

Does Infrastructure have Gender? Third-order Dilemmas

Jennifer A. Rode, Melinda Sebastian, Rachel Magee, Nora McDonald and Sean Goggins

Drexel University

3141 Chestnut St. Philadelphia 19104

jen@acm.org

ABSTRACT

Technology is highly genderized both in function and style; and the absence of technologies designed for women (or to accomplish tasks women value) is marked throughout the technological field. For example, here, we discuss our field research on the selection, management, and storage of clothing in support of a smart closet design. By doing so we make a theoretical contribution to understanding the dimension of gender in HCI through the lens of infrastructure. We argue for the importance of engaging with Star & Ruhleder's [34] concept of third order infrastructure, viewing the smart closet as an extension of existing needs and practices, and thus, emergent "within a given cultural context" as well as establish that the design process can gender infrastructure. We discuss how gender theory acts as third order infrastructure by foregrounding differences in gender during design where the design site is, itself, culturally gendered. Design praxis must, therefore, engage with Feminist theories at design sites that are culturally gendered. We propose new Feminist theory as a first step in doing so.

Author Keywords

Gender, Infrastructure, Ethnography, Ubiquitous computing

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INTRODUCTION

Sarah is 19 and is going to a party tonight. She wants to dress to the same "level" as her friends. She pulls out her new skirt, and sends a picture of it to her friends. Ten minutes later her friends text back that the skirt is "fab", but they heard the party was casual so decided at lunch to wear jeans. Sarah pulls out her trusty favorite pair of jeans, but is not sure what to wear with them. She wants to dress to the same "level" as her friends. She grabs something strappy and something sexy but a bit more modest and sends both pictures over. A few minutes later, she learns the party has a green theme. So she gets out her favorite green tank, a pair of silver heels, and a quirky bangle that express her style. This time does not text anyone, because she wants her outfit to be a surprise. As she walks out she takes one more look in the mirror at her outfit and smiles. Sarah knows she won't feel out of place, but still looks like herself. She feels confident and empowered that she will have a great night out with her friends.

As Dourish and Bell point out in their book technology can be both masculinely and femininely gendered, both of

which need to be supported. Our vignette illustrates possibilities for a new femininely gendered set of HCI research. Something as mundane as getting dressed for many young women, like the ones we have been interviewing over the past two years, is both technologically mediated and highly collaborative. In the face of substantial change in the environment served by HCI research, the field should consider reconceptualizing its boundaries to make it of maximal social benefit.

Our contribution to this reframing of HCI research begins by observing that, in western society, many ideas, lifestyles and material goods are marketed and sold to men and women separately. Many of these products are collaborative, and the nature of such gendered products are inherently different. This is because collaboration in society at large is influenced by messages and design decisions explicitly focused on delivering products differently and different products to men and to women [40]. While not all designs have strong gender dimensions some do [7, 28]. Designing technologies that improve support for collaboration in culturally gendered realms requires understanding of genders differences in current practice.

Clothing is one prominent realm of life where significant variation in choice and practices exists between men and women. Through an ethnographic study we explore women's use of their closets as a basis for beginning design work for domestic ubicomp development centered around the closet. We call this a 'smart closet,' a site for technologically mediated creativity through clothing, that is collaborative in that it is often done in consultation with others to achieve a desired look for a group or couple. Closets are essential, and used daily by household members. Closets, and the closets of the future, can be situated in the category of infrastructure based on qualities described by Susan Leigh Star, such as embeddedness, transparency and invisibility, as well as scope [33]. Closets are embedded within the structures of the home, and are transparent or invisible in the sense that using a closet is process that functions in a similar manner each time it occurs. This use also speaks to the closet's scope; use of a closet has some general similarities across location and time [33]. While these similarities mark closets as infrastructure, use of closets and what goes in them is still influenced by culture and society. Design to alter infrastructure and support the collaborative activities surrounding dressing and closet use will first require an understanding of closet use across diverse types of people. From such a

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phenomenological study we build a foundation from which to explore the role of gender in collaboration design.

With the rest of this paper we discuss the findings of our ethnographic studies looking at the use of infrastructure, closets, and clothing selection. Our contribution is not the study's findings itself, but rather the framing of them in terms of levels of infrastructure as discussed by Star and Ruhleder. Infrastructure and design have been discussed previously in CSCW [22, 24, 48] but here, by using the Star and Ruhleder framework, we raise a series of issues regarding gender and HCI more generally [34]. Closets as gendered sites for identity construction raise unique challenges for the HCI community, because, as we will establish, here they bring third-order issues surrounding gender and design to the forefront. In the framework of infrastructure, views on the role of gender are characterized as politics; so we will refer to these perspectives as political. Our gender politics might not be the readers', but as we discuss here, there are many political perspectives on gender for the HCI community to reconcile in order for us to productively engage with designs that have different political orientations towards gender. This paper is intended as a first step to lay out these issues.

