Envisioning Value-Rich Design for IoT Wearables.

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Fig. 1. Envisioning Cards exploring themes of value tensions and pervasiveness [15].

The mass-market fashion industry maintains complex economic structures globally. In recent years, the adverse consequences of commercialisation driven by these structures have given rise to innovation in production systems, material cultures, and consumer awareness of waste. Alongside issues of long-term lifespan and ecological impact of wearables (wearable technology), focus on the values and thought processes that shape practices within the clothing sector are under-represented. The integration of emerging wireless technologies in garments heightens this problem. The potential to access, collectively experience, wear, monitor or exploit personal data is only just beginning to be understood. In this paper, the author explores the role value-sensitive design [16] plays to further embed sustainability into wearables ideation. From value-sensitive design, the Envisioning Cards toolkit [15] is employed to guide speculation in the design case of *Aura:maton*, an Internet of Things (IoT) connected garment with an olfactory-emitting display. With this in mind, the 'social, economic and aesthetic force' [10] of fashion is leveraged as a living network metaphor, to frame everyday experiences of an IoT ecosystem. Exploratory workshops trace how people perceive value-tensions of wirelessly networked garments. The author's evaluations show the potential of Envisioning Cards to connect the broader social, cultural, economic or political issues as conceptual design tactics, to avoid blind spots. This paper discusses how designers could intentionally explore value dimensions alongside the technologically possible, as they negotiate material-immaterial conditions during fashion wearables development. Interweaving values into decisions of what gets made, or not made can potentially shift the unfolding of design toward value-rich, IoT connected garments.

Additional Key Words and Phrases: value-sensitive design; fashion wearables; olfactory interfaces; Internet of Things; Envisioning Cards; sustainability.

1 INTRODUCTION

Internet of Things (IoT) wearables are a burgeoning genre, and many challenges arise when experimenting with emerging technologies for dynamic, body-worn applications. The emergence of fashion-led wearables places an imperative to address sustainability concerns for practices at the nexus of fashion and technology. Fashion's rich scholarship in sustainability can inform wearables design processes that integrate emerging wireless technologies. Researchers have questioned the effectiveness of ecological sustainability resolutions that comply with existing growth-led economic models in the industry, and call for radical actions built around a new set of values [12].

This study addresses an increasing need for social responsibility that surfaces with the proliferation of IoT connected ecosystems. In this paper, fashion provides a living network metaphor, a social structure in the here and now that allows people to reflexively wear olfactory-emitting displays, in a cultural environment where IoT wireless technologies are widespread. The extensive practices of value and meaning in fashion and textile histories are a pathway to models of sustainability that bring design responsibility to the fore. What does it mean to use the conceptual ideation phase to reflect on moral and ethical issues, and assess

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future implications of widespread use of pervasive IoT technologies? The author draws from value-sensitive design [16], a framework from the field of Human-Computer Interaction (HCI) that accounts for human values in the technical design process.

This paper is a provocation to unveil value-tensions in the social, economic and cultural context of the IoT during early-stage speculative design ideation, with the specific aim to guide sustainable design rationale. The author conducted exploratory design workshops of 6 participants, split into two sessions. Participants came from diverse disciplinary backgrounds and had varying levels of expertise. In order to probe these issues, the author presented an IoT connected wearable called *Aura:maton*, supported by Envisioning Cards [15] to explore concrete ways of engaging value at the onset of the design process. Participants were asked to describe wearing *Aura:maton*, prompted by the themes of pervasiveness, to evaluate issues of *crossing national borders* and *widespread use*. People's impressions of *Aura:maton* revealed complex public and private cultured environments. These studies describe how the use of value-sensitive tools assist designers to evaluate their actions and assess risks, an intervention that prepares a foundation for impact across the product supply chain. It expands the sustainability ecology for fashion-led wearables development, to strengthen how designers think about social needs, and navigate ethical concerns.

