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Gender-Inclusive HCI Research and Design: A Conceptual Review

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ABSTRACT

Previous research has investigated gender and its implications for HCI. We consider inclusive design of technology whatever the gender of its users of particular importance. This conceptual review provides an overview of the motivations that have driven research in gender and inclusive HCI design. We review the empirical evidence for the impact of gender in thinking and behavior which underlies HCI research and design. We then present how HCI design might inadvertently embed and perpetuate gender stereotypes. We then present current HCI design approaches to tackle gender stereotypes and to produce gender-inclusive designs. We conclude by discussing possible future directions in this area.

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1

Introduction

Recent years have seen a growing number of calls for considering gender during the design or evaluation of software, websites or other digital technology (e.g., [27, 37, 65, 74, 221]). Calls like these have arisen from an emerging awareness in HCI of findings from the social sciences that are relevant to the way people use and design technology. For example, gender has been investigated in Psychology, Sociology, Education, Marketing and Politics [10, 13, 23, 27, 47, 146, 152, 187, 197]. Such studies have revealed differences[1] in thinking styles, perceptions, behaviors and attitudes with respect to gender. Empirical research has also shown that gender plays out in the *use* of software and other digital technology [19, 22, 34, 84–86, 100, 119, 125, 141, 175, 188, 190, 192].

However, emerging work on bringing together gender research with software design choices is fragmented across multiple disciplines. For example, research gatherings such as panel discussions, special interest groups and workshops [11, 44, 65, 66] have revealed that even the most knowledgeable participants at these events had little commonality among the papers and venues they cited.

[1] These findings are independent of whether such differences are learned or innate, as most are not tied to physiological sex differences.

This review aims to help bring such works together, by synthesizing the current state of affairs and future possibilities on how gender comes together with HCI design. Our conceptual review focuses on motivations for carrying out inclusive HCI design tackling gender, underlying evidence for considering a range of users' cognitive and behavioral styles whatever their gender, issues that can arise if inclusive design approaches are not adopted, and how to combine gender with inclusive HCI design.

1.1 What is Gender?

This review draws upon a social construct perspective of gender. Under this conceptualization, gender identification, gender expression and performance might not necessarily align with biological sex. Although biological sex characteristics can also play a role in the design of user interfaces and software (e.g. smaller average hand sizes of women can impact touchscreen phone usage [132]), these sex differences are generally outside the scope of this review.

The large majority of the work on gender with HCI implications has been from a binary perspective, focusing only on individuals who self-identify as men and those who self-identify as women. As this is a review of existing work, much of the discussion that follows necessarily also focuses on those two genders. Fortunately, the HCI community has seen recent contributions from queer and intersectional perspectives that include, for example, updated notions of gender identity on a spectrum, and non-binary notions of gender. We explicitly consider these perspectives in Section 3 and Section 5.

1.2 Gender and Inclusive HCI Design

Recent HCI design approaches have sought to address the marginalization of user groups in an effort toward 'universal usability'. Newell and Gregor [155] proposed 'User Sensitive Inclusive Design' for the design of technology and this requires an explicit focus on considering who the 'user' is [176], usually adapting typical user-centered design techniques and processes to include people with disabilities. More recently, inclusive HCI design has been conceptualized as the design of technology so that

it can be accessed and used by as many people as possible, regardless of their background, to achieve a more inclusive society [50]. In line with this endeavor, inclusive design strives to avoid 'variant designs' that cater to only one specific user group.

The scope of this review is where gender considerations meet the design of inclusive technology: gender-inclusive HCI design. Because of the review's focus on *technology*, it specifically excludes related topics of gender-inclusive curriculum design, organizational change for greater gender inclusiveness, recruitment and retention of women in the field of computing, or increasing and broadening women's participation in computing. Likewise, inclusiveness issues not specifically about *gender*-inclusiveness, such as age, race, ethnicity and cultural differences, are excluded. Although these topics add additional complexities and have intersectional relationships with gender, they are sufficiently broad and deep in their own right to warrant reviews of their own.

1.3 Why Investigate Gender in Inclusive Design?

The idea of gender being relevant to HCI research and design is not without controversy. Some might believe that gender does not matter at all in HCI. Among those who do accept that gender matters, there is a range of views. This range includes the 'essentialist' perspective, which hold that cognitive and behavioral differences among genders are innate, to a 'social construct' perspective, which sees gender differences and stereotypes as arising through society's attitudes towards gender roles [38, 218]. Our review leans toward the latter (social) perspective, but is also relevant to those who hold the former (essentialist) perspective.

In this subsection, we review three common motivations that underlie much of the work on gender in inclusive design: economic, ethical/inclusivity, and political/feminist motivations.

1.3.1 Economic Motivation: Market and Market Potential Relating to Women

Most economic arguments in the literature focus on the economic advantages of technology products that are as appealing to women as they have traditionally been to men.

Women often tend to use the same kinds of software as everyone else. For example, 58% of women in the US have used online banking applications and 35% mobile banking, compared with 63% and 35% of men, respectively [75]. According to Pew Research [2], as many men as women accessed social networking sites from their cellphones (41% of women and 39% of men). Even games, in the past primarily used by men, have now been used almost as frequently by women, for example, in 2018, 45% of gamers were women [226]. The previous gender gap in social media, skewed towards women, is rapidly closing, to 80% of women vs. 73% of men [2, 67]. LinkedIn's user base turned from being predominantly men to 44% women and 56% men in 2019 [227].

However, there have been gender differences in the software bought and used. Turning again to games, although games are played and enjoyed by everyone to a similar amount [228], many of the games they chose to play are different. For example, RuneScape reported in 2014 that 84% of their game players were men [107].

Another example domain is mobile applications. Women have predominantly used apps for social media, news, productivity, lifestyle and books, whereas men used more apps related to business, games, travel, health and fitness, and navigation apps. Table 1.1 summarizes some of the reported similarities and differences with mobile applications.

Women make up about half the population (e.g., the US Census 2010 reports 50.8%), and their potential in the marketplace is huge. According to a recent estimate in Forbes Magazine, women drive 70%–80% of consumer purchasing [26]. The Harvard Business Review estimated women's 2014 total income worldwide at over $18 trillion—over twice the GDPs (gross domestic product) of two of the top emerging markets (China and India) combined [185]. Women are already an important consumer sector for technology products. For example, 65% of women in the U.S.A. use a desktop computer at home, 58% a home laptop, and 18% own a smartphone (compared with 71%, 57% and 18% of men) [39].

In some areas, women have outnumbered men as consumers. For example, women seem to be the drivers in social media [21]. There are several studies confirming women's early adoption of and dominant usage

Table 1.1: Gender statistics on mobile apps. Shaded rows show similarities, unshaded show differences

	Women	Men
Monthly usage of apps	30 hours 58 minutes	29 hours 32 minutes
Monthly usage of mobile web	3 hours 46 minutes	3 hours 45 minutes
App purchases	+17% more	
App installations	+40% more	
App spending value	+87% more	
Productivity apps	+89% more	
News apps	+90% more	
Social media apps	+611% more	
Health and Fitness		+10% more
Travel apps		+19% more
Navigation apps		+40% more
In-app spending value		+42% more
Games		+61% more
Business apps		+85% more

Sources: [46, 229].

of social media, for example, women use social network applications more than men [109, 206], and women were the earlier adopters of healthy living social technology and interacted more with this technology than men [117].

There have been differences among the different social media used (Table 1.2). Facebook has been more heavily used by women (77%) than men (66%), while Reddit had only 36.3% women users compared to 63.7% men. Pinterest is reported to be heavily skewed toward women [69] and research has shown different behavioral patterns in relation to Pinterest that might explain its popularity [47, 81, 161]. Miller *et al.* [148] suggested some of the reasons for its appeal to women include: (1) perceptions of the site in popular media, (2) design affordances especially for novices, which initially suggest topics, and (3) the initial visual design and content experience reinforces a 'traditionally feminine' image. Their overall finding is that men are less likely to identify with a site that they perceive as being for women.

