

Design Fiction for Real-World Connected Wearables

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ABSTRACT

Wearable IoT technology has too much potential to be limited to a wristband. How can we design wearables with more variety while still providing value to the user? We describe a work in progress to develop a novel method of Participatory Design Fiction to inspire a real-world, everyday wearable IoT system. We show how this has led to a greater understanding of our users' needs, resulting in a technology probe for an everyday wearable IoT system that works towards meeting those needs.

CCS CONCEPTS

• **Human-centered computing** → **Ubiquitous and mobile computing design and evaluation methods.**

KEYWORDS

participatory design fiction, wearable computing, internet of things, design fiction, science fiction prototyping, participatory design, user-centred design, research through design

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1 INTRODUCTION

It has been alleged that "wearables are boring" [23]. As of 2019, wearables are increasingly popular, but their forms and functions in the mass market are constrained to the "black-slab incrementalism" [30] of smartwatches, fitness bands, and, increasingly in 2019, hearables [11]. Indeed when well-designed, these wearables are useful, sensible and go with everything. Is it too much to ask for wearables to also be exciting?

This paper describes an ongoing research through design of an everyday wearable IoT device using a novel participatory method of Design Fiction [2] at the inspiration phase [6], to elicit concepts directly from users, starting from a clean slate with no predefinition of form or function. We analyzed the Participatory Design Fictions to gain actionable insights into what the users wanted from an everyday IoT wearable. We applied these insights in a user-centred

design phase to build a real-world technology probe [4] to be worn by volunteers in the wild. This is a new approach to the design of everyday IoT wearables.

By eliciting concepts directly from participants about what wearable device to make, our approach contrasts with most participatory design studies, which typically seek participants' insights on a preselected wearable device type. For example, how would the participants design an activity monitor [28]? In this study, the only restriction of form or function is that the device must be an "everyday IoT wearable". By "IoT wearable" we mean that the wearable device must transmit or receive data to or from an endpoint. By "everyday wearable" we mean that it must be for use by independent adults in routine, free-living situations. This means that wearables with a medical, safety-critical, occupational or otherwise specialist application are outside the scope of this study - in effect excluding wearables that are worn out of necessity and including those worn out of preference.

It is well known that wearables need a more user-centred approach to design [26] [12], and there are other identified obstacles, such as privacy, and integration into an IoT ecosystem [12], which we address by the use of the Hub-of-all-Things (HAT) personal data store (<http://hubofallthings.com/>) to provide a privacy-preserving software infrastructure for IoT integration. The study is considering the wearable device as a system, and gaining insights from the success or failure of the wearable device to function within the system. We will be using the Design Fictions for reflection as well as inspiration, allowing us to fold considerations of ethics into the design process from the start.

2 MOTIVATION

The motivation of this research is to find a way of designing novel and interesting wearables as "enchanted objects" [30] that add value to the wearer's everyday life. That value could be practical, emotional, or something inbetween. Lazar et al. [21] did an informative study in which users received a budget to buy their own choice of commercial wearables, and one reason for the high abandonment rate (80%) was users' perception that the device did not match their self-concept: they felt it was not really meant for them but for some other type of person, such as an "avid health freak". Another reason was a perceived mismatch between device functionality and users' needs: "I don't really need to know this information every single day". As ten Bhömer put it, "With these devices here, there is still one question that is mainly unanswered: how can these close-to-the-body technologies create value for us as human beings? [...] I personally still have not found the compelling reason to keep using these systems." [35].

Although most studies of wearables design have focussed on individual solutions, there have been a number of valuable publications on the design of wearables as a whole [26] [25]. Those

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which have featured novel forms and functions [13] have "pushed" the concepts from designer to user. When users positively evaluate such designs in the lab, that does not necessarily mean they want to wear them in the real world.

