CHAPTER

1.2

Social Aspects of Wearability and Interaction

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1. INTRODUCTION

The concept of “wearability” in wearable systems is typically understood as relating to either the physical ability to mount a device on the body (e.g., to be “wearable” or “not wearable”), or to the physical and perhaps mental comfort of the wearer (e.g., to be comfortable physically and to easily interact with the device). However, since wearable systems are by definition worn on the body surface, they can be subject to the social perceptions and norms established by the clothing, accessories, worn artifacts, and body modifications that make up “dress” (as defined by Roach-Higgins and Eicher, [1]). Here, we consider the social facet of “wearability,” the variables and factors that influence how socially comfortable an individual feels while wearing a piece of technology. This often-overlooked aspect of wearability we find to be crucial to user adoption of a technology: if a user refuses to adopt the technology because of social factors, the functional benefit is entirely lost.

Wearable systems are almost exclusively discussed with a functional focus, i.e., in terms of what they do and how well they do it. By contrast, the key functions of dress consist of not only what dress “does” for the wearer, but also what dress communicates to others about the wearer through aesthetics and expressive elements. The latter has been argued as the more important “function” of dress – and in our climate-controlled modern world, there is certainly a less-obvious need for some central functions of apparel, such as thermal protection. Given the capabilities of modern technology, it is more likely that clothing is worn because of social conventions than because of the protection it affords. Certainly, the sheer variety of redundant garments owned and worn by an individual is evidence that functionality is not the only requirement (e.g., see [2], where we studied the size and use of individual wardrobes). Indeed, even the history of clothing reflects this: the earliest forms of apparel evolved in climates where protection from the elements was not a central, everyday concern, and in many early societies protective garments like shoes were not worn even in climates that modern humans would consider quite painful. It is believed that early apparel was most likely developed for spiritual (to ward off evil spirits) and communication (to signify status or group membership, to make visual reference to powerful or beautiful things) purposes [3].

The development of next-generation smart clothing and wearable systems brings a new facet to our understanding of apparel and dress. Similarly, though, approaching wearability of smart clothing through theories of dress leads us to emphasize the social wearability of wearable systems equally with their physical wearability.

In this chapter we address two key facets of social wearability: the "static" visual perception of a wearable system and the visual perception of dynamic interactions with a wearable system.

2. SOCIAL INTERPRETATION OF AESTHETICS

Clothing and wearable devices are primarily perceived through visual and somatosensory (sensations of the body) processes. Somatosensory perception is more pertinent to the wearer's own experience of wearability, and more particularly to the experience of physical wearability and body comfort. The communication functions of dress – the ways in which dress helps to define the individual and group identity of the wearer and the wearer's context – are therefore achieved mostly through visual communication. The degree to which perceptions of one's visual appearance are comfortable for the wearer can be interpreted as the social wearability of clothing and worn artifacts.

2.1 Visual Processing of Aesthetics

DeLong [4] describes the clothed or adorned body as the "apparel-body-construct," the combined influence of the visual properties of the body and the visual properties of worn artifacts. The body alone and a garment alone may have discrete properties, but both are modified as they are brought together. The body and the garment each have visual properties which encode meaning – sometimes literally, in the sense of a graphic t-shirt with a text-based message, and sometimes in a more abstract manner, in the sense of the social judgments that accompany wearing a fashion trend, or having a certain body shape. The intersection of the properties of the garment and the body also contributes to the viewer's perception of meaning in "decoding" the identity and context of the individual. For example, a too-tight waistband may constrict the wearer's waistline, producing folds above and below the waist, and distorting the original shape of the garment. This visual cue may be read in any number of ways, depending on other contributing visual factors, and attributed to elements of identity (too lazy to buy new clothes, too vain to admit a size change) or of context (temporarily wearing ill-fitting clothes, following a fashion for cinched waistlines), or both.

A wearable device worn under clothing may produce a bump or distortion to the body shape. This distortion may or may not be obviously attributable to something being worn under the clothes. Figure 1 shows three body-worn volumes (a rectangular shape with square corners, a curved shape, and a bracelet) worn under and on top of clothing. While curved shapes may be perceived as more “ergonomic” or comfortable, when worn under clothing they may be more easily read as a protrusion of the body’s surface rather than a concealed technology.

DeLong identifies two types of characteristics of the apparel-body-construct: expressive characteristics and referential characteristics (see the left side of Figure 2). Expressive characteristics are direct characteristics of the form itself (visual elements of shape, color, texture, etc.). Referential characteristics are interpreted by the viewer; they are characteristics of the form the viewer understands as related to something outside of the form (such as a brand logo, a visual reference to another time period or a symbol of an occupational role like a badge or white coat). In some ways expressive characteristics are less open to interpretation by the viewer. They tend to play on innate responses and associations (such as bolder colors being perceived as more aggressive, flowing shapes being perceived as softer and more gentle), whereas referential characteristics depend more on the experiences and prior knowledge of the viewer. For example, it is common for teen fashion trends to reference various decades of the past (e.g., 1970s fashion references in the late 1990s and early 2000s; 1980s references in the 2010s). However, while these references may evoke direct memories in older viewers, many of the adopters of these trends have no memory of the time periods they are referencing (and may not even be aware that there is a reference), and may therefore find a different kind of meaning in the aesthetic. The same holds true for wearable systems: while the aesthetic effect of the system may hold one meaning for the designer of the technology, to an observer this meaning may be completely lost, or interpreted as something else entirely. Starner et al. [5] found that the expressive characteristics of a wearable computer were often (at the time) interpreted as being those of a medical device, the nearest mental model that most viewers could compare the wearable to. They found that altering the color of the head-mounted display quickly translated the device into a new referential association: white or light-colored devices were more often interpreted as medical devices, but grey or black devices were more often interpreted as consumer products. This division in device color specifically has blurred to some extent since 1996, but other expressive characteristics of devices still display trends that afford referential grouping by viewers.