Table 1.2: Gender breakdown for social networking platforms

Social networking platform	Women (%)	Men (%)
Overall	76%	72%
Facebook	77%	66%
Twitter	21%	24%
	(17% in 2013)	(18% in 2013)
Pinterest	42%	13%
Instagram	29%	22%
Reddit*	4% (2013)	8% (2013)
	36.3% (2014)*	63.7% (2014)*
LinkedIn	27%	28%

Sources: [68, 225].

* It is difficult to obtain a demographic breakdown as Reddit users are mostly anonymous with no profile information. The 2013 results were from a random sample of 2252 Internet users aged 18+. The 2014 results show traffic flow to the Reddit Media Kit Page and not necessarily users.

1.3.2 Ethical Motivation: Inclusive Design and Use for Everyone

From an inclusive design perspective, any gender that is being marginalized by technology is problematic, and this is the ethical argument for considering whether software is gender-inclusive. One possible reason that potential, unintended gender bias could arise could be that about 75%–80% of technology designers and developers are men [5, 221].

If technology marginalizes according to gender, numerous impacts potentially arise. From a fairness perspective, when HCI designers create software that they believe is for everyone, they (and we) would like that technology to be equally usable and useful for all genders, so that everyone has an equitable chance of accomplishing their goals. Hence, HCI designers need to ensure that they explicitly consider how to design inclusively.

Usability by everyone has far-reaching downstream implications. For example, although Wikipedia has attracted an equal amount of interest from everyone as consumers of the information, it has been found that its contributors and editors tend to be men [123]. Forte *et al.* [74] argue that this gender bias influences Wikipedia's inner workings and is

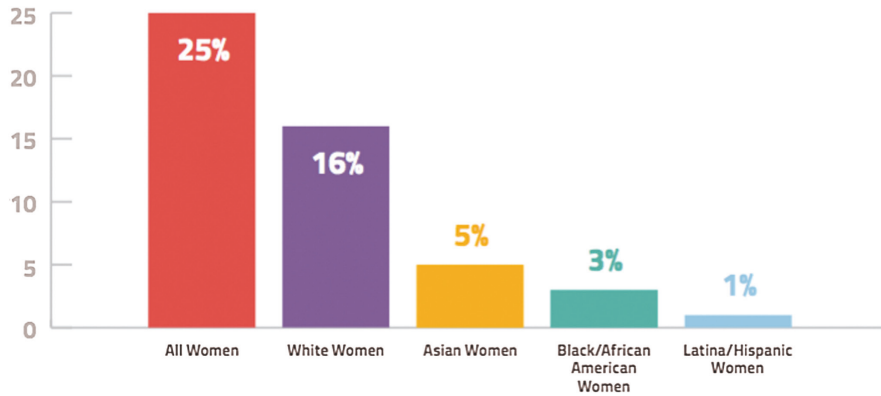

Figure 1.1: Computing occupations held by women.

Source: [5].

damaging as it may reinforce unequal patterns of not only participation but also the knowledge that is produced.

Marginalization and lack of inclusiveness can reinforce attitudes towards technology. For example, attitudes toward technology could impact people's education choices, such as what classes they take and what they major in, potentially contributing, for example, to the current low percentage of women in computing science classes in high-school and college, their career choices, and the low percentage of women in the software industry [5] (Figure 1.1). Potential downstream impacts extend even further, such as by potentially reinforcing the stereotype that women do not like technology in general or are not skilled at it [9, 214]. Finally, given that a diverse workforce produces better products [4, 61, 130, 163], the low gender-diversity in the software industry, potentially due in part to the software itself, is problematic for the industry.

1.3.3 A Political Motivation: Feminism and Feminist HCI

Inclusive design can also be motivated by a political, feminist approach that seeks to expose and/or intervene upon gender inequality and commits to an emancipatory agenda [171]. Feminism views gender injustice as a paradigm example of social injustice, whose struggles, theories, and methods can productively illuminate other emancipatory social

struggles. Thus, feminist theory has sought to delineate the operations of patriarchy throughout different areas of human life, including body practices, sexuality, identity formation, popular culture, and design.

As a movement and an academic discipline, feminism integrates a collection of theories, analytical and interpretative methodologies, ethical values, and political positions, which have evolved over the past two centuries, largely with and through women's struggles during the same period. Feminists engage with a range of concerns, including issues of agency, fulfillment, identity and the self, equity, empowerment, diversity, and social justice [9]. Given this long period of development and the range of areas of engagement it is unsurprising that the idea of what 'feminism' is, what the core issues are, what are or are not legitimate contributions, etc. are all hotly debated. Even when it comes to what are effective, practical and appropriate strategies for understanding and engaging with the world, there is debate.

Thus, it is widely acknowledged that there is no single, canonical feminism, but that feminism includes many form of feminist thinking [203, 209]. These include Liberal Feminism which concerns itself with gender equality in the public sphere, such as equal pay, equal access to education, better work condition for women, etc.; Radical Feminisms which considers the oppression of women as the most fundamental form of oppression and is focused on social change; Cultural Feminism which aims to foster the development and nurturing of a specifically women's culture which is 'inherently kinder and gentler' with gender differences not biologically determined but instead so thoroughly ingrained as to be intractable; Marxist and Socialist Feminisms which see the economic system as the root of oppression of women; Ecofeminism which holds that a patriarchal society will exploit its resources without regard to long term consequences as a direct result of the attitudes fostered in a patriarchal/hierarchical society and that in resisting patriarchal culture, eco-feminists feel that they are also resisting plundering and destroying the Earth; Postcolonial Feminisms seeks to account for the way that racism and the long-lasting political, economic, and cultural effects of colonialism affect non-white, non-Western women in the postcolonial world; and French Feminism which advocates the importance of social and political activism to create equal opportunity and access to justice

for women and is concerned with how women's socio-economic and psychological experiences are intertwined. A unifying aspect of all of these approaches and concerns is that, first, they make a distinction between male and female, masculine and feminine, or men and women; second, they address the existence of a subordinate hierarchy in which women are disadvantaged; and third, these approaches have a macro- and micro-political agenda in opposing women's inequality [90]. This does offer a simpler way of engaging with feminist thinking that sidesteps (without disregarding the importance of) deep debates among and between different feminist approaches.

The study of gender and gender inclusiveness in technology use and design is thus an important focus as part of a feminist approach, because gender is 'embodied in historical and contemporary representations of women as consumers, objects, and designers' [30] and 'ideas about society, including gender, shape the ways we make, do, and design things; these things, in turn, become part of how we identify, structure, represent, and perform gender' [128]. Feminist perspectives consider that technology use and design is not gender-balanced, that relationships of power and agency are central to this, and that the inequities result in unequal power dynamics in the workplace and in the work sphere more broadly [172, 173]. There is research in this area that explicitly calls itself feminist, invoking feminist theories, thinkers, and methods, while pursuing an emancipatory IT agenda for women and marginal population [9]. There is also a common form of feminist research in technology that does not explicitly identify itself as feminist, directly reference neither major ideas or figures of feminism, and stops well short of using terms like 'patriarchy.' At the same time, these works acknowledge and seek to resist the masculinization of technology and to expose gendered assumptions in technologies that might hinder women's access [14, 84, 88].

Adopting a feminist perspective can lead to insights and recommendations to advance and refine theory, methodology, critique and design [8], in part inspired by Bardzell [9] to engage in 'reflective integration of feminist strategies as a resource for interaction design.'

1.4 Review Method

A conceptual review aims to organize ideas of other researchers around an area of study, to synthesize evidence, clarify concepts, and to identify research gaps. Our methodology followed the five-part process we describe next. Although we present them in linear fashion, the steps overlapped and impacted one another as we progressed.