A naive approach would be to simply ask users what they want. This is not often recommended. Michelles et al. [24] suggested that too much focus on users would be a hindrance to designing radically new concepts, and argued for designers to build prototypes as a basis for discussion with users. Mueller et al. [27] tried asking users for ideas but then rejected those ideas as unoriginal, since they were either already on the market in some form, or derived from film or television. Did those ideas deserve a second look?

3 BACKGROUND

If users are taking inspiration from existing media, perhaps they were meant to. Not only has film had a demonstrable influence on HCI [32] [33] [20], the "diegetic prototype" has been used to influence public policy and to successfully attract funding for technology in the real world [19]. As for ubiquitous computing, Dourish and Bell [10] have pointed out the particular relevance of science fiction to design research in this domain, because of its "explicit focus not only on the extrapolation of current technological opportunities, but the imaginative and speculative figuring of a world in which new technologies can be applied". Technologies in science fiction are portrayed as part of a societal context. Dourish and Bell's work heavily influenced Julian Bleeker's [2] seminal work on Design Fiction, in which he argued, "It all matters because we care about imagining and materializing future habitable worlds [...] finding effective mechanisms for creating these more habitable worlds really is our concern."

Might Design Fiction be a way of connecting with users and eliciting concepts for wearables from them? Has anyone successfully elicited concepts for wearables from users, and how? Jones et al. [18] used the "magic thing" [16] technique - mocking up an imaginary mobile device and following a user through daily activities with it. The study was not specifically about wearables, but the form factor was a wristband, and most importantly the functionality was limitless, unbounded by any reality, including the reality of the wristband's form factor. Among the things users wanted their "magic thing" to support were:

- (1) protection from abuse;
- (2) connection to friends and loved ones;
- (3) enhanced ability to read other people;
- (4) dance tutorials;
- (5) emotional wellbeing and health.

Jones et al. used roleplay with a mockup of an imaginary item to get emergent users of mobile technologies to show what they wanted. Could fiction be used as a way of getting potential users of wearable technologies to tell what they wanted?

Although Design Fiction has never been strictly defined [7], arguably its essence is the "deliberate use of diegetic prototypes to suspend disbelief about change" [5]. It is this suspension of disbelief that I hoped would unlock the users' imaginations in this exercise.

A Design Fiction can be delivered in various forms: text, film, comic book, design artefact, advertising copy, and so on. Design

Fiction is usually treated as a thought experiment [3], though a notable variant is Johnson's "Science Fiction Prototyping" [17] which is treated as a step in the development process.

Participatory Design Fiction is beginning to emerge as a discipline [22]. There is only one other instance of Participatory Design Fiction that has touched on everyday wearables [1], which were a detail, not the focus, of a larger study in urban planning.

Johnson provides "Five Steps" to develop a Science Fiction Prototype:

- (1) Pick your science and build your world
- (2) The scientific inflection point [place your technology into your world]
- (3) Ramifications of the science on people
- (4) The human inflection point [characters at their wits' end]
- (5) What did we learn?

This five-step prompt seemed adaptable to a five-minute storytelling timeslot, long enough to flesh out a story but brief enough to devise that story during a workshop, and reduce pressure on attendees who might find public speaking stressful:

- (1) Minute 1: Introduce your character and build your world
- (2) Minute 2: The Wondrous Wearable
- (3) Minute 3: A day in the life
- (4) Minute 4: Drama! Conflict!
- (5) Minute 5: Resolution! Sequel?

If attendees could devise and tell a story from that prompt, and come up with a low-fidelity representation of their wearable - a drawing or a paper prototype [15] - that might provide a basis for inspiration. The prompt, together with the materials provided for the paper prototyping, would become a Creative Toolkit [31] for a Design Fiction-driven framework for designing everyday wearables. I set out to recruit a small group of six members of the public as volunteers, seeking a counterbalance of genders, of technical ability and of fashion interest, as well as a wide range of ages.