LITERATURE REVIEW

We begin by defining our use of the terms closet and wardrobe, since these can be ambiguous terms. Both words are used to refer to places one hangs clothes. In North American homes a closet is usually built into the structure of a dwelling, while a wardrobe is a piece of large, stand-alone furniture most often used in European homes. In North America, wardrobe is also used to refer to a collection of clothes. In this paper we use the word closet to refer to the physical location where clothing is stored, and wardrobe to mean the collection of clothing.

Defining Infrastructure

Although it is not specific to a smart closet design, the notion of infrastructure greatly informs and helps to frame this paper within a discussion of large-scale collaborative systems. Star and Ruhleder initiate their discussion about infrastructure with an analogy to a photo of a physician working at a terminal surrounded by post-it notes and talking on the phone. "A tool is not just a thing with pre-given attributes frozen in time—but a thing becomes a tool in practice, for someone, when connected to some particular activity" [34]. Like this "web of computing" Kling and Scacchi [23] write, "infrastructure is something that emerges for people in practice, connected to activities and structures." Our smart closet emerges from study of women, using existing technology, to make and collaborate on wardrobe decisions. Star and Ruhleder ask not "what" but "when is infrastructure?" because it "emerges" in everyday practice [34]. Smart closet emerges, in part, out of observation of existing practices among women—for example, seeking feedback on sartorial decisions. Differences in biology have led to divergence in men's and

women's fashions, and taboos over nudity have left the dressing act a highly gendered activity [30,46]. Ultimately, we aim to use our findings of the physical wardrobe to inform the design and, to the extent that women are already using digital technology to share wardrobes, instantiation of a virtual one.

Star and Ruhleder frame the role of infrastructure as an invisible yet vital aspect of system adoption through an analysis of a large-scale collaborative system [34]. An infrastructure occurs when a tension between local and global is resolved [34]. In characterizing this communicative context, Star and Ruhleder distinguish three levels or orders of issues that occurred in developer-user communication during the infrastructural development of a large-scale collaborative system. The notion of these issue levels is useful for analysis of existing infrastructure because communication about infrastructure is most likely to occur when issues surrounding the infrastructure surface. In the course of smart closet design, communication about the infrastructure serves to make issues emerging from design visible.

Star and Ruhleder [34] apply Bateson's [5] discussion of three levels of issues to the development of infrastructure. Thinking about smart closet design in the context of these levels provides a framework for discussion of gendered design in HCI. First order issues are the issues that are easy to identify, and can be addressed by adding or redistributing existing resources. Within our data, this includes problems of access and organization within the closet. Second order issues are more difficult to identify, and can arise from the interaction of two or more first order issues. In our observation, this can include the interaction between weather and mood in dressing, as well as the interaction between clothing and closets with biological and physical changes in users. These issues may also result from contextual effects that are not accounted for in design of infrastructure. Third order issues are broader in scope and involve deep conceptual disagreements or political issues. Similar to second order issues, these may, but not always, stem from the interaction of lower order problems. In our work, third order issues include reconciling Feminist theory with design, and the gendering of technology.

Defining Smart Closets

Past attempts at designing smart closets do not explicitly identify the salient issues related to infrastructure; a smart closet must be as invisible as a regular closet. However, this past work on smart closet design informs our framing of the design of feminine technology for collaboration as a multi-level infrastructure challenge. Smart closets are one example of ubiquitous computing, which we frame here as a site for everyday collaboration. Closets are for storing, selecting and finding clothes, arranging outfits, and incorporating bought or made clothes. There is a significant body of work creating prototypes [25, 31, 32, 37, 42].

Smart closet design focuses on automation of closet oriented work, but another thread of literature relevant for changing closet infrastructure are phenomenological studies of how current, not so smart closets are used [1, 7, 47]. By using the concept of infrastructure to help inform the design of the smart closet, a unique viewpoint becomes possible to help assess the needs of users, while simultaneously breaking down the assumptions of the design team as first, second, or third order issues of infrastructure [34]. While the clothes may in some sense make the man (or woman), clothing selection and management behaviors are more sophisticated, complicated, and unbounded by one's closets than most previous research recognizes.

Defining the Space of Prior Smart Closet Research

In our prior study [30], we constructed an ethnographers' understanding of how wardrobe selection occurs in practice. Through contextual interviews with young women in American homes, we went beyond utilitarian concerns to explore the closet as an artifact of recreation and individualism. Our study uncovered relationships between clothing, user identity, and social interaction. The practices of selection, arrangement, and belonging of a garment in one's closet are socially constructed. The decisions people make as they dress are shaped by concerns like what celebrities and their friends are wearing, and in turn interact with their self-image and identity construction.

Anthropologist Sophie Woodward's book *Why Women Wear What they Wear* [46] examines these issues through participant-observation of the choices that English women make getting dressed each day. Participant observation here means being present as women are getting dressed, and being a female anthropologist with Western taboos on nakedness, Woodward is limited to female participants. Dressing allows a woman to establish her identity for the day [46]. If choosing an outfit for the day plays a role in identity shaping, then the closet can be understood as the place of transformation where everyday clothes enter as textiles and emerge as a producer of that identity.