In the first step, we conducted a targeted search through relevant journals and conference proceedings in the ACM Digital Library using the following combination of the keywords: gender, design, software, development, technology, computer use. In the second step, we expanded our search to Google Scholar using the same set of search queries as before. We read through the abstracts of papers and books to determine the relevance of the publication to the subject area. Publications that combined aspects of gender with design considerations for technology were included in our preliminary set. We did not restrict our search to a specific timeframe, topic or specific technology domains, but we excluded articles outside the review's scope and articles in which gender was merely mentioned as a statistical device, blocking or control mechanism in studies. Third, we used the references' sections of the preliminary set of publications to add to our literature survey. Fourth, we performed an informal search on Google using the same keywords as we had used on Google Scholar. This search yielded different information sources such as blogs, online news and magazine sources, which supplemented the previous set of academic publications. Last, when we needed to update statistics, we performed a Google search for the latest statistics in domains and topic areas such as 'e-commerce', 'online social networking', 'mobile apps'.

Our results included articles across computing-relevant fields such as software engineering, human computer interaction, cognitive psychology, consumer behavior and information systems. We then categorized the articles we found by venue, year, topic, theories addressed, design considerations and gender concepts highlighted, and used the categorization to develop thematic groupings of the articles, relating to concepts relevant to cognitive and behavioral styles that impact technology use, and concepts that relate to gender-inclusive HCI design.

1.5 Organization of this Review

The organization of this review is as follows. We begin our review of empirical research on gender differences on cognitive and behavioral styles and how these relate to use of technology. Following this, we survey how non-inclusive design can inadvertently create and reinforce gender stereotypes. We then provide a review of current efforts in how to include gender perspectives in inclusive design. We conclude with a discussion of possible future directions in this research area.

2

Gender Aspects in Cognitive and Behaviorial Styles

In this review, we consider research-validated aspects of gender pertinent to inclusively accommodating ranges of cognitive and behavioral styles in software, so as not to disadvantage a large subsection of any particular gender.

We distinguish the research-based evidence underlying inclusive design from gender stereotypes. Gender stereotypes are often based on society's expected or condoned gender identities and roles, and are often used to reinforce behavior that is considered appropriate [142]. Such stereotypes are often attributed to *all* members of a gender, but they are not necessarily true for an individual or even the group as a whole. For example, stereotypes about men's versus women's intelligence and mathematical ability commonly persist but there is no evidence for differences among genders; intelligence or intellectual ability has not been shown to be linked to the gender of an individual, whether through analysis of intelligence or IQ tests or school performance (although girls on average do tend to get better grades than boys) [91]. In essence, there is no 'smarter' gender.

These existing stereotypes can affect an individual's behavior through what is termed 'stereotype threat'. This refers to a situation in which an

individual fears that they are confirming stereotypes about the group they are associated with, and that fear then affects their behavior or success, often detrimentally. For example, there is a stereotype of men being 'better' at mathematics than women, although there is no difference in mathematical test scores [70, 106]. However, it has been shown that mathematical performance can be influenced by stereotype threat [3, 106, 191], causing those affected to inadvertently start conforming to the stereotype. When the threat is addressed and removed, these differences go away [70, 91, 106, 191]. A detailed discussion of the implications of stereotype threat are beyond the scope of this review but most results reported here – unless explicitly indicated – address only differences in performance without considering the effects of stereotype threat explicitly.

2.1 Perception

Processes involved in perception are not assumed to be susceptible to stereotype threat because they consist of 'hard-wired', low-level processes that underlie high-level cognitive styles. Past research shows gender differences for temporal, auditory, and visual perception [91]. For example, it has been shown that women often underestimate the duration of short intervals of time (up to 20 seconds), while men tend to overestimate the same time intervals, and that women tend to do better at distinguishing and hearing sounds than men [91]. In addition, red-green color blindness (Figure 2.1), is more prevalent in men than women, e.g. on average, 8% of men vs. 0.5% of women are red-green color-blind [168].

2.1.1 How Do these Differences Influence Inclusive Design?

Given current computing systems, of particular concern are interfaces that rely on processing of visual, auditory or temporal information, and thus they need to be designed in an inclusive way while recognizing these differences. Careful thought has to be given to visual perception of color in the same interface to communicate important information. For example, information to indicate availability or non-availability in a

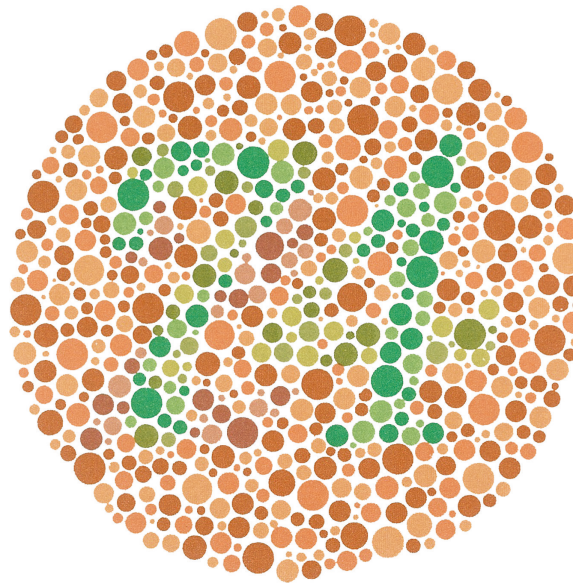

Figure 2.1: Ishihara test plate to determine color blindness. Color-blind people will not be able to perceive the number 74 in the image.

Source: Wikimedia Commons.

calendar widget must not use green and red. Similarly, auditory alerts need to be clear and easily perceptible while automatic timeouts during which tasks need to be completed should be long enough so that no gender is disadvantaged.

2.2 Language and Communication

Verbal abilities are a combination of skills in language comprehension and production, and there is some evidence that women tend to have better verbal abilities. For example, women, on average, tend to perform better at language comprehension tasks such as reading and also language production tasks such as writing [142].

Gender differences in everyday communication have also been observed. Sociolinguists argue that in verbal communication, men tend to establish superior social standing, control the conversation, and

exchange information whereas women tend to seek rapport, compassion and empathy [116, 200]. It has been suggested that women, much more than men, use communication to create rapport and affinity, which influences their communication style to be more emotionally expressive, more tentative, less forceful than men's and socially oriented towards creating a group where all the participants are involved and cooperate [51, 94, 116, 153, 200, 201, 216, 223]. It has been reported that men tend to have a greater inclination to 'win' the conversation, get the facts right, seek to protect and increase their social standing and independence [200, 201]. Hence, men tend to rely less on discourse as a source of social support, because discussing one's problems might be seen as displaying weakness and imply an inferior social standing [200].

How people communicate and relate to others has been linked to empathy. Baron-Cohen [12], in support of the theory of the Extreme Male Brain (EBM) as a cause for autism and Asperger's syndrome, defined 'empathizing' as being focused on people and the interactions between them, while 'systemizing' focuses on the physical world and logic. Although the EBM theory is contested [91], other research findings suggest that women indeed tend to be more empathic and socially-oriented than men [24, 62, 71, 120, 136, 145, 156, 204].

2.2.1 How Do these Differences Influence Inclusive Design?

Language production abilities might have an effect on any technology that relies on the user adding or using keywords, such as tagging or searching. Stumpf *et al.* [193] studied an email filtering tool which allowed users to tell the system what messages to sort into folders through adding and changing the weight on words contained in the email messages. They found that there are some gender effects at play: women participants took significantly longer to complete the task of giving feedback on the messages, mainly because they added twice as many keywords than men and changed more weights, with all other interactions with messages being equivalent. A study of gender differences in a slightly different email filtering tools also highlighted further gender differences in the kinds of barriers women encountered using the tool [121, 122]. In this tool, users could interact through a complex

Table 2.1: Top 10 tags in vocabulary of number of users using this tag to apply to images uploaded

Gender	Tags
Female	red, blue, green, flower, sky, flowers, water, tree, white, pink
Male	sunset, sky, night, water, red, beach, blue, tree, portrait, light

Source: [165].