This research draws inspiration from Wallace's [38] explorations of digital jewellery. Keeping the number of volunteers small was important in order to devote proper attention to each volunteer's story, understand their desires and motivations and tastes, and personalize the technology probe. With only the skills of a maker at my fingertips, any device I offered to users had to be something they would plausibly wear in public at least once.

4 IMPLEMENTATION

4.1 Pilot Studies

In October 2017 I set up two pilot studies consisting of two 150-minute and two 60-minute workshops respectively. The first pilot was open to the public, as part of the Cambridge Festival of Ideas 2017 (CFI17), hosted by Makerspace. The second was hosted by the Design Informatics Program at the University of Edinburgh. The purpose of the pilot studies was to see if the workshop format and creative toolkits were supportive enough for attendees to successfully tell stories, and find the experience at least reasonably enjoyable.

At the first CFI2017 workshop, one of the attendees had radically misunderstood the brief and opened up an analytical discussion of the current market in wearables, and what people (in general) might

want from them. I let the discussion continue for 15 minutes before intervening. The analytical start produced a detailed breakdown of the problem space, but the storytelling was stilted and the wearable concept was nebulous compared to subsequent workshops, in which the analytical discussion came after each story.

4.2 The creative toolkit

The creative toolkit consisted of a) story prompt; b) craft materials; and c) a dressing-up box.

For the story prompt, I emphasized that the participants could draw upon existing media or make up their own original story, which could be set in any time period in the past, present or future; and be in any genre (not just Science Fiction). I also emphasized that the Five Steps were a basis for improvisation and not a mandate. I provided a sheet of preparatory information, and led each session with an example Design Fiction based on the children's book "Many Moons" [37].

For the paper prototyping, I provided abundant craft materials including plenty of paper, card, pens, paints, glitter, glue, brushes, rulers, scissors, adhesive fabric and so on. I also provided a large variety of embellishments.

I also provided a dressing-up box with children's toy costume items as well as a set of real but characteristic clothing. The latter was not much used, so only the toy items were retained in the finalized creative toolkit.

4.3 Recruitment

After four pilot workshops, 20 participants had told 11 different stories and I concluded that the workshop format was feasible with no changes needed. I held an inaugural public workshop to recruit six volunteers for the two-year longitudinal study. Eight volunteers signed up including three from the public pilot workshops. Of these, one moved cross-country and another faded, leaving technically seven but really six long-term volunteers.

Only one of the volunteers is male, even though the workshops were publicized through multiple channels including Makespace, which counts no shortage of men in its population. The goal of counterbalancing genders was therefore not met. However, the group does feature a wide range of technical ability and a reasonable age range, and two of the volunteers have disclosed disabilities. Notably, although five of the eight CFI17 attendees were white British, all of the long-term volunteers are white British; this may be an effect of the current political situation.

I considered recruiting a control group to compare Participatory Design Fiction against a more classic method. I ruled it out because recruiting 12 longitudinal study participants instead of six seemed like a precarious dependency, as would doubling the resources required to complete the research activity. Furthermore, given the inherently subjective nature of the workshops and the reality that I would have been the one leading the workshops for both groups, it would have been too easy to bias the results in favour of my own method; I would have expended twice the resources and still not necessarily produced strong enough evidence either way. Furthermore, my goal is not necessarily to prove that my method is better than other participatory methods for inspiring everyday IoT wearables - only that Participatory Design Fiction is a potentially

worthwhile method for the purpose. Additionally, I wanted to create a particular kind of imaginative space in which to work with the participants. Therefore I decided to focus on developing the method first, and verify it afterwards.

