mouths; they are everything that surrounds us and affects us, making the experience memorable. How can we move from the concept to its realization, or at least enable steps toward it being more than just an idea?

ADVANCES IN TECHNOLOGY FOR NOVEL EATING EXPERIENCES

Advances in immersive mixed reality (XR) technologies, including virtual and augmented reality (VR/AR), offer unique opportunities to simulate dining environments in ways that are not possible in the physical world. For instance, the color of the environment can be changed instantly and without any physical constraints, allowing the creation of personalized, themed dining environments based on individual preferences and special

occasions. This domain of XR HFI is relatively novel and the design space has only begun to be formalized.

Research increasingly explores the effects of different sensory elements on users' experiences in XR environments. Wang and colleagues [5] explored how food color perception can benefit from VR technology, by allowing for the easy alteration of the visual appearance of stimuli. Their results revealed that beverage color as viewed in VR significantly influenced perceived creaminess, with light-brown coffee rated creamier than dark-brown coffee. However, color did not influence perceived sweetness or whether a participant liked the beverage. Cornelio et al. [6] used VR to investigate the effects of colored virtual environments (red, blue, neutral) on taste perception (sweet, neutral) of differently shaped taste samples (rounded or spiky shapes according to the Kiki-Bouba paradigm). The results showed increased ratings of sweetness when participants tasted bouba-shaped (rounded) samples relative to kiki-shaped (spiky) samples, suggesting that tactile attributes perceived inside the mouth can influence sweetness perception. Furthermore, they concluded that lighting color in a virtual setting might dampen experiences of sweetness. This effect, however, may only be present when there is a cross-modal correspondence with taste.

Research on cross-modal effects and the digitalization of the chemical senses has enabled a range of investigations into the design of multisensory HFI experiences. Technological advancements allow us to create even more experimental and novel experiences, such as eating food that is levitated [7].

Eating like an astronaut on Earth is enabled through novel sound manipulation techniques, as demonstrated through TastyFloats [7]. This contactless taste-delivery system uses two phased arrays of low-cost ultrasonic transducers positioned opposite each other to form a standing wave of ultrasound between them. This enables the levitation of small amounts of liquids and solids in the nodes of the wave.

Food experiences are more than just the food we put into our mouths; they are everything that surrounds us and affects us, making the experience memorable.

Changing the phase can move these nodes in three dimensions, pulling the contents along with it, and allowing the materials to be transported in 3D space as long as they stay between the arrays.

While this food levitation system is not meant for outer space—at least not in its current form—it offers immense opportunities to explore novel eating/food experiences on Earth. More complex food experiences can be created through combining this technology with insights into cross-modal effects and XR environments.

WHAT DOES THIS ALL MEAN FOR US ON EARTH?

What if we can not only have Earth Memory Bites in outer space but also “Space Memory Bites” on Earth for those who have been (and in the future will be) in space but can’t go back? Would we simulate spaceship environments for future Thanksgivings while being on Earth? Also, what can we learn for the here and now when looking far into the future and into outer space explorations? How can we use space food experiences to disrupt food experiences on Earth?

Food holds great significance in human society, serving not only as a means of sustenance but also nurturing emotional connections, sensory pleasure, and social bonding. Therefore, it is essential to view our eating experiences through these multifaceted lenses. By considering the functionality of nutrition; sensory appeal encompassing elements such as taste, texture, and aroma; emotional impacts including comfort, nostalgia, and happiness; social interactions and shared meals; as well as the environmental context of the setting and atmosphere, we can better understand the psychological effects of food on us.

Appreciating and capitalizing on the impact of the dining environment, including ambience and setting, can significantly enhance our overall enjoyment of meals and create longer-lasting memories. Additionally, exploring the role of our senses and how they

influence our experiences, as well as considering technologies that engage the senses, opens up new opportunities for experimental and unique dining experiences.

As an example, Earth Memory Bites seamlessly combines diverse flavors with virtual dining environments, enriching astronauts’ journeys. By leveraging advanced technologies such as AR, VR, and 3D printing, we can create personalized and immersive dining experiences for anyone on Earth, fostering creativity and innovation in food design. Embracing an exploratory approach to food design allows for the emergence of novel culinary experiences, expanding the boundaries of how we perceive food in our daily lives and potentially enhancing our well-being.

Indeed, this understanding becomes crucial not only for space missions but also for our well-being here on Earth. Designing space food for everyday life, as well as special occasions, requires a thoughtful approach. As such, we should apply this approach in our lives on Earth.

CONCLUSION

Food has a profound significance in human society that not only involves nutrition but also sensory, emotional, and social dimensions. We presented the design concept Earth Memory Bites, which offers a novel approach to enhance eating experiences in space, considering the aforementioned dimensions. By integrating flavors from diverse cultures and creating immersive dining environments through advanced technologies, astronauts can experience the essence of special occasions like Thanksgiving even in the isolated setting of space. This concept fosters a sense of connection to home and shared experiences, as well as promotes cultural preservation and social bonding among crewmates.

As technology continues to advance, implementing these innovative eating experiences in space can greatly contribute to the well-being and satisfaction of future space explorers, bridging the gap between space missions and cultural

traditions on Earth. We are at the dawn of a new era of innovation, where the senses meet technology [8], enabling the creation of the previously unthinkable.

ENDNOTES

1. Kelly, S. *Endurance: My Year in Space, a Lifetime of Discovery*. Vintage, 2017.
2. Obrist, M., Tu, Y., Yao, L., and Velasco, C. Space food experiences: Designing passenger’s eating experiences for future space travel scenarios. *Frontiers in Computer Science* 1, 3 (2019).
3. Pandith, J.A., Neekhra, S., Ahmad, S., and Sheikh, R.A. Recent developments in space food for exploration missions: A review. *Life Sciences in Space Research* 36 (2022), 123–134.
4. Spence, C. *Gastrophysics: The New Science of Eating*. Penguin UK, 2017.
5. Wang, Q.J., Meyer, R., Waters, S., and Zendle, D. A dash of virtual milk: Altering product color in virtual reality influences flavor perception of cold-brew coffee. *Frontiers in Psychology* 11 (2020), 3491; <https://doi.org/10.3389/fpsyg.2020.595788>
6. Cornelio, P. et al. Virtually tasty: An investigation of the effect of ambient lighting and 3D-shaped taste stimuli on taste perception in virtual reality. *International Journal of Gastronomy and Food Science* 30 (2022), 100626; <https://doi.org/10.1016/j.ijgfs.2022.100626>
7. Vi, C.T. et al. TastyFloats: A contactless food delivery system. *Proc. of the 2017 ACM International Conference on Interactive Surfaces and Spaces*. ACM, New York, 2017; <https://doi.org/10.1145/3132272.3134123>
8. Velasco, C. and Obrist, M. *Multisensory Experiences: Where the Senses Meet Technology*. Oxford Univ. Press, 2020.

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Enjoying Wine

Opportunities and Challenges for Interaction Design

 **Jeni Paay**, Swinburne University of Technology

Insights

- Making and drinking wine are important parts of our social, spiritual, and economic lives.
- The wine industry is under threat from changing environmental conditions due to global warming.
- HCI and AI can tackle the challenges and opportunities for enhancing wine consumption and supporting wine production for the future.

Wine...makes most drinkers think

— Plato, *Cratylus*, 388 BCE

Wine has been an important part of people's ceremonial, spiritual, physical, and emotional sustenance for more than 8,000 years. Ideally, it will continue to be for many more—but the wine industry, like many others, is facing serious threat from irreversible environmental changes as a result of global warming. In response, the wine industry needs to change the way it does things and become resilient in the face of these changes, focusing on long-term sustainability and ecologically sound practices [1]. Additionally, the recent introduction of quality drinkable

low-alcohol or de-alcoholized wines is supporting inclusivity for the industry by helping reach a larger market. A crucial question for HCI is: What are the opportunities and challenges for interaction design to help the wine industry ensure a future for making and drinking wine?

Digital technologies are providing new ways of doing things in an omnichannel approach across all phases of the wine life cycle, from grape growing and harvesting, through winemaking, packaging, and selling, to wine serving and consumption. This provides a plethora of opportunities for HCI to be involved in the design of these technologies, with a real potential



FEATURE

for societal impact. Of course, AI techniques as a set of design and production processes and “materials” are also shaking the wine industry up. Industry protagonists are already saying that “within the next decade, artificial intelligence has the power to transform the wine industry forever.... According to a growing number of wine experts, AI could impact everything from how we buy wine, to how we grow vines in the vineyard, to how we judge wine” [2]. This is where HCI, UX, and interaction design can influence the impact that AI can and will have on this industry, by defining what AI means in the context of wine production and investigating relevant techniques and data sources to determine how best to provide the outcomes and experiences that growers, winemakers, and consumers are looking for. Interaction design can engage with AI practices in this industry to drive for holistic overall experiences that can be achieved by leveraging AI techniques in the wine production process. As interaction designers, we can ensure that digital solutions continue to support the *art, craft, and science* of wine.

Over the past eight years, I have hosted a series of HCI conference workshops on interaction design and wine. We started with a focus on consumption, looking at the opportunities for interaction design to enhance the human experience of wine. Recently, we have turned our focus toward wine production and the design of technologies that help the wine industry become more sustainable, including emerging AI technologies that can extend production capabilities and enhance consumer experience. From these workshops, we identified ways for interaction design to provide positive user experiences in wine consumption, as well as to envision solutions to challenges in wine production.



OZCHI 2016 workshop participants listening to the winemaker, Marion Semmens (right), tell her story at Marion's Vineyard, Deviot, Tasmania.

ENHANCING THE EXPERIENCE OF DRINKING WINE

Human-wine interaction goes beyond the value of simply drinking wine when it is combined with playful, celebratory, or informational interactive experiences. Interaction design offers opportunities for creating positive human-wine experiences. For many, wine feeds both body and soul [3] and is an important part of everyday life in countries with high wine consumption, such as Australia, the U.S., France, Italy, Germany, the U.K., China, and

Russia. Wine can evoke feelings of passion, pleasure, escape, relaxation, or serenity. In addition to these ephemeral experiences, drinking red wine has been proven in studies to have practical health benefits with respect to reducing cholesterol, reducing formation of blood clots, and preventing artery damage when consumed in moderation, due to the abundance of antioxidants and resveratrol [4]. Alcohol-removed wines, also high in antioxidants and generally lower in calories, are an even healthier option that have experienced widespread popularity in recent years, as global health and wellness trends drive consumers toward healthier selections.

Drinking wine can be both very personal and a shared experience. Wine can be served at family gatherings and cultural events or integrated into religious ceremonies. Take a moment and imagine you're drinking a glass of wine and how it

Interaction design can support, enhance, extend, augment, excite, and explore the sensual experience of wine and food through technologies that celebrate the activities of drinking and eating.



Top: Local and international HCI and UX academic and industry participants at the inaugural workshop, Wine and Interaction Design, at OZCHI 2016, at Marion's Vineyard, overlooking the Tamar River, Tasmania. **Bottom:** Discussions over lunch in the wine cellar at Pipers Brook Winery, Pipers Brook, Tasmania, at OZCHI 2016.

engages your senses. The experience of wine for most of us starts when we select the bottle. We admire the label, feel the weight and shape of the bottle, check that the grape variety aligns with our taste, read about provenance and year of production, and consider the reputation of the producer. We listen for the twist of metal cap or the pop of the cork and sniff for that first aroma signaling readiness for drinking. We hear the splashing sound as the wine is poured, feel the action of swirling it in the glass to assess color and texture, and then finally, if we have chosen well, enjoy the taste of it.

Interaction design can support, enhance, extend, augment, excite, and explore the sensual experience of wine and food through technologies that celebrate the activities of drinking and eating [1]. Digital technology takes the wine drinker beyond simply sharing wine experiences on social media [4] to experiences that use QR codes to

provide information to the wine buyer about the bottle they are holding; video projections on bar surfaces that give tasting notes and prices and guide wine drinkers through a personal tasting experience; and proximity and movement sensors that offer guided tours in wineries [5]. Wine apps on smartphones, such as Vivino (vivino.com) and Hello Vino (hellovino.com), offer assistance at the point of sale by providing information, prices, and user reviews about a wine through the use of label recognition. These apps also suggest food and wine pairings or wines for particular occasions.