Meanings are often defined and agreed upon by groups and sub-groups within a society (Figure 2, right side). Bell described one facet of this definition process as “sartorial morality” – the codes and mores established by a society that govern “appropriateness” of dress. These codes change with context, such that a form of dress that may be appropriate on the beach is rejected in an office setting, or clothing that is appropriate for a younger person may be inappropriate for an older person [6]. While some codes may be explicitly enforced, more often they simply carry undesired social weight: social repercussions in the form of unwanted attention or negative responses that an individual may receive when “inappropriately” dressed [7].

FIGURE 1 Three styles of wearable volume in three body locations, worn under and on top of clothing.

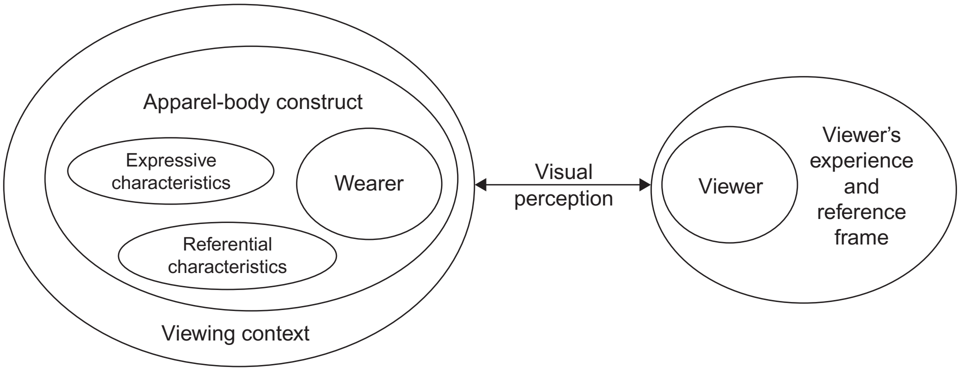

FIGURE 2 Visual perception of aesthetics.

2.2 Visual Expression of Individual and Group Identity

One of the most important ways in which the aesthetics of dress are interpreted is in understanding and assigning group identity. In some ways, the individual can be perceived as the intersection of the many groups of which she is a member: explicit groups such as her occupation, age, and socio-economic status, as well as less explicit groups like the kind of trends she adopts, products she buys, and the way in which she wears her clothes. In wearable sensing, a device may communicate group affinities like "handicapped," "sporty," or "high-tech," depending on its aesthetics and context. For example, the wearable volumes shown in Figure 1 may evoke very different group affinities depending on the shape, body location, and visibility of the "device." By assembling the many referential characteristics of her appearance, the observer forms an aggregate impression of this individual's identity. This impression is also heavily influenced by the observer's experience: for example, a young man wearing very tight jeans may be displaying allegiance to a certain trend, communicating to others that he is style-conscious enough to know that this is a trend and confident enough to pull it off. An older observer, however, may not be aware of this trend or that there exists such a group of younger people who all agree that this is a stylish way to dress, and may interpret the tight jeans by drawing on other previous experiences in which men were observed wearing tight jeans. If no suitably similar previous experiences are found, the viewer may perhaps interpret the visual appearance in another context, such as evidence of rebellion, lack of social awareness, or any number of other reasons.

Because wearable systems have not yet achieved widespread adoption, it may be difficult for observers to identify the group representation afforded by a visible device. As such, the aesthetics of the system may be grouped with a nearest-neighbor reference point, by interpreting expressive characteristics that fit a known category (such as the aforementioned influence of color).

In addition to communicating group identity to others, the way we dress also communicates some element of identity to ourselves. The "role" theory of social organization posits that an individual's understanding of how he is perceived by others mediates the roles he believes he is able to perform, and can actually affect his abilities and skills. A 2012 study by Adam and Galinsky [8] found effects in cognitive performance between groups of participants wearing identical white lab coats. The group told that their coat was a doctor's coat performed significantly better than the group told that their coat was a painter's coat. In wearable systems, similar effects can be found. Wearing a medical device may result in the wearer adopting a "sick person" or "patient" role, causing them to reduce their physical activity and restrict their movements in some way. For example, Costa et al. [9] found that patients wearing an ambulatory blood-pressure monitor were significantly less active when wearing the device.

3. ADOPTION OF INNOVATION AND AESTHETIC CHANGE

Wearable systems are at the same time required to be worn on the body, and not part of the current set of things typically worn on the body. Pervasive wearable systems rely on users wearing devices long-term, in their everyday contexts, which is generally a use pattern that relies heavily on social wearability. In turn, social wearability often depends on the normalcy of the wearer's appearance. Further, attempts to circumvent the requirement that worn devices subscribe to the aesthetic limitation of current forms of body adornment (devices that attempt to impose an entirely different aesthetic, such as the aesthetics of carried devices or small electronics) have to date not been successful in widespread adoption. It seems that attention to the structure and mechanisms of aesthetic changes in body adornment may benefit the development of wearable sensing devices. The following section will present theories of trend propagation and adoption of innovation in wearable products and technology. The case study at the end of this chapter applies these theories to a specific wearable technology product.

