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Day-to-Day Speculation: Designing and Wearing Dynamic Fabric

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Abstract: In this paper we describe *Greenscreen Dress*, a material speculation inquiry (Wakkary et al., 2015) that investigates the wearing experience of dynamic fabric in everyday life. In this study the researcher has worn a "greenscreen garment" every day for seven months. Coupled with a chroma-key smartphone application, she has photographed the garment and digitally composited upon it multiple digital colours, patterns and videos. The fashion expressions were uploaded to Instagram and so situated within a digital social ecosystem.

We argue that combining the wearing of dynamic fabric with design activities, the inquiry of what it might mean to wear dynamic fabric moves speculation into day-to-day living by drawing from the interactions of the researcher's everyday life. As innovations in smart textiles and wearable technologies become more accessible, knowledge gained from this research critically inquires into the everydayness of this breed of technological system. The research draws insights from design, fashion, and material performances in the daily life of the researcher. The project contributes critical insights into fashion and technology for clothing designers and in to new methodological terrains for RtD.



Mackey, Wakkary, Wensveen, Tomico, Hengeveld | Demonstration of smartphone application used in Greenscreen Dress

Introduction

If garments are made with dynamic fabric – fabric that can change colour, pattern, image or text like a computer screen – how might this change personal fashion? The integration of dynamic fabric into clothing could challenge many of the norms of fashion. Explorations of dynamic fabric, also referred to as dynamic *textiles, pattern-* and *colour-changing textiles*, *animated textiles*, *smart textiles*, *computational textiles* or *digital fabric,* have occurred mainly in the last fifteen years alongside innovations in soft and flexible electronic materials. This area is rich within the fields of smart textiles, wearable technology and fashion, inspiring many to speculate, design and develop technology for.

In the early 2000s there was significant technological and expressive developments made in this area involving the pairing of LEDs with textiles and conductive materials (Orth et al., 1998; Seymour, 2008), and electronically stimulated thermochromic inks (Berzowska, 2004; Orth, 2004). Following these explorations have been further refinements towards both the technological and expressive possibilities of these approaches in the form of prototypes and textile samples (Worbin, 2010), custom-made artistic, high-fashion or entertainment-related garments (Berzowska and Skorobogatiy, 2009; Chalayan, 2007; Lamontagne, 2005; Philips Design, 2006; Rosella & Genz, 2005) and short-run commercial product releases (Berglin, 2013; Harold, 2006). More recently, the proposition that dynamic fabric could exist through combined physical-virtual means, as in augmented- or mixed-reality technologies, has appeared in fashion design (Normals, 2015; Weinmans, 2013) and speculative design projects (Matsuda, 2016; Superflux, 2011) adding another dimension to the concept of state-changing or responsive textiles in dress.

Currently, dynamic fabric in an “ideal” form for clothing, i.e., fabric that is washable, comfortable, durable, affordable and capable of presenting any digital content desired, does not exist at the consumer level. Our research in this area does not attempt to make prototypical or technological contributions towards dynamic fabric, rather we performatively and through design anticipate for investigation the wearing experience of dynamic fabric and what can be learned from it. We focus on the implications dynamic fabric could have on personal expression through fashion and everyday clothing-wearing rituals. We aim to move the discussion further from what is *possible* with dynamic fabric, to what is *plausible* within the context of fashion and the complexities of everyday life.

We approach these notions by introducing *Greenscreen Dress*, an autoethnographic study that focuses on wearing dynamic fabric in everyday life, and simultaneously exploring it through fashion design activities and processes. Over a seven-month period, the first author incorporated the colour green into her wardrobe every day and captured videos and images of her garments composited with digital content using a chroma-key smartphone application (iDevMobile Tec., 2015).

Autoethnography was used to document and analyse her activities, which aims to describe and 'systematically analyze personal experience in order to understand cultural experience' (Ellis, Adams, & Bochner, 2010). She kept regular diary entries, periodically recorded high-level reflections on these entries, followed by group analysis with the second and third authors of this paper to develop themes that could provide insight for future dynamic fabric designers.

Beyond Speculation

Most of the aforementioned related work on dynamic fabric stayed at the conceptual and prototype level in order to explore the technological and expressive possibilities while speculating about the consequences. In this paper, we focus on how the activity of wearing an approximation of dynamic fabric in everyday life combined with design activities can bring speculative explorations of dynamic fabric into day-to-day living. What we mean by this is that the inquiry is moved into a space where an extended time period, situated audience and genuine social context become variables. These variables, in turn, allow us to challenge previous assumptions or speculations, observe new opportunities that emerge, and place a genuine socio-cultural perspective at the center of the discussion.