2 RELATED WORK

2.1 Sustainability innovation in systems of fashion

Life Cycle Assessment (LCA) [1,8,19,21], and circular economy (CE) [20] strategies have become increasingly popular to address ecological and social challenges facing the fashion industry. These systems optimise and account for material longevity and efficiency during all phases of industrial manufacture, to curb waste issues. More recently, studies have engaged LCA of e-textile garments to measure functional features decided in the conceptual design stages; conscious material selection, garment lifetime and ecological impact [15]. Van der Velden et al. posit decisions made during the technical design phase positively reduce environmental impact, more so than the use phase [ibid]. However, Resta et al. observe that LCA critical path synergy is problematic for business-wide implementation [30]. Aligning heterogeneity in various stages of fashion production cycles involves various material components, elements, practices, supply chains, standards criteria and ultimately, end-use. Payne [27] points to the Promethean approach adopted by the fashion industry. In Payne's view, it is a solutionist strategy that employs technology to tame and solve the negative environmental impacts of excesses created by large-scale fashion manufacture. While both LCA and the CE track ecological material and process in fashion manufacturing systems [21], ultimately, they serve economic growth-led models and promote rising material consumption. The focus of this paper is to acknowledge the limiting practices of these models and introduce disruption before supply chain application plays out.

Fletcher defines sustainable fashion as an 'interconnected view of fashion, people and the world' [11]. This understanding gives rise to ways of thinking that better explore and understand this interconnected relationship, and its inherent behaviours, to extend the conversation beyond materials and technology [ibid]. In Fletcher and Grose's view, LCA logic accounts for quantifying the manufacturing process [13]. They urge more in-depth analysis of social factors, which prove more difficult to evaluate; locational, and specific to geography and culture. Van der Ryn and Cowan [33] argue that sensitivity to place and context is crucial to avoid generalised solutions. Solutions they view as 'anti-ethical' and disparaging for the complexity of sustainability challenges. Thus, it is opportune to introduce counter-narratives to economic growth-led models, and bring attention to design tools that help rework the logics of conceptual design development. Thackara acknowledges that 'nurturing a wave of small adjustments' can exist alongside ambitious systems [32]. Incremental improvements that begin with co-creation and tools that enable people to contribute or share resources. Collectively, this research points to an underrepresentation of the opportunities presented in the design phase of the fashion production cycle. It is timely to consider a deeper analysis of design process form the outset, to update sustainability ecologies for wearables.

2.2 A reorientation toward values

The cultural conditions that have stimulated a product obsolescence model in fashion can be useful to encourage alternatives. Researchers in the realms of fashion and HCI have extended fashion-thinking as a tactic to counter planned obsolescence [26]. Pan et al.'s study consider the positive social force of fashion, to influence consumer behaviour toward increased product longevity and durability [ibid]. In Tan et al.'s view, the innovation potential of technology has overshadowed research into design processes for

interactive materials [31]. Which, in turn, undervalues product end-use, and impacts conditions for longevity. Kuusk et al. posit fashion's 'rituals of making things together' gives meaning to users [22]. They attribute values as a pathway to 'ecologically responsible' and argue that shared-knowledge making practices, passed on for generations through fashion practice, can be transferred to wearables development. Leong & Lee define values as enduring beliefs that are culturally dependent [23]. In a similar vein, values 'shape actions' [25], and are acquired through socialisation [28]. In Ferraro et al.'s view, reorientation toward value-led thinking is an opportunity for innovation [9]. However, Pepper et al. argue that a long-term change in consumer behaviour remains challenging [28]. In their view, a value-shift in consumer behaviour in a contemporary outlook of growth-led material consumption requires deeper level change.

Leong and Lee examine the material ecologies of digital sustainability issues [23]. In what they describe as the 'illusion of minimal impact', they outline environmental waste triggers of virtual consumption; energy-intensive practices, emissions, increased material, exponential turnaround of trends, e-commerce mechanisms, logistics and distribution, data. Much of what Leong & Lee deal with is the very ecosystem which IoT wearables operate, a landscape where technological progress equates to product obsolescence and modernity. They argue that understanding values and meaning within contextual restraint will empower greater social and cultural sustainable innovation. From the field of HCI, value-sensitive design [16] is a tripartite conceptual, social and technological framework, foregrounding human values and social context in technical design work. From this framework, the Envisioning Cards [15] toolkit provides envisioning criteria such as, 'value tensions' and 'pervasiveness' in the design ideation process. The cards, a practice-oriented design tool, centre around human values, directing attention toward long-term and systemic design issues. More recently, cards have been developed to guide sustainability in conceptual design models [29]. However, the themes of Envisioning Cards readily examine moral and technological concerns in IoT wearables development. According to Friedman, it is crucial which mental models, or narratives are associated with design propositions [14]. Mental models and simulations position people to consider their relationship with materials, artefacts or systems, 'when to use them, how to adapt them, when to dispose of them, and when to eschew them' [ibid].

