Don't Mind Me Touching My Wrist: A Case Study of Interacting with On-Body Technology in Public

Halley Profita[1,2], James Clawson[3], Scott Gilliland[3], Clint Zeagler[2,3], Thad Starner[3], Jim Budd[2], Ellen Yi-Luen Do[2,3]

[1]Department of Computer Science
University of Colorado – Boulder
halley.profita@colorado.edu

[2]Industrial Design, [3]Interactive Computing
Georgia Institute of Technology
{jamer, scott.gilliland, clintzeagler, thad, jbudd, ellendo}@gatech.edu

ABSTRACT
Wearable technology, specifically e-textiles, offers the potential for interacting with electronic devices in a whole new manner. However, some may find the operation of a system that employs non-traditional on-body interactions uncomfortable to perform in a public setting, impacting how readily a new form of mobile technology may be received. Thus, it is important for interaction designers to take into consideration the implications of on-body gesture interactions when designing wearable interfaces. In this study, we explore the third-party perceptions of a user's interactions with a wearable e-textile interface. This two-prong evaluation examines the societal perceptions of a user interacting with the textile interface at different on-body locations, as well as the observer's attitudes toward on-body controller placement. We performed the study in the United States and South Korea to gain cultural insights into the perceptions of on-body technology usage.

Author Keywords
Wearable technology; fashion; electronic textiles; gesture interactions.

ACM Classification Keywords
H.5.2. Information interfaces and presentation: User Interfaces – *Input devices and strategies.*

INTRODUCTION
The past decade has witnessed the emergence of electronic textile-based wearable computing systems that combine technology and fashion. This innovative advancement enables a plethora of opportunities for mobile computing as electronic textiles (e-textiles) allow for a seamless integration of technology into clothing. Potential applications of e-textiles include interacting with one's clothing to interface with a mobile phone or any number of portable electronic devices carried on-body. Implementing such wearable systems poses a number of challenges as these systems need to be not only usable but actually designed to be worn and used in public. Two challenges designers face when coming up with e-textile interfaces are where to put the interface and how to design an interface that can be manipulated easily. To that end, designers of e-textile wearable systems need to focus on designing interfaces that are both usable and socially appropriate.

Social conventions play a role in the acceptability of such novel interaction methods, as willingness to perform these gestures will largely be dictated by how appropriate those actions look and feel when performed in public. Previous studies have explored novel gesture-control techniques [23], hands-free device operation [4, 5, 6], and the self-perceived level of acceptability of novel gesture input methods for mobile devices [23, 24]. However, understanding the external perceptions of an individual's interactions with a wearable system has little precedent [7]. To explore this question, we developed an e-textile interface dubbed the "Jogwheel" (Figure 1a), which we used to conduct two evaluations: the first explored attitudes toward on-body interface placement, while the second assessed attitudes toward gesture interaction at a given on-body location (Figure 2). These research questions were selected to understand acceptable locations for prolonged "wear" of a system, and because wearable interface operation requires manipulation to occur on the body. This makes the touch interaction a socially sensitive issue. While hand-holding couples might be a common sight in American culture, in many Asian countries married people do not demonstrate affection or hold hands in public. An on-body touch interaction (based on location and interaction gesture) may be perceived differently in different cultural settings, thus, we decided to run the study in the United States of America (USA) and South Korea to gain cultural insights to on-body e-textile system usage.

BACKGROUND

Social Acceptability
Social acceptability involves the social skills and the presentation in which one comports oneself so as to interact comfortably within society or to not embarrass or call attention to oneself [13]. Clothing falls naturally into this category as, within cultural settings, there are outfits deemed 'appropriate' or 'inappropriate' for particular social

situations. One such example of situational-based inappropriate attire could entail wearing a bathing suit to a corporate meeting. The adoption of wearable technology may be subject to such societal conventions as integrating electronics into clothing may result in new designs, take on new shapes, and principally entail novel interactions for operation that are unfamiliar to the general public. As clothing, aesthetics, presentability, and gestures are all societally prescribed [12], consideration of these aspects within the bounds of social suitability may help inform designs and potentially contribute to overall system success.

Historically, social acceptability has played a prominent role in the adoption and usage of worn forms of technology. Prior to World War I, wristwatches were donned only by females until their function and placement proved vital for coordination of soldiers in the trenches [20]. Additionally, some of the first hearing aid devices were embedded in the frames of glasses to disguise the apparatus. Perhaps one of the most notable wearable consumer electronic devices is the Sony Walkman, which debuted in 1979 as the first portable music player. It revolutionized the way we listened to music; however, the developers knew that the most challenging obstacle would be convincing individuals to wear this foreign device conspicuously on one's head. To address this challenge, marketers launched a clever ad campaign that entailed displaying young, attractive models donning the device. This strategy helped generate a cultural phenomenon that made this device fashionable to wear [8].