This opens up a design space for exploring ways to revive, release, refocus, or reimagine drinking wine, but despite this, the innovative design of technologies to add value to drinking wine remains largely unexplored [4]. Opportunity, the addition of AI technology to apps has added a new dimension to the wine-buying

experience with the personalized experience, giving recommendations of wines the consumer may enjoy. Tasty (tastry.com) is AI-driven technology that presents a virtual sommelier that will “taste” the wine for the user. Algorithms and machine learning use chemical analyses of wine properties to define characteristics of a wine, interpret them as flavor, and make recommendations on wines the user will like based on their taste profiles and preferences. HCI has an important role to play in the design of these AI-driven systems, as the human-computer interface needs to empower the user, while ensuring trust in the systems’ choices and recommendations.

Opportunities and challenges for interaction design in consumption. So, what does this mean for interaction design at the consumer end of the wine life cycle? Now is the time for us to critically reevaluate what is technically possible and understand the ways in which AI can usefully expand the abilities of end-user systems. This will involve understanding the human experience of wine and the contexts in which it is purchased and consumed, and exploring ways to enhance or share activities and human experiences involved in wine consumption. We then need to ideate, prototype, and evaluate new products and services with the people who will be using them. The challenge is in using technology for good, by integrating sustainable practices into future designs and encouraging consumers to prioritize sustainable wines.

ADDRESSING THE CHALLENGES OF WINE PRODUCTION

Human appreciation of wine drives the need to preserve and grow the wine industry. However, climate change is challenging this by affecting the ability to cultivate the key ingredient of wine: grapes. Traditional grape-growing environments are changing to the extent that growers will need to change how and where they grow grapes in the future. Growing grapes for wine has been a human endeavor for more than 8,000 years; it is still an important part of the economy in Italy, Spain, France, the U.S., Australia, Chile, Argentina, South Africa, Germany, and Portugal, where the



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wine industries are key contributors to gross national product [4].

Achieving sustainability in the face of climate change is forcing grape growers to face new ecological challenges alongside economic and social concerns. Grape-growing conditions in different regions of the world are changing. Places that were ideal for growing grapes are seeing less rainfall or increased temperatures, making them unsuitable for the varieties traditionally grown. Grape growers need assistance in understanding how to adapt to these new conditions and how to manage their vineyards with available resources. Sustainable wineries need to practice water and energy conservation, use renewable power, and preserve existing ecosystems. Technology is already helping growers. Smart wireless sensor networks are providing temperature measurements and soil moisture readings at different points in the vineyard to send necessary information on microclimates to vineyard managers. These systems deliver relevant, timely, and comprehensive information that can support crop maintenance decisions [5]. Robots and drones in vineyards that report on vine and soil health provide feedback and images at different times of the day and cover distances that would be difficult for growers. Robots are also improving the cost effectiveness of growing by performing labor-intensive or repetitive tasks such as soil cultivation, weeding, and controlling the machine-picking of grapes. On the winemaking side, temperature and humidity influence the subjective taste of the wine, so the winemaker also needs detailed information about vineyard conditions [4].

Enter AI technologies, and the power to support wine growing rapidly expands into providing interpretive and predictive advice. Recent wine industry reports claim that AI will be critical in helping winemakers adjust to changing climate conditions. Emerging and experimental AI technologies are delivering climate forecasts and

analyzing comparable grape-growing regions to recommend grape varieties to suit changing environments. AI-powered machines and sensors in the vineyards are reporting on current conditions, helping growers assess water needs and advising on how soil conditions need to be modified. Drones or vehicle-mounted systems with infrared thermal-imaging cameras are identifying which vines need water or are suffering from disease or pest infestations, alerting the vineyard manager and giving advice on how to deal with these problems [2,6].

AI also has the capacity to influence winemaking. In the future, AI could monitor the condition of the wine as it ferments and matures and make blending suggestions to the winemaker. An AI system analyzing data related to the aroma, flavor, and taste of the wine could identify patterns and provide insights that might be overlooked by the winemaker, providing comparisons between vintages to help the winemaker be more consistent with their wines [2]. However, some of us might consider the creative and intuitive decisions of the winemaker a vital part of the *art* of winemaking, that which gives wine a distinctive character and defines the identity of particular winemakers.

Opportunities and challenges for interaction design in production.

Science is working on solutions, but science needs people and technology to activate these solutions for the wine industry. This interaction between people and technology gives HCI an opportunity to make a difference to the future of grape-growing and winemaking. Information collected in vineyards by smart devices needs to be tailored for different decision makers. Understanding the grape growers' challenges, what information is needed to make the right decisions for successful growing, and the context in which decisions are being made is an important part of the design process for HCI. Including AI in the mix gives interaction designers an opportunity to explore previously unimagined and

Recent wine industry reports claim that AI will be critical in helping winemakers adjust to changing climate conditions.



View of the vineyards at Jansz Tasmania, Pipers Brook, Tasmania, looking toward Emu Ground Reserve.

otherwise impossible forms of interaction that increase industry resilience in the face of growing environmental challenges. With respect to winemaking, while AI can technically analyze wine properties such as aroma and flavor to provide historical comparisons and consistency, perhaps HCI should focus on designing technology solutions that augment the winemakers' creative processes, supporting the *art* of winemaking.

WHAT NOW?

AI-driven technologies are having and will continue to have an impact on the wine industry at all stages, from production to consumption. This presents a key opportunity for HCI to get involved now.

In the glass, the opportunities for increasing the user experience of buying and drinking wine include the following:

- Smartphone apps that identify, inform, and advise on the current wine choice at the point of sale, including personal taste compatibility as assessed by AI, to enhance the tasting experience
- Interactions with augmented and enhanced tangible elements of drinking, such as QR-coded bottles, sensor-tagged glasses, and countertop video projections, to delight, entertain, and inform the wine drinker
- Illumination and illustration of sensual and scientific aspects of the wine during drinking

- Supporting communication and sharing of drinking experiences and ceremonies with friends, family and community.

In the vineyard, the challenges of climate change for grape-growing and winemaking will benefit from the following:

- Smart sensor systems that register, report, and advise on current environmental growing conditions to assist grape growers and winemakers in crop maintenance
- AI systems that interpret current and historical climate and grape-growing data and forecast weather conditions to give advice on how to adapt to changing growing environments
- Decision-making support for streamlining and adding sustainable practices to the harvesting, winemaking, bottling, and distribution processes
- Digital designs for supporting, celebrating, and exhibiting the creative processes (*art*) of the winemaker.

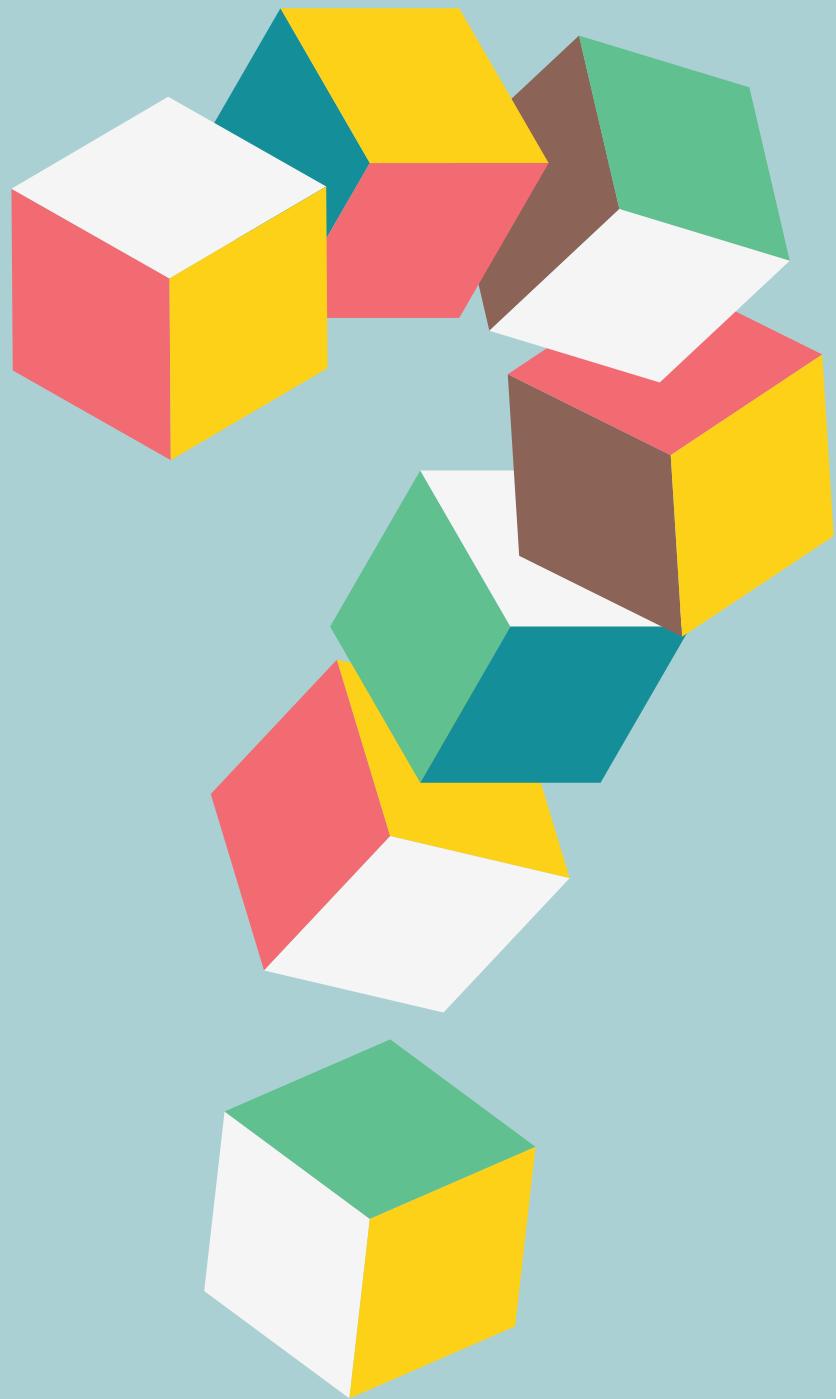
As interaction designers, we have the opportunity to make human-wine interactions personally and socially satisfying as well as sustainable. We can design new technologies and AI systems for the wine industry that enhance people's experience of consuming wine while also addressing climate-related challenges faced in wine production. Ideally, research collaborations between HCI experts, wine scientists, the wine industry, grape growers, and

winemakers will illuminate issues faced by different stakeholders and inform the design of systems that meet needs, as well as extend what is currently possible or known toward a resilient and sustainable wine future. We can leverage opportunities and overcome challenges toward ensuring that the *art* of the winemaker, the *craft* of wine fermentation, and the *science* of growing grapes can adapt and continue into the future, supporting the very human activities of making and drinking wine.

ENDNOTES

1. Paay, J., Davis, H., Rivas, A.M., Rogers, Y., and Brereton, M. HCI supporting food and wine futures: Resilience through reflective practice. *Proc. of the 35th Australian Conference on Human-Computer-Interaction*. ACM, New York, 2023.
2. USA Wine Ratings. How AI will revolutionise the future of wine. May 2022; <https://usawineratings.com/en/blog/insights-1/how-ai-will-revolutionize-the-future-of-wine-236.htm>
3. Davis, H., Paay, J., Kjeldskov, J., and Dolejšová, M. On and off the table: Re-imaging food and wine interactions. *Proc. of the 30th Australian Conference on Computer-Human Interaction*. ACM, New York, 2018, 612–617; <https://doi.org/10.1145/3292147.3293452>
4. Paay, J., Engeler, B., Taylor, M., Day, K., Brereton, M., and Rogers, Y. Wine and user experience design. *Proc. of the 31st Australian Conference on Human-Computer-Interaction*. ACM, New York, 2019, 4–7; <https://doi.org/10.1145/3369457.3369548>
5. Paay, J., Robertson, T., Brereton, M., and Rogers, Y. Wine and interaction design. *Proc. of the 28th Australian Conference on Computer-Human Interaction*. ACM, New York, 2016, 668–671; <https://doi.org/10.1145/3010915.3011865>
6. Marr, B. The incredible ways the 4th Industrial Revolution and AI are changing winemaking. *Forbes*, Jul. 2019; <https://www.forbes.com/sites/bernardmarr/2019/07/03/the-incredible-ways-the-4th-industrial-revolution-and-ai-are-changing-winemaking/?sh=6344cbe31f61>

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Designing for Uncertain Futures

An Anticipatory Approach

Tim Moesgen, Antti Salovaara, Felix A. Epp,
and Camilo Sanchez, Aalto University

Insights

- HCI and design fields must better take into account the volatile, uncertain, complex, and ambiguous world where multiple factors are simultaneously shaping the future.
- Technologies may have unintended consequences and end up being used in unexpected futures.
- By being able to holistically anticipate possible futures and by studying them “in action” in prototype-based field studies, HCI and design can increase their importance in shaping futures.