2.3 Speculative design - sustainable futures in the here and now

Dunne & Raby's speculative design uses conceptual design as a mode of critique [3]. It purposes the aesthetic value of design, as a medium materially situated in the here and now. In this paper, two strategies of speculative design imagining are useful. Firstly, the notion of *ideas as stories* bring background contextual issues into focus. In this paper, these ideas as stories directly examine social values inherent in IoT wearable use, to unearth social, cultural and ethical overtones, in addition to design materiality issues. Secondly, the more forward-thinking *what ifs* consider synergies and breakdowns of a proposed design idea. In Galloway's view, design speculation in technology development works to reinforce the idea of emerging technologies [18]. Galloway extends Dunne & Raby's position, speculation as an approach to question design, yet points to a timely need for grounded and complicit speculation, rather than distant from immediate social context. Black draws our attention to speculative trends, ideation, garment orders and manufacturing, that characterise the fashion industry supply [2]. Entwistle considers this speculation in fashion as 'spatialisation' [6], the role of which responds to immediate contexts, risks and demand. Furthermore, Blumer proposes that 'fashion operates as an orderly preparation of the immediate future...a means of adjusting to what is on the horizon'[3].

Mazzarella et al. extend Fletcher's notion of fashion activism, applying 'counter-narratives' to existing modes of fashion [24]. Counter-narratives reinstate design responsibility in the here and now and redirect sustainability issues away from future scenarios. Fairburn et al. argue the emergent area of 'future materials' integrates textiles, technology, and the human body is inherently speculative, and offers alternatives to current economic conventions [7]. Furthermore, Leong & Lee consider culture-orientation, and context-based approaches provide a promising lens to envision and motivate alternative futures for socially-motivated sustainable fashion action through design [23]. In their view, sustainability issues based on 'social impact' such as wearability, usability, ethical data usage, power, and durability relate to quality and value of life, or what is considered 'good' for public social interest.

3 METHODOLOGY

In this study, speculative and value-sensitive design activities are employed to disrupt the ideation of sustainable fashion wearables. A performative design activity is drawn from the Fluxus event score [17] to acquaint participants with olfactory material. Secondly, the speculative design concepts of ideas as stories

and what ifs provide the grounds for design provocation. Collectively, these tactics imagine beyond the present context of wear to disrupt systemic practices and underlying assumptions. Faced with limitations and agendas that serve economic growth-led models in the garment industry, speculative design in early-stage ideation reconfigures conceptual capacity for sustainable fashion wearables design. Finally, the Envisioning Cards toolkit a) scaffold a concrete process to reconfigure the logic of fashion wearables design, and b) inspire discussion among participants with divergent perspectives.

3.1 Study Structure:

The author conducted a series of semi-structured sessions, each lasting 2 hours. The workshop has three sections. The first section focuses on a performative design activity to evoke, contest and destabilise any fixed impressions of olfaction amongst participants. This part weaves the drifting character of olfactory materiality and experience into a spatial, social representation, and supports participants to glimpse and imagine emerging technologies coupled with olfaction. During an adapted version of Ay-o's Fluxus performance piece Rainbow No. 1 for Orchestra Variation [16], scented soap bubbles are blown, and participants are invited to break the bubbles with various provided objects to release scent [fig. 3].

During the second section, the speculative design case of Aura:maton, an IoT connected olfactory wearable, is introduced to paint a vivid mental picture and spark discussion:

> Aura:maton is an embodied technology which uses a brain-computer interface to detect the wearer's physiological states. It then displays these states through an internet-connected, olfactory leather belt. A scent is released according to the electrical activity of the wearer's brain. Aura:maton can be worn by people. It can help prompt memories or perform mundane daily tasks to enhance connection, such as those with mild-cognitive disorder. It can be worn to express a layer of fashion style. One can use it to send a scent message wirelessly.

