# Skilled or Gullible?
# Gender Stereotypes Related to Computer Security and Privacy

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***Abstract*—Gender stereotypes remain common in U.S. society and harm people of all genders. Focusing on binary genders (women and men) as a first investigation, we empirically study gender stereotypes related to computer security and privacy. We used Prolific to conduct two surveys with U.S. participants that aimed to: (1) surface potential gender stereotypes related to security and privacy ($N = 202$), and (2) assess belief in gender stereotypes about security and privacy engagement, personal characteristics, and behaviors ($N = 190$). We find that stereotype beliefs are significantly correlated with participants' gender as well as level of sexism, and we delve into the justifications our participants offered for their beliefs. Beyond scientifically studying the existence and prevalence of such stereotypes, we describe potential implications, including biasing crowdworker-faciliated user research. Further, our work lays a foundation for deeper investigations of the impacts of stereotypes in computer security and privacy, as well as stereotypes across the whole gender and identity spectrum.**

## 1. Introduction

Stereotypes are reductive beliefs about social groups, e.g., people of a certain gender or age. Gender stereotypes have been widely studied in numerous areas of society (e.g., medicine [1], law [2], education [3], politics [4], STEM [5]) and have documented impacts on a multitude of attitudes and behaviors. For example, researchers in other domains have found that gender stereotypes can significantly alter behavior by boosting or hindering self-efficacy, i.e., an individual's belief in their ability to achieve their goals [6], [7], [8]. In STEM, stereotypes also have adverse consequences, e.g., on girls' interest in computing [9].

Given the widely-documented existence of gender stereotypes and associated harms in other domains, we hypothesize that gender stereotypes exist for computer security and privacy, contributing to gender inequities. However, these issues have not been rigorously studied, leaving open questions about how gender stereotypes manifest in our field. This work provides a critical theoretical foundation for understanding gendered differences in attitudes and behavior, and thus exemplifies how gender analysis can foster scientific discovery [10] in security and privacy.

We investigate what specific security- and privacy-related gender stereotypes exist and how widely they are held. Our research questions are:

1) What gender stereotypes (about women or men) do members of the general U.S. public hold that concern everyday computer security and privacy issues?
2) What explanations or rationales do people give to justify gender stereotypes?

Though we do not aim to compile a comprehensive list of stereotypes with respect to computer security and privacy, our investigation lays the necessary groundwork to study the harms of specific stereotypes. Further, we investigate the rationales for stereotypes in order to inform efforts to combat stereotypes and mitigate their impacts.

The computer security and privacy research field must ultimately consider gender beyond the binary to contend with gender's full multiplicity [11]. We begin by investigating binary genders in order to build on existing research instruments on sexism, which primarily consider binary genders, as well as our own experiences and identities. Further, we note that considering gender as a binary is itself a widely held stereotype [12], [13].

**Contribution one: specific instances.** Through a pre-study of 202 U.S. Prolific participants, we surface specific instances of potential gender stereotypes with respect to computer security and privacy. These reside in three categories — general engagement, personal characteristics, and specific behaviors — and lay a foundation for our next phase.

**Contribution two: quantitative evidence.** We provide quantitative evidence that people hold gender stereotypes about computer security and privacy. Among other results from our second, 190-participant Prolific study, we find that:

- Men were expected to be more engaged with security and privacy topics, including being more skilled at protecting their security and privacy. Women were expected to be gullible and emotional about these topics.
- Participants believed men were more likely than women to behave in security- or privacy-enhancing

This work was done while Pardis Emami-Naeini was with the University of Washington.

ways, e.g., to verify HTTPS, install software updates immediately, and enable two-factor authentication.
- Most negative stereotypes we observed were negative towards women, but we also found negative stereotypes towards men: e.g., participants expected men to be more overconfident and less likely to ask for help.

Furthermore, we found beliefs correlated with other factors:

- Many stereotypes were held by both women and men — including negative stereotypes about women.
- Sexism (measured with the validated ASI scale [14]) was strongly correlated with belief in gender stereotypes with respect to computer security and privacy.

**Contribution three: characterizing rationales.** In order to combat stereotypes, we must first understand why people hold such stereotypes. To sample our findings:

- Many rationales were adapted from gender stereotypes outside of computing: "Men are more likely to be more logical when it comes to computer security and privacy because men are natural born problem solvers and always try to explore the best possible means to fix a problem" (P189).
- Other stereotyping rationales included flawed reasoning about biology: "Women are less biologically driven to use technology and thus may not be as aware of the risks of sharing too much information online" (P31).