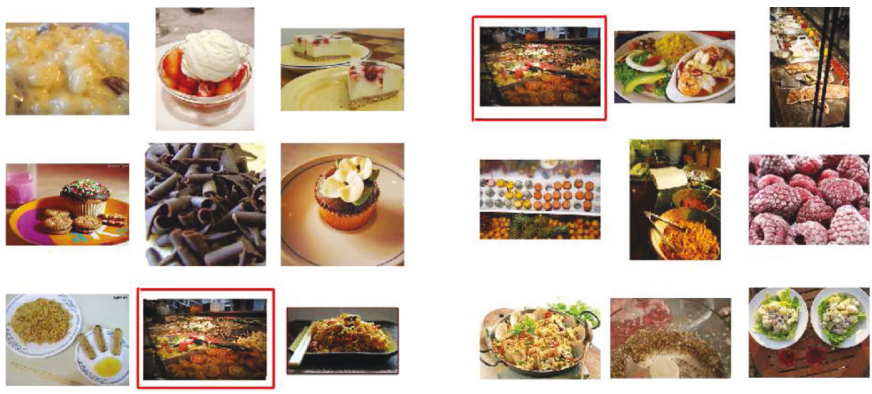

Figure 2.2: Example image search results adapted for women's use of keywords (left) and men's use of keywords (right).

Source: [165].

visualization with keywords in messages to train the tool to sort messages correctly into folders. Women participants again tended to work with more words but also tended to encounter more barriers selecting appropriate keywords. Research on Flickr image tagging (Table 2.1) has found that women not only used more adjectives, but also have a larger color vocabulary than men [165]. This study also highlighted differences in images search, usually driven by keyword searches matching tags (Figure 2.2).

Differences in communication styles manifest in online, text-based environments. Many researchers contend that these environments encourage interaction that reinforces existing social structures [224], and indeed gender differences in communication styles have been observed

from the early multi-user dungeons (MUDs), listservs, and email to our social networking sites today such as Twitter, Facebook and Pinterest [6, 47, 55, 78, 79, 81, 95, 99, 161, 192].

Various research papers hint at empathy and social orientation in their communication with others as underlying reasons why women tend to dominate in social media spaces [198, 202]. For example, women tend to be more focused on social interaction and intimacy than men in social networking spaces and this can result in women having larger friend networks than men in these virtual environments [72].

2.3 Spatial Abilities

Spatial abilities refer to being able to understand and manipulate shapes or objects in a 2D or 3D environment. These abilities matter in abstract mathematical subjects such as geometry, are used in everyday tasks such as map reading or interpreting diagrams and also might influence choices in careers that place importance on figuring out spatial relationships, such as architecture, aircraft piloting, etc. Spatial abilities are usually separated into three main components: spatial perception i.e. being able to discern and process spatial relationships, spatial visualization and mental rotation.

It has been shown that women, on average, perform less well than men on spatial perception tasks, such as the 'water-level test' which requires the participant to identify the horizontal or vertical in a display, and mental rotation tasks, such as figuring out whether two shapes are identical (Figure 2.3) [118, 164]. Only spatial perception and mental rotation appear to be linked to gender, whereas for spatial visualization – where spatial information must be processed in a complex way – gender differences disappear [91].

There are intriguing hints that these gender differences are not stable and might disappear in certain circumstances. It has been found that women and men differ in the way that they approach mental rotation tests, especially trading off speed versus accuracy [91]. There is also a possible influence of stereotype threat [191] where women perform worse in these tasks when primed with women's lower spatial ability beliefs [72]. Moreover, recent research started to doubt men's superiority in

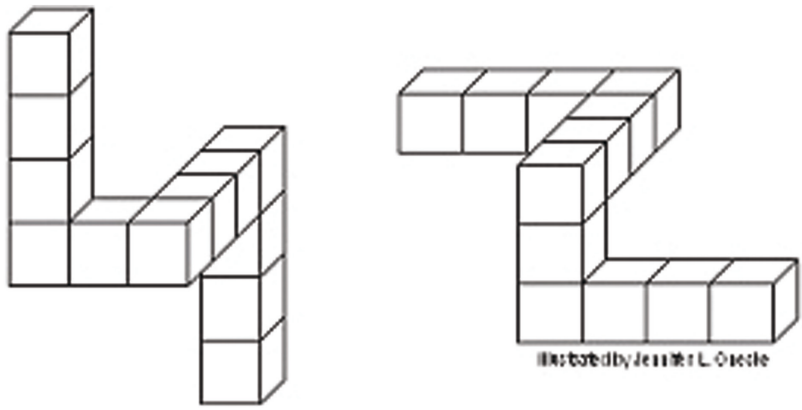

Figure 2.3: The mental rotation task is to identify whether the two shapes are identical. Men tend to be quicker to respond.

spatial abilities and no mental rotation differences were found linked to gender [42, 72].

2.3.1 How Do these Differences Influence Inclusive Design?

Spatial abilities might especially matter in using 3D virtual reality environments, such as Second Life. However, possibly because gender differences in spatial abilities might be slight and not persist in all circumstances, there are conflicting results of how they affect technology designs. Recent research has shown that gender differences for the 2D mental rotation task disappeared with tests taking place in 3D virtual environments [164]. However, there is evidence that women tend to be more susceptible to an induced Roelofs effect, an optical illusion in which the perceived location of an object shifts depending on its surrounding context in virtual reality environments [59, 60]. These conflicting results suggest that more work is needed to understand the effects of these abilities in technology design.

Navigation through virtual environments also relies on spatial skills and evidence on the impact of gender is much stronger. Previous literature has indeed shown gender differences in navigational strategies and location cue preferences, such as use of landmarks [58, 89, 133, 135, 212]. Women have been found to use a landmark in a virtual environment

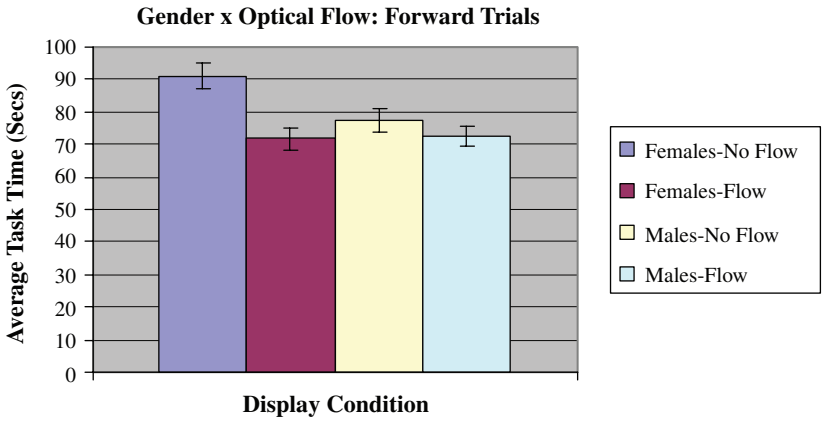

Figure 2.4: Optical flow cues helped women significantly more than men in forward moving navigation, and evened out their performance times.

Source: [199].

to create an external reference while men do not use a landmark [59, 60]. In addition, because they are 'landmark' navigators, women were shown to benefit more from optical flow cues than men, and when both had optical flow cues, their performance was equal (Figure 2.4) [199].

2.4 Information Processing Styles

To solve problems, people often need to process new information. It has been suggested that when problem-solving, women tend to use comprehensive information processing styles – gathering fairly complete information before proceeding – whereas men tend to use selective styles – following the first promising information, then potentially backtracking, in 'depth-first' order [40, 145, 146, 170].