As elucidated by the previous examples and academic research [7, 21], wearable technology usage can be heavily influenced by its perceived level of social acceptability. The development of novel wearable forms of technology can benefit society by offering new product functionalities; however, these wearables may present themselves in new form factors and may be accompanied by a set of gesture interactions that individuals may or may not be comfortable performing in a private or public setting. Wearable technology will likely face some of the same barriers to entry as exhibited by the Sony Walkman. By investigating societal perceptions preemptively, we can make informed decisions regarding the design of on-body technology.

RELATED WORK

Social Acceptability of Wearable Technology

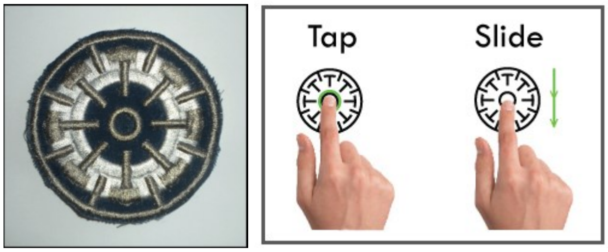
Malhotra and Galletta ascertained that social influences will have a large impact on system usage and acceptance of new technologies [18]. While societal perceptions of wearable technology usage have remained relatively unexplored, many studies investigating wearable systems acknowledge the importance of social acceptability for overall technology adoption [16, 17, 20, 26]. Karrer *et al.* explored on-body usage of The Pinstripe, a wearable e-textile input device, and found that on-body placement of the wearable system was accepted or rejected with respect to the social or personal reasons of the user [17]. In Toney *et al.,* it was recognized that the social weight of context could greatly impact the acceptability of interacting with a technology-outfitted suit in the workplace. Thus, actions for operating a piece of masked wearable technology should align with what is considered appropriate behavior to an outside observer: a user should appear to be interacting with "conventional technology" (a watch) or no technology at all [26]. Feiner acknowledged the importance of appearance in terms of receptiveness to wearing an item such as a head-worn display [9]. Bodine *et al.* also determined that desirability to don a wearable computer will be dependent on the comfort and overall functionality of the wearable [2].

While social conventions may dictate adoption and use of new technology, it is also important to note that social acceptability is culture- and time-dependent. While attitudes toward novel technology can appear severe at first, continued exposure to the technology can result in higher overall acceptance over time. This effect has been exhibited with the Bluetooth headset, which at first caused users to appear as though they were talking to themselves. However, through continued use, Bluetooth headsets have become more readily accepted within society [24].

Social Acceptability of Mobile Device Gesture Interactions

Rico *et al.* explored the social acceptability of novel full motion gesture types to control a mobile phone [23] and the social acceptability of gesture-based interactions in specific contexts (public, home, workplace, etc.) [24]. The results indicated a significant relationship between audience/ location and the willingness to perform a particular gesture. This relationship indicates that gesture techniques (as a byproduct of the challenges of overall interface design) require a higher level of scrutiny if they are to be acceptable for use within a public context. In examining how to design mobile device control gestures that would have the possibility of false triggering, Ashbrook [1] explicitly instructed study participants to create socially acceptable gestures. The resulting gestures were often surprisingly inappropriate, suggesting that his gesture designers had difficulty with the task. While current research has looked at the user perceptions of gesture-based mobile control techniques [23] as well as the feasibility of hands-free mobile control techniques (e.g. head-tilting [6], foot tapping [5], EMG controllers [4], and wrist-tilting [22]), to our knowledge, limited research has been conducted to assess third-party attitudes toward e-textile system interaction.

For wearable technology, novelty of interface operation (due to on-body manipulation) may supersede existing acceptable practices for mobile device interaction. As such, one can exploit common clothing interactions (e.g., adjusting a shirt collar) in order to establish a baseline for acceptable gestures. Karrer *et al.* gleaned that negligible rubbing of one's front pant pocket to control a wearable device was rated as highly acceptable by the user [17]. Since our study used an exposed interface, conspicuous



(a) (b)

Figure 1: a) The Jogwheel, b) Gesture interactions.

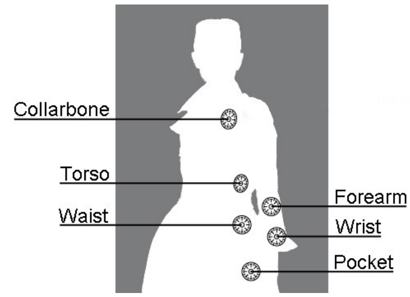


Figure 2: Body locations for controller placement.

gestures were chosen to adhere to the notion that interaction techniques should visually communicate intent [26]. Furthermore, this study has drawn from current mobile technology interactions, common to a touchscreen and iPod interface, and mapped these gestures onto a textile medium for participant interpretation and assessment.