In addition to characterizing the rationales to combat stereotypes, surfacing these rationales deepens our understanding of how people evaluate and manage their own security and privacy, as well as how people view others.

To conclude, we reflect upon our findings and make recommendations for system designers and researchers by compiling ten guidelines for the future. We make suggestions for short-term work to be conducted to study the implications of gender stereotypes, as well as for long-term efforts to combat gender stereotypes in research and design processes. In particular, we highlight how gender stereotypes could bias the results of user studies conducted with crowdworkers. Though potentially linked, we advocate distinguishing gender stereotypes from empirical measurements of gender, attitudes, and behaviors, because stereotypes cause harm regardless of the status quo. Ultimately, we hope this work validates the experiences of people who have been at the receiving end of gender stereotypes in security or privacy, and serves as a call to action to combat these stereotypes.

## 2. Related Work

### 2.1. Gender in security and privacy research

Prior research in computer security and privacy has found that gender can be a contributing factor in security behaviors, e.g., password choice [15], usage of private browsing [16], usage of two-factor authentication (2FA) [17], interpreting security warnings [18], susceptibility to phishing [19], [20], as well as in security intention [21], attitudes [22], and risk perception [23]. Privacy research has also found that gender may influence self-disclosure on social media [24], [25], [26], information disclosure generally [27], protection strategies [28], [29], or privacy concerns [30]. Most of these prior works do not primarily focus on gender; instead, they include it among other demographic factors. Our focus in this work is not on the direct study of gender differences in security and privacy behaviors, but the biased assumptions and stereotypes that people hold about them — which may play a role (alongside other factors) in disproportionate adoption of security and privacy behaviors by gender (e.g., due to stereotype threat, a psychological threat of confirming negative stereotypes [31], and the barriers they form [32], [33]).

Other security and privacy work focuses on gender through the lens of specific marginalized populations, e.g., the cultural context of women in South Asia [34], [35] or ways women are vulnerable, e.g., as survivors of intimate partner violence [36], users of menstruation [37], [38] or women-specific apps [39], or victims of gender-based harassment [40], [41]. Our work studies gender through a different specific lens, i.e., U.S.-based internet users.

### 2.2. Gender stereotypes

Gender is a social construct that exists distinct from, but may be related to, biological differences between women and men [42], [43]. In many societies, gendered expectations exist about the ways that women and men should be [42], [44] and manifest as cultural stereotypes. An abundance of research continues to theorize about the creation and reinforcement of gender stereotypes (e.g., [45], [46], [47]). The Stereotype Content Model posits stereotypes are composed of two dimensions: competence and warmth [47]. Decades of research study stereotypes that men are more competent but women are interpersonally warmer (e.g., [47], [48]).

Stereotypes create two classes of implications: distorted perceptions by stereotype holders, i.e., for "perceivers", and the experience of targets, i.e., for "experiencers" [49]. With respect to perceivers, gender stereotypes may negatively influence perceptions of others (e.g., [50], [51]) or change what people value in others [52]. Gender stereotypes also become more apparent when people are asked to assess others as opposed to themselves [53]. With respect to experiencers, gender stereotypes may contribute to various individual outcomes, e.g., career paths [54], as well as generally decrease performance via stereotype threat [31].

Our research is grounded in feminist theory and practice [44], [42], [55] and takes a feminist perspective on gender stereotypes by viewing them in the broader U.S. social, political, and cultural context. Feminist theory holds that identity is intersectional [56], [57] (connected to multiple identities) and closely and inextricably linked to structural oppression, and its goal is to end these forms of oppression [44]. Our work is motivated by the desire to contribute to the awareness and combating of gender stereotypes.

### 2.3. Gender stereotypes in STEM

Gender inclusivity in Science, Technology, Engineering, and Math (STEM) is drawing significant attention, as evidenced by recent handbooks, guides, and reports on

gender inclusion and other identities (e.g., [58], [59], [60]). Education and economics research confirm the existence and extent of gender biases, including implicit biases associating men with STEM fields [61], [62], [63], stereotypes [64], stereotype threat [65], [31], and other barriers to participation (e.g., [66], [67], [68]). Other work also characterizes how stereotypes affect self-efficacy perceptions of women in STEM [69], [70], [8], including sense of belonging [71] and the interest [9] of girls in computing. Though this forms a considerable literature, the existence of gender biases is not always accepted, and its denial in STEM persists despite evidence [72]. Moreover, people who do not believe this bias exists may be more likely to perpetuate it [73].