In terms of speculative design, we see the Greenscreen Dress study as sharing characteristics with this field in its aim to contribute a future vision (Auger, 2013). We also see the main design artifacts – images and short videos clips from Instagram, as well as various simple green materials, garments and a smartphone application – to sufficiently act as the relatable elements required for a "successful" speculative design project that bridges the audience's perception of the world with the fictional elements of the concept – the "perceptual bridge" as described by Auger (Auger, 2013).

However, we argue that the act of living with the proposed technology over an extended period of time brings the exploration into the everyday, where the elements that might be perceived as a perceptual bridge are in fact real interactions and artifacts from an individual's everyday life. The speculative inquiry is therefore not weighed against human nature or a plausible environment or context, but against a real human, environment and context.

For these reasons, we see Greenscreen Dress as a material speculation inquiry described by Wakkary et al. as emphasizing 'the material or mediating experience of specially designed artifacts in our everyday world in order to speculatively and critically inquire through design' (Wakkary et al., 2016). We see it as such because of the characteristics it exhibits which define it as a *counterfactual artifact*, most notably it appearing to not 'fit the logic of things' in the everyday world yet undeniably existing in the actual world (Wakkary et al., 2016). The tension that this creates in the study, where the researcher aims to explore future visions of dynamic fabric while living the experience of it in her present life, offers a unique perspective from which to speculate. This perspective and its authenticity reveal opportunities and challenges to the proposed future artifact based

on sociocultural concerns that will be important for designers to articulate, as equally important as technological concerns. Furthermore, it positions itself to challenge previous speculations within the field – such as whether dynamic fabric would reduce the consumption of clothes (Dunne, 2010) – and thus move it from the possible to the plausible or implausible.

In the following section we contextualise the goals and general experiences of the researcher in the Greenscreen Dress study, after which we describe how the wearing and design activities evolved over a seven-month period, highlighting the value gained from the first weeks when it was viewed as a "gimmick". We then describe the outcomes of the study that challenge or refine previous assumptions and speculations about dynamic fabric in clothing.

Greenscreen Dress

Contextualising the Study

Our inquiry into what it might mean to wear dynamic fabric in everyday life was motivated by the possibilities of new fashion expressions (Devendorf et al., 2016) as well as opportunities to counter consumption habits of clothes that threaten their sustainability by way of having multiple garments in one (Devendorf et al., 2016; Dunne, 2010). Furthermore, it was motivated by the preceding eight-year practice of the first author as a clothing designer working with wearable technologies



Figure 1. Greenscreen Dress. Sample images from Instagram. Credit: Angella Mackey.

and smart fabrics. Throughout this time (2007-2015) she observed the smart garment industry focus on technological innovations with relatively little understanding of their socio-cultural implications. The approach of this study therefore aims to demonstrate the value of this perspective. We aimed to explore the potential of dynamic fabric as it relates to changes in daily clothing-wearing habits or considerations of personal style.

The central activity of this study is the wearing of visual digital content everyday. We see *wearing* as the space for personal expression and social reception to happen within a contemporary fashion dialogue. We see *the everyday* as the space for exploring elements dependent on time such as pattern, repetition, change, spontaneity, learning and the coming and going of phases. The focus on living with the dynamic fabric positions the enquiry inside a genuine socio-cultural context and thus reveals the opportunities and challenges of dynamic fabric as they are confronted with the daily interactions of a wearer's life.

Without access to a fabric that possessed the properties of a clothing-grade textile and the abilities of a computer screen – we rapid-prototyped these capabilities by using a "greenscreen" system. In wearing green fabric, we were able to composite the surface of the garments with digital content (colours, patterns, still images, and videos) using an off-the-shelf chroma-key application on a smartphone (iDevMobile Tec., 2015).

For seven months the researcher (and first author of this paper), incorporated green fabric daily into her wardrobe. She began by wearing the same green garment and then expanded the wardrobe to include a range of green materials, green patterns, garments and accessories. She regularly changed the digital content of her clothing and posted pictures and videos of the digitally altered garments on her personal Instagram account (instagram.com/angellamackey) a social media platform based on image and video exchange. This activity allowed the digital versions of the garments to be "worn" and exist within a social ecosystem with an established fashion dialogue.