Woodward's ethnographic insights are framed to understand current practice rather than to inform the design of future smart closets. Thus, our study builds on her work by interpreting wardrobe practices through the lens of the smart closet. We wish to extend our understanding of the closet to dimensions such as intelligence, emotion, sense of self, and social engagement, and consider how these factors might be incorporated into the design and evaluation of smart closets. Through this effort, we will frame smart closet design practices as an infrastructure for the HCI community, while talking about examples of closet infrastructures as constituting a relationship between users and designers; with the ultimate goal of making smart closet infrastructure as invisible as a hanger.

METHODS & DATA

Our main objective was to understand closet use of individuals who define themselves as feminine, with a

secondary focus on their housemates. We recruited a total of 24 participants from the UK. All participants were recruited via snowball sampling. Three interviewers with ethnographic training worked with eight participants of the demographic to which their age and gender gave them the most ready access: 1) women with employment between the ages of 25 to 45 (FP1-8), 2) students ages 18-25 (FS1-8), and 3) young men between ages 23 to 27 (M1-8). The focus of the study was on women, but male input is relevant since men and women often share closets, in the context of developing smart closet programming targeted primarily at women. Semi-structured interviews were conducted during a tour of the participants' stores of clothes focusing on how they used, stored and maintained their clothes, as well as their attitudes and values towards clothing. The interviews lasted for one to two hours. Our study, while not an ethnography, had ethnographic elements, primarily our emphasis on rapport and access, as well as our reflexive stance towards the data [27]. We took fieldnotes and analyzed our data creating open and axial codes. Finally, we engaged in selective coding where we created grounded theory [35] around gender, which we will discuss as third order infrastructure.

We use grounded theory to theorize about the role of gender in design and to reflect on user needs for smart closet designs. In line with Cooper we aim to focus design on a particular demographic group [15], as good design needs to focus on the needs of a particular type of user. Like Woodward, the ethnographic nature of our work and that the only male anthropologist on our team graduated, means that studying women is of practical necessity. We focus on individuals with identities that make clothing and closets an area of importance to them. Thus, in reporting results we emphasize findings that help us design for this demographic; we will discuss the men's finding only to the extent they are relevant in the to a smart closet targeted primarily at women. For example, we discuss men's organizing needs when they share closets with women, and how couples interact to coordinate wardrobe. We recognize that individuals with masculine gender identities will also be primary users of smart closets, but we leave that to future work.

In line with grounded theory we do not present our findings and theory separately. Doing so would be inappropriate. Our contribution is reflexive in nature [27]. Our data is important only in as much as it allows us to form grounded theory, and then position our findings in existing theory. As such, our focus on women is critical to testing the gender theories of design we explore later.

FINDINGS AND RESULTANT THEORY

The smart closet has design considerations that fall into each of the three levels discussed by Star and Ruhleder [34]; however, in our findings, we often see first order issues combining to create second order issues, and first and second level infrastructure issues commonly contribute to

third level challenges. This illustrates that while these are distinct conceptual categories, in practice, infrastructure issues can quickly accumulate into higher-level problems for users. Consequently, it is crucial that designers consider issues of each level in infrastructure development. The structuring and development of infrastructure is an important consideration for smart closet design. Star and Ruhleders' [34] first, second, and third order issues provide an effective framework for considering our findings and guiding design goals. Next, we will discuss the patterns we observed in our data with regards to these issues.

First Order Issues

We found many first order infrastructure issues including storing clothing, organizing the closet, and deciding what to wear based on access, cleanliness, or occasion.

Places for storing clothes

The employed women stored their clothing in multiple areas at home, including closets where clothes can hang, dressers where one can store folded clothes, and miscellaneous storage areas, such as shelves, drying racks, suitcases, and storage containers under the bed. The women had from 1 to 3 closets (average 2.0), 0 to 2 dressers (1.0), and 0 to 3 miscellaneous storage areas (1.1). The multiple closets were often in the same room, but one woman had three closets: in the bedroom, a spare bedroom, and one near the entrance of the house.

Four employed women had standard closets built into flats and two had small movable closets added in the home for more flexibility. Three women had closets with custom additions, for example, custom shelves, bars, and shoe storage arranged to the user's needs and preferences. In one case, shelves were designed specifically to showcase the owner's shoes. Transitional spaces were also important. For instance, a woman might put dirty clothes in a basket where they stay until the clothes are put in the washing machine. Coming out of the washing machine, the clean clothes are put on a drying rack, another transitional space. When the clothes are dry, they are put in the closet or left on the drying rack. The drying rack becomes a place where clothes are stored. Other transitional spaces are chairs with clothing draped on them or even piles of clothing.

In the student study, one student living at home had two closets and the other two living at home had one closet and either one dresser or one set of shelves. Five participants living in halls or rental accommodations had one closet or one closet plus a dresser. One lucky student had two closets and a shelving area. With only one or two small closets, the students had to prioritize the clothing to bring to university.