As climate change, economic instability, new uses of AI, and other transformations are affecting the world, life is becoming more volatile, uncertain, complex, and ambiguous (often referred to as a VUCA world). This poses a challenge for humans, organizations, and governments to navigate.

Exploring the potential impact of these transformations is important for us HCI researchers and designers, as we strive to build better futures through new technologies. Through prototyping, workshops, user studies, and other future-oriented activities, we can craft possible futures and thereby

shape the way by which future societies, economies, and environments develop from the present. New technologies may have unexpected direct and indirect impacts that could pave undesirable pathways for the environment and for our future societies. A key challenge is how we can take a systems approach across these transformations, rather than scrutinizing individual aspects in isolation.

One problem is that the future is uncertain and there are myriad possible futures. Methods such as speculative design [1] can help us explore possible futures and can

remind us to be critical of overly optimistic or technology-centric utopias. While these are useful approaches, there is room for more systematic techniques, whereby naive visions (such as simplistic dystopias) can be avoided, and comprehensive, substantiated viewpoints can be created. We propose holistic and analytical methods that deal with uncertainties about the futures and consider the trajectories by which different futures may come about. Such approaches could complement speculative design by providing HCI researchers and designers with additional means for considering technologies that they would like to propose and develop, or warn about.

This article presents methods for dealing with future-related uncertainties in different phases of HCI evaluations. By *evaluations* we refer to studies where new technologies are designed and then their uses are studied with possible futures in mind. These studies include not only “near futures,” such as when a new version of a technology is developed and usability studies are conducted to evaluate its match with user needs, but also “far futures,” where designers inquire how it might be like to live with a new technology that mediates our lives in new ways. We consider evaluations consisting of three phases: envisioning a potential technological innovation, concretizing that innovation by means of a creating a prototype and carrying out a user study about it, and projecting the findings and interpretations of the study “back to the future” to improve our understanding of this possible future [2]. We propose an approach, building on the concept of anticipation, that offers a means for HCI scholars to assume an active stance toward the uncertainties that need to be addressed.

ANTICIPATION OF UNCERTAIN FUTURES

Uncertainty may appear as a problem or challenge to be overcome. “Future-proof” innovations are designed to match the requirements of forecast futures that are highly probable and have high impact (such as global warming). This implies that focusing on them has more weight than considering alternative futures.

Uncertainties about futures on such a macro level can indeed be disciplined, and simulations, forecasting, and trend analyses exist for such purposes.

Much will remain unknown even after such measures, however, since high certainty about the future may be achieved only in broad strokes. In addition, there are high-impact futures that may warrant consideration even if their occurrence would be highly improbable. Foresight researchers in futures studies identify and analyze such futures, primarily by applying scenario-based qualitative methods. Instead of attempting to predict only the most likely futures and present them as worthy for analysis, scenario-based foresight seeks to map a variety of trajectories, threats, and opportunities, and increase preparedness and sensitivity to these futures [3].

With this constructive turn where futures are actively envisioned instead of passively predicted, an anticipatory conception about uncertainty can be adopted. One can begin to ask what kinds of reflectively created possible futures one should generate and be prepared for and possibly act on [4]. This aligns well with how HCI operates: As a matter of course, we envision technologically mediated futures, discover consequences and implications of technology, and show how users may behave in such futures, possibly in unexpected ways that make us change our view of such futures.

In the remainder of this article, we suggest in more detail how

anticipation of futures, and the active stance that it introduces, can be fruitfully carried out in HCI research. HCI exploration does not entail only scenario-building activities. We propose we can utilize our field’s unique strength—that of being able to study possible futures “in action” by building interactive prototypes and conducting user studies.

ANTICIPATION OF FUTURES IN DIVERGING AND CONVERGING PHASES OF HCI EVALUATIONS

Evaluations of futures in action can be conducted only on selected few possible futures, because user studies with prototypes are resource-heavy exercises. Selecting the most relevant future is a challenge, but can be dealt with by alternating between diverging and converging ways of working: widening to a multiplicity of possibilities, reflectively selecting candidates among them for a closer study, carrying out the study, widening the focus again by generating implications, and so on. This way, HCI researchers can apply the principle of divergence and convergence in design processes to the anticipation of possible futures, and integrate it with the well-known Futures Cone, as discussed in Dunne and Raby’s book about speculative design [1]. They present a cone-shaped visualization for divergence to different futures—preferable, probable, plausible, and possible—each one potentially reachable from the present.

Building on the Futures Cone, Figure 1 illustrates how HCI evaluations alternate between divergence and convergence in three phases. The first phase is divergent and includes the envisioning of possible HCI-related futures. Phase 2 is convergent, where the most relevant futures are concretized in the form of user studies in which prototypes and arrangements stage the futures that are interactable for users. The final phase is divergent, projecting user studies’ findings “back to the future,” with a goal of expanding the insight of the futures beyond those that were already envisioned in Phase 1.

In the following sections, we consider ways by which an anticipatory approach can be applied in these phases so that uncertainty about possible futures becomes a starting point for an

A key challenge is how we can take a systems approach across these transformations, rather than scrutinizing individual aspects in isolation.

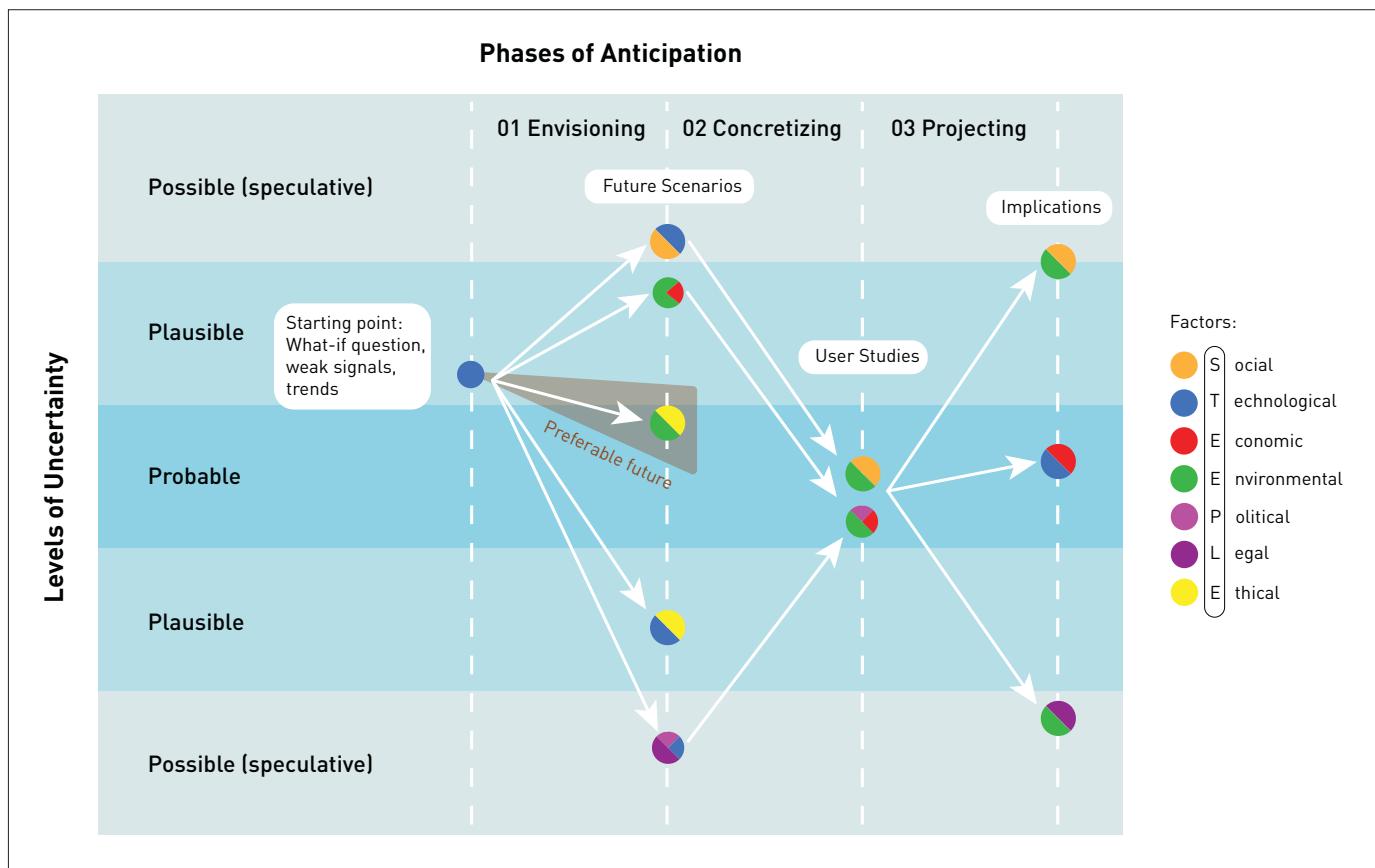


Figure 1. A three-phase view of future-oriented HCI evaluations: 1) Envisioning by diverging to consider possible futures; 2) Concretization by converging to futures that are important to investigate via prototypes and user studies; 3) Projection by diverging to possible future implications from user study outcomes. One can examine potential future scenarios, user studies, and implications from various STEEPLE perspectives, each depicted through differently colored dots. The diagram's coloring follows the convention introduced by Dunne and Raby [1], where a preferable future is presented with a brown outline, and the uncertainties of different futures are represented with different hues of blue and distance from the center line.

anticipatory, active approach to designing. We present methods developed in futures studies that we find applicable for HCI practice and research, so as to increase our field's sophistication in futuring and envisioning credible futures.

PHASE 1: ENVISIONING POSSIBLE FUTURES

At the start of a project, designers explore possible directions, outcomes, opportunities, and alternative pathways in a divergent working mode. Similar practices can be found in future studies (e.g., [5]), where the creation of a set of possible futures, even extreme ones, can drive awareness and anticipation of future opportunities and risks.

Similarly, in HCI, when considering future products and services, we should not immediately fixate on just one future or scenario, but rather explore possible futures, thereby enabling ourselves to anticipate those that are most relevant to our design efforts.

Building on this idea that extreme

futures may deserve consideration, the cone in Figure 1 illustrates a process where the envisioned futures are not the most probable ones: The one with a brown outline is a preferable future, but it is only on the boundary of being a probable one. The others are more uncertain and speculative. The diagram also shows that the starting point for futuring is speculative: The blue (i.e., technologically motivated) circle is not located within the band of probable futures. Instead, it represents a starting point, such as a trend, whose eventual relevance is uncertain, yet important to examine.

The quality of future scenarios is also important in this diverging phase. Appropriate methods are needed for the ideation of possible futures, to improve their insightfulness and to avoid field-specific biases. HCI needs to avoid gravitation toward naive technocentric futures that single-mindedly present new technologies as the sole shapers of the lives of future people.

Futures studies literature offers several methods by which one can stay mindful of a larger set of future-shaping factors than technology alone. A widely used list is STEEPLE (future-shaping social, technological, economic, environmental, political, legal, and ethical factors). Considering these factors in combinations (as illustrated in Figure 1, where different futures are represented as multicolored circles) can help HCI researchers and designers remain holistic in their envisioning of possible futures.

STEEPLE can be used as an ingredient of methods, such as the Future Ripples [6]. Similarly with the Futures Cone, the Future Ripples starting point is the present world, and particularly an aspect of it, such as an ongoing trend or a weak signal. That aspect serves as a seed for envisioning consequences of different kinds (e.g., using STEEPLE as a guide). When immediate (first-order) consequences have been generated, waves of higher-order ones are created. This generates



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concentric wheels of mutually connected possible futures, and suggestions of increasingly unexpected scenarios, all of which can be traced back to the present world.