Furthermore, she interacted daily with friends, family and colleagues who recognised the green in the garments as "active." These interactions lead to a small community who participated in the study through workshops, play, discussion, reflection and personal usage of the system. The same occurred on Instagram where a community of 206 followers generated dialogue about the videos and pictures she shared. Within seven months the researcher had posted 151 images and videos on Instagram, with approximately 6400 images and videos left "unworn" on her smartphone.

This greenscreen system had limitations with regards to mimicking an idealized future form of dynamic fabric. For example, it did not permit the wearer or audience to experience the digital content "in the real world." One could not see and touch the digital garments physically and instead relied on a computer or smartphone screen to see them. This meant the system worked most similarly to augmented reality (AR). It also lacked the ability to have dynamic input, such as a live feed from social media, readings of a heartbeat, body-mapping, or gesture-responsive displays. It was instead only capable of manually imitating these features.

However, recognizing these technical limitations we would like to establish that the aim of the study was to gain insights into the wearing experience of dynamic fabric as it relates to personal style and clothing habits. The most general questions being explored by the researcher were

What will I wear? and *How will this change my experience of clothes?* As a lo-fi version of dynamic fabric, the system was successful in its' goal to give the researcher the capability to wear fabric that can visually hold and change digital content as she went about her daily life. Her awareness of this ability and how it altered her personal style and clothing rituals is the space in which we can draw insights. It is in the behavioural and mental shifts of the researcher over seven months that we observe possible socio-cultural implications of future dynamic fabric design.

The researcher acted as a *wearer* and *designer* simultaneously in this study. Throughout the seven-month period she lived the experience of dynamic fabric in an organic way – integrating green into each outfit she wore and allowing the experience to evolve through her social media, personal and work-related social interactions. During work hours, she engaged her background as a fashion designer – sourcing materials and testing how they reacted through the chroma-key application in order to design clothes or design digital content. She worked towards the task of creating a future brand-concept for dynamic fabric that represented her aesthetic sensibilities as a designer – proceeding through the design activities as if she would release a new line of clothes that took into account her experiences as a wearer.

Entering and Exiting a Gimmick

In order to explore the potential of dynamic fabric in everyday life, it was the main objective of the researcher to genuinely integrate the concept of dynamic fabric into her personal style. If the experience of the system she had entered – wearing green, changing the digital content of her garments, and posting the results on Instagram – felt too much like an "artistic" performance and not an authentic reflection of her fashion sense then the goals were not being achieved. This confronted the researcher with trying to answer the following questions: *If I can wear anything, what do I wear and how do I wear it? If my garment can change at any time throughout the day, when should I change it?* and *How should I plan or prepare for this ahead of time?*

Over the seven-months the explorations went through different stages, each highlighting different aspects of what it might mean to wear dynamic fabric. The first four months were mainly exploratory where the researcher built up her green wardrobe, "tried on" various kinds of digital content, reflected on audience reactions, designed garments and collected a variety of green materials to explore how they reacted through the chroma-key application. In the fifth month, the researcher reflects that she felt "style" finally began to happen both personally as a wearer and in her fashion design activities. She observed that she had reached a certain skill level and confidence and that she could now make "fashion sense" out of the clothing-wearing and clothing-design activities for the greenscreen system.

We think it is important to highlight the first three weeks of the study, which were part of an exploratory period but very different in that the researcher saw them as a "gimmick". She characterized these first weeks as being "silly" and "playful" interactions with the system that did not



Figure 2. The “gimmick phase”. The researcher and colleagues playing with the greenscreen system. Credit: Angella Mackey.

accomplish what she originally meant to achieve. For example, because she felt embarrassed about the task of taking pictures of her garments and herself in public, she chose to take selfies with other colleagues as a live demonstration of how the system worked (Figure 2). She thought this gave more purpose to the activity. The digital content she chose to place on her green garments was the default imagery that came with the chroma-key application which was mostly depictions of landscapes. Like a party trick, the outcome of these activities appeared to say “look what I can do”, as opposed to appearing as a serious fashion expression.

In the researcher’s experience of introducing the greenscreen system to other colleagues, researchers and designers for short periods of time in a casual encounter or workshop setting, their first explorations of the system are similarly playful (Figure 3). The researcher reflects in a diary entry,

“The first silly steps of experimenting with this technology is to play with it openly and joyfully, which I have. When showing it to friends and colleagues we have become invisible, placed our body parts on someone else’s, laughed at terribly deformed pictures of ourselves, put our eyes inside our hands, etc., until we became bored and wanted a new toy.”