Organizing the closet

The closet could be organized in various ways, but there were some commonalities. Women divided their closets based on the context of their activities; typically the divide was work clothing versus casual clothing. Another distinction was the type of clothing, e.g., all trousers hang

together, and likewise groupings of skirts, dresses, and shirts. At a lower level of organization, participants grouped clothing by color, e.g., all blue shirts go together. Clothing's location in the closet was dictated by physical constraints, for example, with double bars in the closet, trousers and dresses have to be placed on the higher bar. Clothing also had to fit into the closet, e.g., all coats probably will be in a closet near the entryway. Another consideration was the frequency of use of items of clothing. Infrequently used clothes are moved to more remote areas.

Access and Visibility

Lack of visibility and access were key problems throughout the three studies. Visibility is important to choosing what to wear and access is a first order issue; generally it is not interacting with other issues for the closet user. The visibility issues occurred when participants found that they could not easily view their clothes. One male participant explained that he had a low shelf in his closet for his folded shirts. However, the hanging pants made it impossible to see the shirts toward the back of the shelf; consequently he only used the shirts in the front of the shelf. Another special case of visibility was seasonal clothing, which exists as a first order issue with the exception of unexpected weather. Transitioning between the seasons was a major problem of visibility because the clothes had been moved months ago, and the owner may have forgotten where specific items were stored and even forgotten that they had the clothes. Access issues arise when people attempt to retrieve clothing in storage areas. Even if the desired clothing is in the main closet, the individual must push to the back or reach a high shelf to retrieve the item. This often ends in a rain of items that fall from above. The value of good visibility and access were obvious to the participants. Without organizing their closets, they could not quickly find their clothes and make decisions on clothing in a timely way.

Deciding What to Wear

Deciding what to wear is a complex process that includes access to clothes, what's clean, the occasion, the weather, your mood, and what your friends are wearing. Different occasions call for different wardrobe selections. Participants ponder on their selection of clothes, from everyday clothes to special clothes. "I tend to think when I'm brushing my teeth in the mornings of what to wear" (FS3). One person's everyday wear, might be another's occasion wear depending on career and income level.

A person's career is often what determines 'everyday dress code,' which can be similarly understood as, "how participants dress when there are no special events," as it was defined in the student study. Social 'norms' such as enforced dress code for work could be seen to limit self-expression somewhat, compared to the freedom of a university student's dress. Yet, students also rely on norms, having:

"tried and trusted garments" that go with everything for everyday dress. "I have default black tops that could be worn underneath cardigans or with jeans or a skirt" (FS6).

These garments represented familiar touch stones on days where one did not want to reinvent oneself, but wanted certainty in dress.

We found that the student participants approached dressing for a special occasion differently than they did for every day wear with a goal and a plan in mind. “I will choose what to wear the night before while lying in bed going through combinations in my head” (FS6). This is consistent with prior work [30, 46] showing individuals pick out formal outfits several days in advance, and many factors might go into the process of selecting what to wear, elevating it to second order issue. In addition to the numerous first order issues, there were multiple second order issues, which we will now describe.

Second Order Issues

As discussed by Star and Ruhleder, second order issues come from the interaction of first order issues or from “unforeseen or unknowable contextual effects” [34, p. 120]. In the case of closet infrastructure, some common second order infrastructure issues include the selecting, and maintenance of clothing, as well as social dressing and body image considerations.

Creating a Wardrobe

A wardrobe is a collection of clothes, shoes, and accessories, but it is also a place of memory and identity creation that is constantly being redefined and updated. This personal aspect of wardrobe selection often raises this activity to a second order issue. In addition to those elements of creating a wardrobe, often the social aspects of creating a wardrobe work to make it a second order issue. People may purchase an item for a social occasion or buy something because a friend suggested it, or they saw a celebrity wearing something similar and it influenced their decision. An item in the collection might flow in and out of active use as the season changes or perhaps as the owner also changes her/his mind or her/his shape. Creating a wardrobe is something that some people do for pleasure and it also provides them with a chance to express themselves through their sartorial choices. Next, we will discuss adding, removing, and maintaining a collection.

Maintaining Clothing or “Handling the Collection”

Rode and Harris [30] describe the maintaining of a wardrobe as the “domestic flow of clothing.” They see the constant redefinition as a natural cycle of acquisition, use, and often eventual disuse. Woodward writes that only 37.25% are actively worn, with another 50.55% listed as “potentially” worn—clothes that are worn, but not in the common rotation [46]. Finally, some clothes may gain a sentimental value over time and so they might be kept long past their actual use or are now “inactive clothing.” Inactive clothing, according to Woodward, represents 12.25% of the wardrobe, and is held onto as a reminder of past selves [46]. While we did not see this with our male participants or younger women, it was an issue for older women in our study. For instance, FP7 kept her wedding dress due to the

associated pleasant memories. Inactive clothing became a second order issue for the older participants in our study, because the act of physically keeping an item in their collection had the potential to affect visibility and access to other items that may still be “active”. If space is made for a wedding dress that is not to be worn, then that space may not be occupied by something else the participant might frequently need. While younger women have had fewer opportunities to construct past selves to be recalled through their clothing, they may have also been constrained by lack of available space.