4.4 Final Stories

Following another workshop to firm up the Design Fictions, we had the following stories:

- (1) AI Companion: a knowledgeable AI kimono. "Ursula" told a story about her character "Jacinda Dragonfly" from her previously published work. Jacinda is a steampunk space archaeologist who seeks out antiquities and outwits villains across the galaxy. In her spaceship is an AI companion, "Mr X", who has transcended his programming and developed a mind of his own. Mr X can "assist with information both tactical and historical", and is good company to boot. To support Jacinda to go planetside, Mr X is woven into a jacket which "looks like a cross between a 1940s detective overcoat and a traditional kimono". The pattern of the fabric changes as Mr X's preferred avatars are seen moving across the hem. Combined with Jacinda's quick thinking, Mr X's just-in-time retrieval of information about rare artifacts helps them to triumph in confrontations with shady characters.
- (2) Empathy-In Glasses, Empathy-Out Gloves: "Trudy" imagined these to help her little brother, who is on the autistic spectrum. She was inspired by the novel *Extremely Loud and Incredibly Close* [14]. A boy has special glasses that let him read others' emotions by showing them to him as an aura of colour. He has gloves that change colours to express his feelings to others around him. One day on the playground, the jealous school bullies beat up the boy, and steal his glasses and gloves. But then the glasses show them what they have done to the boy, whose aura is so sad and grey. Moved to remorse, they return the glasses and gloves to the boy.
- (3) Mood Bracelet: a colour-changing, emotion-sensing bracelet, ring, or shirt. "Serena" imagined an alter ego, "Margherita Banks", known as Rita to her friends. Margherita wished she could be known as "Daisy" but feared her disposition was not sunny enough. Rita told herself her name was probably short for IrRITable, so troubled was she by her high-strung disposition. One day, Rita found a curious bracelet in her local junk shop, but when she went to pay for it, the shopkeeper questioned her taste. Rita felt a stab of irritation, and she saw that the bracelet turned red. The changing colours would not only help Rita to regulate her moods and plan around them, but would also signal to others when a gentler interpersonal approach was needed.
- (4) Jacket of the True Self: a jacket with a dynamic gallery display. "Warren" told a quasi-autobiographical story of growing up as a misfit artist forced to study STEM. On the autistic spectrum, Warren was always on the outside looking in, a situation compounded by hearing loss from a workplace accident. But as his artwork practice expanded, people were drawn to speak to him, lessening his isolation. Warren imagined that one day, a strange jacket appeared, that showed images of the night sky and the beauty of nature as though

in an electronic frame. The jacket, a unique item, became an installation in a touring exhibition where people could wear the jackets and become a living gallery. The wearable gallery became "a confidence booster, something to engage others, and start that initial friendship", something that reduced the need for small talk and was "always available to cross this boundary".

- (5) Amelia-8 Positivity Patch: a context-aware badge with emotionally supportive images and slogans. "Hunter" told the story of Amelia, a disadvantaged but inventive girl genius, whose driving ambition was to make other people happy. Amelia invented and discarded one thing after another: the Anxiety Anklet to soothe you; the Watch of Wisdom to guide you; the Breathing Bracelet to calm you; the Scarf of Secrets to confide in; the Mask of Mystery to save face; Creativity Curtains to bring colour to your room; the Huggable Hoodie with Serotonin Sleeves to assuage your loneliness, plus Gloves of Glamour to match your outfit and look fabulous no matter how you feel. Finally, an encouraging teacher reviewed Amelia's inventions and suggested she combine all the concepts into one, so as to help as many users as possible. So she invented the Positivity Patch, which reads your serotonin level, incorporates a SAD lamp, and coaches you with context-aware slogans and images. Amelia pitched it as "The Badge that Boosts your Mood!" The Positivity Patch became a huge hit, and Amelia became a successful entrepreneur with a group of friends who understand her. And when the Positivity Patch isn't enough to make her friends happy, Amelia just sits with them, and listens.
- (6) Hat-of-all-Assistance: a magical healing hat made of moss. Rachel prepared a richly detailed five-step story of a woman suffering from the same fatigue disorder as she does. The woman endures many trials as her illness obliterates her life inch by inch. One day the woman is in the woods and, overcome by tiredness, lies down to sleep. She wakes up to find that she is wearing a beautiful hat trimmed with tendrils of moss. Gradually she realizes that the hat has healing powers. Bit by bit the woman gets her life back, and lives it to the full, enjoying countless adventures.
- (7) Wooden Horse: intuition doll for wisdom and self-protection. "Grace" was inspired by the film *Blade Runner 2049* [8], the daemons in *The Amber Spyglass* [29], and the Disney film *Child of Glass*. [9]. John is in an orphanage in a stark and joyless world where wood is rare and precious. He finds a wooden horse inside a chimney, where miraculously it was not burned by the fire. John hides the horse in a secret pocket near his cuff, where it communicates telepathically with him. When he puts the horse to his ear it jumps in and morphs into a hearing aid, and it speaks guidance into his ear. When he walks down a corridor, it warns him that bullies are that way, and he should take another route. When the bullies falsely accuse him, the wooden horse tells him the right words to say to stand up for himself. The horse speaks kindly and empathetically to John, protecting and comforting him.
- (8) Cloak of Carrying and Wish Spell Bottle: tactical pocket cloak; sympathetic magic pendant. "Erica" told a story using