Cultural Perceptions of Public Technology Use

To date, few studies have looked at the cross-cultural perceptions of public mobile technology use. Public technology usage and perceptions may be driven largely by culture, "as norms for social behavior vary according to culture" [3]. Understanding these characteristics beforehand may reveal significant design implications when developing mobile technologies for different countries. Campbell studied attitudes of mobile phone use in different settings (theaters, restaurants, sidewalks, buses, classrooms, and stores) in America, Sweden, Taiwan, and Japan. The study found that cultural differences arose. In most cultures, confined public spaces (theaters, classrooms, etc.) were the least socially acceptable for mobile phone use. However, in Japan the use of a mobile phone on a bus or a sidewalk was less socially acceptable than in a restaurant or a grocery store [3]. A number of other studies have recognized the importance of culture with respect to website design, looking at country-specific online content differentiation [14, 19]. These studies shed light on cultural differences toward technology usage and highlight an interesting area to be explored with respect to wearable technology.

EVALUATION

This study assessed the societal perceptions of interacting with an e-textile wearable interface. To capture attitudes toward usage behavior and system placement, participants were asked to view a series of videos of users interacting with the Jogwheel at six on-body locations (Figure 2). The study was deployed in survey format in the USA and South Korea to ascertain country-specific attitudes of gesture-based on-body technology usage. We chose to present the videos in an online survey as it allowed the scenarios to be depicted within a controlled, public context and supported widespread dissemination. An elevator was selected for the controlled environment as it visually communicated a public setting. We decided to portray the Jogwheel as an input device that paired with one's mobile phone as it made sense that a wearable piece of technology would be used in conjunction with another mobile electronic device. We were interested in exploring a concise use case (silencing a mobile phone call) as wearable technology would best be suited to support such swift and succinct interactions [1]. Participants served as the third-party viewers that watched video footage of a user with the Jogwheel. The videos were recorded using a native born male and female actor of each represented country speaking in the primary language of each respective culture, English and Korean.

The advantage of the Jogwheel is its ability to support multiple types of one-handed gesture interactions. Tapping and sliding (Figure 1b) gesture commands were proposed for this study based on their current familiarity (i.e., mapping to an iPhone or iPod) within society. An initial pilot study revealed an American preference for the sliding gesture command versus a South Korean preference for the tapping gesture command. Thus, the preferred gesture was used when deploying the survey in each respective country.

Hardware

For this study we constructed an e-textile interface similar to the research prototypes developed by Gilliland *et al.* [11]. Embroidering the pattern with conductive thread created a raised surface topography (Figure 1a) that helped guide one's finger along the embroidered path. The Jogwheel is twice the diameter of an iPod click wheel (~3.81 centimeters). This larger size allowed for greater operational accuracy and increased functionality. The Jogwheel was attached to the various body positions with adhesive backing for easy relocation. The incoming phone call in the video was simulated using sound effects.

Body Placement of the Jogwheel

We considered a significant number of body locations for the Jogwheel to capture a range of emotional responses. Drawing from previous studies of feasible wearable technology body placement [10, 15, 17] and discussions with our research group, six on-body positions (wrist, forearm, collarbone, torso, waist, and front pant pocket) were selected for system evaluation (Figure 2). Locations were chosen based on current areas of wearable technology usage and storage (watch worn on one's wrist , or an mp3 player attached to one's forearm, clipped to one's sports bra or belt, or stored in one's pocket). Locations on the lower

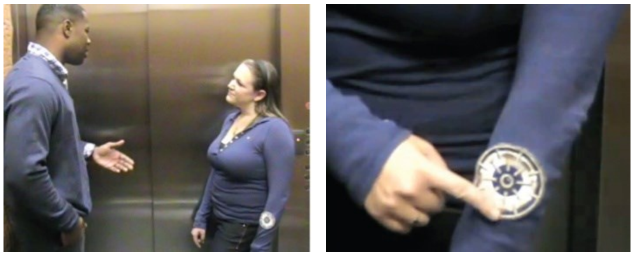


Figure 3: Distance (left) and close-up (right) views of interaction with Jogwheel on female forearm (USA).

extremities were not considered as the system had to be within one arm's length of comfortable reaching distance. Furthermore, it was important to evaluate a large number of on-body locations to ensure that the societal reaction was a result of the actual body placement as opposed to the novelty of the e-textile wearable controller. For the actors' apparel, blue jeans and a long-sleeved, navy blue shirt/sweater were chosen. The long-sleeved shirt permitted easy interface placement on both the wrist and forearm and was conservative in nature. Navy blue was selected as it had a neutral association across cultures, confirmed by international members of the research team.