Compared to Delphi—a well-known envisioning method in futures studies—the methods presented above are lighter and faster to apply in a design process. For a Delphi study, a panel of experts willing to contribute their reflections is required. The study therefore takes weeks or even months to be completed. Techniques involving STEEPLE and Futures Wheel, in contrast, may only take from a few hours to a couple of days to perform, depending on the amount of preparation and background work dedicated to identification of weak signals, trends, and other future-oriented intelligence. Even if their rigor cannot match that of a Delphi study or more-extensive scenario-based methods in strategic foresight [5], these approaches can nurture both academic and corporate innovation teams' holistic capability to anticipate possible futures in practice.

PHASE 2: CONCRETIZING FUTURES IN A USER STUDY

After having created a set of anticipated possible futures that are important to consider for design efforts, and when the evaluation process thereby changes to a converging phase, the possible futures can be studied “in action” with interactive prototypes and user studies. This lets us learn about futures in more detail and anticipate how humans might behave in them. Concretization via prototyping and user studies requires convergence to only those futures that have the highest anticipated importance. In Figure 1, the concretization is illustrated through a drop from five scenarios to two for which user studies are arranged. This can happen by discarding and synthesizing the existing scenarios. To

avoid biases, this convergence should be carried out mindfully. The choices the team makes will affect how the user study can enact the possible future in the present and how implications can be drawn from its outcomes.

In choosing between the futures that were envisioned in the diverging phase, we can apply the Critical Uncertainties [3] analysis to HCI. This entails identification of unpredictable but influential factors in the envisioned futures (such as the five shown in Figure 1). If the team identifies two uncertainties from the scenarios, such as the effect of global warming and severity of political unrest, they can use the 2x2 matrix technique [3], whereby they combine and shape the scenarios, and finally place them into the matrix’s four quadrants. This process seeks to crystallize the scenarios’ significance for the study.

The 2x2 matrix technique helps in converging two or at most four possible futures. However, the convergence becomes its narrowest at the execution of a user study, where possibly only one of the futures will be concretized. Other futures, in turn, will remain at a scenario level. In the user study, the enactment of a believable future is essential so that user behavior in the would-be future would be most natural.

User studies require staging [2] where future-related features are made live and experienceable through propping. The most important staging elements are interactive prototypes. In near-future studies such as usability evaluations, the prototype can be supported with mock-up materials, purposely prepared content, and tasks that increase immersion. In far-future studies, more techniques may be needed, such as recruitment of lead users, use of external actors, and more-elaborate technological setups. Furthermore, controlling techniques

HCI needs to avoid gravitation toward naive techno-centric futures that single-mindedly present new technologies as the sole shapers of the lives of future people.

[2] may be necessary to temporarily remove those present-day features from the study that would not belong to the future world of interest. For example, users may be prohibited from using those present-day communication technologies that in the envisioned future would no longer be used.

To summarize, the converging-oriented activities in this second evaluation phase focus on two important goals. From a conceptual point of view, through identification of critical uncertainties and the use of techniques such as the 2x2 matrix, the anticipated possible futures are conceptually crystallized so that the critical aspects of the envisioned features are identified. In turn, from an empirical point of view, through staging of a prototype-based user study, the possible future can be enacted “in action” so that users can experience it interactively and more information can be learned about it.

PHASE 3: INTERPRETING FINDINGS AND PROJECTING IMPLICATIONS TO BETTER-INFORMED FUTURES

In most HCI evaluations, user studies are followed with analyses of the findings and reflection about implications. Paradoxically, this is a phase where findings obtained from the present-day user study are projected “back to the future.” This is essentially a divergent process where emerging issues can lead the HCI team to consider new or more-informed interpretations. In the framework of future-oriented research, these activities are ways by which teams increase their anticipatory capacity about possible futures by learning about futures with more detail, correcting assumptions, and discovering new courses of action.

Projection requires holistic analysis in the same way as the envisioning and concretization phases. Building on the idea of the STEEPLE factors, one should avoid considering one-sided implications, where a future is considered from a one-factor POV only. Similarly, it may not be beneficial to consider entirely positive or negative implications, since more-nuanced views may be more insightful.

Although we are not aware of HCI

studies that would have applied any of the future studies’ scenario assessment methods in this evaluation phase, we find a lot of promise in the cross-impact analysis method, where future-contingent factors are systematically juxtaposed pairwise in a table so that the factors’ interdependencies can be assessed. This directs researchers to consider how phenomena, courses of action, and other factors, as discovered during the study and also during the evaluation’s earlier phases, may affect one another. This method can safeguard HCI teams from overemphasizing one finding’s importance. Instead, the teams may identify implications that are deeper and more overarching than if each finding is considered in isolation. To additionally safeguard the process from crossing the boundaries of realism, “margins of tolerance” [2] can be added to the projections: The team can explicate what conditions and state-of-affairs must hold in the future for each possible implication to be plausible.

CONCLUSION

Over the past decade, the HCI field has deepened its engagement with systematic and more-holistic approaches in shaping the future and raising awareness of the problematic issues related to technological progress. Speculative design is one approach that has become more popular and has started to address this need.

In this article, we have proposed a complementary approach that builds on anticipation. We have stressed the importance of recognizing and reflecting on the intrinsic uncertainty around possible futures, and offered methods, building on the work in this research tradition, for systematically and thoughtfully addressing that uncertainty and anticipating its possibilities. Combined with our field’s strengths in building future-oriented prototypes and studying their use in action, we can contribute to society by anticipating possible futures that are worth striving toward or that should be avoided.

ENDNOTES

1. Dunne, A. and Raby, F. *Speculative Everything: Design, Fiction, and Social Dreaming*. MIT Press, 2013.

2. Salovaara, A., Oulasvirta, A., and Jacucci, G. Evaluation of prototypes and the problem of possible futures. *Proc. of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, New York, 2017, 2064–2077.
3. Schwartz, P. *The Art of the Long View: Planning for the Future in an Uncertain World*. Currency, 2012.
4. Alvial-Palavicino, C. The future as practice. A framework to understand anticipation in science and technology. *Tecnoscienza: Italian Journal of Science & Technology Studies* 6, 2 (2016), 135–172.
5. Schoemaker, P.J.H. Multiple scenario development: Its conceptual and behavioral foundation. *Strategic Management Journal* 14, 3 (1993), 193–213.
6. Epp, F.A., Moesgen, T., Salovaara, A., Pouta, E., and Gazilusoy, I. Reinventing the wheel: The Future Ripples method for activating anticipatory capacities in innovation teams. *Proc. of the 2022 ACM Designing Interactive Systems Conference: Digital Wellbeing*. ACM, New York, 2022, 387–399; <https://doi.org/10.1145/3532106.3534570>

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Money as an Interface

 **Belén Barros Pena**, City, University of London

Insights

- As designers, we should acknowledge the fundamentally social nature of money.
- We must design financial technologies that facilitate and nurture collaborative financial behaviors.
- We must abandon our focus on convenience and optimization, and envision technologies that safeguard money as a public good and enable financial citizenship.

Money, it would seem, has always been a puzzle. — Geoffrey Ingham

Nobody seems to know what money is. This is despite all of us using money every day—or perhaps because of it. The question *What is money?* has traditionally been a subject reserved for economists. Their standard answer is that money is what money does, and that money does three things: It is a medium of exchange, a unit of account, and a store of value. Perhaps dissatisfied with this function-centered answer, other disciplines have started to volunteer alternative definitions of money, bringing their own particular

perspectives to the matter. We have the sociologists, for whom money is first and foremost a social relation—a universally accepted measure of value originally established through hegemonic power but now constantly co-constructed, negotiated, and maintained through the interplay between economic agents and monetary authorities [1]. Anthropologists have also chimed in, defining money as “an instrument of collective memory” [2], a way of remembering the relationships we establish with others. For media scholars, cash is “a mass media form,” and money itself is becoming social media [3]. But what about human-

computer interaction? How would a definition of money look like from our disciplinary perspective? The answer should be obvious. For us, money is, of course, an interface. What else could it be?

Like all interfaces, money ultimately mediates human interactions and relationships. Often, when money is involved, those relationships include payment in exchange for something else. But when we look at how people interact with and through money in more detail, we soon realize that money is involved not just in payments but also in many other kinds of human interactions. People give money to each other in exchange for nothing, donating funds to charitable, cultural, and even technological endeavors. People agree to keep money safe for other people, a practice called *moneyguarding*. People split the cost of things, turning a single payment into a social affair. People combine their money to create a single pool of wealth, or to strengthen their negotiating position in commercial exchanges. People save money in groups. When banks close, like in Ireland in the 1970s, or money disappears overnight, like in India in 2016, people come up with alternative ways to keep exchange going. And sometimes people help mind other people's money, a deeply humane act that goes by the dry name *financial third-party access*.

THE PROBLEMS WITH FINANCIAL THIRD-PARTY ACCESS

Financial third-party access is a form of financial collaboration through which we receive someone else's assistance with financial decision making and the management of our money. This assistance mostly includes day-to-day tasks such as paying bills, banking, or paperwork; but it can also involve long-term management of assets to ensure financial security. Minding

money is a common caregiving task, and many people—for example, those living with physical and cognitive impairments, either temporary or permanent, and those diagnosed with certain mental health conditions—rely on others for this type of help. Legal and contractual mechanisms exist to formally give someone else access to and decision-making powers over our money. In the U.K., these mechanisms include lasting power of attorney and bank arrangements called *third-party mandates*. The problem is that they are woefully underused.

In 2017, a very concerned U.K. Financial Conduct Authority commissioned research about how older adults who need help with managing money shun these formal mechanisms and instead resort to so-called informal work-arounds or coping mechanisms. Examples of these work-arounds include:

- Sharing bank cards and PINs with helpers in order to delegate payment authority and to get access to cash through others
- Disclosing telephone and Internet banking credentials, which allows helpers to set up direct debits and pay bills on someone's behalf
- Signing blank checks or withdrawal forms to be used by caregivers
- Opening joint accounts, through which third parties can control spending and take over financial responsibilities when needed.

The problem with these informal work-arounds is that they are phenomenally risky. When you give your bank card to someone else, you are giving them access to all the money in your bank account. When you give your Internet banking credentials to someone else, you are giving them full access to all your accounts with a certain bank. These informal work-arounds not only expose people to fraud and financial abuse, they are also a breach of banks' terms and conditions, voiding all

fraud protections banks provide their customers. This is a double whammy: You increase the risk of fraud while simultaneously losing all protections against it. Not a good place to be.

It turns out that it is not just older adults resorting to these dangerous work-arounds. We all do, a fact that tends to remain hidden, because there is very little research about it. The evidence is scattered across studies on different subjects and from different disciplines. For instance, in a security paper from 2000, where the authors mention in passing how “[a]lmost all participants shared their bank PIN with family or friends” [4]. Another security paper, this one from 2011, briefly comments on how spouses “frequently shared bank account details and PIN codes” [5]. These two studies were done in the U.S., but couples in Australia also use these work-arounds. Card- and PIN-sharing is also prevalent within Saudi Arabian households, between friends in India, and within remote aboriginal communities in Australia. In Ghana, people use other people's mobile money accounts; and in Chile, people lend their credit cards to friends and family. In the U.K., the Money and Mental Health Policy Institute estimates that more than 16 million people in the country know someone else's PIN, almost 8 million know someone else's online banking credentials, and almost 7 million have used someone else's contactless card [6]. A few days ago, I gave my card to my husband to pay for a couple of pints in a London pub. By the way, he used his mum's online banking to take care of her finances when she could no longer cope by herself.