2.4.1 How Do these Differences Influence Inclusive Design?

A number of studies have shown that gender differences in information processing styles might link to feature use and exploration in software-based tasks. For example, users' debugging strategies in spreadsheets showed that women tend to spend more time sorting through information

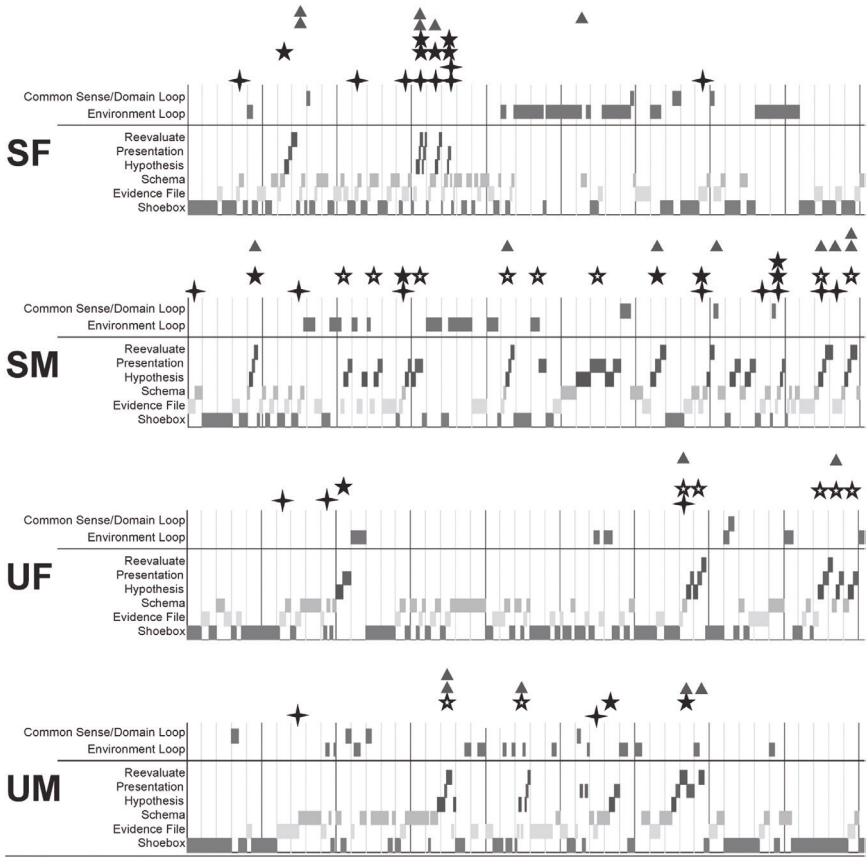

Figure 2.5: Women (SF and UF) spend more time evaluating information before taking action.

Source: [87].

Notes: Visualization of the sensemaking steps (y-axis) performed over time (x-axis). The top of each graph also shows the number of: ✦ = correct (filled) or ✧ = incorrect (hollow) finds; ★ = correct (filled) or ☆ = incorrect (hollow) fixes; ▲ = reevaluates.

before taking action (Figure 2.5) [87]. Similar results have been shown for e-commerce web sites [186] and software-based auditing [157].

2.5 Attitude to Risk and Its Relationships with Learning New Technologies or Features

Previous research has found that women tend to assess risk differently than men in most domains (Figure 2.6) [73]. In numerous decision-making domains (e.g., in ethical decisions, investment decisions, gambling decisions, health/safety decisions, career decisions, online shopping, etc.), women tend to be more risk-averse than (white) men [63, 145, 217].

2.5.1 How Do these Differences Influence Inclusive Design?

There are a number of effects that differences in attitude to risk can have in inclusive design, such as with trust in technology on the macro-level and exploring new, untried features of digital systems on the micro-level.

Attitude to risk might influence the trust placed in ecommerce and social media. Studies found that women's lack of trust in online relationships was related to their greater concern about online privacy and trusting online sources [1, 77, 145, 147]. Women have been found to be less trusting than men in e-commerce and online games [126, 145, 147].

However, risk perception of these systems might be changing. While research on e-commerce from the early 2000s indicated that women spent less time online and were less likely to purchase online than men [48, 57, 77, 83, 174], nowadays they engage almost equally in online shopping and online banking [75, 221] and perceive transaction security similar to that of men [57]. This change could be attributed to inclusive feature design such as product recommendations and reviews, greater privacy assurance and privacy notices, and avatars to enhance the experience [145, 215].

There have been many studies that investigated the impact of attitude to risk on using new features and results suggest that risk aversion can impact women's decisions as to whether to use new or complex feature sets. For example, one series of studies showed that women using spreadsheets employed new features that had been embedded to help testing and debugging of calculations significantly less than men [14–16]. Such gender differences have also been reported in people's

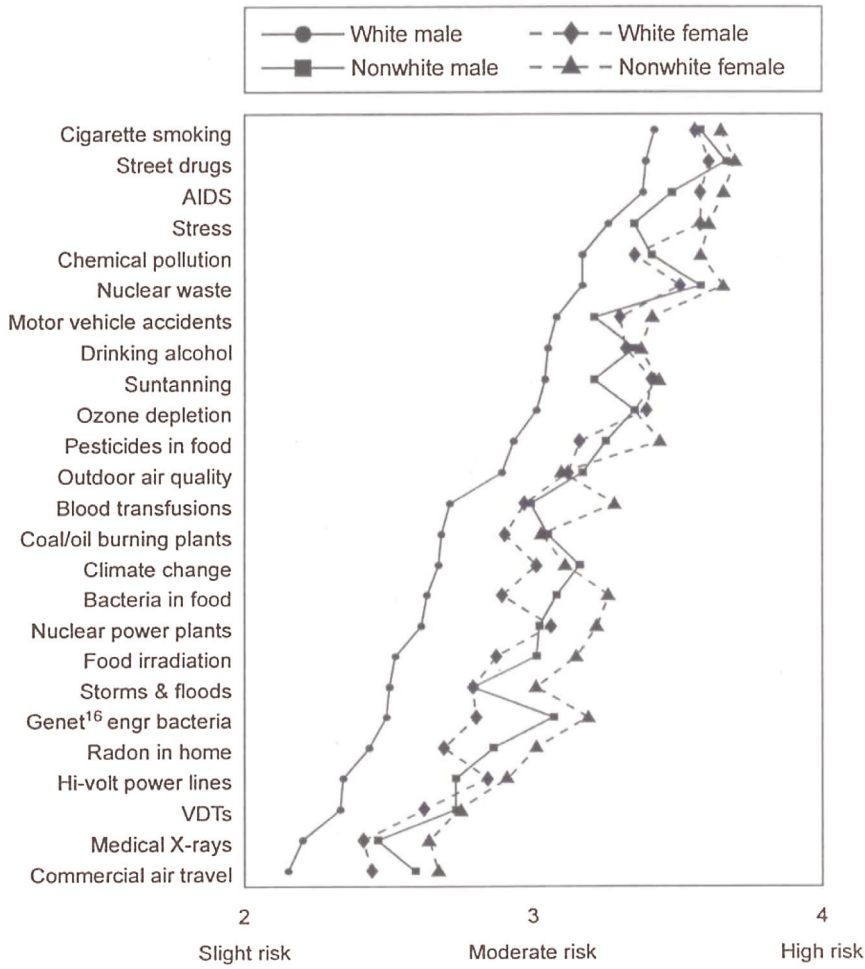

Figure 2.6: Women tend to judge risk consistently higher than (white) men. *Source*: [73].

use of visualization tools [22, 199], in the way they interact with online classwork platforms [187], in the way they design and debug web automations [178, 179], and in their debugging strategies [195]. In a study of an email filtering tool, women participants frequently called for a need to 'roll-back' any potentially risky changes in the learned behavior

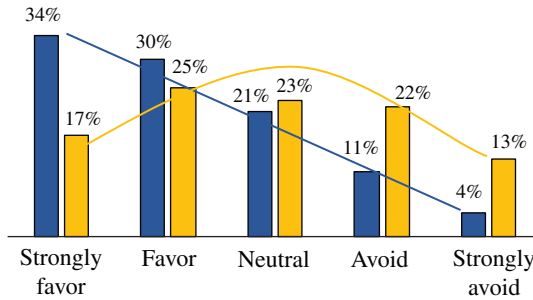

Figure 2.7: Results from a survey of attitudes toward tinkering. Blue = men, orange = women.