This “gimmick phase” can be compared to Gaver et al.’s *trajectory of appreciation* (Gaver et al., 2006) where a new technology may be met with excitement because of its novelty. When the novelty fades people may feel frustration or disillusionment, and over time either accept or abandon the technology into their everyday life. What we observed through the Greenscreen Dress study is that the researcher reached a frustration with the system as a wearer and a designer, because she thought it was being misused and misunderstood by herself and those around her. She found the solution was to continue to design and explore. Furthermore, she found it useful to imagine that these first steps were not a “misuse” of the system, but rather held clues to what might

become “serious” fashion expressions at a later time. For example, she considered whether ‘missing body parts’ (Figure 3) could transform into the fashion expressions of a particular kind of wearer.

This period of novelty has become a space within the Greenscreen Dress study that allow us to discuss what one can easily do with the system, what one is initially inspired to do with the system, and what one assumes they would do with the system before beginning. Initially this period felt like a failure for the researcher to meet her goals, but in retrospect has become a valuable point of reflection where outcomes of the study over seven months are consistently compared to it. This offers insights into how the technology was initially used and repurposed for other uses, how certain aspects persisted and did not persist, and how things can be initially discounted but reappear further in time. With regards to moving speculation into everyday living, this early period marks the beginning of the story that shows how the technology changed or persisted over time.

Exploring the Potential of Dynamic Fabric

In the following section we describe selected themes that emerged through the Greenscreen Dress study that tell us something about what it might mean to wear dynamic fabric. These sections are not consecutively ordered by time, but are ordered in a way that reading one should make it easier to understand the next. We describe initial assumptions or previous speculations made about the future direction of dynamic fabric, and compare them to what we observed in the study as it changed over time. In some cases, assumptions and speculations are doubted. In other cases, we found them to be further refined.

Multiple Garments in One Garment

If garments possess the ability to change colour or pattern on their surface, we might consume less clothes. In theory, the “ultimate garment” potentially could mitigate the waste and unsustainability of “fast-fashion”, i.e. the cyclical change of fashion based on trends and seasonal changes of spring and autumn collections (Dunne, 2010). This speculative idea, more than once cited as a possibility of dynamic fabric (Devendorf et al., 2016; Dunne, 2010), was one of the main inspirations for this study. Instead, we have come to doubt it.

In the first two weeks of the Greenscreen Dress study the researcher wore the same green dress each day, predicting that if periodically washed and dried overnight it could fulfill her fashion needs. Instead, she quickly found she desired new textures, silhouettes, shades and amounts of green in order for her to fit into social norms and remain consistent with her personal style. She felt she must find additional ways to incorporate green into her outfits. Her wardrobe increased from the original green dress to twenty green garments and accessories over a six-month period. We do not see this outcome as suggesting outright that dynamic fabric will not decrease clothing consumption. We see the

limitations of our study in that the researcher wore “green clothing” rather than truly dynamic clothing. What we can say is that this outcome highlights the desire in contemporary fashion for variety of texture, silhouette, and the complex construction of outfits rather than simply being satisfied with changes in surface colour and pattern.

Wielding the Technological System to Personal Tastes

What a person might choose to wear if their garment has the ability to visually change with dynamic input will often be dependent on the technological capabilities or limits of the system. For example, it has been speculated that if a fabric can be connected to social media input, it could bridge the social interactions performed through garments with social media interactions (Berzowska, 2005; Devendorf et al., 2016) – a person might choose to wear information fed from their Facebook feed (Devendorf et al., 2016). Alternatively, if the technology uses thermochromic inks with heat sources placed in particular areas, the wearer could be limited to wearing the patterns pre-planned by the designers (Nilsson et al., 2011).

In the initial explorations of the study, it seemed to make sense to the researcher to use the greenscreen system as it was technologically intended. Meaning, the researcher would collect bright green fabrics and garments that would “perfectly” key-out (could be composited with digital content). Additionally, the digital content she initially chose to wear proceeding the default landscapes were graphic patterns like polka-dots or stripes downloaded from the internet. When both of these