Study Parameters

The survey consisted of a study introduction, a demographic questionnaire, the wearable technology acceptability assessment, and a follow-up questionnaire. Participants were required to be of legal consenting age: 18 in America and 19 in South Korea, and were screened based on self-reported nationality to ensure attitude correspondence with country-specific values. To establish full participant comprehension of the e-textile system, a qualifying question, "Do you understand what a wearable controller is?" was administered after the introduction.

The Wearable Technology Acceptability Assessment

This survey featured videos of Jogwheel interaction followed by questions asking participants to rate each interaction. The videos depicted two individuals (actors) chatting inside of an elevator when their conversation is interrupted by a mobile phone call. The actor outfitted with the Jogwheel uses it to silence the incoming call. Participants were then asked a series of questions assessing the actor's interaction with the Jogwheel. Participants first watched a video (Figure 3) of the interaction at a distance and were prompted to answer a series of eleven, 5-point Likert-scale questions ranging from "Strongly Agree" to "Strongly Disagree" regarding Jogwheel placement. Participants were then shown the same video cropped to focus on the gesture interaction and were asked to rate it according to a similar set of questions. Due to the fact that there is no established social acceptability metric for wearable technology, questions were devised based on Rico *et al.* [24]. Additional attitudinal questions were asked to convey varying perspectives regarding system interaction (*Does the interaction look: normal, silly, natural, cool, bothers me, embarrassing, awkward, weird, easy to perform, impolite, tiring)* and placement *(Does the placement look: normal, silly, natural, cool, bothers me, embarrassing, awkward, weird, easy to access, annoying to access, comfortable to access).* We selected roughly an equal number of words with positive and negative connotations to collect a range of perspectives.

Overall, the study depicted both a male and a female actor interacting with the system at six different on-body locations (wrist, forearm, collarbone, torso, waist, and pocket) filmed at 2 views: distance (~1.2-1.5 meters) and close-up (~30-45 centimeters). A button press with a BlackBerry Curve 8320 was also rated by the participants to establish a baseline score of what is currently considered a socially acceptable interaction with a mobile device. This combination of areas (6x2x2), plus the BlackBerry interactions, resulted in a total of 28 video-captured interactions. Each video sequence at the distance view ranged from 6 to 20 seconds. Each close-up video sequence lasted 1-2 seconds and was looped five times. The video sequences were randomized using a partially-balanced Latin Square algorithm to reduce an ordering effect. We were wary that response trends toward the "Awkward' and "Normal" rating would be the result of a question order bias. Thus, after the first dataset for the American study (n =56) was received, we changed the order of the questions in the surveys for both countries using a random number generator. A t-test (unequal variances) conducted on a random sample of responses on pre and post randomized questions determined that there was no statistically significant effect of question order on attitudes.

The Follow-Up Questionnaire

Due to the fact that social acceptability is time- and culture-dependent, we wanted to collect substantive data to gain post-assessment cultural insights into the current participant attitudes toward the Jogwheel system. Participants were asked to provide open-ended responses on their two most preferred locations for Jogwheel placement, two least preferred locations for Jogwheel placement, and concerns with the system. Participants were also asked if they found such a system useful, their willingness to use the system, as well as the two most important system features.

RESULTS AND OBSERVATIONS

In total, 125 participants (96 from the USA and 29 from South Korea) were recruited for this study. Results from the wearable technology acceptability assessment and the follow-up questionnaire yielded key insights into attitudes toward e-textile wearable interface usage.

General Perceptions of Jogwheel Placement by Country

Figures 4a, 4b, and 4c depict the overall median scores for attitude ratings toward system body placement. Two of the most definitive descriptors for capturing participant perceptions were the terms "Normal" and "Awkward". For these descriptors, the BlackBerry received the highest and

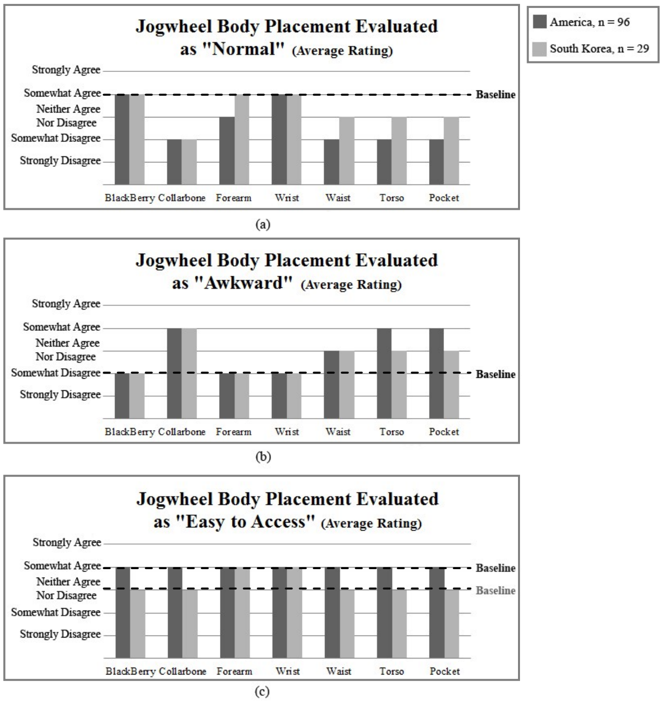


Figure 4a, b, c: Country comparison of median ratings for Jogwheel body placement.