3.1 The Fashion Cycle: Aesthetic Change in Fashion

While the adoption of wearable devices has not been studied in depth, adoption of apparel fashion trends is well-researched. The term "fashion" as pertains to aesthetic changes in dress can be described as a gradual evolutionary process, inspired by changes in cultural identity and values, and established through a process of social consensus. A trend is not a trend until it is agreed upon by enough people, and innovation most often happens gradually, couched in the context of current norms [10]. (An aesthetic that is truly entirely new, with very few references to current norms, is more likely to look crazy or silly than to look cool.) Successful innovations often must resonate with the cultural "zeitgeist" [11] – the moods, values, and focus of a group or sub-group of a given society at a given point in time. This process is fuzzy and difficult to define (if it were straightforward, we'd all be rich!) and in practice relies heavily on the intuition and subconscious processing of members of the design community (i.e., designers, stylists, trend forecasters, journalists).

While the origin of trends and direction of trend propagation varies widely, the adoption and progress of a trend generally follows a similar structure. Innovators and early adopters are the first to adopt a new concept. (For fashion, early adopters are those invested in aesthetics and aesthetic change, who devote considerable time and attention to perceiving and developing trends, and who are usually more interested in differentiating themselves through aesthetics rather than conforming.) As the concept progresses and gains traction (is adopted by more and more people), certain factors are at play. Rogers [10] identifies the following factors that contribute to an individual's decision to adopt or reject an innovation: relative advantage, compatibility, complexity, observability, and trialability. Many of these factors relate to questions like: Do I understand it? Do I like it? Have I seen anyone else doing it? (And if so, who? Were they people like me?) Can I try it out before committing? For wearable devices, the relative advantage of the innovation is usually the key focus of the designer (making the device do something that the designer perceives as useful). However, if the remaining factors are not also taken into account, relative advantage may not be enough for widespread adoption.

If the innovation is adopted by early adopters and opinion leaders (Figure 3), and also meets the needs of the mass-market consumer, it will continue to pick up speed. Fashion consumers in the middle of the consumer spectrum are generally less sensitive to noticing trends, and are more interested in conformity in aesthetics ("fitting in") than in differentiating themselves ("standing out") [12]. Therefore, a mass-market consumer or late adopter must see the device adopted by far more people than a fashion innovator before they perceive it as something they could adopt.

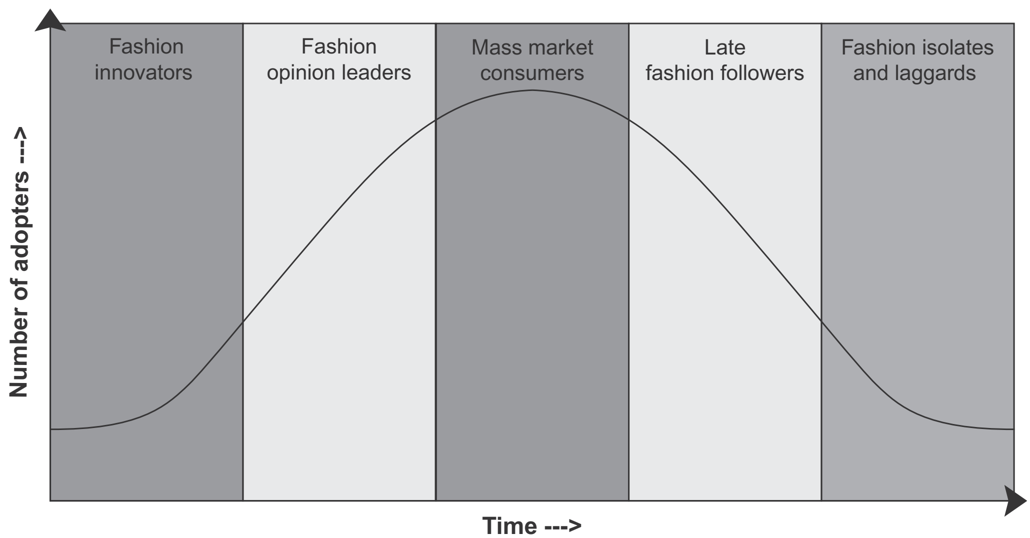

FIGURE 3 The consumer spectrum for fashion trends. *Adapted from Rogers [10].*

Finally, as innovations are adopted by the most-resistant adopters (fashion laggards), they can either become staple or non-fashion items (if they are still in use by fashion innovators and opinion leaders), or they can become symbols of insensitivity to fashion trends (e.g., become "uncool," if they have passed out of use for fashion innovators and opinion leaders). Laggards have also been characterized as particularly insensitive to aesthetic trends: for technology, this user group may actually be more willing to adopt a technological innovation that fashion innovators might perceive as socially unwearable, precisely because they are less sensitive to the emotional and identity-based factors of social wearability.

3.2 Social Leadership in Fashion

Many researchers and theorists have discussed possible influences of social roles on diffusion of fashion ideas. One of the first of these is the "trickle-down" theory, reinforced by Veblen's theory of "conspicuous consumption" [13]. In this model, the wealthy upper classes consume new fashions as a means of displaying wealth and influence. These status-symbol fashions are then disseminated through lower classes. However, with the advent of mass manufacturing and mass communications, innovations became more accessible at all social strata. King [14] discussed the "horizontal flow" theory, wherein innovations "trickle across" populations rather than down from higher social classes. Finally, "trickle-up" effects, where innovations are generated by youth and social minorities and subsequently adopted by a broader section of the population, have become more prominent in the last few decades (an example of this would be the rise of "street fashion" trends).