Adding/shopping

Each individual accumulates a wardrobe over time and each successful shopping trip concludes with a purchase that is now part of that person’s collection. There are myriad reasons why someone might need or want to make an addition to their wardrobe, often with several first order issues colluding to make it a second order issue. Sometimes the purchase is to replace an item that has been lost or outgrown, or has grown outdated. All of the employed women in our study discussed having a “mental catalog” of their current wardrobe, and new items would be compared to inform shopping decisions. Most participants mentioned experiences where they thought new clothing would match their current wardrobe only to be disappointed by issues with color, fabric, line, or fit where the newly acquired piece did not actually go well with anything already owned.

I bought a shirt, thinking it would go with... jeans, but then when I got it home, it just didn’t look right. The silhouette was off. I tried the top on with a skirt I also had, and it ended up looking great. I kept the shirt, even though it didn’t go with what I bought it to be worn with. (FP6)

Purchasing something that did not match the existing collection would in turn prompt additional shopping and could make an issue that originated as a first order issue transition into a second order issue. This sort of example highlights the complex nature of infrastructure, which remains invisible until something goes wrong [33]. The process of adding clothing to a wardrobe is not as simple as finding clothing that fits, it must be integrated into a collection of garments and accessories across many dimensions—fabric, color, style, formality, all pointing towards a second order level of infrastructure.

Social dressing

While routine dressing occurred alone, for special occasions or going out deciding what to wear can also be a very social process. Because clothing selection for occasions often shows interaction between multiple first order issues and social and contextual issues, social dressing is a true second order infrastructure issue. Our prior study [30] found that what was most important socially for these women was dressing to the “appropriate level,” which meant getting dressed to the same level of formality as everyone else. Women would consult, ask a friend, or a roommate’s advice on an outfit selection before making a final decision, and this was in part to ensure consistency in level of dress.

Similarly, we found these patterns in our own data amongst all three groups of interviews.

I would get advice from friends to make sure the combination is not weird and to make sure the combination is alright for the occasion (FS5).

Amongst the employed women, FP8 told multiple stories about the social side of clothing selection, and two other participants were open to the idea of obtaining advice from friends or family, but on a more opportunistic basis, rather than specifically seeking out help (FP3 and FP6). As an example, FP3 lived near her sister and said that she would never ask her sister to visit with the specific intention of requesting advice, but had on occasion received help from her sister. Similarly, the two men with girlfriends, M4 and M8, both expressed a desire to dress in a coordinated fashion with their partner. As M4 explains,

When I go out with my girlfriend, I will try to match with her. I will talk to her on the phone, or sometimes she will come to my place first (he would know how she is dressed already), because I don't want her to feel uncomfortable (M4).

Men also reported shopping with their partner, despite doing so rarely.

In our prior work [30], we found complex patterns of clothing sharing amongst non-cohabitating sorority sisters, their friends and biologic families. This was not reflected in our UK participants. Only five of our participants discussed their clothing with others. Thus, we were struck by how much less social dressing we saw in the UK. This could stem from cultural differences the UK versus the US, or differences in the populations' attitude towards clothing emphasizing the need for ethnographic work not to be applied too cavalierly outside its original population. Still, there was support that dressing then was not an isolated activity, but is done in concert with others. Body image is another aspect of dressing that is impacted by sociality. We discuss this next.

Body Image and Menstruation Cycles

The literature surrounding body image is too complex for a detailed discussion here, but it provides an example of a second order issue with regards to the monthly menstruation cycle of our female participants. This is an example of a second order issue that stems from both unknown contexts and the interaction of lower order issues. This was commented on by younger women who wore more body-conscious fashions and had less experience in accommodating them.

I borrowed trousers from my mum one day because I could not fit into mine as I was on my period and... bloated. Hers had an elasticized waist making it much more comfortable (FS7).

Borrowing one's mother's clothes due to an inability to fit into one's own has the potential of being embarrassing. Other women made these feelings more explicit.

I quite like this outfit, but I tried it on today and it made me look fat, because I felt bloated. (FS4).

These cyclic body changes kept her from fitting in her typical body conscious clothing, which she internalized as looking "fat." Further, these changes were unexpected.

It's all about comfort because you may wear one clothing one day but the next day it may feel different (FS2).

Body shape then was transitory in period of weeks or days that represented a challenge for dressing, and a challenge for infrastructure. How best to design for this type of issue when it is never uniformly experienced by all potential users of the product? Some women may experience bloating and have concerns about their physical appearance, and some may also experience shifts in moods because of it. However some may not experience these issues and may feel alienated by being confronted with the issue by a technology like the smart closet. Because of the complex nature of this issue, body image and menstruation cycles are prime candidates to contribute to third order issues.