lowest ratings, respectively, indicating the current accepted behavior of interacting with a mobile device. This was considered an acceptable baseline by which to compare the ratings of "Normal" and "Awkward" attitudes for the on-body Jogwheel interactions. As one can see, the perceptions toward the placement of the Jogwheel received rather comparable ratings between countries (most "Normal": wrist and forearm locations (Figure 4a)). The most awkwardly rated locations for controller placement were consistently opposite to the most normally rated body locations. This indicates that the words "Normal" and "Awkward" serve as serviceable terms to bound the range of attitudes toward interaction with wearable technology. From the ratings, we garner the acceptable body locations with which to introduce a wearable interface such as the Jogwheel. Garnering information on whether or not a location was "easy to access" helped contextualize attitudes toward Jogwheel placement. While an on-body location for the Jogwheel may have elicited a response of "Easy to Access," it does not necessarily indicate that the particular location looks "Normal" to an external viewer.

United States of America

Fifty-five females and 41 males, ages 18-76, were recruited. Since participants were asked to evaluate the Jogwheel interactions on a male and a female actor, we looked to see if there were significant differences in attitudes of interface interaction and placement when viewed across genders. We used a Wilcoxon signed-ranked test for data analysis given that we were working with non-parametric data. Only the statistically significant ($p < .05$) results have been included.

Gesture Interaction Attitudes

Attitudes toward Jogwheel interaction on the torso were significantly less awkward (0.005), less silly (0.0), less bothering (0.0), less embarrassing (0.0), less weird (0.0), and less impolite (0.0) on a male actor. This corresponds to the fact that torso interactions also appeared less natural (0.02), less normal (0.001), and less cool (0.004) when performed on a female actor. However, attitudes toward interaction on the pocket were less awkward (0.0), less silly (0.0), less impolite (0.0), less weird (0.001), less embarrassing (0.001), and less bothering (0.008) when performed on a female. The pocket interaction was rated as less natural (0.0), less cool (0.002), and less normal (0.0) when performed by a male actor. The results also revealed that interaction at the collarbone looked more embarrassing (0.047), more impolite (0.002), less natural (0.012), and less cool (0.007) when performed by a female actor versus a male actor. Wrist interaction looked less embarrassing (0.04), less silly (0.012), and less bothering (0.04) when performed by a male. Finally, waist interactions looked significantly less easy to perform (0.025) by a male actor.

Controller Placement Attitudes

Placement of the Jogwheel on the torso looked significantly easier to access (0.006), comfortable to access (0.007), normal (0.001), natural (0.002), and cool (0.005) on a male actor. Correspondingly, Jogwheel torso placement looked more embarrassing (0.0), weird (0.0), awkward (0.0), silly (0.004), bothering (0.0), and annoying to access (0.042) on a female. Waist placement was rated as less normal (0.011) and more annoying to access (0.015) on a male, and pocket placement looked less comfortable to access (0.045) and more embarrassing (0.019) on a male. The forearm location looked less cool (0.004) and more embarrassing (0.022) on a female. Finally, the collarbone location looked less natural (0.013) and less cool (0.007) on the female actor.

South Korea

Fifteen females and 14 males, ages 25-41, were recruited for this study. Akin to the American study, we examined if differences existed in attitudes toward input gestures and controller placement based on actor gender.

Gesture Interaction Attitudes

Interaction with the Jogwheel located at the collarbone (0.022), the wrist (0.046), the torso (0.012), and the waist (0.027) looked less embarrassing when performed by a male. Interaction occurring at the waist looked less impolite (0.013) and less weird (0.007) when executed by a male. Interaction taking place on the pocket also appeared to bother participants less when performed by a male (0.017).

Controller Placement Attitudes

South Koreans rated the Jogwheel collarbone placement as less embarrassing (0.003) and less weird (0.002) on a male actor, while placement on the wrist looked more natural (0.038) on a female. Attitudes regarding the waist location appeared more awkward (0.017), more embarrassing (0.008), less easy to access (0.021), and less normal (0.046) on a female. Finally, the torso location looked easier to access (0.032), more comfortable to access (0.018), less embarrassing (0.012), and less weird (0.034) on a male.