So lots of us continuously and knowingly breach our banks' terms of service and engage in money practices that are considered dangerous, irresponsible, and deviant. If this behavior is truly irresponsible and risky, why do we do it? Policymakers, banks, and security professionals tend to answer the question of why by blaming those pesky humans. They argue that people lack knowledge about the lawful ways of setting up financial third-party access, and that they are oblivious to the dangers of their own behavior. As HCI researchers and design practitioners, we have a different take. We know informal work-arounds like these are flashing beacons; they

Capacity to manage money is not all or nothing. We are not either capable or incapable of handling our finances. Instead, people can do certain things, but not others.

signal some kind of fracture—a disconnect between products, services, and infrastructures and the circumstances, needs, and wishes of those who use them. In short, we know the problem is that money services and technologies are designed with a chronic disregard for human behavior. There are several issues with money services and technologies that contribute to triggering dangerous work-arounds: 1) their binary nature, 2) their disregard for cultural meanings and values, and 3) their extreme individualization of finance.

The binary nature of money services and technologies.

Many of the mechanisms and technologies around access to money nowadays are binary. They either give full access to assets or no access at all. Lasting power of attorney is a great example of this “binarism.” The moment it is activated, it grants full power over someone else’s financial assets: pensions, investments, savings, property—everything. Security mechanisms like PINs and digital access credentials are also binary. If you know the PIN to my card, you have full access to all the funds in my bank account. If you know my Internet banking credentials, you have full access to all the accounts I have with that bank.

The problem is that our interactions with and through money are not binary. They come in all kinds of shades and variations. Capacity to manage money is not all or nothing. We are not either capable or incapable of handling our finances. Instead, people can do certain things, but not others. A person who is housebound due to a mobility impairment can be perfectly capable of managing her money, and may do so online and by phone. But since she cannot get out of the house, she cannot withdraw cash by herself. For that, she must rely on someone else. Sometimes what people can do changes from day to day. People living with mental illness can have long periods of time when they have full capacity to manage their money. But at moments of mental health crisis, they may lose that capacity. Once they recover, capacity returns. Given the variability of human behavior, the binarism of existing money-access mechanisms is unable to match the fluidity of our day-to-day financial lives.

The disregard for cultural meanings and values. Money services and



technologies treat money in the same way as classical economists: as if it were a neutral veil. Money is money—an instrument, a tool, a means to an end. It is indifferent to and detached from all cultural matters and value judgements. This is, of course, nonsense. Money mediates power relationships between people, and as such it is a loaded thing. Financial third-party access is often part of complex filial relationships in which trust, past experiences, and future expectations of ownership all play a part. People in Saudi Arabia view the sharing of cards and PINs with family members as “a way of supporting each other” and “a kind of solidarity” [7]. People in remote aboriginal communities in Australia share cards and PINs because cultural norms establish that “money is shared with kin” [8]. Our existing money services and technologies are completely out of touch with the cultural meanings and values we attach to money.

The extreme individualization of finance. The bulk of money services and technologies today are designed under the overarching assumption that your money is strictly and exclusively yours. That assumption, as we have seen, is incorrect. Informal mechanisms for financial third-party access clearly demonstrate that money is not a strictly individual affair. My money is not just mine: I share my money life with those in my social circle. Our money services and technologies not only ignore our collaborative financial behaviors but also actively punish them. Logging into

someone else’s digital banking, even if just to provide help, is considered a “fraudulent behavior.”

Financial services and technologies seem intent on convincing us that our money is ours alone, and work hard to prevent any form of financial collaboration. But we don’t pay them any attention. We just find ways around the barriers they create, and continue to be the social animals we have always been. By turning a blind eye to the collaborative reality of our day-to-day financial lives, money services and technologies render themselves fundamentally incapable to support our money practices.

MONEY AS AN INTERFACE

It seems clear that people are not the problem; our money services and technologies are. Financial collaborative practices should not be prevented or punished but instead enabled and nurtured so that they can happen safely. This requires a reframing of financial services and technologies from strictly personal to essentially social and collaborative, and a rethinking of the individualizing paradigms currently underpinning their design. In short, it requires that we design for money as an interface.

As HCI scholars, we are the right people for this job. HCI as a discipline has a long history of uncovering the hidden collaborative nature of supposedly individual affairs. We have done so with privacy, for instance. The study of interpersonal boundary

management in the context of social media highlighted how privacy does not pertain exclusively to individuals. It is instead negotiated and enacted with others. We have also exposed the fallacy of assuming that every digital account belongs to, and is always accessed by, a single person, and have proposed design models for multiple account ownership. In addition, we have identified secondary and intermediated digital use, describing how some people rely on others to gain access to digital devices, information, and services.

These and other studies of collaborative practices with and through technology constitute a strong foundation we can build upon as we strive to redefine and redesign financial technologies from a social and collaborative standpoint. In our own work, we have suggested that enabling financial collaboration requires us to design technologies and services that are flexible, that encourage reflection, that can be appropriated and adapted by their users, that recognize we often rely on others to stay safe and secure, and that enable delegated use and information sharing.

DESIGNING FOR FINANCIAL CITIZENSHIP

Money as an interface, with its turn to the social and its emphasis on interaction, should also be firmly aligned to understandings of money as a public good, and to ideas of citizen participation in financial governance. As opposed to physical cash, which is issued and maintained by national institutions with a public service mandate, our digital money infrastructure is mostly developed and run by commercial companies. These companies are accountable only to their shareholders, rather than to society as a whole, and their main goal is the pursuit of profit, rather than promoting collective economic prosperity. As money becomes digitized and privatized, citizens lose leverage over a fundamental social technology. The notion of financial citizenship becomes crucial at this juncture. Conceived by the geography scholars Andrew Leyshon and Nigel Thrift in the mid-1990s, financial citizenship recognizes the critical role that money services and technologies

play in our ability to act as full members of society. Today, in many parts of the world, you cannot be legally employed without having a bank account where your wages can be deposited, and it is impossible to own a home without access to credit. As these simple examples illustrate, we can no longer live full lives without availing ourselves of a set of basic financial services. Financial citizenship recognizes that this is so. It aims to move beyond the financial inclusion agenda, to advocate instead the democratic oversight of money-related policies and practices. It suggests that citizens should have a say in the stewardship of the economy, in questions of money governance, and in how the financial system functions, in order to bring about policies that strengthen our collective—and not just individual—economic well-being.

Designers and HCI scholars can contribute to this democratizing agenda through the design of financial services and technologies that fully embrace money's sociality. This will require us to recognize the political nature of financial service provision, and to incorporate it into our work. For instance, we may need to acknowledge that certain financial services have become fundamental utilities, akin to electricity and water provision, and that access to them is a basic right. We may have to stop designing financial technologies that focus solely on maximizing convenience and optimizing individual financial resources, and instead create technological artifacts that enable citizens' oversight of how financial institutions, both public and private, operate. We may have to distance ourselves from notions of citizens as consumers and from limited financial inclusion initiatives; or actively contribute to the development of alternative models for the provision of financial services where the pursuit of profit becomes a secondary concern.

As we fast approach a world of digital fiat currencies (digital euros, digital pounds, digital yuan, etc.), we cannot continue designing our money technologies under incorrect assumptions about human behavior; or under the pretension that money governance is disconnected from the

exercise of citizenship. We must design financial technologies that account for the social and collaborative nature of our interactions with and through money, and that uphold our right to democratically safeguard our collective economic well-being.

ENDNOTES

1. Ingham, G. *The Nature of Money*. Polity Press, 2004.
2. Hart, K. *The Memory Bank—A New Commonwealth*. Prickly Pear Pamphlets, 2000; <https://thememorybank.co.uk/book/chapter-6/>
3. Swartz, L. In praise of the dollar bill. *MIT Technology Review*. Apr. 15, 2022; <https://www.technologyreview.com/2022/04/15/1049604/cash-digital-payments-money/>
4. Dhamija, R. and Perrig, A. Déjà vu: A user study using images for authentication. *Proc. of the 9th USENIX Security Symposium*. USENIX Association, 2000; https://www.usenix.org/legacy/publications/library/proceedings/sec2000/full_papers/dhamija/dhamija.pdf
5. Kaye, J.J. Self-reported password sharing strategies. *Proc. of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, New York, 2011, 2619–2622; <https://doi.org/10.1145/1978942.1979324>
6. Murray, N. *Strength in Numbers: Consumers, Carers and Financial Services*. Money and Mental Health Policy Institute, 2016; <https://www.moneyandmentalhealth.org/wp-content/uploads/2016/11/Strength-in-Numbers-report.pdf>
7. Alghamdi, D., Flechais, I., and Jirotka, M. Security practices for households bank customers in the Kingdom of Saudi Arabia. *Proc. of Symposium on Usable Privacy and Security*. USENIX Association, 2015, 297–308; <https://www.usenix.org/system/files/conference/soups2015/soups15-paper-alghamdi.pdf>
8. Singh, S., Cabraal, A., Demosthenous, C., Astbrink, G., and Furlong, M. Password sharing: Implications for security design based on social practice. *Proc. of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, New York, 2007, 895–904; <https://doi.org/10.1145/1240624.1240759>

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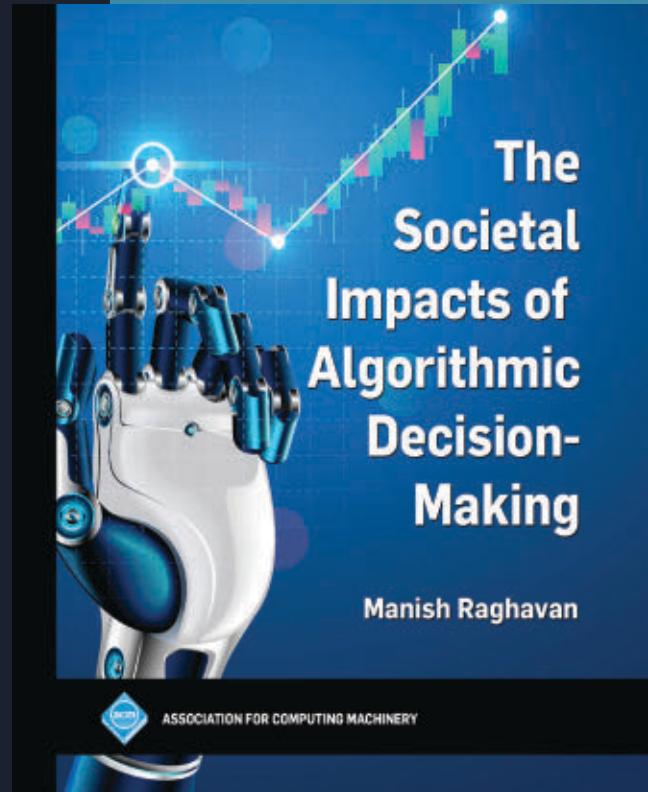
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Collection III

This book demonstrates the need for and the value of interdisciplinary research in addressing important societal challenges associated with the widespread use of algorithmic decision-making. Algorithms are increasingly being used to make decisions in various domains such as criminal justice, medicine, and employment. While algorithmic tools have the potential to make decision-making more accurate, consistent, and transparent, they pose serious challenges to societal interests. For example, they can perpetuate discrimination, cause representational harm, and deny opportunities.

The Societal Impacts of Algorithmic Decision-Making presents several contributions to the growing body of literature that seeks to respond to these challenges, drawing on techniques and insights from computer science, economics, and law. The author develops tools and frameworks to characterize the impacts of decision-making and incorporates models of behavior to reason about decision-making in complex environments. These technical insights are leveraged to deepen the qualitative understanding of the impacts of algorithms on problem domains including employment and lending.

The social harms of algorithmic decision-making are far from being solved. While easy solutions are not presented here, there are actionable insights for those who seek to deploy algorithms responsibly. The research presented within this book will hopefully contribute to broader efforts to safeguard societal values while still taking advantage of the promise of algorithmic decision-making.



The Societal Impacts of Algorithmic Decision-Making

Manish Raghavan

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This forum focuses on the conditions and futures of the labor underpinning technology production and maintenance. We welcome standalone articles as well as interviews and conversations about all tech labor within the global supply chain of digital technologies. — **Seyram Avle and Sarah Fox, Editors**

Building Dreams Beyond Labor: Worker Autonomy in the Age of AI

Dan Calacci, Princeton University

In April 2023, four months after ChatGPT was released, the Writers Guild of America (WGA), which represents screen and TV writers, was on the verge of a strike vote heading into contract negotiations. Before negotiating, they published a list of the broad goals the union's bargaining committee would take to the table. Nestled between items on discrimination and contract exclusivity was a goal whose language-model-fueled subtext was clear: "Regulate use of material produced using artificial intelligence or similar technologies" [1]. The WGA was seeking to effectively self-regulate the use of large language models (LLMs) in their workplace. AI-generated scripts or job automation may not have topped the union's list of demands, but the anxieties that ChatGPT generated for screenwriters offers an important glimpse into the evolving dynamics of creative, white-collar work in the era of large language models.