Stereotypes lead to significant negative consequences in STEM for women and gender minorities [74], e.g., lower pay and less mentoring [75], increased stress [76] and other physical health problems [77], harassment [78], [40], and depressed performance [31], [32], [33].

Within the computing field, human-computer interaction researchers have found that gender stereotypes change perceptions of image search results [79], [80] or trust in robot voices [81]; machine learning researchers have found that gender stereotypes are also detectable in natural language with machine learning classifiers [82], [83].

A recent NSF report shows that in the U.S., while some fields in STEM are close to, or have even achieved, gender parity in education and employment, e.g., math and biology respectively, computer science remains one of the farthest from parity, with less than 20% of CS bachelor's degrees in the U.S. going to women [60]; this percentage decreased from 27% in 1998 [60]. Emerging research suggests that stereotypes about robotics may be stronger than stereotypes about STEM generally [84], calling for further identification and investigation of gender stereotypes in other specific areas of computing, such as security and privacy.

## 3. Motivation

Having taken stock of work on gender in security and privacy research, as well as gender stereotypes in other fields, we now motivate the scope and goals of this paper.

**Explore an explanation for gendered differences in security and privacy behavior.** As described in Section 2.1, a cluster of usable security and privacy research has identified gendered differences in behavior, but does not explain what accounts for such differences. For example, Sheng et al. found that women may be worse at identifying phishing [20] and Mazurek et al. found that women may choose weaker passwords [15]. One category of explanations could originate from *biological essentialism*, or intrinsic differences predetermined by one's gender (e.g., [85], [86]), and another from *social constructionism*, or cultural differences arising from societal expectations or other non-biological factors (e.g., [43], [87]). In other words, if women are worse at security and privacy behaviors, is it because of their biology or their society? Debate between proponents of each continues in academia (e.g., [88], [89], [90], [91]) and in society [92]; here, we study gender stereotypes, which has been posited to be an explanation for gendered differences in the style of social constructionism [93]. Our study asks participants about stereotypes related to previously found gendered differences, e.g., who is more likely to fall for scams or reuse passwords, thereby contributing to this literature by investigating gender stereotypes as a potential contributor to gendered differences.

**Identify specific stereotypes whose impact should be evaluated.** Initially, the research goal of our team was to measure the impact of gender stereotypes in security and privacy, and we conjectured research questions such as:

1) Do gender stereotypes in computer security and privacy negatively impact users themselves?
2) Do people who hold gender stereotypes in computer security and privacy cause negative impact to others?
3) To what degree do user interfaces reinforce gender stereotypes in computer security and privacy?

However, as we designed preliminary experiments, we encountered the following fundamental challenge: while we hypothesized the existence of gender stereotypes with respect to computer security and privacy, we did not know *what* gender-related beliefs were commonly held and should be included in our experiments. This observation led us to the need for a foundational, broad, and general study of gender stereotypes with respect to computer security and privacy. Our work empowers future researchers hoping to study impact with *specific, concrete, precise* gender stereotypes in security and privacy.

**Inform future security and privacy research and practice.** Understanding whether security and privacy-related gender stereotypes exist (and which, specifically) has the potential to help researchers and practitioners. Armed with knowledge about specific gender stereotypes, researchers can account for stereotypes in their methodologies, and designers can avoid unintentionally reinforcing them.

## 4. Pre-Study Method and Results

We conducted a pre-study in late 2020 to identify potential stereotypes to evaluate in our main study. Our institution's IRB determined this survey to be exempt; we followed the same ethical considerations and positionality statement as described in more detail in Sections 5.5 and 5.6.

### 4.1. Pre-study method

We sought to explore gender stereotypes with respect to security and privacy but found no prior work to examine. Thus, we recruited 202 U.S. participants from Prolific and asked: "What stereotypes can you think of about men, women, and people of different genders, when it comes to computer security or privacy? Please list as many as possible, including ones you don't believe in, but think others might."

One member of the research team followed a thematic coding process [94] to surface potential stereotypes. One coder led this process because our goal, i.e., to identify potential stereotypes for investigation in the main study,

was subjective and generative [95], [96], [97]. To balance researcher subjectivity with thoroughness and integrity [98], the main coder reviewed the pre-study results with other research team members throughout the process. The other members corroborated that selected items would be meaningful and interesting to evaluate in the main study.