Aura:maton provides a mental model for participants to engage in embodied simulation [4], a full sensory imagining for value-embedded 'what if?' implications alongside technical possibilities. The purpose of this design case is to position people to think about an IoT wearable capable of producing automated scent. It is used to inspire conversation regarding social and ethical dimensions, by engaging with the public cultural context where networked olfactory wearables are worn. In this part, people are asked to retrospect their physical experiences of scent material qualities to simulate wearing and controlling scent directly. The focus is to imagine social lives that have olfactory wearables.

Fig. 2. a) Materials used for embodied explorations with olfaction, essential oils, scent molecules, scented bubbles, scent diffusers, and atomisers. b) Example of the Envisioning Card theme of pervasiveness, through 'Widespread Use'.

Lastly, a set of Envisioning Cards [fig. 1] is provided to stimulate creative exploration of the mental model of Aura:maton. Envisioning Cards guide the *Aura:maton* design case, to critically engage with the benefits and breakdowns of new interactions. The envisioning cards were used to surface critical issues for potential networked olfactory wearables. From the Envisioning Cards, the criterion of *pervasiveness* was chosen to guide the design case scenario, in the early stage design ideation stage. The cards *Widespread Use* and *Crossing National Boundaries* prompt participants to localise themes of pervasiveness. As designers, wearers and observers in scenarios of scaled manufacture, where networked olfactory wearables are widely available and worn in many different countries. The text of the cards remained unchanged. However,

the imagery was adapted to evoke issues surrounding the use of emerging IoT technologies in economic, ecological and mainstream fashion style terms. All sessions were photographed, video and audio recorded, with field notes later transcribed for analysis. Audio transcripts were analysed using a grounded theory approach [5] to unearth common themes that shaped understandings and uses of *Aura:maton*.

4 FINDINGS

Six individuals: professionals (aged 20-35, five female, one male) participated in this study. Participants volunteered for the study through a public meetup group and had a range of expertise broadly spanning fashion design, software engineering, egyptology, and olfactory art. The workshop structure involved design activities and semi-structured interviews of two sets of three participants. This setup allowed for both a group dynamic and in-depth analysis of the topic.

Fig. 3. Participants are invited to corporeally experience olfactory displays in order to ground a conversation about potential widespread uses of olfactory-emissive garments in their personal style.

During the session, the focus shifted; from physical encounters with olfactory material behaviours [Fig. 3] to speculation of the design issue *Aura:maton* supported by the Envisioning Cards. People were invited to discuss the pervasive use of wirelessly networked, olfactory wearables. Participant responses, associations and experiences varied during discussions about wearing a networked, olfactory wearable, as they imagined the role it would play as part of their social lives. People were compelled to discuss the social and cultural context the artefact was embedded, rather than the *Aura:maton* artefact itself. Supported by the Envisioning Cards, the design activity allowed participants to talk about issues that concerned them about scaled use of olfactory-emitting wearables.

As participants imagined how to integrate wearing *Aura:maton*, particular themes emerged in relation to how it could evoke particular kinds of experiences in their social life. Noting the potentials of *Aura:maton*, Isabelle describes a favourable scenario:

> *It's another way of getting to know someone if you smell someone. Someone is wearing a really familiar scent, like, a scent that feels really good to you. Then it's another way of talking to them.*

Dora, Xiluva and Aleksandra also liked the idea of using *Aura:maton* for intrigue-based interactions with the potential to connect strangers, something they felt might be exciting:

> *Dora: You smell the same, let's go on a date.*
> *Xiluva: Or maybe you've got apples, and they have cinnamon and you're like (suggests connection). It's a talking point. You might send a scent message.*
> *Aleksandra: You are shit.*
> *(Combined laughing)*
> *Aleksandra: Haters gonna hate*
> *Dora: Hate messages.*
> *Aleksandra: Skunk bombs!*

Xiluva: That could be used the other way around I mean, politically controlling people in riots or things that you don't want to happen. Water hoses, like a smell hose.