This isn't the first time that generative AI has entered Hollywood contracts. Many actors are already familiar with agreements that give studios the right to train generative models using their voice, creating new content using creative workers' intellectual property. So why did the WGA feel the need to include this particular goal in their demands?

First, effective generative AI models are poised to significantly inflate the value that can be extracted from intellectual property such as past screenplays. Using a dataset of past screenplays, accessible and effective models like GPT-4 could allow unskilled

managers, producers, and executives to create a torrent of new scripts that are derivative of screenwriters' past work. This transforms culturally important work into valuable raw material for algorithmic production. By limiting how management can use generative AI and what data they can be trained on, the WGA can better control the value that Hollywood management can extract from their members' labor.

Second, and perhaps more important, it would protect screenwriter jobs from a "hollowing out" of their agency and autonomy. After a strike was approved, John August, one of the *Charlie's Angels* screenwriters, clarified the writers' anxieties, focusing on how management might use an LLM to rewrite existing scripts: "A terrible case of like, 'Oh, I read through your scripts, I didn't like the scene, so I had ChatGPT rewrite the scene'—that's the nightmare scenario" [2]. Rather than full job replacement, he worried that if studios could freely generate

screenplays using writers' past content, it would undermine the core creative control writers enjoy in their work.

REBOOTING WORKER AUTONOMY

The anxiety that automation and the new forms of organizing work it enables will severely affect creative workers' autonomy is not new. It is a concern that resonates with the principles of *operaismo*, or workerism, a sociopolitical philosophy that emerged in Italy in the 1960s and 1970s. Operaist theorists were some of the first to recognize that creative work, like other forms of labor, are embedded within and influenced by our political economy [3]. In the 1970s, operaists argued that the emerging "creative class" enjoyed a false sense of autonomy. Operaists would argue that while an advertising art director might have benefited from some creative freedom in choices such as color, layout, or visual themes, the principles and goals of their work were ultimately aligned with profit-making. Their work was valued not for its artistic merit or creative potential but for its ability to generate profit; their creative work was transformed into a commodity.

Although this commodification has been true for decades, creative workers risk facing a severe intensification of this process through the unfettered use of generative algorithms. Just as an art director's work was valued for its ability to sell products, a screenwriter's work in the ChatGPT era can be valued for its potential as a training set for future AI models that generate profitable screenplays in part or in whole. This process formalizes the consumption

Insights

- Academics, business leaders, and policymakers treat automation as an uncontrollable force, but is this really the case?
- Workers have more power to direct the force of automation than many think by using data as leverage in negotiations.
- Researchers and HCI practitioners can influence this process by working on democratic and participatory AI systems.

of culture, turning creative works into raw material for algorithmic production. The goal of creative work like screenwriting then becomes a kind of dataset creation rather than a creative pursuit in itself, stripping writers of creative control and removing what is arguably the most meaningful and fulfilling aspect of their work.

CREATIVE PIECEWORK AND CONTROL

While most scholars agree we are a ways away from models that can generate compelling, original content comparable to that of a human, this doesn't mean we won't see this new pattern of creative value production in the near future. Rather than fully automate screenwriting, tools leveraging models like GPT can enable new ways of delegating and recombining human work that might achieve the same effect. *Algorithmic management*, a term coined to describe the use of complex algorithms to manage human workers, has mainly been a concern in the realm of what's considered blue-collar work: gig economy drivers and delivery workers, warehouse workers, and "clickworkers" on platforms like Amazon's Mechanical Turk.

However, a significant amount of literature in the CSCW and CHI communities investigates how crowd work can be leveraged to perform complex, context-dependent tasks that are core to what we consider "creative work." Although using algorithmically guided delegation or management for tasks like programming have been investigated, writing has been the gold standard for systems aimed at delegating and distributing complex creative work. Even without models like GPT, task delegation systems in creative work remove important aspects of agency and control from workers. Some studies even found that removing levels of creative control from crowd workers doing broken-up "piecework" writing tasks actually improved final pieces produced by the system, further incentivizing such agency-stripping designs. As HCI researcher Ali Alkhateeb's work warns us, combining task-delegation systems with new generative AI tools could lead to a "contemporary instantiation



of piecework" [4] if designers do not carefully consider their impacts on worker well-being.

THE RISE OF SURVEILLANCE AS WORKPLACE TRAINING DATA

The reality of workplace monitoring and productivity scoring in modern white-collar workplaces puts many workers uncomfortably close to this vision. After millions of people were forced to work from home during the Covid-19 pandemic, workers are increasingly under heightened scrutiny by employers seeking to translate workplace discipline and surveillance into the work-from-home context. This heightened surveillance takes the form of algorithmically determined productivity scores,

tracking text communications in the workplace, and software that takes regular screenshots of workers' computer screens for employer review. In the LLM era, all of this surveillance—and the data it creates—turns into potential training material for future AI systems.

For example, LLMs could be used to monitor and analyze workers' written communication, providing managers with summaries of their productivity, work habits, and emotions. New models could predict in detail what specific subtasks in a project should be completed by which team members, a form of AI-powered micro-delegation. Futures like this have consequences beyond individual workers' job satisfaction or dignity. Improvements in delegation and management technologies that analyze and predict worker behavior can create severe asymmetry in the workplace while limiting workers' ability to challenge or negotiate the terms of their work.

If workers choose to withhold their labor, they can effectively starve these systems of the data they need to improve.

STARVING THE SYSTEM AS A LABOR STRATEGY

LLMs like ChatGPT are not just tools that can be used to automate tasks

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or manage workers. They are also systems that require constant input and training to improve and evolve. This means that they rely on a steady stream of new content from people to function effectively. This dependence on human creativity and labor is a feature, not a bug—it is what allows them to generate content that is fresh, relevant, and engaging.

This dependence of LLMs on human labor also provides a glimmer of hope for workers seeking to exert some control over the direction of future AI model development. If workers choose to withhold their labor, they can effectively starve these systems of the data they need to improve. Although developed mostly in the context of consumer relations, Nicholas Vincent's proposed strategies of "data leverage" or "data strikes," where users withhold or manipulate data collected for algorithmic training, might prove to be effective, modern organizing strategies for workers seeking to negotiate better terms and conditions for their work. These approaches are effectively a strategy of refusal [5], rooted in the principles of operaismo and autonomism, that emphasize the power of workers to resist and shape the economic forces that affect their lives.

This strategy of refusal is not without its challenges. For one, it requires a high degree of coordination and solidarity among workers, a major issue among fragmented and algorithmically managed workforces. Workers also need to have a better understanding of the value of their data and the role it plays in the development of AI systems. This is a difficult task, particularly given the often opaque, "black box" nature of algorithmic management systems and the fact that current data protection law focuses on individual, rather than collective, rights [6].

Traditional strikes can be part of this strategy. Members of SAG-AFTRA, the union that represents Hollywood performers and other media professionals nationwide, approved joining the WGA through their own strike vote on July 13, 2023. In a statement to CNBC, SAG-AFTRA Executive Director Duncan Crabtree-Ireland said that a major negotiating point is ensuring "a human-centered approach to the implementation

of AI" as studios experiment with using generative models. Worker codetermination and union negotiation can be important ways of defining red lines around AI use in the workplace.

WORKER POWER AND THE RIGHT TO INFLUENCE AUTOMATION

This potential power to influence how automation advances raises an important question: What, if any, kinds of automation should workers, and the labor movement at large, strategically advocate for? Political theorists like Nick Srnicek and Alex Williams have made the case that workers should argue for full automation in certain fields, such as industrial manufacturing, as part of a "political project against work." Empirical work on the automation priorities of workers, however, is sparse. Answering the question of what, exactly, workers *want* to be automated is broader than protecting certain jobs from automation or enforcing labor rights, although these goals are important. It is about shaping the future of work in ways that enhance human creativity, dignity, and well-being.

Collaborating with workers and valuing their perspective on automation can provide an important, complementary thread to work that focuses on automation itself. More research like that of University of Texas at Austin's Min Kyung Lee, who prototypes systems for participatory algorithmic management, can inform the design of systems that prioritize workers' values. The public discourse on automation at work is preoccupied with the technical aspects of AI, such

Rather than treating automation as an inevitable force that workers must adapt to, we need to recognize it as a social process that can and should be shaped by those it affects most—workers themselves.



as evaluating model capabilities and the specific tasks they may be able to perform. This preoccupation treats automation as an unstoppable, technical force that workers must adjust to [7], rather than as a sociopolitical one they can influence and direct. Workers have agency. They can resist automation, shape it—even refuse it.

TOWARD WORKER-LED AUTOMATION

HCI researchers and practitioners have a crucial role to play in challenging these assumptions and informing the development of worker-led automation. There are several main ways to do this. First, *empirical studies of worker autonomy*, preferences, and the impact of automating certain parts of work are essential. For example, how does task automation affect workers' sense of agency at work? Existing research largely investigates this topic with the goal of measuring how automated a task can be before one feels a loss of control. Are there contexts, tasks, or working structures where automation can increase workers' feelings of agency? Which tasks do workers see as most pressing to automate?

Second, most AI models are far from democratic or participatory, even in the most basic sense. Further design methods, case studies, and technical tools for *developing participatory AI and governance in the era of LLMs* will be crucial to maintaining worker

agency. What are democratic ways of uncovering the automatable tasks that people find least fulfilling? How can workers best have a say in how automated systems do those tasks? Hollywood writers may not want management to create new scripts using GPT, but they might be open to other writers using a model trained on their work to brainstorm story ideas. Systems that allow writers to place limits on that model's use, such as only using work from a particular era of their career, could help writers maintain agency. With worker voice, automation has the potential to be an empowering tool. Frameworks for answering these questions will be critical to workers fighting for advancements or limits in how their work is automated.

Third, the impact of algorithmic management systems and workplace automation on *worker well-being and mental health* is still largely unknown. Scholars like Emilia Vignola have raised urgent questions about these technologies' impact on several dimensions of job quality, such as task significance, schedule stability, and trust, that have links to health. Understanding these impacts will be central to workers and organizers who want to negotiate and strategically direct automation in their workplaces. To measure this impact, longitudinal studies done in collaboration by HCI researchers, occupational health

scholars, and public health scholars are desperately needed.

Finally, the case of the WGA's stance on AI-generated screenplays offers a glimpse into how workers can collectively negotiate the use of these technologies in their industry. As I've argued elsewhere [6], collective regulation through worker codetermination, union negotiation, and other forms of workplace democracy is a promising way to shape the future of work in a manner that prioritizes worker autonomy and agency.

Achieving these goals requires more than developing new technologies. It asks for a paradigm shift in how we approach technology in the workplace and automation as a whole. Rather than treating automation as an inevitable force that workers must adapt to, we need to recognize it as a social process that can and should be shaped by those it affects most—workers themselves.