Our final codebook included 17 codes (i.e., potential stereotypes) across two high-level themes: stereotypes about why men would be better, or about why women would be better. For our main study, we selected only potential stereotypes that were mentioned by at least 5 participants.

### 4.2. Pre-study results

Participants reported potential stereotypes that men were more likely to be **logical**, but **overconfident**[1] and **lazy**, while women were more likely to be **perceptive**, but **emotional** and **gullible**. These were the six *personal characteristics* stereotypes in the main study. Participants also reported potential stereotypes that men **knew more**, were **more interested in**, and were **more skilled at protecting** their own security and privacy: these were the three *general engagement* stereotypes. Based on our participants' qualitative responses, we also interpreted that these stereotypes were either positive or negative, as indicated in Table 1.

## 5. Main Study Method

In early 2021, we conducted another online survey to evaluate gender stereotypes related to computer security and privacy surfaced from the pre-study. We submitted our study protocol to our institution's IRB, which determined that our study was exempt (Section 5.5).

### 5.1. Affinity diagramming

In one section of our main study, we sought to investigate stereotypes about specific security and privacy tasks. Few behaviors were surfaced organically by participants in our pre-study, likely because enumerating specific security and privacy tasks is much more salient to researchers and practitioners than to the general population we sampled in the pre-study. Thus, we reviewed the security and privacy advice literature and performed affinity diagramming to identify further tasks to include. Affinity diagramming is a method suitable for consolidating a large number of ideas through an iterative grouping process [99].

We gathered potential tasks from three recent papers from usable security and privacy: Ion et al.'s review of security and privacy advice (14 items, see Figure 1 in [100]), Redmiles et al.'s work on the same topic (35 items, see Figure 1 in [101]), and Egelman et al.'s standardized scale to measure end-user security behavior (16 items, see Table 4 in [102]). We additionally added two behaviors that were mentioned by some participants in the pre-study: falling for shopping scams and falling for dating scams.

We collected all security and privacy behaviors from the aforementioned sources and grouped similar ones, e.g., tasks related to internet safety, authentication, privacy, or finances. We iteratively pared down the list and removed those that were not applicable to all internet users (e.g., use parental controls, set up IoT devices) or that were too vague (e.g., act anonymously online, remove unnecessary programs). To sample a range of behaviors, we selected five behaviors that are beneficial for one's security and privacy (marked as positive in Table 1), and five detrimental (negative).

1. Participants used "overconfident" and not "confident," which may contribute to a gendered interpretation; for fidelity, we use "overconfident."

### 5.2. Survey structure

Participants first completed a consent form and read the following instructions: "While we understand there are many genders, for the purposes of this study, we will ask about specifically men and women." We further clarified that we were interested in participants' honest thoughts and opinions, that there were no right or wrong answers, and that their responses would have no impact on compensation. We emphasized this information at the beginning of the survey to minimize the potential for social desirability biases [103] to influence participants' responses. The full survey instrument is shown in Appendix A.

**Three stereotype categories.** The first three sections of the survey asked about three different categories of potential stereotypes regarding security and privacy perceptions and behavior, totalling 19 potential stereotypes (full list in Table 1). Participants saw these sections in a randomized order. We asked: "Based on your personal beliefs and experiences, who is more likely to be more [potential stereotype] when it comes to computer security and privacy?" Answer choices were "Definitely men," "Probably men," "Men and women equally," "Probably women," "Definitely women," "Another gender, please specify," and "Don't know or not sure."

**Follow-up questions about stereotype sources and rationales.** In the fourth section of the survey, we asked participants who had *not* responded that women or men were equally likely (i.e., who expressed a gendered stereotype) for the prior questions to elaborate on why they believed the gender stereotype with respect to computer security and privacy existed. Prior work highlights a divide between biological and non-biological reasons for gendered expectations, so we focused on this distinction [104]. Replicating a prior (more general) Pew research study [105], we offered the following answer choices: "Biological reasons," "Non-biological reasons," "Other reasons, please specify," and "Don't know or not sure." We also asked participants to explain their choice with a free-text response.

In the fifth section of the survey, we asked some general questions about sources where participants may have heard gendered stereotypes regarding security and privacy.

**Ambivalent Sexism Inventory and demographics.** The survey concluded with the Ambivalent Sexism Inventory (ASI) [14], [106], a standardized measure of individual sexism scored from a low of 1 to a high of 6 (reproduced in full in Appendix B), as well as demographic questions.