Sources: [34, 97].

and frequently used the 'undo' button to get back to previous 'safer' versions [194].

New features in technology are often explored through the use of 'tinkering' i.e. playful experimentation. It has been shown that women across age groups and professions are less likely to tinker with features new to them, whereas men often do so excessively [16, 34, 41, 47, 101]. Figure 2.7 shows data about attitudes to tinkering [34, 97]. This particularly impacts which features of technology women or men will elect to use, because a design choice underlying many technology products is that users will learn new features by exploring and tinkering with them. Past research also showed that end-user programming environments do not adequately support features shown to enhance women's success, but do so for men [195].

2.6 Motivations and Self-Efficacy

There are two main aspects that govern starting and continuing behavior to achieve a goal; these are motivations and self-efficacy. Motivations are the *reasons* someone goes about certain behaviors.[1] People can be intrinsically and extrinsically motivated, for example, the need to be recognised or accepted by others, i.e. an extrinsic motivation, is

[1] This is different from 'amount of motivation'; it has been shown that women and men are equally motivated to succeed [142].

rated higher by women as a motivation than men [111]. There are also different reasons for different types of motivations; for example, power is also an extrinsic motivation alongside the need to be recognised or accepted by others. Recent studies in management have found that women were equally motivated by power as men [111].

Stereotype threat can affect motivations that tend to underlie behavior, and stereotype threat is often intertwined with self-efficacy. Self-efficacy is the belief that we can achieve a specific goal given the environment/tools we expect to have available to us [7]. Self-efficacy is important in problem solving because it influences the use of cognitive strategies, amount of effort put forth, level of persistence, and strategies for coping with obstacles. There is significant previous evidence that men tend to have higher self-efficacy than women in a number of domains (including computer self-efficacy) [91], except, it seems, for tasks that are strongly associated with women's stereotypes [142], for example, cooking, etc.

2.6.1 How Do these Differences Influence Inclusive Design?

There are many research reports of gender differences in the reasons or *motivations* for using technology. Women are more often than men motivated to use technology for what it can accomplish for them, whereas men are more often intrinsically motivated by their enjoyment of technology for its own sake [34, 35, 45, 101, 137, 175, 186]. Figure 2.8 shows differences in distributions for motivations [34, 36]. This difference in motivations interacts with some of the other traits such as risk aversion and tinkering to affect which features of problem-solving software a user chooses to employ.

Other examples of motivations influencing technology use come from virtual environments and video games. One of the biggest problems in the online virtual city of Amsterdam was that women's reasons for use differed from that of men [177]. In the end, the site only attracted 9% women, despite being developed by a mixed team, the main founder being a woman, and the design philosophy was 'access for all' [177]. Gender differences for motivations have also been found in video games. Men displayed higher need to surpass others, a stronger 'need to win'

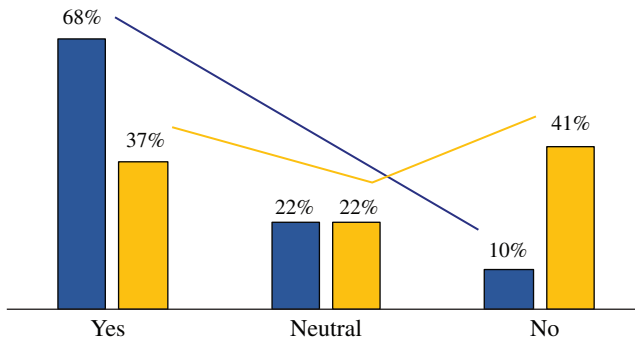

Figure 2.8: Results from a survey of whether people tended to use software because technology is enjoyable (i.e., intrinsic motivation) as versus other reasons (e.g., extrinsic motivations). Blue=men, orange=women.

Sources: [34, 36].

while women did not attach as much importance to winning play actions than men and were less confident in their abilities to master the game [93].

Self-efficacy has also an impact on using computer technology. It has been found that women on average tend to have lower computer self-efficacy than their peers (Figure 2.9) in intelligent systems [122], spreadsheets [14, 16, 34, 35], and video games [93].

Lower computer self-efficacy in women can affect their behavior with technology such as which features they choose to use, how willing they are to persist with hard-to-use features, and tinkering (see Section 2.5) [14–16, 34, 35, 134]. Rosson *et al.*'s study of web developers also showed suggestive gender differences in the use of novel web-based database features that are consistent with these findings [178].

Computer self-efficacy can be reinforced by experiences with technology. If the technology is designed from perspectives more common in men than in women, many women might perform less well because the technology does not match their needs [103]. These types of negative experiences can feed back, reinforcing low computer self-efficacy and also impacting their willingness to use the technology in the future.

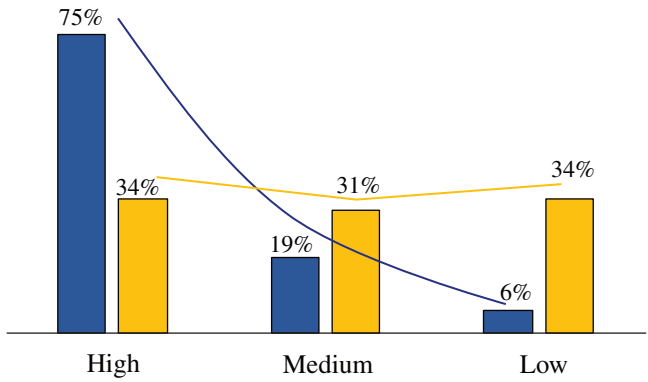

Figure 2.9: One survey's responses self-reporting their own technology self-efficacy. Note that, although women's responses were fairly uniformly distributed for this facet, the men's responses skewed toward the high self-efficacy category. Blue=men, orange=women.

Source: [34].

3

Gender Stereotypes and Technology Design

Gender stereotypes are shaped by society and its prevailing culture, and are often reflected and reinforced in designs, whether consciously or unconsciously [28, 221]. The social stereotypes that designers embed into technology can influence users actions and become a 'self-fulfilling prophecy' [96, 103, 205, 208, 224]. We now review the influence of three gender stereotypes – genderized aesthetics, the gender binary, and gender roles – on the design of technology as a counterpoint to the tenets of inclusive design.

3.1 Stereotype 1: Genderized Aesthetics

Stereotyping aesthetic preferences is perpetuated in our environment through color-coding and targeted advertising of gendered products, so we are continuously exposed to aesthetics that are designed to appeal to stereotyped gendered norms [45, 129]. 'Unnecessarily gendered' products[1] and designs abound, such as sticky tape 'just for girls', pens for women, etc.

Design aesthetics used in websites follow this trend, shaped by societal and cultural factors [54]. Men and women designers often have

[1] http://unnecessarilygenderedproducts.tumblr.com/

different preferences in how they create web pages, for example, women tend to include more images in their website design [152]. It has been argued that the majority of websites tend to cater for a 'male design aesthetic' [150], for example, described as consisting of darker colors, no detail on surfaces, straight lines whereas women generally prefer bright colors, surfaces with detail, curvy lines, humor, and elements blending in with their surroundings. However, no link has been shown between preference for cooler (blues) or hotter colors (reds) and gender [53].

Genderized aesthetics are then reinforced and perpetuated by users of the designs. For example, it has been shown that different genders preferred websites built by same-gender designers and that women tended to choose greeting cards that were designed by women more than cards that were designed by men and vice versa [149, 151].