While these theories differ in their perspective on the origin and direction in which an idea spreads, the mechanisms in each theory are similar. The influences outlined by Rogers hold true regardless of the social status of individuals in each adopter group.

In the "fashion" of behavior (including adoption of technology), there are similarly several theories that have been used to explain the manner in which new technologies are explored and adopted by user groups. Ajzen's [15] theory of planned behavior describes the influences on an individual's consciously intended behavior as being influenced by both the person's attitude toward the behavior, the person's perception of his ability to perform the behavior, and the person's normative beliefs about the behavior (perception of what others believe he should do).

Davis's Technology Acceptance Model [16] reduces influences on a user's decision to adopt a technology to two major facets: the perceived usefulness and perceived ease-of-use of the technology. Malhotra and Galletta [17] expand this model to incorporate the social aspect of "psychological attachment," the user's perception of how well the technology fits her value system.

Wearable systems can be seen as the intersection between the processes that influence technology adoption, the processes that influence behavior change and the processes that influence fashion adoption: the usability and utility influence of technological systems, the social influence on behavior, and the emotional identity influence of fashion and worn artifacts.

4. ON-BODY INTERACTION: SOCIAL ACCEPTANCE OF GESTURE

Many wearable systems require some kind of interaction between the user and the device. Through interaction, the visual aesthetics of the device take on a new dimension: a dynamic dimension influenced by the interaction being performed. With interactive wearable systems, the user is visually evaluated not just by how they look, but by what they're doing. From the technology designer's standpoint, there are two major types of interaction that can take place with a wearable system: passive interactions and active interactions.

Passive interactions are sensed by the device without any explicit intent by the user. That is to say, passive interactions are activities, actions, and body states the device senses continuously. A wearable system may use this kind of information to infer context or to respond to a specific set of events.

Active interactions are actions performed by the user specifically for the purpose of interacting with the device. These activities can be seen as separate from (although often in parallel with) "natural" actions that are happening for a purpose other than interacting with the device.

Because passive interactions rely on detecting natural activities that have been defined within contexts outside of a wearable device, they are generally easy to socially understand (as they tend to be commonly-observed activities like sitting, standing, eating, etc.). However, the design and placement of the device itself will still affect the static aesthetics of the system (the aesthetics of the system "at rest"), and the relevant impact must be taken into account. By contrast, many active interactions introduce entirely new "vocabulary" into the visual vernacular in addition to the aesthetics of the device.

Here, we concentrate on active interactions that are performed with the hands or body. As such, we describe all active interactions as being "gestural" in nature (as in, requiring a specific movement of a part of the body). However, it is important to note that active interactions can be performed in other modalities as well — most significantly, through vocal interactions. The social perceptions of gesture have an effect similar to that of static aesthetics on the social wearability of a sensing device. Similarly, though not perceived in the visual domain, verbal interactions are also subject to social constraints on "aesthetic" and contextual appropriateness. While the following discussion concentrates on variables pertinent to physical interactions, a parallel can be drawn to similar variables pertinent to verbal and auditory interactions (voice commands and audio output).

4.1 Conspicuity and Social Weight

While active gestures are inherently more conspicuous than passive gestures, even passive gestures can be conspicuous when performed in an inappropriate context. For instance, a device that uses eye movements as inputs to perform specific commands (such as seen in [18]) may rely on movements that are often performed in daily life, such as blinking. However, if such a movement is performed when there is no readily observable reason for it to occur, it can become conspicuous as an active command (i.e., excessive blinking or long, drawn-out blinking).

Similarly, not all active gestures have the same conspicuity. Toney et al. [7] discuss the impact of device interactions on social interactions as "social weight": the degree to which interacting with a device has a negative impact on a simultaneous social interaction. This is an effect familiar to most users of technology: for example, interacting with a smartphone while mid-conversation can have a distinct social effect. If an interaction can be disguised as a "natural" gesture (in the case of Toney et al., gestures like touching buttons in a pocket or hem of a suit jacket), it may decrease the perceived social weight of the interaction.

4.2 Impact of Body Location and Handedness

Conspicuity of gesture is tightly coupled to two other design variables: body location and handedness. In previous work [19], we have explored the effect of body location on perceived acceptability of on-body interactions. When viewers observe users interacting with devices placed in various body locations, the perceived acceptability shows some interesting trends. For example, interactions that occurred in body areas where existing technology is already heavily worn and interacted with (the wrist and the forearm) were much more preferred to socially sensitive areas on the body core (e.g., the torso, which is proximal to a woman's breasts, or the pocket area, which is proximal to a male's genitalia).

Gestures that access readily reachable body locations (such as the forearm, as seen in Figure 4, or torso) may be more "naturally" performed than gestures that require contortion of the body to reach (such as the ankle or back). It is also clear that the more intensive the interaction with respect to body resources it occupies, the more conspicuous it may become. For example, a gesture that needs only one hand is likely less to be conspicuous than a gesture that needs both hands (even more so when one or more hands may be occupied prior to initiating the gesture). Furthermore, a gesture that also demands visual attention becomes even more conspicuous.

FIGURE 4 Distance (left) and close-up (right) views of interaction with the Jogwheel on female forearm (USA).