characters from a modern television series, but in a neolithic setting. A Hermit has a cloak with many interior pockets, held closed by the latest technology - buttons. The Hermit carries supplies in the pockets: food, water, medicine and first aid. He helps an injured Shepherd Boy, who wears a wish spell bottle around his neck. The bottle contains iridescent insect wings and is decorated with an image of the Shepherd Boy's dog, his only true companion. When the Shepherd Boy is in distress - for example, over violence at home - he takes an insect wing out of the bottle and wishes on it, whereupon he is protected by sympathetic magic.

I then conducted 1-1 unstructured interviews to flesh out my understanding.

4.5 Proposed Real-World Designs

For each story and device I proposed a design that I estimated would be feasible for me to make. This is the difference between dreams and reality, and I set expectations accordingly.

Ethics prohibit monitoring of others without consent (such as, say, reading facial expressions with a mobile device) so all such functionality was excluded.

- (1) Artcodes Companion: coat or kimono with Artcodes [36] linking context-aware search
- (2) Empathy-Out Shirt: LED emoji shirt
- (3) Mood Bracelet: mood bracelet with idiosyncratic colour code
- (4) Gallery Shirt: conversation starter, displays artwork on eInk screen
- (5) Amelia-8: context-aware serving of affirmations and morale boosting pictures/slogans
- (6) eInk Visor of Wisdom: hat displays most important smart-watch alerts on front inside brim
- (7) Wooden Horse: context-aware earpiece speaks affirmations into ear
- (8) Cloak of Carrying and Wish Spell Bottle: tactical RFID pocket cloak; bottle pendant with small voice recorder

4.6 The Gallery Necklace

Participants voted by ranked majority on which device to build. The winner was the Gallery Shirt by a large majority. eInk shirts have existed for over a decade, but the important thing is the wearer's motivations. In Warren's case, the goal was to display his artwork while providing an icebreaker to connect with others socially.

A technology probe is supposed to provide the minimum viable functionality, so I chose an Adafruit eInk breakout board for ease of use. The small size made it suitable for a necklace, not a shirt. The microcontroller, an Adafruit Feather M0 Wifi (for sending a "hello world" record to the user's HAT personal data store), grew inexorably bulkier when connecting wires and casing were fitted. The only choice was to make it a statement necklace. Each device was personalized to the aesthetic expressed in the wearer's paper prototype. To fit Warren's minimalist style, he received a badge holder while everyone else got a necklace.