3.2 Stereotype 2: The Gender Binary

In Western culture, often two binary genders – men and women – are assumed, and this categorization shapes many interactions in everyday life [218]. This does not reflect the argument that gender is a complex performance that takes in identity and expression [38], in which gender is conceptualized along a spectrum to which people choose to associate themselves. In addition, differences among genders are not simply categorical and instead are multi-dimensional [43]. The gender binary also does not leave any room for other identifications, such as non-binary, genderqueer, etc. [131, 188, 189].

This binary categorization is often extended to – and thus reinforced by – virtual settings, e.g., games, social media platforms, web forms, etc., where a binary male/female indicator is presented to the user to indicate their gender [138]. Another example of gendered design is an algorithm that scans the size of breasts to detect the gender of a person [167]. In addition, researchers have pointed out that binary design in automatic gender recognition are trans-gender-exclusionary [115]. Only very recently have digital settings moved away from a male/female gender binary, with the inclusion of more varied gender options [52, 188]. Some web forms now also offer 'prefer not to say' or

'other' as an alternative for gender input fields, and Minecraft does not ask for the player's gender.

When a user's gender is specified to a system (or inferred somehow by the system), that gender setting can have far-reaching consequences on the features available to a user. Such consequences are especially apparent in technology that assumes the gender binary. For example, gender choice might open up different design options that are gender-dependent, like gender-specific avatars, roles or different strengths and skills in video games; it thus 'genderizes' the technology. For example, in the original Diablo game, the Warrior's (man character) strength attribute was from 30 to 250 points compared to 20 to 55 points for the Rogue (woman character). The Rogue also featured less *vitality* and *life* points but could develop more *magic* and *dexterity*.

Perhaps to escape from gender stereotypes placed on individuals based on a binary conception of gender and to circumvent genderized designs, many users opt to 'gender-swap' in which users take on identities reflecting the opposite gender, or 'queering the interactions' [29, 131, 198]. In online settings, especially games, gender-swapping has become common, and it has been shown that 70% of women players have a man avatar [104], and that women more often assumed a different gender than men [134]. Initially, gender-swapping was seen as positive, as it might allow users to gain experiences from the others' viewpoint and, in turn, to change real life [29, 207], with a hope that this would lead to changes to work practice, culture and values [29]. However, the positive changes anticipated from gender-swapping did not materialize. Instead, gender-swapping has seemed to reinforce gender stereotyping [224].

Some online environments and games offer a variety of gender representations, such as indeterminate or non-gendered identities, to circumvent binary gender representations. For example, Facebook in the past used avatars for users without a profile picture that represented stereotypical gender attributes, but recently changed it to a more gender-neutral icon design [112]. Patapon, Locoroco, and LittleBig Planet all offer an 'animal-blob' avatar as the player's representation. Minecraft's game's blocky character has specifically been designed to be gender-neutral, and it is up to users to design their own avatars to reflect their identity.

However, even gender-neutral avatars often end up with an assumed gender. For example, Pac-Man is often seen as a male character while its appearance is gender-neutral. Few humanized avatars offer a gender-neutral representation, which might allow the player to make up their own gender identity for the character. Gender-neutral designs might not go far enough as a recent study has shown that even supposedly gender-neutral terms like 'users' are often conceived as either men or women [25].

Inappropriate feminization of women's representations, i.e., stereotyped gender expression, can be felt as 'disrespectful' to women as a whole, as explained by Layne and Blackmon [124]:

> When we do encounter the elusive heroine, she is typically either portrayed as a sexual object to be gazed upon and controlled, or she is simply a female "skinned" version of the male protagonist.

For example, 'Ms. Pac-Man' showed the avatar with stereotyped feminine attributes, such as lipstick and a bow on its head. It has been noted that not much has changed concerning gender-stereotyped accounts of women [49, 108, 213, 220, 222].

3.3 Stereotype 3: Gender Roles

A common stereotype is that there are 'appropriate' roles for each gender, and associated with that, suitable choices for pastime and work. The number of women in computing education and careers has been decreasing over the last decades (Figure 3.1); among the reasons attributed have been lack of recruitment and retention, being forced into stereotyped job roles, and stereotype threat, and more [5]. Research has shown how gender bias for career images in their search influence people's perceptions of real world distributions, and exaggerate and reinforce stereotypes. Research has also shown that women were systematically underrepresented in career searches, women were presented less professionally, and people believe career search results were better when they agreed with the gender stereotype [113].

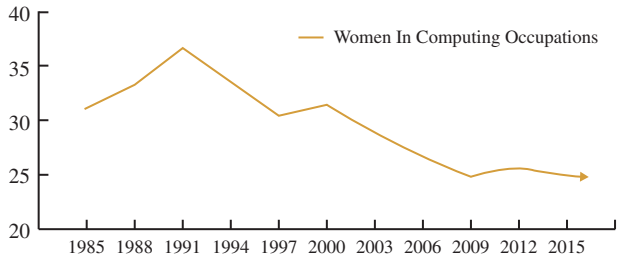

Figure 3.1: The number of women in computing has decreased from a high of 36% in 1991 to 25% in 2015.

Source: [5].

This trend of stereotyping gender roles continues in the design of technology yet it has been argued that the impact of gender identities and roles has not been investigated adequately in technology [173]. Investigating gender roles in computer games showed that women are often depicted as weak, dependent or needing assistance, in subordinate roles, and often hypersexualized [29, 45, 78, 124, 141, 208, 224]. Women protagonists are almost non-existent, but, as has been argued by Layne and Blackmon [124], there are plenty of princesses or 'damsels in distress' in video games whose only role is to be saved by the man hero, who wins 'his prize' [124]. In a study of the professions of non-player characters (NPC) represented in video games, Bergstrom *et al.* [19] found that most NPCs associated with a profession were men's characters, and that they usually had higher professional status than their women's counterparts, e.g. a man NPC was given the title of 'Doctor', but the woman equivalent was referred to as a 'nurse'. Similarly, in conversational agents, 'Julia', a MUD chatterbot, was assigned the gendered role of a personal assistant or secretary who rendered help and tours in the MUDs [224].

Role stereotypes are also re-enacted by users themselves. For example, it has been argued that one girls' game, Barbie Fashion Designer, is not really a game, but rather extended doll play [196]. Likewise the Sims is also viewed as an extended version of doll play and is preferred by girls more so than boys [159]. There are increasing numbers of women playing and making games, but it has been argued that many games still continue to reproduce gender-stereotyped accounts of women [108].

4

Gender-Inclusive Design

Having provided a review of gender as it relates to technology design, what can HCI designers do to create gender-inclusive technology?

As a first step, unconscious and implicit assumptions and stereotypes that are already built into technology need to be surfaced and examined. The I-methodology [176] or 'self-as-user' outlook in HCI design, where designers imagine themselves as users, is one of the causes for the inadvertent gender bias in design [102]. Since 80% of designers are men, their viewpoints by designing for users like themselves can pervade technology [136, 162, 175, 221].

There are currently only few approaches to evaluate whether there might be barriers that have already been put into the design based on stereotypes or implicit assumptions [82]. One approach is to actively involve participants to evaluate gender barriers, including diverse participants in user testing, however, involving users directly is costly, both in terms of money and time.

Reflective design and critical design are two other approaches to consider gender in design. Reflective design is a critical reflection on the role of technology in our lives that should not only be limited to the design phase alone, but rather the technologies themselves should

support reflective practices in designers and users alike [181]. Without this reflection, users might adopt certain values and norms unconsciously. A historical account of technology that critically analyses the design process and the means of gathering the data that informs designs can draw attention to embedded gender scripts [17].

There is some progress towards extending the range of approaches that can be integrated into the practices of HCI designers. Bhargava [20] provides a checklist for evaluating educational software to facilitate girls' interest in IT. This checklist aims to avoid gender bias by recommending simple questions to ask for assessing embedded stereotypes and offers strategies to introduce unbiased computer education in the classroom. The GERD process model [64] aims to formalize reflective design by considering gender in all stages of the design process, which can be supported by woman personas [139]. Themis, a formal method for testing predictive software, has recently been proposed to uncover gender-based discrimination [76]. Spiel *et al.* have suggested ways to include more gender-inclusive surveys for HCI design [188].