Follow-Up Findings

This questionnaire captured additional participant attitudes toward the Jogwheel. Participants were asked to discuss the reasons for their two most preferred on-body controller placements. In both countries, the wrist (USA: 75%, South Korea: 96.6%) and the forearm (USA: 54.17%, South Korea: 65.5%) locations were the most popular. Americans indicated the ease with which those areas could be accessed, their unobtrusive location, and that those placements appeared the least "awkward" or the most "normal" for donning technology. Many South Koreans also emphasized the ease with which these locations could be accessed. One must consider that these preferences may be due to the fact that current forms of wearable technology are already used at these locations - influencing overall acceptability ratings. This tendency was reflected by both countries. Nevertheless, these locations depict a feasible starting point for designing future wearables.

Participants were also asked to discuss the reasons behind their two least preferred on-body Jogwheel locations. The Americans and South Koreans displayed a similar distaste for the collarbone (USA: 56.25%, South Korea: 65.5%) and the torso (USA: 63.54%, South Korea 58.6%). South Koreans stated that the collarbone and torso were unaesthetic, inconvenient to access, and uncomfortable to view. There was also a large emphasis on the awkward and uncomfortable position of the placement, with participants indicating that they were "shy", that interaction at that specific area bothered them, or that the interaction might be distracting to others. Americans also stated that such areas were "awkward" (both aesthetically and to interact with), uncomfortable, noticeable, at an awkward line of sight, and might result in an embarrassing movement and call too much attention to private areas, especially on a female.

The findings also yielded pertinent concerns and desired system attributes regarding our wearable interface. For Americans, the most common concern was accidental triggering. Many other concerns revolved around system robustness, questioning its stability, attachment, and breakage, as well as its durability with respect to sweat, weather, and washing. A number of participants indicated the importance of pure aesthetics, specifying that they found the system useful so long as it did not unfavorably draw attention to a person. One user described not wanting "to explain something unusual to people." Participants felt that the system should be smaller and less conspicuous so as not to interfere with clothing or activities. A few participants indicated optimal system features, highlighting comfort, speed, and an easy connection to electronics. Mention of the overall safety of the system was also present

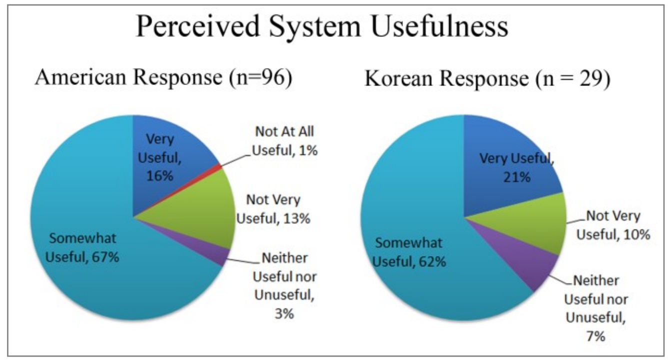


Figure 5: Country comparison of perceived level of usefulness of a wearable system like the Jogwheel.

as a few participants were concerned about the hazards of electrical waves. Over half (55.7%) of the South Korean participants also indicated concern with the interface, expressing the same sentiment about hardware malfunctions and accidental triggering. Statements about moisture, price, and side effects from electro-magnetic waves were also listed, showing consistency with the American study.

Reported product usefulness (somewhat or very useful) was relatively high for both countries (USA: 83%, South Korea: 83%, (Figure 5)). Over 65% of South Koreans stated that they would be "Very Willing" or "Somewhat Willing" to use this device. No one stated that they would be "Not At All Willing" to use the device. Similarly, 64.5% of Americans indicated that they would be "Very Willing" or "Somewhat Willing" to use this device. Only 5.2% of participants stated that they would be "Not At All Willing" to use the device. Participants were also asked to report the two most important features of a wearable system from the following options: easy to access, easy to operate, doesn't interfere with movement, doesn't interfere with items worn on-body, can use without looking, is not very noticeable to others, can be moved between different pieces of clothing, doesn't make me look weird or awkward, or other. South Koreans indicated desirability for a system that was "easy to access" (48.3%) and "doesn't make me look weird or awkward," (41.4%). Americans preferred a wearable system that was "easy to access" (35.4%) and "easy to operate" (34.3%). These responses reinforce accessibility [25] as a prevailing heuristic for wearable systems.

DISCUSSION

Unlike many previous studies which have focused on the self-perception of gestures performed using a mobile device, this study specifically explores third-party attitudes toward interaction with a wearable device. The data revealed a number of insights regarding cultural distinctions of on-body gesture interactions.