While first and second level infrastructure allowed us to classify many of our findings, with third level issues we were forced to bring in our theoretical orientation to gender that emerged as we created grounded theory.

Third-Order Issues

Our users had a range of gender identities, gay, straight, masculine-femininities and more normative femininities; in analyzing and determining the implications for design, third order infrastructure issues emerged. If third order infrastructure issues arise from "permanent disputes," usually arising from political or other resource conflict sources [34] then using our ethnographic work serves as a sensible "site survey" of the closet as gendered place one quickly sees how the closet could be a source of tension. There are three areas where our attempts to build infrastructure for the investigation of feminine collaborative technology may encounter level three infrastructural issues in the HCI community. These include 1) the difficulties reconciling different schools of Feminist thought in design, 2) how to reconcile definitions of sex and gender, and 3) gendering technology. We will raise each of these in turn.

Reconciling Feminist Thought

As outlined elsewhere [36], there are numerous schools of Feminist thought with widely divergent opinions. However, before we even address them there are principled orientations to the relevance of gender as a topic when engaging with technology, Rode [26] outlines four:

- (1) "individuals who choose on principled grounds not to engage with gender as it is irrelevant to their subject of study regardless of their personal beliefs"
- (2) "individuals who over-look its relevance"
- (3) "in many communities... there are individuals who have a hostile attitude towards the topic altogether"
- (4) "individuals who pick up the topic of gender and engage with it passively or actively in their work."

We assume the fourth orientation. We propose change, and change is likely to evoke controversy. Thus, even engaging with gender is politically problematic; which means that when considering gender and infrastructure, we are dealing with third order issues. Though a rich literature demonstrates women's needs are repeatedly unmet with

regards to technology [13, 14, 41], it is far from taken for granted that this will be recognized as an important issue in the HCI community.

Once a designer takes an implicit stance saying gender is relevant to design, he or she is engaging in a form of value-oriented design [18], and must pick an orientation amongst the various Feminist theories. Though there is growing use of Feminist thought in HCI, [2, 3], gender is often not considered; commonly studies are not even gender balanced [4]. Rode argues that Liberal Feminism is a dominant view in the HCI community [26]. Liberal Feminism advocates men's and women's achievements would be comparable if given the same opportunities [36]. This approach hides the complexity of social structures that disadvantage women, which includes structures around the creation of technology [26]. This is but one orientation. Radical Feminism; Marxist and Socialist Feminism; Psychoanalytic Feminism; Multicultural, Global, and Postcolonial Feminism; Ecofeminism; and Postmodern and Third Wave Feminism all offer competing positions on reconcile these issues [36].

A smart closet design with a Feminist agenda would have to pick a school of feminism as a starting point. Rode in her work [26, 28, 29], which we build on here, draws from the Science and Technology Studies literature of Wacjman and Cockburn which discuss 'Technology as a Masculine Culture' [13, 14, 41]. This view [13, 14, 41] suggests that the inherent male bias of technology is in part caused by women's lack of involvement in the design of technologies that are often shaped by male power and interests. As a result, women feeling alienated from technology define their femininity in terms of rejection rather than adoption of technology [38]. Thus some women may intentionally define themselves as not technological to preserve their femininity [38]. This makes it problematic for women to pursue technical interests both personally and professionally. This theory could be used as a starting point for achieving social equality for women in technology.

The third order infrastructure issues we evoke are, therefore, problematic for those who would argue that gender is not a factor that is central to design. For those who do not share our frame of mind, we are likely to encounter controversy about which Feminist values to focus on. We will return to this theory later in this paper as we discuss its additional implications for infrastructure. For now it should be clear that advocating the "Technology as Masculine Culture" school of thought takes a strong stance when designing infrastructure, in that it essentially advocates that the technology design process is inherently exclusionary to women. This is a provocative starting point for design but this is certainly a valid theoretical motivation for design, regardless of one's opinions of this theory. Thus, it illustrates how choosing amongst these varied theories is an inherently political decision, and as such commits infrastructure to a position with which all users, or reviewers, may not be comfortable.

Defining Sex and Gender

The words sex and gender are culturally constructed terms and are used inconsistently within groups that engage with gender, and technical uses have little to do with how they are used in everyday life. Thus we will clarify our use. We often conflate physical sex and psychological gender [43]. In our work we use gender to refer to which is culturally constructed, and sex to refer to attributes of the physical form. This is consistent with Harding's use of gender, which she further refines as individual gender, structural gender and gender symbolism [20]. Individual gender is how an individual orients their gender construction, which may differ from the sex of their physical body [20]. Structural gender refers to larger social norms of normative behavior [20]. Finally, gender symbolism, which we will refer to later, discusses giving gendered attributes to objects. Harding's concepts are just one definition, and using any set of definitions reflects usage by Feminist theorists, which, as outlined above, have inconsistent theories. In our eyes, one strength regarding Harding's three-part definition of gender is that it can be used while still applying Butler's theories on Binary Gender [10]. Butler argues that our use of gender terms can be mapped back to a heterosexualization of desire. She discusses this as a heterosexual hegemony with regards to gender, and based on Foucault she argues:

The heterosexualization of desire requires and institutes the production of discrete and asymmetrical oppositions between 'feminine' and 'masculine'. [10, pp. 23-4]

Butler adds that if a man can have either masculine or feminine characteristics, this mimetic relation of sexed and culturally constructed bodies breaks down because

It is no longer possible to subordinate dissonant gendered features as so many secondary and accidental characteristics of a gender ontology that is fundamentally intact. [10, p.33].