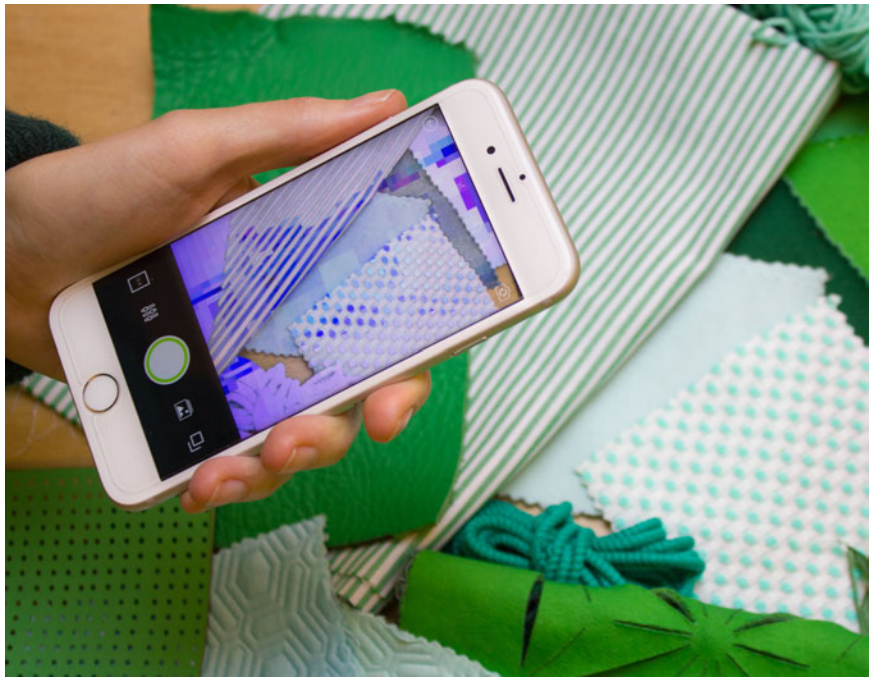


Figure 3. Exploring how different green materials react through the smartphone application. Credit: Rachel Rietdijk.

activities were combined the garments lost their three-dimensionality – shadows, collars, textures, and depths of the garments would disappear and render them looking “flat”. As a wearer, the researcher observed that she felt the garments were being transformed into a “cartoon” aesthetic, which for her tastes were undesirable.

Throughout her explorations the researcher discovered new ways of achieving three-dimensionality and other forms of aesthetic expressions using varying characteristics of green materials (Figure 3), capabilities of



Figure 4. Abstract videos captured from the researchers surroundings. Credit: Angella Mackey.

the chroma-key application, and a “performative wearing” of the green clothes. For example, she used the sensitivity slider in the application interface to render fabrics less “effective” to the keying-out, so that shadows and textures could remain. She found that dark greens and pastel greens gave a “grainy” effect to the digital content. She found that sheer materials worked in surprising ways whereby they could hold a faint layer of the digital content while still remaining transparent. She observed that instead of downloading pre-existing images and videos of things from the internet to wear, it felt more natural to capture imagery from her surroundings that were unique (Figure 4). She began unexpectantly “wearing” her surroundings in ways that were explicitly performative or only known to her as such.

These explorations that step outside the intentions of the technological system do not answer the question of whether one might want to wear input from their Facebook feed, whether they would be satisfied with a predetermined textile pattern change, or suggest that everyone will want to wear grainy digital content or images from their surroundings. However, it does suggest that how a new interactive system might be used is difficult to predict or even design for. Particularly in the case of fashion which relates so strongly to personal identity, unique diversions could be made.

Aesthetic Extensions Beyond the Borders of a Garment

There are four recent examples of researchers, designers and artists exploring dynamic fabric through augmented reality (AR) technologies in fashion. One, titled *Apparelv1.0* (Normals, 2015), depicts black clothing with white numbers and patterns printed on it that a smartphone application can recognize and then generate large white geometrical patterns surrounding the wearer. Another exploration by Dutch designer Marga Weinmans (Weinmans, 2013), has a similar system that generates floating cubes around the wearer. The third by Keiichi Matsuda, in a critical design short film called *HyerReality* (Matsuda, 2016) depicts at one moment during the film a lady walking down the street with a “Follow. Outfits. Like.” text graphic hovering from her shirt, and also a thief who completely covers her body with digital distortions to hide her identity. The fourth is a design fiction video called *Song of the Machine* (Superflux, 2011) detailing the experience of a person who is visually impaired and thus wears an assistive AR headset. At one point in the story the character encounters a man with an overlaid three-dimensional wolf-head recognized by his headset because of a QR code on the front of the man’s T-shirt.