Humans are sensitive to the direction of gaze in others – for example, McAtamney and Parker [20] found that a head-mounted visual display re-directed gaze sufficiently to interrupt the flow of a conversation. To mitigate the effect of re-directed gaze, in circumstances where interface visibility is somewhat or entirely obscured, device surface topography can be employed to help tactilely guide the user toward the appropriate interaction (see an example in Figure 5). In previous work we employed design techniques to improve the "gropability" of a wearable display to minimize the demands for visual attention in interaction [21,22]. Tangible protrusions such as buttons, beveled or chamfered edges, or discernible apertures can help to orient the user for interface operation and reduce fumbling or accidental triggering.

4.3 Impact of Cultural Norms

From our previous research (Figure 6) it has also become clear that visual perceptions are strongly dependent on cultural norms and background. As these perceptions are largely judged relative to previous experience, the source of this influence is clear. The physical appearance and fashionable properties of an item may largely be driven by culture and context [23]. Additionally, perceptions of technology use may vary as normative behavior is not identical in all cultures [24].

In our work, which looked at societal attitudes toward textile-based on-body technology placement and interactions [19], we found that Americans and South Koreans reflected a similar affinity for on-body technology placement and interactions that occurred on the wrist and forearm, and a similar distaste for their least preferred on-body locations and location-based interactions: the torso and collarbone. However, in America, there were

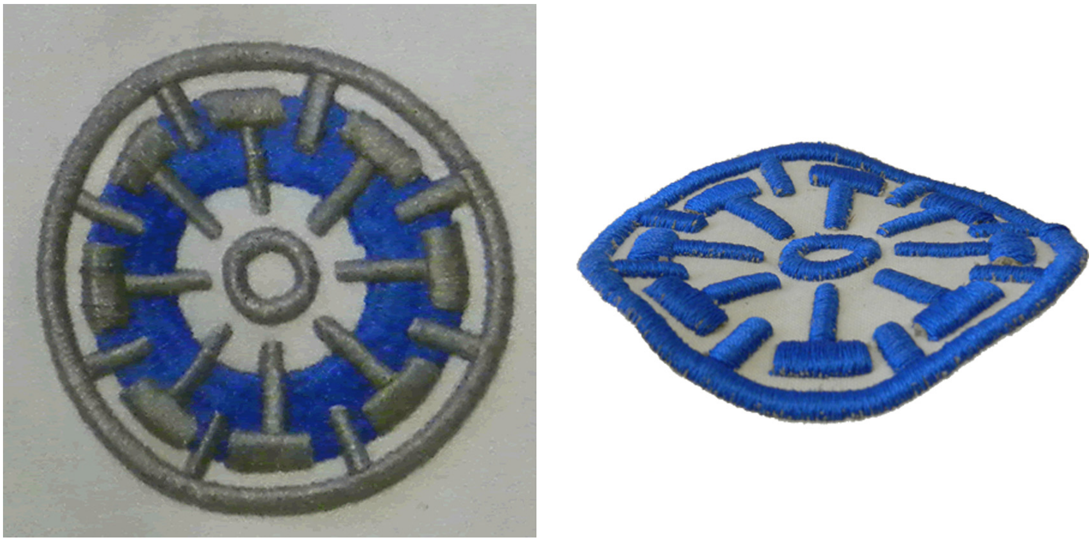

FIGURE 5 E-textile interface with discernible surface topography to aid touch (non-visual) interaction.

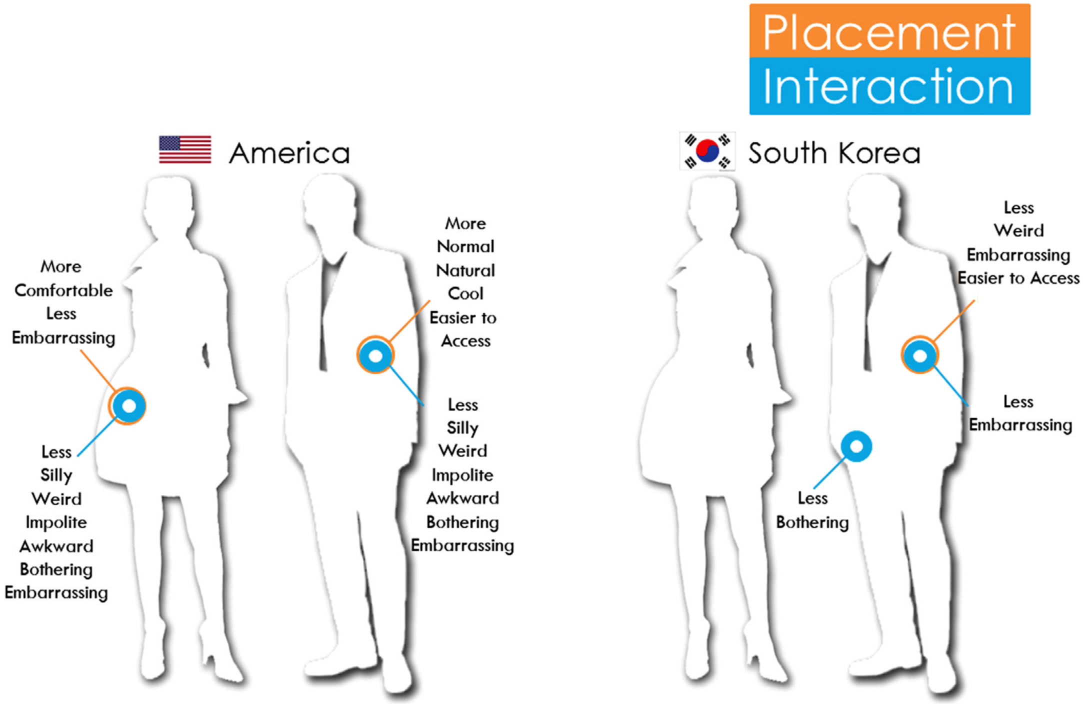

FIGURE 6 Cultural and gender comparison of on-body device placement and interactions. These were some of the least preferred locations, and despite this there were still significant attitudes toward gender preference.