Like an inside joke, this quality of Aura:maton brought enjoyment and a shared understanding, yet highlighted value-tensions in the system, as potential breakdowns of pervasive, networked wireless technologies emerged. The quality participants most disliked about experiencing scent was its permeating material texture, a characteristic of volatility for the worse. People spoke of ethical concerns, negative associations of scent permeation and volatility, as they imagined how olfactory-emission would play into strategies of exploitation, manipulation, or crowd-control:

Magda: I heard there are already drugs in eyedrops so maybe there will be drugs like morphine in the perfume. Or maybe they could even plant in nuclear attacks? Instead of bomb attacks they could use fragrance.
Henry: Chemical attack. Scent can be used in a large-scale scenario.

On the theme of Crossing National Boundaries, participants discussed potential for scent pollution. Dora described the experience of scent as *'problematic'* and *'subjective'*. She states the reaction to any one particular smell may range from *'very pleasant'* to *'unpleasant'* or *'bothering'*. She considers different scents in public spaces, *'there's gonna be some sort of problem. Someone's gonna be outraged at a certain point'*. Isabelle recalled memories of the Canadian Centre for Occupational Health and Safety's scent-free policy and the *No scents is good sense* movement [35,36]. People also described public and private cultured environments of scent-emitting objects (fragrant white flowers attached to clothing during a temple visit), products (cosmetics available in soviet-era Poland), social boundaries (rose fragrance codes of use since Roman times), regional activities (ceremonial), and food (citrus, durian, or mouth-numbing Szechuan peppercorn). These associations are locational, compellingly positive or negative, co-evolve over time, and shape how participants imagine wearing olfactory displays

6 DISCUSSION

Fashion, a social structure in the here and now, provides a living network metaphor to reflexively wear olfactory-emitting displays, in a cultural environment where IoT wireless technologies are widespread. While discussing potential system synergies and breakdowns, people deeply explore value-tensions and increase value for Auramaton, investing shared experience in the design. Narratives for olfactory-emitting wearables are constructed, sensitive to the value for relationships between people, to demonstrate the kind of behavioural turn Kuusk speaks of [22].

The Envisioning Cards were useful to define sustainable design rationale at an early stage for controlled-use design, reduced-use design, or no design. However, other significant issues in the wearables critical path require value-sensitive consideration. In order to probe greater sustainability issues and implications of Aura:maton, Envisioning Cards are useful to rework the logics of current understandings of fashion wearables sustainability in terms of material selection, product lifecycle, sourcing options, certifications, supply chain, environmental impact. They illuminate IoT-specific issues of localised and global specific wireless communication rules and infrastructure issues, or data security. This process informs the design of a networked olfactory wearable; how it functions and operates in scale, how the social body conforms to the technology, in what situations of use, how much projection of scent, which controls for interaction, or how to negotiate issues of personal data ownership.

To take these provocations beyond the conceptual design phase, further prototypes for wearer-led investigation can provide richer experiential accounts of olfactory-emitting displays. A wearer-led investigation will observe how the public sphere will interpret Aura:maton, the site where a wearable is worn and socially accepted. Further studies across geographical regions would enrich these findings. The author acknowledges a small participant range; however, it is in line with a qualitative investigation which does not aim to generalise responses for design guidelines.

6 CONCLUSION

Expanding a sustainability criterion is vital to address a growing interest in the social value of designing and wearing emerging technologies as fashion wearables. This study shed light on ways value-sensitive tools from the field of HCI, and fashion sustainability literature integrates to refine value-rich, responsible

design practices from the onset. This study is a provocation for integrating value-rich design support in early-stage ideation. Participants in this study envisioned scenarios where cultural value-orientations are engaged. People use these scenarios to cultivate intriguing social encounters, assess risks of widespread use, or red flag ethical and ecological concerns. Attending to values first and foremost, using the Envisioning Cards draws out wearer perceptions in what is useful, desirable and ethical, alongside what is technologically possible. This shift systematically shapes fashion wearables design process towards expanded ecologies of sustainability and contributes to the growing theory of design sustainability for fashion wearables. Leveraging fashion as a socially positive catalyst for action played a major role in this study. Seen through this lens, the uncertain social and cultural potential of wearing emerging IoT technologies confront the current sustainability conversation for fashionable wearables. A force that strategically informs the design rationale for what, how, why, or *if* something gets made.

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