Consequently, because it is impossible to reconcile these dissonant gender characteristics into a binary gender system, Butler is arguing for a more complex system of gender identity than that allowed by dualistic notions based on heterosexuality. Gender then should be viewed as a spectrum, with men and women free to position their identity anywhere along it. Amongst American culture and parts of European religious culture homosexuality remains controversial. Creating a design that is sympathetic to Butler's non-binary gender theory and the resultant terminology takes a position in this debate, and resolving these competing uses and beliefs such that all parties can use infrastructure remains a third order problem.

Clothing is a gendered part of this infrastructure:

Skirt: After the late Middle Ages, it became customary in the Western world for women to wear garments with skirts and for men (unless their professions required wearing robes) to wear BIFURCATED GARMENTS, a practice that ended online in the 20th c." [11 p. 420]

Yet, take for instance the counter-cultural fashion trend of the male skirt that has been a fashion constant well past the Middle Ages [8], which has most recently resurfaced as the

utili-kilt [39]. How would the smart closet infrastructure address the male skirt?

Skirts are worn by men with a range of individual gender identities and sexual orientations. Of course, outside the West, non-bifurcated garments such as the sarong or the dhoti, as well as kilts in the West are commonplace. They have masculine symbolic gender and exist as fashion trends that men of all sexual orientations can wear. Additionally, the femininely gendered skirts can be worn by men who are cross-dressing. So, how would infrastructure support this?

Most clothing websites initially filter clothing by gender, and in doing so, ease usability for most users. This is in part because fashion texts [11] list hundreds of garments that are commonly worn by only one gender. However, consider the same infrastructure issues exist for a smart closet if a man with a normative individual gender identity is given the option to input his collection of skirts. The technology has lower usability in strict usability terms, as task-time increases due to irrelevant (for him) menu items. On the other hand, if male users are not provided an opportunity to do so, this hampers the formation of both alternative fashion identities, and individual gender identities. There is a tension between supporting usability and avoiding reinforcing traditional gender roles and heteronormativity.

If closet designers were to engage with creating infrastructure for the task of a catalog, designers would need to take a stance on these issues, which have significant political dimensions. A closet could present all men the option of adding skirts or not, or it could allow them to configure the option to add skirts to the default list of men's garments. Regardless of how the interface supports it, by allowing for non-binary, non-heteronormative gender constructions in clothing choice, it is taking a political stance on what for many is a moral issue. Just as in Star and Ruhleder's original paper [34], triangulation and definition of objects is instrumental to defining infrastructure. Terms such as sex, gender, and the issue of the heterosexualization of desire present unique challenges for designers of smart closets, and serve as provocative examples for how gender presents unique third-order issues for infrastructure.

Gendering Technology

Having now picked a Feminist theory, and established a consistent terminology with which to describe it let us look at the symbolic gendering of technology. The decisions associated with giving technology symbolic gender teeters atop the other two third-order infrastructure issues mentioned previously. Just as artifacts have politics [45], objects have gender, and understanding this gender symbolism is critical to understanding gendering infrastructure. Berg and Lie write, "artifacts do have gender and gender politics in the sense that they are designed and used in gendered contexts" [7, p. 347]. When acquiring situational gender, artifacts (devices, technologies, and physical items) are situated in a gendered environment, and

can contribute to the change of the understandings of gender [7]. They write,

To us, the study of technical artifacts is important because, as social constructs, artifacts are reservoirs of information on socio-cultural patterns but also on possibilities for change within these patterns" [7, p.347].

As we socially construct the values around technology, we ascribe gender traits onto it. This also happens as part of the design process. While undoubtedly some of this is unintentional, there are also explicit examples of gendering of technologies and interactions.

In her study of electric shavers, Ellen van Oost [40] discusses the purposeful development of electric shavers by the Philips Company to expand their market to women. As women began to reveal more of their bodies with changes in fashion, they also began to remove more hair from their bodies. Van Oost argues manufactures of electric shavers, in targeting this technology for women, engaged in both social shaping and social construction of society and the new technology [40]. This market developed, and later models of women's shavers were specifically "designed and marketed as a cosmetic device, not as an electric appliance," through elements like color and shape, in addition to marketing strategies [40, p. 202]. Design then is intrinsically linked to the symbolic gendering of objects, and resolving it is a third-order infrastructure issue.