some distinctions between attitudes toward on-body interactions. While, overall, the torso was one of the least preferred areas for device placement, interactions occurring at the torso were still significantly less acceptable on a female actor versus a male actor. Opposingly, interactions occurring at the pocket area were significantly less acceptable on a male actor versus a female actor. In South Korea, by contrast, this gender distinction was minimally present. Despite overall positive attitudes toward a particular placement or wearable, it was almost always less acceptable for the interactions to be conducted by a female actor versus a male actor, especially at areas on the upper body core.

4.4 The "Vocabulary" of Gesture

Social acceptability involves the manner in which one presents oneself so as to act comfortably within society [25], thus, societally prescribed conventions will ultimately play a role in how the physicality of interaction methods are perceived – i.e., whether they are deemed acceptable when performed within a particular context. Furthermore, the previously discussed facets of wearable technology (interaction technique, on-body placement, appearance, and aesthetics) and their perceived level of social acceptability will have a strong influence on their overall adoption.

Given these circumstances, how should gestural interactions be "designed"? Several precedents may lend insight. Many gestural interactions employ techniques common to hand-held and stationary devices, such as button-presses, taps, and touches. Newer gestural norms have emerged with hand-held touch screens, often based on real-world interactions, such as "swipe" (to move) and "pinch" (to zoom in/out) gestures. However, not all gestural inputs based on real-world interactions have taken hold: the "pinch" and "swipe" may be nearly ubiquitous now, but the "shake" gesture (to erase or undo) is not as well-entrenched.

Ashbrook and Starner [26] used a gestural toolkit to gather gesture inputs for a music player as designed by naïve consumers. While participants were relatively successful at creating distinct gestures for the audio player operations, a few participants expressed having quite a bit of difficulty devising gesture-based interactions that did not overlap with "everyday" gestures. Based on this study, a number of design strategies, such as "gestures should be easy to remember" and "gestures should be socially acceptable," were developed to help guide future gesture design.

Many investigations of gestural input have focused on gestures made by the hands, perhaps because affixing sensor devices to phones, watches, and other devices mounted on or held in the hands is a relatively accessible application. Other natural gestures like foot tapping, shrugging, head tilting, etc., have been less fully explored, perhaps because they require sensing more "distant" body parts. An electronic-textile interface that is seamlessly integrated into clothing might benefit from input methods that exploit current clothing interactions, such as pushing long sleeves up one's arm, or adjusting one's tie. Capitalizing on current clothing-based interactions may help minimize any cognitive dissonance experienced by a third-party viewer.

4.5 Differentiating Passive and Active Gestures

In the space between conspicuous and inconspicuous active gestures is the ambiguity of differentiating between active and passive gestures. Gestures that appear more "normal" often begin to approximate passive gestures, and can therefore begin to be confused with actual passive gestures (risking false positive triggering of interactions with the device). Large sweeping gestures may be easily and reliably detected as inputs to a device, but may also bring unwanted attention to a user, not to mention physical fatigue or obstruction of the use of other devices. Therefore, gestural interactions should be designed so that operations delineate intent from passive actions [7]. Ashbrook and Starner [26] describe the "push-to-gesture" interaction, where an "intent" button is activated before commencing the input gesture. Our "gropable" interface used a thumb anchor-pad to both tangibly orient the hand relative to the interface, and to enable touch-based activation of interface inputs [21]. Similar techniques include micro-gestures that frame an interaction to trigger the "input" phase: an audio analog is the "OK Glass" verbal activation command interaction with Google Glass.

There is also a crucial interaction between the static aesthetics of the device and the dynamic aesthetics of the interaction. Interaction with a device that is visible to third parties may self-evidently communicate intent; however, a conspicuous interaction with an inconspicuous device may obscure intent and induce confusion for observers. A solution is to pair an inconspicuous device with an inconspicuous interaction, as seen in Karrer et al. [27] in their Pinstripe e-textile interface, developed for eyes-free continuous input. Pinstripe can be embedded on the underside of one's shirt sleeve or pant pocket, and is manipulated by pinching the fabric between one's fingers. User preference was found in matching the inconspicuity of the device with a subtle interaction (pinching the inner and outer side of one's front pant pocket), thus not calling attention to the placement of the device.

5. CASE STUDY: GOOGLE GLASS

Because the spread of an innovation is so socially driven, and the genesis of a "good" idea so contextually sensitive, it can be difficult to force an idea to take root in a society. In technology, the concept of a "killer app" supposes that a very compelling function can overcome many of these social limitations to the spread of an idea. Similarly, in fashion there is a not-uncommon idea that a supremely influential innovator (individual, brand) can dictate a change that others will follow without question. In practice, both of these are difficult to achieve and prove more sensitive to subtleties of cultural context than expected. Gregory Abowd is credited with the observation that "It's not about a killer application with wearables; it's about a killer existence!" [5].