ENDNOTES

1. Writers Guild of America. 2023 Pattern of Demands. Apr. 29, 2023; <https://www.wgacontract2023.org/the-campaign/pattern-of-demands>
2. Scheiber, N. and Koblin, J. Will a chatbot write the next 'Succession'? *New York Times*. Apr. 29, 2023; <https://www.nytimes.com/2023/04/29/business/media/writers-guild-hollywood-ai-chatgpt.html>
3. Galimberti, J. *Images of Class: Operaismo, Autonomia and the Visual Arts (1962–1988)*. Verso, 2022.
4. Alkhatib, A., Bernstein, M.S., and Levi, M. Examining crowd work and gig work through the historical lens of piecework. *Proc. of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, New York, 2017.
5. Tronti, M. The strategy of refusal. *Semiotext(e) 3, 3* (1980), 28–34.
6. Calacci, D. and Stein, J. From access to understanding: Collective data governance for workers. *European Labour Law Journal 14, 2* (2023), 253–282; <https://doi.org/10.1177/20319525231167981>
7. Frank, M.R. et al. Toward understanding the impact of artificial intelligence on labor. *Proc. Natl. Acad. Sci. 116, 14* (2019), 6531–6539. DOI: 10.1073/pnas.1900949116

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This forum features game-practitioner perspectives on the interaction design process, techniques, and evaluation involved in creating playful experiences. We focus on how technology advancement, infrastructure, and constraints shape the player experience. — **Pejman Mirza-Babaei, Editor**

Unleashing Immersive Experiences

The Power of Gesture-Based VR Interaction

Nour Halabi, Ontario Tech University, **Evan Jones**, Stitch Media, **Pejman Mirza-Babaei**, Ontario Tech University

Games, as a platform, have the power to transport us to different worlds, providing unique and captivating experiences. In the realm of virtual reality, this potential is amplified, offering a level of immersion that was previously unimaginable. What makes VR even more exciting is the possibility of gesture-based interactions, where the players' bodies become the controllers, bridging the gap between the virtual and physical worlds. In this article, we delve into the realm of gesture-based VR interaction design, exploring the experiences they unlock and how they have changed not only the gaming landscape but also the interaction design space. Our exploration is inspired by a collaboration between Stitch Media, a Canadian game development company, and UXR Lab, an academic research lab at Ontario Tech University, on the development of *Broken Spectre*, a commercial VR game that utilizes gesture-only interactions to enhance player immersion.

VR platforms such as Oculus Quest have revolutionized the gaming landscape through groundbreaking innovations such as full-body movement and gesture-based interactions. These platforms leverage advanced technologies such as microelectronic sensors, including gyroscopes, magnetometers, and accelerometers, to determine the orientation of a user's body, providing inside-out tracking and hand-tracking capabilities. Combined, they represent a fundamental change in

the way we think about designing game interactions. For example, by freeing players from the constraints of traditional controllers, VR platforms are enabling players to use their own body parts (e.g., head, hands, legs) as intuitive input mechanisms. Unlike in the real world, however, the absence of proper force feedback limits the ability to make interactions feel truly natural. Moreover, VR experiences may create a mismatch between the vestibular system and other sensory stimuli; for example, when your vision indicates an acceleration of some sort but that acceleration doesn't match with your movement in the real world, it could lead to the unpleasant sensation of motion sickness (also referred to as *simulation sickness* in VR design). Balancing the enticing possibilities of this platform with the complications it poses is the challenge of designing for virtual reality.

Gesture-based VR interaction has the potential to revolutionize gaming experiences, offering players unparalleled levels of agency, presence, and immersion. Agency involves the control and influence that players feel over their virtual surroundings. By using their bodies for in-game actions, players experience a heightened sense of agency, as their physical movements seamlessly translate into virtual actions. This empowerment allows them to shape their experiences and make meaningful choices, resulting in a deeper sense of engagement and presence. Presence is the feeling of truly "being there" in the virtual environment, both physically and mentally. Gesture-based interactions play a significant role in enhancing presence by establishing a direct and immediate connection between the player's physical body and the virtual world. When players can perform gestures that mirror real-world actions and interact with objects directly, they become immersed in the game world. Immersion is crucial, as it integrates the player's senses, emotions, and actions with the digital experience, creating more captivating, memorable games. The seamless and responsive nature of gesture-based interactions elevates the level of immersion that players can achieve, allowing them to fully embrace the narrative and challenges presented by the game. This level of immersion has the potential to enhance storytelling, deepen emotional connections, and empower players to fully embody their virtual counterparts and shape their individual destinies within the game.

Insights

- Gesture-based VR interaction offers unparalleled immersion and engagement, blurring the boundaries between the real and virtual worlds.
- Design considerations such as intuitiveness, tutorialization, and accessibility are crucial for creating user-friendly and fulfilling gesture-based interactions.
- The collaboration between game development studios and academic HCI research labs may provide valuable insights and guidance for designing effective gesture-based interactions.

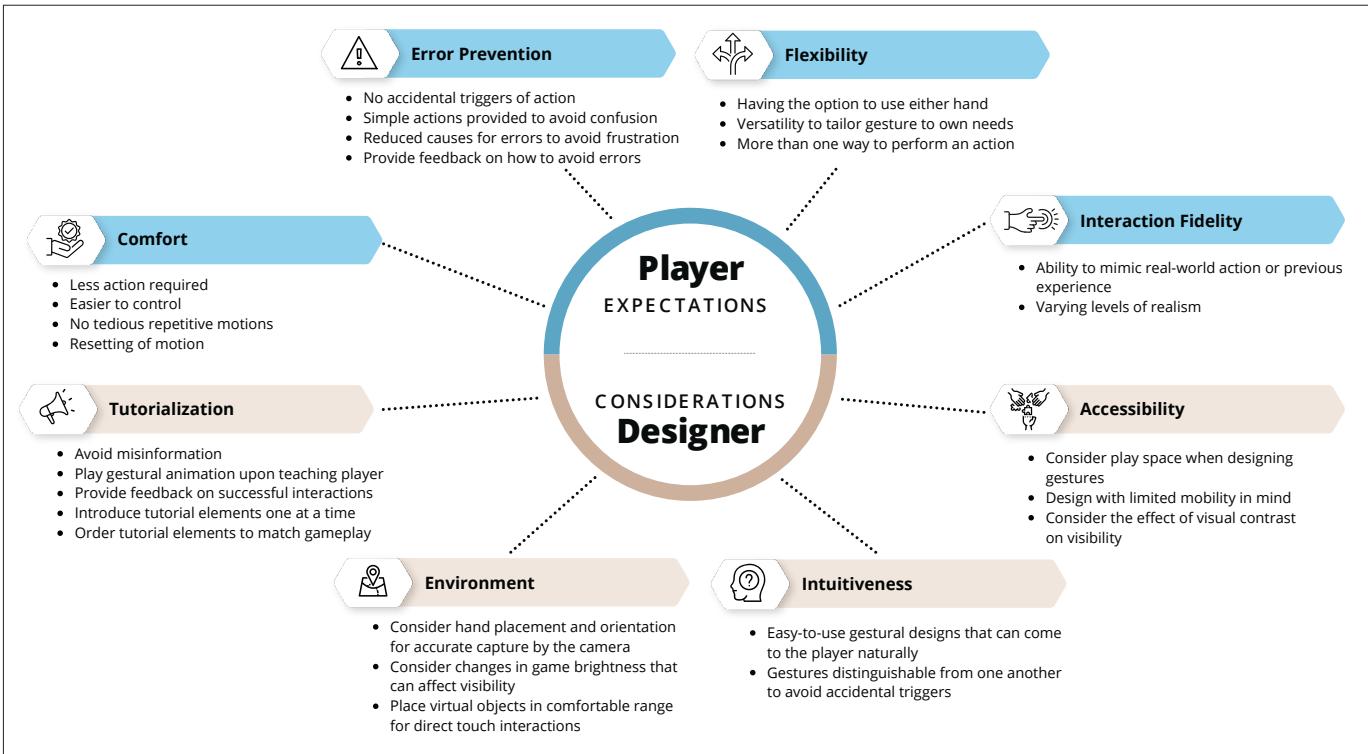


Figure 1. A reflection on designer considerations and player expectations.

DESIGNING FOR IMMERSIVE GESTURE-BASED VR INTERACTION

Designing controls that feel natural and intuitive is an exciting challenge. Game designers often have their own expectations and ideas about how a game should play, but it is crucial to align these with the player's actual experience. We strive to understand the player's needs and requirements, taking inspiration from their mental model—a framework that helps us grasp their expectations and how they interact with the system. By designing games that take the player's mental model into account, designers can create intuitive and user-friendly systems based on familiar interaction patterns.

Through our collaboration, an understanding of the key design considerations emerged, which we dive into below. From the designer's perspective, considerations such as intuitiveness, environment, tutorialization, and accessibility are crucial (Figure 1). First, designers should align gestures with the player's mental model, providing intuitive interactions that are distinguishable from one another. Second, the environment, both physical and virtual, plays a significant role. Designers must

consider the affordances and technical constraints of the system, such as the hand placement and orientation being accurately captured by the camera or the visibility within the digital environment. Third, tutorialization is important for introducing novel interactions to players and avoiding misinformation when adapting and learning new ways of interaction. The lack of tangible feedback generated by controller-free interaction in the virtual world may require both additional time for players to get accustomed to and adequate attention to other feedback sources (audio and visual). Lastly, accessibility should be addressed, taking into account factors such as play space, handedness, and the ability to play seated or standing. Providing options that cater

to different user needs expands the accessibility of the game. For example, in *Broken Spectre*, players are given the option to sit while playing, which makes it accessible for a broader range of users. Another example is the rock climbing interaction, which has a significant role in *Broken Spectre*. Through iterative development to the climbing gesture, two modifications were implemented that take into account the discussed considerations. One is where the players' virtual hands can securely latch onto rocks after performing a grasping motion. The other is a visual indicator that simultaneously informs the player which rock is eligible for snapping when gazed upon and when their hand is fully snapped to a rock.

Players, however, have their own expectations when it comes to gesture-based interactions in VR. They expect comfort to be taken into account by avoiding tedious or repetitive motions. Accounting for the ergonomics of the interaction and conducting user testing will help designers decide which gestures are unsuited for continued repetition over a long time period. Another key expectation is interaction fidelity, which we discuss in greater detail below, where players' level of immersion is influenced

The introduction of gesture-based VR platforms has unlocked a multitude of experiences that were previously unimaginable.



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SUGGESTED FURTHER READING

Jicoli, C. et al. Effects of Emotion and agency on presence in virtual reality. *Proc. of the 2021 CHI Conference on Human Factors in Computing Systems*. ACM, New York, 2021; <https://doi.org/10.1145/3411764.3445588>

McMahan, R.P., Lai, C., and Pal, S.K. Interaction fidelity: The uncanny valley of virtual reality interactions in virtual, augmented and mixed reality. *Visual, Augmented and Mixed Reality: VAMR 2016. Lecture Notes in Computer Science* 9740. Springer, Cham, 2016; https://doi.org/10.1007/978-3-319-39907-2_6

Rogers, K., Funke, J., Frommel, J., Stamm, S., and Weber, M. Exploring interaction fidelity in virtual reality: Object manipulation and whole-body movements. *Proc. of the 2019 CHI Conference on Human Factors in Computing Systems*. ACM, New York, 2019; <https://doi.org/10.1145/3290605.3300644>

Stahlke, S. and Mirza-Babaei, P. Chapter 7: Rejecting your reality. In *The Game Designer's Playbook: An Introduction to Game Interaction Design*. Oxford Univ. Press, 2022.

Warren, L.E. *The Effect of Interaction Fidelity on User Experience in Virtual Reality Locomotion*. Master's thesis, Virginia Tech, 2018.

by their expectation of having varying levels of interaction fidelity, such as the ability to mimic real-world actions in certain situations. Flexibility in interactions empowers players to tailor their experience, while error prevention is necessary to avoid frustration when the resulting behavior does not match what the player expected from the gesture or the player is uncertain why an error occurred. To ensure a seamless immersive experience, minimizing errors and providing reliable feedback is necessary.

These considerations serve as a valuable guide for developers, helping them navigate the challenges and complexities of designing gesture-based interactions in VR, ultimately leading to the creation of captivating and immersive gaming experiences.

ENGAGING WITH OBJECTS THROUGH GESTURES: EXPLORING THE SPECTRUM OF INTERACTION FIDELITY

Engaging with objects in the virtual world through gesture-based interactions is another key element for immersion based on varying levels of

interaction fidelity. Interaction fidelity is a spectrum that refers to the realism and responsiveness of the virtual world's response to the player's physical actions.

At the lower end of the spectrum, we find basic interaction fidelity, where virtual objects respond in a simplified and generalized manner. At this level, the focus is on conveying a basic sense of object presence and interaction. While the level of realism and responsiveness may be limited, it still allows users to engage with and manipulate virtual objects to some extent. Basic interaction fidelity is suitable for introductory experiences or situations where a more casual and accessible approach is desired. Moving up the spectrum, we encounter moderate interaction fidelity, which enhances the believability of object interactions. Here, virtual objects exhibit more-realistic behaviors and responses. Physics simulations, material properties, and object dynamics are taken into account to create a heightened sense of authenticity. For example, when we pick up a virtual cup, it may have weight and react to our movements as we tilt it or pour liquid from it. At the highest end of the spectrum, we find advanced interaction fidelity. This level aims to replicate the real-world interactions with the utmost precision and realism. Virtual objects respond in a highly realistic manner, closely mirroring the physics and behaviors of the real world. Every gesture, subtle movement, and touch is accurately captured and translated

The player's "mental model," their intuitive understanding of how things function, greatly influences their gaming experience. By aligning the designer's perspective with the player's understanding, we can bridge the gap and create seamless experiences.