The results reveal the existence of a gender effect with respect to controller placement and gesture interaction. In both the USA and especially South Korea, overall on-body interactions and Jogwheel placement appeared to be more acceptable by/on a male. However, in the USA, interactions and Jogwheel placement at the pocket and waistline were considered less acceptable when performed by a male, revealing a socially sensitive sentiment toward interactions occurring on or around a male's waist area. In the USA, interactions and interface placement at the collarbone and torso were less acceptable by/on a female, suggesting unease with watching a female user performing touch gestures on socially sensitive areas of the upper body. In South Korea, the placement of the Jogwheel was rated less positively on the collarbone, torso, and waist areas of a female, and interactions occurring on the collarbone, torso, waist, and pocket were also rated less positively on a female, suggesting on-body touch gestures as being less socially acceptable on the waist and upper body areas on women. The consistency of the forearm and the wrist as being the areas with the most positive interaction and controller placement ratings suggest an overall neutrality of these locations as sites for on-body gesture interactions and interface placement across cultures. This may be due to the fact that these locations are already being used for donning wearable technology, and that these areas are removed from private/sensitive regions of the body.

Furthermore, it is important to treat system location and interaction at said location as two different dimensions for evaluation. While the collarbone location might yield an acceptable response with respect to location (as the collarbone area is a common location for embroidering logos on t-shirts), actually interacting with an interface at that location might be considered entirely unacceptable in a social setting. From the results, we can also extract a number of relevant design implications for consideration when developing wearable technologies. Mention of accidental triggering, material/system robustness, and safety highlight existing barriers to entry for wearable technologies. These concerns were present amongst both Americans and South Koreans and yield immediate insight into system quality necessities.

There were also a number of insights gained from the follow-up questionnaire. Interesting points included the South Korean preference for a system that avoided making the user look weird or awkward. This may be attributed to the modest culture of South Korea with its propensity to minimize impoliteness or embarrassing situations. Americans preferred a system that was "easy to operate," while only 6.9% of South Koreans reported that the system should be "easy to operate." This variability in frequency might suggest a strong American bias toward user-friendliness. Possible explanations could include an American preference for a system that is more intuitive, versus South Koreans' confidence in their ability to learn a novel interface. This might be explained by the South Korean affinity for new technology adoption.

Reflection

This case study yields insight into the societal perceptions of a wearable, e-textile interface. While this study has generated pertinent criteria for consideration in the design and implementation of wearable systems, some points must be made with respect to the overall results. These results are specific to the e-textile controller, body locations, and gestures used in this study and therefore cannot be generalized for all types of wearable interface interactions. As such, this research cannot speak to the societal perceptions of system usage on attire not used in this study, even if it covered the same area of the body, e.g. a skirt. However, our methods for system evaluation are transferable to future e-textile interfaces and can be applied for other mobile systems to produce a set of more generalizable conclusions. As true with many forms of technology usage, what is considered socially acceptable today may not be common practice in 5 to 10 years. While socially acceptable practices are constantly changing, our research sought to capture a snapshot of the current societal perceptions regarding wearable technology placement and usage. In light of this, social acceptability research should be continued with respect to novel wearable interface designs and body placements for a broad range of classifiable elements to serve as a design aid for wearables.

FUTURE WORK

Future work involves expanding our research to include other types of e-textile interfaces and gesture techniques. Doing so has the potential to broaden our understanding of socially acceptable perceptions toward wearable technology usage. As such, we hope to evolve both our methodology and our platform to enable more rapid deployment of video surveys. Long-term deployment and evaluations of these technologies would be another interesting avenue to explore as there is little research on longitudinal investigations into the daily use of e-textile interfaces. One of the most suitable conditions for conducting such a study is in a constrained contextually-defined wearable technology space. Such applications can support activities that can greatly benefit from an on-body system while avoiding the underlying problems that result in an attempt to create a more generalized system. An example would be to evaluate a profession-specific use of a textile input system such as for law enforcement officers, emergency medical technicians, or other first-responders.

We are still very interested in exploring societal perceptions with respect to interface/gesture/location combinations. A challenge arises to design e-textile wearables that can either clearly communicate interaction intent to a third party observer or can fully enable subtle, inconspicuous interactions. Assessing the attitudes for different interface/gesture/location combinations will help organize appropriate wearable technology applications and their corresponding usage criteria.

CONCLUSION

In this paper, we present a cross-cultural examination of the societal perceptions of gesture interactions with, and on-body placement of, a wearable e-textile interface. Our research suggests aligned attitudes in both countries toward interface on-body placement (wrist and forearm). We discerned a bias toward important wearable system features: "ease of operation" in America versus a limited awkward appearance in South Korea. Encouragingly, a majority of participants deemed the Jogwheel interface tested in the study as "useful" and indicated a "willingness to use" it, suggesting that electronic textile interfaces may be accepted by consumers.