The Sony Walkman is an example of a technology that required a significant and abrupt aesthetic change (asking users to wear a conspicuous device on their heads and bodies, for the first time), yet also proposed a significant technological benefit (pervasive access to personal music). Sony's approach to encouraging the spread of their innovation was to hire young, attractive models who might be considered fashion innovators. These models were depicted in advertisements donning the device (a conspicuous transformation) and were also hired to wear the device in everyday situations, in major cities [28]. Through this strategy, Sony increased the observability of the device and to some extent, the trialability, lowering the barrier to adoption for fashion opinion leaders. Because the device already had a clear relative advantage, and, in Sony's opinion, an acceptable level of complexity and compatibility with existing systems (e.g., cassette tapes), the observability/trialability barriers were the key to facilitating adoption.

This model seems compelling: with the right application and enough marketing clout, it might be possible to push an aesthetic transformation into the mainstream. Google is currently in the middle of just such an effort, through the Explorer program for Google Glass. Google Glass is a head-mounted display, designed for micro-interactions with information technology. In Figure 7, the display itself is the blue component on the wearer's right side. In current models, the display is suspended from a metal band worn across the forehead, supported on the nose and ears as eyeglasses would be. (The device model shown in Figure 7 is custom-built onto a pair of eyeglasses. Consumer models would be worn on top of existing eyewear and would not contain lenses.)

The Explorer program is the mechanism by which Google has distributed early models of the device to users outside of Google employees. Glass Explorers were selected by the Glass team, and by a highly publicized open application process through which everyday

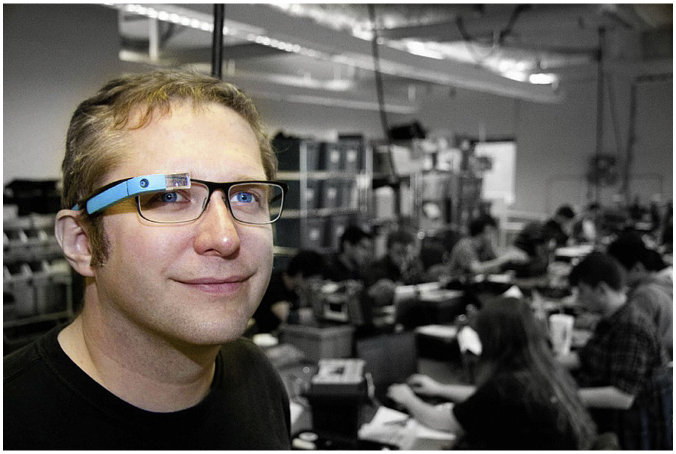

FIGURE 7 Google Glass, worn by project technical lead Thad Starner.

users could pitch Google on why they should be selected to purchase one of the first Glass devices. This strategy implements something of a trickle-down approach (by putting Glass in the hands of celebrities and other thought-leaders) as well manipulating the observability and trialability of the device through a wide variety of "everyday" users.

In parallel, putting the device into the world expands what Thad Starner (Technical Lead for Glass) calls the "living laboratory" in which the device can be further developed.

"Most of our experience comes from the team wearing the devices ourselves. With enough people wearing the device in normal life, a "living laboratory" is formed where a lot of these issues become self-evident. The main reason for the announcement of Glass as a Google Project in 2012 was to enable Googlers to wear Glass in public, expanding the living laboratory to everyday life on the street." [29]

This approach both increases the exposure of the device, allowing potential adopters to see it on everyday users (and expanding the likelihood that a potential user will see the device in use by someone similar to themselves), and helps illuminate some of the usability and social acceptability issues of the device as it is used "in the wild."

The design of Glass has inherent expressive characteristics but is intended to integrate with existing eyewear in a modular fashion, to allow users their own influence on the overall aesthetic. Glass designer Isabelle Olsson says:

> "Glass is different from eyewear that you are used to seeing both in its form and function. We took a reductionist approach to the design and removed everything that wasn't essential to create a light, minimalistic and transformable design. The key challenge for the design team was how can we create a product that people can make their own, you walk into a glasses store and there are thousands of styles to choose from. With this in mind we made Glass modular, so people can choose their eyewear whether it be sunglasses, prescription glasses or the band that's free from lenses. Glass at its core is ever evolving." [29]

As such, the design team took the approach of designing a sleek, modern device that adopts the future-facing aesthetics of other current consumer products such as mobile phones, rather than the nostalgic aesthetics that are currently popular in eyewear. Although the intent of such a modular design was to allow the device to be paired with other eyewear, the contrast in aesthetic between Glass and current trends in eyeglasses (many of which are nostalgic and reference vintage styles) could be abrupt. However, the designer's challenge is clear: the amount of aesthetic variability possible in traditional eyewear is significantly larger than the amount of variability that is feasible in the first consumer version of an emerging technology. If enabling the user's current norms in terms of choice and aesthetics is not possible, the alternative approach is to create enough demand around one single (novel) aesthetic that it overcomes the demand for variability in aesthetic. Demonstrating Glass in the context of fashion opinion leaders increases the chance of success for a transformative aesthetic that transcends current norms. Indeed, historically many significant aesthetic changes are attributed to either periods of dramatic social change, or to the invention of new technology.