So what would adopting a particular political standpoint look like in design? Let us return to the "Technology as Masculine Culture" school of thought. If we choose to engage with this as a starting point for design, in doing so the design goal is to avoid the alienation of women from technology thus constructing identities that define their femininity in terms of rejection rather than adoption of technology [38]. Turkle calls this experience 'gender inauthenticity', and as such resolving this inauthenticity is a necessary design goal for women's inclusion in technology use [16]. These Feminist scholars are all relying on the notion of the symbolic gendering of technology; women are getting the message these technologies are not for them. In other words, the technologies they are using have a masculine gender symbolism. The next question is then how to achieve a broader appeal. Clearly, a non-binary treatment of gender goes a long way to explaining why masculinely gendered technologies work for some women; however, for women who construct their individual gender in more normative ways, it is quite possible that technologies or infrastructures with feminine symbolic gender might be more fruitful.

We arrive quickly at designs that allow women to celebrate their femininity through their smart closet. This brings us back to the issue of third-order infrastructure. Arguing for femininely symbolic gendered infrastructures in some circles is akin to anti-feminism; however, as laid out here it has a firm foundation in feminist theory. Despite desires not to be heteronormative, and to allow women to define their individual gender as masculinely or femininely as they like,

creating infrastructure that allows some women to be more feminine is likened to a form of oppression. Young [47] discusses these issues at length when discussing gaze and wearing of clothing. On the one hand, a woman wearing clothing can be the object of male gaze (referring to the heterosexual majority, though one could also be the object of female desire), and as such clothing can be the source of oppressive behavior. On the other hand, a woman could be dressing for herself, in which case clothing could be a source of empowerment and self esteem. For this research, we are treating women who choose to identify as normatively “feminine” as a minority population with regards to technology, because they do not have the opportunity to encounter technology as a source of feminine empowerment and self-esteem. This is not attempting to describe all women, as many women do not feel this way, but merely highlighting that some women do feel left out with regards to technology and that designing for that population is a valid point of view for design. There are principled reasons for arguing it is important that design allow women to experience this type of relationship with technology; however the complex feminine politics will make realizing this sort of infrastructure politically difficult.

CONCLUSION & FUTURE WORK

Here due to pragmatic limitations on access and our long-term research goals to increase technology access to women, we have studied closets as a femininely gendered space in the home. Future work will need to study men’s use of smart closets, as well as, examples of spaces that are not as femininely gendered. Our research moves beyond prior research on smart closets, which lacks rich cultural understanding of clothing use in context. In line with Bell and Kaye’s Kitchen Manifesto’s [6] critique of design’s focus on efficiency, our data suggests efficiency is not of core importance to closet users because it preempts the creativity and spontaneity of dressing. We show there is more going on in the closet than outfit selection, clothing arrangement, and wardrobe rotation.

We see four areas with implications for design. First, the closet is a site of identity creation; we explore our alternate selves as we dress. Second, as illustrated by our data, closets are sites of relationship building that facilitate intimacy amongst women. Third, our data shows how some women have significant issues with their body image and that the closet is where the work of resolving them is carried out. Technology could help support this work. Finally, according to Woodward [46], inactive clothing represents 12.25% of the wardrobe. This suggests that clothing is held onto as a reminder of past selves. Smart closets afford the possibility of engaging with these past selves. Designers have the unique opportunity to address these experiential needs.

Not only have we shown how the smart closet is a piece of collaborative infrastructure supporting the work of dressing to accomplish individual identity construction, creativity,

and a sense of dressing in keeping with social norms; we have shown, by using Star and Ruhleder’s three levels of infrastructure, how our data has clear implications for designing a smart closet; infrastructure can have a gender. Bell and Kaye [6] argue designers should be focused on “experience, affect, and desire,” and that technologies should “make sense of people’s daily practices so that these practices can meaningfully inform design and innovation.” In order for designers to make this step, they must explicitly or implicitly accept that gender is relevant to design.

Views on gender, like those on politics or religion, are socially delicate because they hold implications for personal morality and values. Indeed our work often creates reactions, viewed from an infrastructural perspective, as gender politics. If designers wish to address the gender gap in the technology space, we argue that Feminist theory discussing why the gap occurs is an important resource for design—after all, this theory comes from studies of why women chose to avoid technology [13,14, 40,46]. Here we explored one theory, ‘Technology as Masculine Culture.’ We selected a more provocative theory to incite active discussion in the HCI community. This provides a starting point for design work focused on gender advocacy. If gender and politics are ultimately about values, then technology is called upon to support value structures [2]. As a community we will need to decouple judgments of the intellectual merit of designs from discussions of designer’s values, and we need processes for debating whether the values inherent in a design are problematic. These need to be separate dialogs. We have cited theoretical evidence for gender inauthenticity. Thus, there is scientific merit for future work [38]. Future work will need to examine other theories, but we have shown here infrastructure is gendered, thus it is critical studies and theory of gender must be taken up for design.

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