4.7 In The Wild

The necklaces were released to the users in January and February 2019 and all but Serena (Mood Bracelet) have worn it. I solicited



Figure 1: A Gallery Necklace ©Helen Oliver. Cat photo by "Threehahns", reformatted as b&w bitmap. [Public domain], via Wikimedia Commons. Licensed under the Creative Commons Attribution-ShareAlike 3.0 Unported license (https://commons.wikimedia.org/wiki/File:Female_tuxedo_cat.JPG).

feedback by email using the "I like - I wish - What if?" format (see <https://dschool-old.stanford.edu/wp-content/themes/dschool/method-cards/i-like-i-wish-what-if.pdf>):

- I Like: the most liked features were: the "statement" nature of the necklace, which served as an icebreaker that drew strangers into conversation. Warren and Grace (Wooden Horse) in particular found it useful for networking and showing off their artwork. However, Serena, who received the most flamboyant necklace, did not like the "statement" nature of the piece and wished for something more "everyday". During a particularly busy period of her life Serena had trouble finding an occasion to wear the necklace, and to select and process

images to display. Warren had the plainest-looking device but still did not want to wear it more than once for the same audience because of its core function as a gallery. Hunter (Amelia-8) found the form factor impractical and wanted a badge instead, and overall preferred the idea to its implementation.

- I Wish: the most wished-for enhancements were a GUI to upload pictures, change settings (e.g. intervals between image changes) and facilitate setup; more colours; convertible form factor (e.g. to a badge); a stronger and better-finished mechanical assembly; and a lighter weight (Grace alone was happy with the weight, and her necklace was the lightest at 67g). Grace wanted animated images, and Hunter wanted an app with a library of preformatted images.

All of the wished-for enhancements would normally be included in the process of developing the necklace from a technology probe into a mature product. Warren, an engineer, had no trouble with the manual setup whereas Grace, who struggles with technology, found the setup process extremely stressful.

- What if: Ursula (AI companion) wondered if the necklace could be made more sturdy with a 3D-printed or vacuum-formed unit to form a solid collar (currently the neckpieces hide the wiring and the on-off switch). Warren and Serena both wondered if the form factor could be made convertible to a badge or bag charm.

Time permitting, we had an opportunity to replace the Feather with a very small component with a choice of Lax-driven sensor [34] (at the cost of porting all the code to C). Everyone wanted a smaller/lighter device except Warren and Grace. Warren did not want a sensor but would have accepted an accelerometer (which is available) but preferred a decibel monitor (which is not). Grace wanted a compass, as did Ursula who also wanted an air quality monitor.

Otherwise, does the Gallery Necklace do what it is supposed to do? Warren, Grace, and Ursula all found it to be an effective icebreaker. Warren wore it to several social occasions right away, finding it a great piece for self-marketing and networking. Grace said she could show it off and have an excuse to talk about her paintings to strangers.

Since it was designed in light of Warren's story, it is encouraging that he experienced it as working right out of the box (despite the manual setup) and that it supported social interactions in just the ways he wanted.

5 DISCUSSION AND FUTURE WORK

I used a novel method of Participatory Design Fiction to elicit stories from a small group of users. I used the stories to inspire concepts for real-world everyday wearable IoT devices, then built the most popular concept as a technology probe. Initial feedback from in-the-wild usage indicates that the method does help to develop wearable IoT devices that enhance the user's everyday life. The most positive feedback came from the user whose Design Fiction was selected for development.

All of the stories told throughout the process, starting with the pilot studies, give insight into what the users want from an everyday

wearable IoT device. The Design Fictions were rich with insight and will be analyzed in a paper all their own. In a nutshell, the Design Fictions expressed desires for:

- (1) communication with self
- (2) communication with others
- (3) connection and social inclusion
- (4) self-care and other-care: mental and physical; healing
- (5) self-protection
- (6) seamless access to knowledge

Development of this method is ongoing. Once the first iteration of the method is developed, it can be verified against a control group using a more classic method such as simple brainstorming. Meanwhile, the next steps in developing the method are to hold a workshop to discover what kinds of data the participants want their Gallery Necklace to capture, and how they would combine it with other data in the IoT ecosystem provided by their HATs. Another workshop will follow to develop the Design Fictions to reflect upon what we have all learned so far.

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