In addition to the impact of static aesthetics on the social acceptability of Glass, the device's interactive aesthetics are also an important influence. Glass is designed to be interacted with either through verbal commands, or through a few gestures. Gestural interactions include looking up (to activate the device), swiping the touch-pad in front of the ear or pressing a button on the top of the right-hand temple. All of these gestures ostensibly fall into the category of "natural" gestures (or can be disguised as natural gestures, such as adjusting one's glasses), but as previously discussed, may be distinguished as contextually inappropriate depending on the context of interaction. Among the gestural interactions, head-tilt is the gesture most likely to suffer from confusability with natural movements (and, in anecdotal experience, it often does): because the gesture depends on angle of the head and can be calibrated to the user's specifications, the user must decide whether to rely on a potentially conspicuous head gesture (lifting the head to a more dramatic angle) or to risk accidental activation (when the head is lifted to a "natural" level).

By contrast, the verbal activation command ("OK, Glass") is explicitly distinct from phrases that would likely come up in conversation. In order to distinguish activation commands from everyday speech, it was necessary to design a unique verbal command. An alternative approach is what Lyons et al. [30] identify as "dual-purpose speech," natural words and phrases used in everyday conversation that can also serve as input to a wearable system. They use examples like appointment scheduling, where the user activates a "push-to-talk" button to activate the speech interface, then proceeds with natural conversational structures like "I'll pencil you in on Thursday at 1 pm" to deliver commands to the system. Starner describes "OK, Glass" as an explicit signal to a conversational partner that the user is now interacting with the device. He says:

> "One thing was to make the use of the device observable. The display is mounted above the user's right eye. Using the device is a social gesture. When I say "let me look that up," I literally look up into the display. When I do a Google search, I say "OK Glass, Google..." which implicitly tells bystanders that I'm doing a web search. Taking a picture is "OK Glass, take a picture" or pressing a button on top of the device close to the camera, similar to the gesture of triggering the shutter on a SLR or a point and shoot camera. All of these interactions are social gestures, just like looking at the time on a wristwatch. They cue your conversational partners to the interaction and help include them in it. Having a transparent display, where your conversation partners can actually see the interface as it is being used or at least get a sense of it, further includes them in the interaction. In essence, one is making the interface not just for the user, but for others in the social context of the user." [29]

The link between commands/gestures and visual feedback helps others to build a more accurate mental model of the functionality of Glass than a system like the Private Eye (discussed in [5]) allowed, which may help build more accurate first impressions of the device.

The combination of the viewer's mental model of what the device is and what it does and the viewer's social impressions of the identity conferred by the device on the wearer mediates the decision of whether or not to adopt a new device like Glass. Starner goes on to say that "First impressions are important with these devices. Unless potential users are willing to at least put the device on their head to try it, it does not matter how good the interaction is nor how powerful the interface. When I taught with my old systems, only 50% of the class would be willing to try it on. With Glass, that number is 99%. That is a major success for the project."

Sony's experience with the Walkman is one of the few examples of a top-down, trickle-down approach to the design of a conspicuous wearable device being commercially successful. However, the Walkman is closer to a "carried" device than a "worn" device, an important emotional distinction (carried technology has less influence on identity and sense of self than "worn" technology — a carried device is "something I have," where a worn device becomes "something I am"). Like Sony, however, Google has many of the important social influencers in place: a brand name with considerable caché, enough clout to put the device visibly in use by opinion leaders, and (for some, arguably) a compelling function.

By recruiting celebrities and innovators in many demographics and social strata, the device will gain targeted observability in everyday life. Assuming the relative advantage is significant enough and compatibility and complexity are in-line with user expectations, in theory the device will gain wider adoption. However, in the case that this approach is not successful, it will be less straightforward to determine which obstacle prevented user adoption. Glass as a case study for trickle-down adoption is better positioned than most other technologies for such an approach to be successful, and to date has seen acceptance/adoption by some high-profile thought leaders (for example, *Vogue* Magazine independently decided to feature Glass as an accessory in a fashion spread in their iconic September 2013 issue.) As yet, it is too early to tell whether or not it will gain mainstream traction, but this "living laboratory" may serve as a long-term example of how such an approach plays out in the marketplace.

6. CONCLUSION

Fully functional and high-performing devices have oftentimes been abandoned because aesthetics were not considered. This has been exceptionally true with respect to assistive devices [31]. Physical properties of the system will also dictate how readily a wearable device is received and adopted. Weight, volume, and placement [32] should be taken into account so as to avoid situating the device in areas that can hinder device use, obstruct other activities, or garner unwanted attention from outside observers.

As discussed in this chapter, the question of social wearability is complex, ever-evolving, and influenced by human psychology and sociology in many ways. Because of the inherent complexity of social dynamics, it is not feasible to prescribe a "how-to" or comprehensive rubric for designing effectively for social wearability. However, the following questions may help guide the design process:

1. For how long and in what contexts will the device be worn/interaction take place? How frequently will the system be accessed?
2. What resources does the device/interaction require? Which body parts, and which sensory systems? How much attention?
3. Where is the device located in relation to how it will be accessed? Is it visible?
4. Is the device/interaction similar to or different from "natural" interactions or existing aesthetics? In what ways?
5. How widely acceptable is the device/interaction to different user groups? What mechanisms are available to mediate that acceptance process?

Although it can be tempting to assume that a novel functionality may "trump" the influence of social wearability in mediating the adoption decision-making process, in most cases social factors have an unexpectedly strong influence on adoption decisions. Most importantly, the nature and influence of social factors for wearable products is distinctly different (and higher-impact) than the nature and influence of social factors for other types of personal devices (including handheld and mobile devices). The transition from mobile to wearable also includes a transition of the device into the wearer's intimate, emotional identity space. The impact of this transition on decisions around adoption and use of a device is paramount for wearable devices and must be creatively addressed to produce a successful product.

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