Perhaps the most developed formalized method so far for considering gender in technology design is the GenderMag method [36, 37, 97]. It consists of a specialized cognitive walkthrough and a set of personas structured around five underlying gender differences in technology use (see Sections 2.4, 2.5, 2.6), offering HCI designers step-by-step how-to guides and ready-to-use forms to uncover and document gender barriers in existing systems [33, 56, 144, 182]. Recent work has also shown its promise as a design aid [211] (Figure 4.1).

Once issues or barriers have been found that marginalize or disadvantage one subgroup, they will have to be designed out to make the technology more inclusive. There are a number of methodologies and techniques that can be employed by HCI designers to remove these barriers or to design inclusively in the first place. First, designs could be 'degendered' [103, 210] which removes inscriptions and representations of gender (see Section 3.2). However, inadvertent biases might still cause the technology to be genderized, as we saw in Sections 3.1 and 3.2. 'Indetermined' design is suggested as an approach where no one gender is favored in the technology [45], achieved by the designer employing multiple perspectives when designing. A technique to challenge cultural

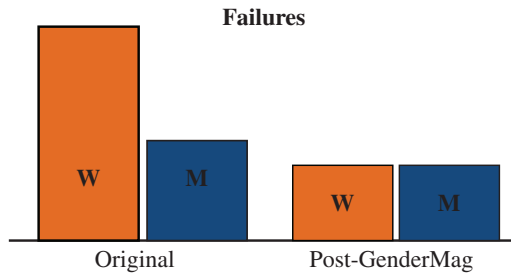

Figure 4.1: Average number of failures per person by gender identification (orange: women, blue: men). In the original version of the technology, women's failure rates were more than twice those of men; with the post-GenderMag redesign, all failure rates went down, and the gender gap disappeared.

Source: [211].

assumptions, especially of the gendered division of domestic labor, has been proposed through 'defamiliarization' [17]. This technique draws on a defamiliarization practice within Anthropology, giving descriptive ethnographic accounts of the norm by making it strange and questionable. This provides the lens necessary to see and question the designer's own viewpoints in the use of technology and to consider future needs and behaviors.

Newell and Gregor [155] proposed 'User Sensitive Inclusive Design' and this requires an explicit focus on considering who the 'user' is [176], usually adapting typical user-centered design techniques and processes. Our survey has highlighted a number of aspects in which gender differences impact inclusive design (see Section 2). These can form the basis to address gender barriers directly, by inspiring designs that help all genders. For example, Gidget [127] – an online debugging game designed to teach novice computer programming concepts by debugging/fixing faulty programs – integrates an other-oriented style (helping others, saving animals), specifically to balance gender differences in motivations (Section 2.6). Similarly, Alice [114] leverages storytelling to attract girls to programming. Grigoreanu *et al.* [86] showed that changes to spreadsheet features relating to risk and tinkering (see Section 2.5) reduced gender gaps while improving all genders' attitudes and feature usage. Some of these features involved adding 'maybe' nuances

in addition to right/wrong choices and these particularly helped low self-efficacy users (see Section 2.6). Providing help features that support women's comprehensive processing and men's in-depth first processing style (see Section 2.4) can help all genders. For example, Grigoreanu *et al.* [86] added both extensive and shorter explanations of concepts to a spreadsheet and those explanations are provided both as video and hypertext. The Gidget game [127] offers help information in ways that aids both selective and comprehensive information processing styles.

An alternative way to encourage including a range of perspectives is to increase participation of all genders in design endeavors. This could be achieved by including more genders in technology design teams [100], or including a greater variety of users as equal design partners. Participatory Design is one strategy that captures the essence of inclusive design [140], by considering gender as an essential component during the design phase.

5

Discussion and Future Research Directions

We have presented a wide range of research dealing with gender and their implications on inclusive design in Section 2. We have also provided an overview of ways in which gender could be accommodated in technology design, either through features or through design processes in Section 4. We now discuss the wider scope of gender in HCI research, and the impact of gender on future technology and society.

One could argue that HCI research should be gender-blind, and that gender should not matter. Unfortunately, this might result in a lack of data to reveal whether, what, and where gender inclusivity issues may arise in the technologies being studied. In fact, sometimes studies into gender differences reveal changing findings. For example, a gender difference in spatial ability has been disputed in recent years [42, 72]; this 'disappearing' difference might be attributed to various factors such as more women playing games, implicit stereotypes being challenged or simply due to test measures that differed between research studies. To answer questions like these, more research addressing gender is needed but in ways that do not essentialize gender or the gender binary [188, 189].

Looking into the future, there are novel technologies, such as artificial intelligence (AI), robots and voice user interfaces for conversational agents, in which gender-inclusive design issues are arising in new ways. For example, there is already mounting evidence that AI and machine learning can embed stereotypes, or discriminate against women, trans, or non-binary people, if not designed and evaluated carefully [115, 119, 125, 154]. There have been gender issues noted in the interaction with robots [184], and in user reactions to gendered robot designs [160]; however, there is also research indicating that robot gender does not play a role [169]. Voice user interfaces are being designed that are based on stereotyped gender roles which reinforce the existing power structures [92]. More research in these novel areas is warranted.

We have also presented a number of ways to start designing inclusively. Work presented in Section 4 has provided some suggestions of how to embed gender perspectives explicitly in evaluation of technology but there is a need for further design and evaluation approaches to lead to inclusive technology. More work in this direction might eventually yield design guidelines and heuristics that suggest how to design gender-inclusively.

There is also a bigger job to do: to address gender barriers and gender imbalance and therefore to change society. For instance, already in kindergarten and early school, the computer is seen as a boy's toy [80, 105, 219]. Boys tend to perceive the computer as recreational (playing games, program, etc.) and girls perceive it as tool to accomplish a task [158]. Important steps are being taken in recent years towards including more women and girls in computer education and use [143], especially exploiting entry routes of crafting and making [31, 32, 98, 110, 172]. The Microsoft Executive Vice President for Business Strategy, Peggy Johnson, recently called for more women as technology designers in order to address this balance [230] but it has been argued that one of the problems with getting everyone involved as designers is that tech innovation is impacted by the men-dominated VC firms and 'brogrammer' culture in startups [166].

Likewise, gender stereotyping is perpetuated in our environment through color-coding of products, children's programs, and gender-segmented advertisements, so children and adults are continuously

exposed to these [45]. Whether conscious or unconscious, gender stereotypes in design decisions get embedded in the social worlds of the users and contribute to shaping their ideas and identities [18, 96, 103, 140, 183, 205]. We, as parents, consumers, researchers, and designers can easily fall prey to gender stereotypes and it requires us to actively resist and change them wherever they arise.

There are also calls to transcend conventional thinking about gender as binary and fixed, drawing on queer scholarship [190]. Increasingly, research is directed at the intersectional nature of identity that is shaped by lived experiences of gender, sexuality, race, and class [180]. This move could lead to a richer understanding of users and how to better design for everyone.

6

Conclusion

In this review, we have presented the current state of concepts related to gender and inclusive design. We have presented motivations why considering gender is necessary, based on economic and ethical considerations and also as part of a political agenda.

We then presented the evidence for gender differences in cognitive and behavioral aspects. For each, we presented examples of how these manifest themselves in inclusive design.

We investigated the impact of gender stereotypes on technology design around aesthetics, the gender binary and gender roles, and how this results in non-inclusive technology, and reinforcement of gender stereotypes.

Gender can be addressed through careful design: by considering gender as part of the design process, to produce gender-inclusive technology as a natural outcome of the design process, and by offering features that are gender-inclusive. We have provided a review of the current attempts at designing to include everyone, irrespective of their gender.

Research surrounding gender is still very active and our discussion highlighted some of the issues and open research directions. This review

places gender at the heart of societal concern – with the hope of eventually moving beyond gender.

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