Figure 2. A screenshot from the game *Broken Spectre* showcasing the use of the compass movement gesture and the representation of a ghostly figure. Upon gaze detection, the figure appears ahead to represent preordained locations where the player can teleport to once they confirm the movement by closing their hand.



Figure 3. A screenshot from *Broken Spectre* showcasing the use of swing gestures (interaction) to cut through thick grass with a sickle that mirror real-world actions.

into the virtual environment, creating a profound sense of presence and agency.

Broken Spectre creatively leverages these interactions, enabling players to seamlessly pick up, manipulate, and interact with various objects in the game world. For instance, players can extend their hand to grab a virtual object and perform gestures to manipulate it (Figures 2 and 3).

CONCLUSION

Gesture-based VR interaction has opened up new avenues for immersive experiences in gaming. The insights shared in this article highlight the significance of agency, presence, and immersion in designing effective gesture-based interactions. By empowering players with control and influence over their virtual

surroundings, creating a sense of “being there” in the virtual environment, and enhancing overall engagement and immersion, developers can fully harness the potential of gesture-based VR interaction. Through the collaborative efforts of Stitch Media and UXR Lab, key design considerations have emerged, encompassing intuitiveness, environment, tutorialization, and accessibility from the designer’s perspective, as well as comfort, interaction fidelity, flexibility, and error prevention from the player’s perspective. By integrating these considerations, developers can navigate the complexities of designing gesture-based interactions, resulting in user-friendly and captivating gaming experiences. As we venture further into the realm of gesture-based interactions, there are still many unexplored research avenues and exciting possibilities to be discovered.

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Matt Jones,
ACM SIGCHI



Purpose, Passion, Growth, and Service

Why You Should Join a SIGCHI Chapter

When you hear the name *SIGCHI*, what comes to mind first? For many, I expect it's the conferences and other events that SIGCHI volunteers curate and organize every year. When you attend one of these events, you probably—like me—are inspired and enthused by the passion, energy, and diversity of the people and ideas you encounter. But what happens to these energies between such intellectual gatherings? The answer for many in our community is that they continue to encourage, learn, and build one another up through being part of a SIGCHI chapter.

Join a SIGCHI chapter—that is my main message. Why? Because it will give you access to a bigger community of like-minded people—scholars, practitioners, entrepreneurs—who care about the future of technologies and how they affect our lives.

What is a chapter?

Yes, *chapter* is a strange word that derives from medieval times when communities would meet to develop their sense of togetherness.



More recently, chapter, as applied to professional and scholarly organization, has signified a welcoming of perspectives and backgrounds—a safe intellectual space for people to come together and debate ideas. As I hope you know, this is what we welcome within the SIGCHI community.

So what are SIGCHI chapters?
There are more than 60 active

SIGCHI chapters. They're made up of scholars, students, practitioners, entrepreneurs, and thinkers who care about making *people* and *people's values* the primary focus of all design thinking and come together to push ideas forward. Chapters have typically been strongly connected to a particular city or region, although we also have a number of thematic ones (such as arts

Together, SIGCHI chapters create space for conversations that are both hyperlocal and globally inclusive.

in HCI). Some have been active for decades, with new ones starting up all the time.

Each of our SIGCHI chapters is a place where people meet to express their design creativity and work to drive a vision of technology and technologies that is focused on designing with and for people—globally. Together, SIGCHI chapters create space for conversations that are both hyperlocal and globally inclusive.

In joining a chapter you benefit in many ways. SIGCHI chapters organize regular seminars, networking events with industry and social enterprises, fun meetups, and more. Visit our chapters site (<https://sigchi.org/chapters>) to find out how to join one. I also encourage you to think about what you can *give* by being part of one of these communities. Your ideas, experiences, and concerns are important to the global SIGCHI community—your participation and ideas are part of enriching us all. With your help, we can understand how to affect and change the direction of developing digital and technological economies. Together, we can push for technologically enhanced infrastructures and societies that are open, accessible, and equitable.

Since forming the current SIGCHI Chapters Committee in 2022, my team and I have met with many chapter leaders and members to understand what makes for a successful chapter. We have been uncovering barriers to as well as opportunities for growth. The chapters team and I believe that SIGCHI chapters are the “hidden superpowers of SIGCHI,” offering on-the-ground, local perspectives to create a more globally grounded SIGCHI. We have set up initiatives to help reenergize chapters post-pandemic. We have enabled interchapter visits within and between regions. We have facilitated conversations on creating better connections between local and global understandings. We have surveyed the community and hosted in-depth one-on-one conversations so that we can improve our support materials for both new and existing chapters. In the coming months, we will launch a Web-based visualization so that you can see where chapters are already present and find one near you. If there isn’t one, we can help you form one!

In closing, I hope when you next see or hear the name *SIGCHI* your first

thought will be of the thousands of community members around the world who are part of our chapters network, the people who support, grow, and sustain the valuable work of HCI—human-computer interaction, with the emphasis on *human*. I also hope you will be motivated to find a chapter that you can serve and jump right in.

To find out more about our work, visit our website (<https://sigchi.org/chapters>). Look for announcements via email, X, and Slack that flag our regular chapters online meetings or drop us a line, including requests to join our Slack channel, at sigchi-vp-chapters@acm.org.

ACKNOWLEDGMENTS

Many thanks to the members of the SIGCHI Chapters Committee who have provided valuable volunteer labor as we work to help our community thrive and flourish: Mark Kramer, Dani Raju, Jeni Paay, Masitah Ghazali, Manjiri Joshi, Pranjal Jain, and Pawel W. Wozniak.

 **Matt Jones** is SIGCHI vice president for chapters. He lives and works on the beautiful and inspiring West Wales coast.
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When Sir Tim Berners-Lee first proposed the foundations of the World Wide Web at CERN in 1989, his manager called it “vague, but exciting.” How things have changed since then! Twenty-six years later, Berners-Lee won the ACM Turing Award “for inventing the World Wide Web, the first Web browser, and the fundamental protocols and algorithms allowing the Web to scale.” This book is a compilation of articles on the original ideas of a true visionary and the subsequent research and development work he has led, helping to realize the Web’s full potential. It is intended for readers interested in the Web’s original technical development, how it has changed over time, and the social impacts of the Web as steered by Berners-Lee since the very beginning.

The book covers Berners-Lee’s development of the key protocols, naming schemes, and markup languages that led to his “world wide web” program and ultimately to the Web as we know it today. His early efforts were refined as Web technology spread around the world, and he was further guided by the work of the World Wide Web Consortium, which he founded and still directs. He was instrumental in the conceptualization and realization of the Semantic Web, a field that is gaining momentum in the age of big data and knowledge graphs; was a driving force for the field of Web Science, a new and growing research area dedicated to the study of both the engineering and the impacts of the Web; and he continues to innovate through his research work at MIT on open and decentralized information. Berners-Lee is also known for his contributions to keeping the Web open and ubiquitous via his work with the World Wide Web Foundation, the UK’s Open Data Institute and his recent call for a crowdsourced magna carta for the Web. This book will help the reader to understand how Sir Tim’s invention of the World Wide Web has revolutionized not just Computer Science, but global society itself.

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Linking the World's Information

*Essays on
Tim Berners-Lee's
Invention of the
World Wide Web*

Oshani Seneviratne, James Hendler (Editors)

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February

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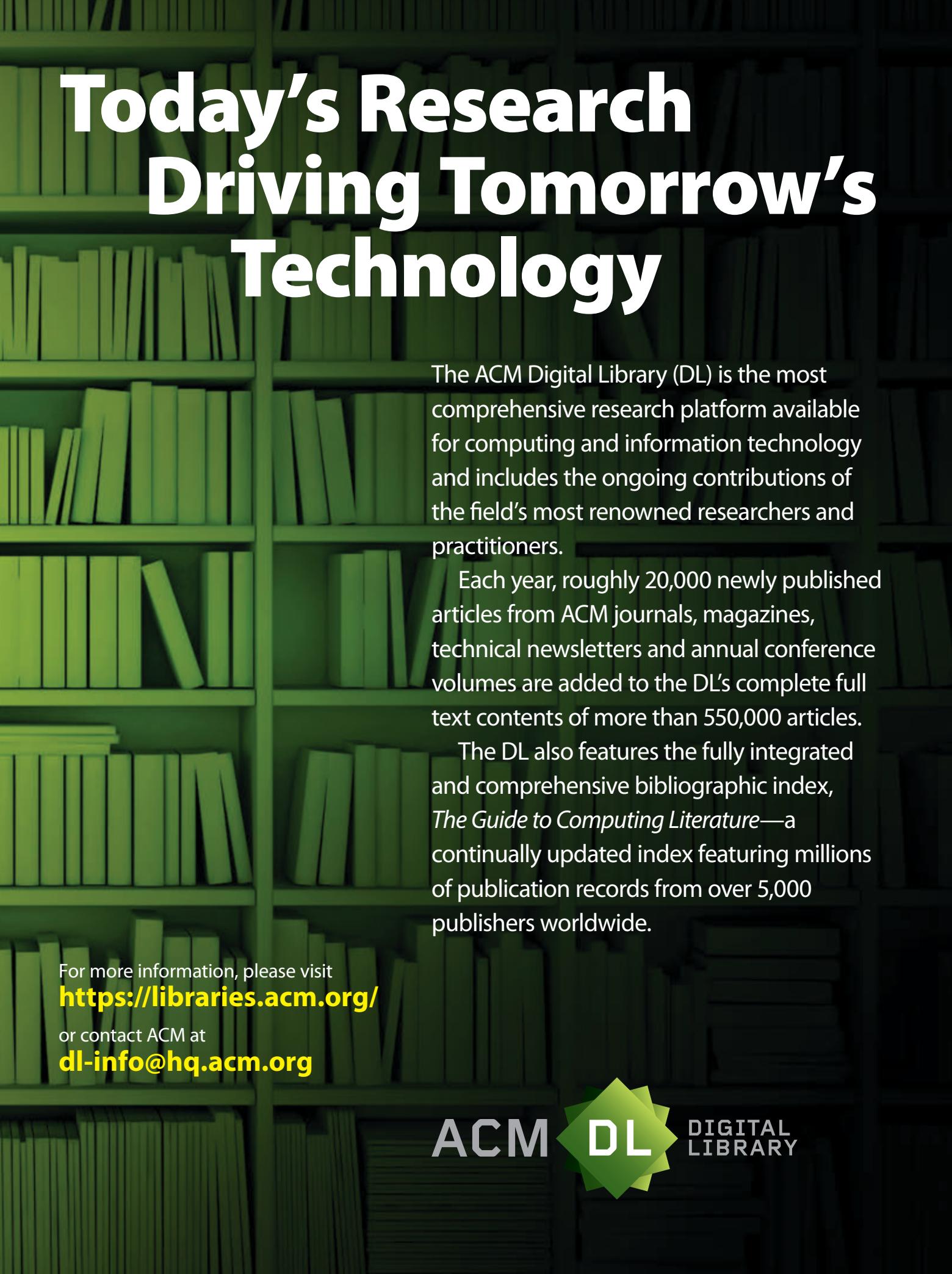
Bukit Brown Index #133

Contributor: Jennifer Teo, acidiq@gmail.com
Curator/Editor: Jude Yew

Triptych of the Unseen (Redux) is a virtual reality installation artwork by Post-Museum in Singapore. Since 2011, Post-Museum has been involved in trying to save Bukit Brown, an important cemetery and nature space in Singapore. The artwork encapsulates the issues of the campaign through the viewpoints of an activist, a bureaucrat, and a female ghost, relating a struggle that is reenacted in any site that undergoes redevelopment. The work is currently showing at Perilous Playground at the Chinese Culture Center of San Francisco.

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