In the Greenscreen Dress Study the researcher was familiar with these examples, but did not consider them as an aesthetic possibility she could explore because the greenscreen system was only able to alter the flat surface of the fabric. Also, as a fashion designer, she saw these speculations as beautiful and intriguing but initially discounted them – judging them partly as a gimmick, or obvious first steps of what the technology could achieve. However, organically the aesthetic expression of moving off of the flat surface of the garment emerged in her designs. In the fourth month of the study the researcher received positive feedback for an image she posted on Instagram picturing her "blending" with her background (Figure 5). This was achieved by simply sitting next to a green wall and keying-out her garment as well as the wall. Over time, this lead to a series of images and videos with this technique as the central theme in her personal expressions – blending with other green things like chairs, objects, plants and trees, etc. 'Blending' was also adopted as a key concept throughout her design activities towards the end of the seven months. We see this outcome as further refining the speculation that AR versions of dynamic fabric will include expressions that leap outside the borders of the garments.

Control of Personal Style

Shortly before beginning the Greenscreen Dress study, the researcher assumed that she would have complete control of what she wore – both in her green garments and their virtual counterparts. As a wearer and designer with a fashion background she saw little reason to doubt this.



Figure 5. The researcher blending with her surroundings. Credit: Angella Mackey.

What occurred on the very first day of the study and persisted many months in, was a complete lack of control tied to the relationship with a colleague who shared an interest in the chroma-key application. He began intermittently photographing the researcher when he felt inspired, and compositing what she perceived as unfavorable digital content on her garments. For example, in one image the colleague "dressed" her in a screenshot of his smartphone home screen, another time in an orange tie-dye pattern, and later a cartoon monkey. The researcher experienced an unanticipated loss of control through these interactions.

This opens up a broader discussion about permissions and control related to dynamic fabric in dress. With connectivity to computational input, how might this be regulated? The solution could be technical – designing a system where access is secured. The solutions found by the researcher instead came in two different forms. Firstly she discovered she could wear small pieces of green instead of entirely green, and this would break up the continuity of the digital content and "protect" her from recognizable versions of the unfavourable images. Secondly she talked to her colleague about the activities, asking him to be more sensitive to her opinion of the images. The first solution, similar to a "DIY" approach of covering your mouth to fool a face-recognition program, worked well but also felt limiting to the researcher. She reflected that taking away the ability to wear all green was like surrendering to an attack and stunted her expressive freedom. The second approach to open a dialogue with the colleague was also effective and allowed her to retain the option of wearing all green.

What we mean to highlight through this example is that both solutions – DIY and social – were accessible to the researcher without a change to the technological system. When designing or planning for the introduction of internet-enabled dynamic fabric, it should not be overlooked that just as rules are created and "worked out" for other new dynamic systems, new social conventions and rules would likely emerge with dynamic fabric in everyday fashion contexts.

Conclusion

Through the combined activities of wearing and designing with an approximation of dynamic fabric, we see the Greenscreen Dress autoethnographic study to have engaged day-to-day living as a speculative strategy. These steps discovered and explored themes of Multiple Garments in One Garment, Wielding the Technology to Personal Taste, Aesthetic Extensions beyond the Garment and Control of Personal Style. Even though these thematic outcomes are still speculative – offering visions for what *could be* if dynamic fabric existed in everyday dress – the genuine social contexts that they draw from puts a different kind of value to the perspective.

Where speculative design aims to provide or uncover a critique on themes like human behaviour or interactions with technology, Greenscreen Dress critiques the speculations themselves – challenging them by attempting to answer *Would I really consume less clothes?*, *Will I*

really want a dress that can be entirely transformed by digital content? or *How would I actually choose what to wear?*

As a material speculation inquiry, we see incredible value coming from the activity of placing explorations within the context of everyday life. It offers a unique perspective from which to challenge previous assumptions or speculations, observe new opportunities that emerge, and place a socio-cultural perspective at the center of the discussion.

We have exemplified through the themes extracted about the potential of dynamic fabric. We now challenge the assumption that dynamic fabric would reduce clothing consumption habits but agree that AR versions of the technology may include expressions outside the traditional borders of a garment. We observed new opportunities for what one might choose to wear (photographs taken from the environment) and how different social-cultural contexts inspired different kinds of wearing behaviours ("blending" with the surroundings, or wearing less green to protect oneself from being dressed by a colleague). We also observed how the limits of the technology did not prevent the wearer from adapting it to her tastes, through gathering of various green materials and textures and designing how they were worn.

For designers working in fashion, smart textiles and wearable technology, and especially those engaged in research through design, we encourage explorations beyond concepts and the initial speculation. We encourage them to combine their design activities with research on the activity of *living with,* or *wearing,* over an extended period of time.

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