ACKNOWLEDGEMENTS

The research team would like to extend a special thank you to the actors who participated in the survey videos, as well as the statistical acumen of Vlad Pop and Dana Habeeb. We would also like to express our appreciation to Dr. Young Mi Choi, Seunghyun Tina Lee, and Dr. Seungyon Claire Lee for their help with South Korean cultural insights and translations.

REFERENCES

1. Ashbrook, D. *Enabling Mobile Microinteractions.* PhD Diss., College of Computing, Georgia Tech, 2009.
2. Bodine, K. and Gemperle, F. Effects of functionality on perceived comfort of wearables. *ISWC, 2003,* (2003).
3. Campbell, S. Perceptions of mobile phone use in public settings: a cross-cultural comparison. In *Proc. of the Intl. Journal of Communication 1,* (2007), 738-757.
4. Constanza, E., Inverso, S.A., and Allen, R. Toward subtle intimate interfaces for mobile devices using an EMG controller. *CHI 2005,* ACM Press (2005).
5. Crossan, A., Brewster, S., and Ng, A. Foot tapping for mobile interaction. *BCS HCI 2010,* (2010).
6. Crossan, A., McGill, M., Brewster, S., and Murray-Smith, R. Head tilting for interaction in mobile contexts. *MobileHCI 2009,* ACM Press (2009).
7. DeBlasio, J.M., Caldwell, B., Mauney, L., Lyons, K., Kintz, E., Walker, B.N., Jacko, J., and Starner, T. The use of different technologies during a medical interview: effects on perceived quality of care. Georgia Tech GVU Center Technical Report # GIT-GVU-07-13, October 2007.
8. Du Gay, P., Hall, S., James, L., Mackay, H., and Negus, K. *Doing cultural studies: the story of the Sony Walkman.* Great Britain: Sage Publications Ltd.,1997.
9. Feiner, S. The importance of being mobile: some social consequences of wearable augmented reality systems. *IWAR 1999,* (1999), 145-148.
10. Gemperly, F., Kasabach, C., Stivoric, J., Bauer, M., and Martin, R. Design for wearability. *ISWC 1998,* (1998), 116-122.
11. Gilliland, S., Komor, H., Starner, T., and Zeagler, C. The textile interface swatchbook: creating graphical user interface-like widgets with conductive embroidery. *ISWC 2010,* (2010), 1-8.
12. Goffman, E. *Behavior in public places: notes on the social organization of gatherings.* Free Press, New York, USA, 1963.
13. Goffman, E. *The presentation of self in everyday.* Double Day , New York, NY, USA, 1959.
14. Gould, E.W., Zakaria, N., and Yusof, S.A.M. Applying culture to website design: a comparison of Malaysian and US websites. In *Proc. IEEE 2000,* (2000), 161-171.
15. Harrison, C., Lim, B., Shick, A., and Hudson, S. Where to locate wearable displays?: reaction time performance of visual alerts from tip to toe. *CHI 2009,* ACM Press (2009).
16. Holleis, P., Schmidt, A., Paasovaara, A., Puikkonen, A., and Hakkila, J. Evaluating capacitive touch input on clothes. *Mobile HCI 2008,* ACM Press (2008), 81-90.
17. Karrer, T., Wittenhagen, M., Lichtschlag, L., Heller, F., and Borchers, J. Pinstripe: eyes-free continuous input on interactive clothing. *CHI 2011,* ACM Press (2011).
18. Malhotra, Y. and Galletta, D. Extending the technology acceptance model to account for social influence: theoretical bases and empirical validation. In *Proc. HICSS 1999,* (1999).
19. Marcus, A., and West, G.E. Crosscurrent: cultural dimensions and global web user-interface design. In *ACM Interactions 2000,* (2000), 32-46.
20. Martin, T. Time and time again: parallels in the development of the watch and the wearable computer. *ISWC 2002,* (2002), 5-11.
21. McAtamney, G. and Parker, C. An examination of the effects of a wearable display on informal face-to-face communication. *CHI 2006,* (2006).
22. Rahman, M., Gustafson, S., Irani, P., and Subramanian, S. Tilt techniques: investigating the dexterity of wrist-based input. *CHI 2009,* ACM Press (2009), 1943-1952.
23. Rico, J. and Brewster, S. Gestures all around us: user differences in social acceptability perceptions of feature based interfaces. *MobileHCI 2009,* ACM Press (2009).
24. Rico, J. and Brewster, S. Usable Gestures for Mobile Interfaces: Evaluating social acceptability. In *Proc. CHI 2010,* ACM Press (2010), 887-896.
25. Starner, T. The challenges of wearable computing: part 2. *IEEE Micro,* (2001), 54-67.
26. Toney, A., Mulley, B., Thomas, B., and Piekarski, W. Social weight: designing to minimize the social consequences arising from technology use by the mobile professional. *Personal and Ubiquitous Computing 2003,* (2003), 309-320.