**Survey pre-testing.** To pre-test the survey, we conducted 5 expert reviews with researchers familiar with security and

TABLE 1: We studied 19 potential stereotypes related to security and privacy, in three categories: general engagement, personal characteristics, and specific behaviors. Items in first two categories were generated from our pre-study (see 4.2), and items in last category from affinity diagramming security behaviors listed in prior work (see 5.1).

| Potential stereotype | Pos. | Neg. |
|---|---|---|
| *General engagement [from pre-study]* | | |
| Interested in learning about protecting | × | |
| Know how to protect | × | |
| Skilled at protecting | × | |
| *Personal characteristic [from pre-study]* | | |
| Be logical | × | |
| Be lazy | | × |
| Be overconfident | | × |
| Be perceptive | × | |
| Be emotional | | × |
| Be gullible | | × |
| *Specific behavior [from [100], [101], [102]]* | | |
| Verify HTTPS | × | |
| Install software updates immediately | × | |
| Use antivirus software | × | |
| Enable 2FA | × | |
| Ask for help if have questions | × | |
| Fall for shopping scam | | × |
| Fall for dating scam | | × |
| Leave device unlocked | | × |
| Reuse password | | × |
| Share sensitive info on social media | | × |

privacy user studies, as recommended by best practice [103]. This process allowed us to catch best-practice errors and validate that our survey was serving our research questions. We further conducted 10 pilot tests with Prolific participants (data excluded from our results) to identify any remaining misunderstandings or technical issues, and we updated question wordings or survey code accordingly.

## 5.3. Participants

We recruited participants from Prolific, a crowdworking platform shown to be better than other crowdsourcing platforms, such as Amazon Mechanical Turk, in terms of comprehension, attention, and honesty of its participants [107], [108]. We recruited participants who lived in the United States and were fluent in English. For the main study, we collected responses from a total of 190 U.S. participants. We verified participants were paying attention to our survey by checking the coherency of their responses to open-ended questions. Participants took 17 minutes, on average, to complete the survey. We compensated them $2.50, which was calculated based on the average length of our pilot tests (10 minutes) at an hourly rate of $15/hour. 74 were women, 107 were men, 4 were non-binary, 1 was a woman and non-binary, 1 was a woman and man, 1 was genderfluid, and 2 preferred not to say. 11.6% of participants reported having an education or working in security and privacy in particular. Table 2 shows additional demographic information.

## 5.4. Data analysis

We used a mixed quantitative and qualitative approach. For statistical analysis with participants' gender, we excluded responses not from women or men because we did not have enough responses in these categories to have adequate statistical power to make accurate claims. However, we report qualitative data from all participants.

**Quantitative.** For all quantitative analyses, we binned responses into those towards women ("Definitely women" / "Probably women") or towards men ("Definitely men" / "Probably men") to increase our statistical power, but we report these gradations in figures for context. We did not perform statistical testing with the other responses ("Another gender, please specify" and "Don't know or not sure").

To understand whether significantly more participants believed stereotypes about women or men, we conducted two-sided exact binomial tests to determine whether the proportions of responses towards either differed significantly (dropping the "Men and women equally" option). We performed Holm's correction to reduce Type I error.

We were interested in how participants' gender and sexism scores impacted their stereotype beliefs, but we did not include gender and sexism scores in the same model because they were significantly correlated ($p < .05$). To identify how participants' self-identified gender affected their security and privacy stereotype beliefs, we conducted two two-sided exact binomial tests on responses towards women and men for each stereotype, one for the subset of women participants, and one for the subset of men participants. We performed Holm's correction within each family. To identify how participants' sexism impacted their stereotype beliefs, we constructed 19 multinomial logistic regressions models, one for each stereotype. The dependent variables (DV) were responses to the stereotype question, retaining the "Men and women equally" option to account for participants with low sexism scores. The independent variable was the numeric overall ASI score.

Finally, we investigated whether participants believed stereotypes for biological or non-biological rationales with two-sided paired t-tests. We also conducted two mixed logistic regressions to investigate whether participants' sexism score correlated with their selected rationales. The independent variable for both regressions was sexism score; the dependent variable for one was selecting biological rationales (dummy-coded to 0 or 1), and for the other, selecting non-biological rationales (also dummy-coded). Regressions were separate because rationales were not independent, and we performed Holm's correction within each family.

**Qualitative.** For participants' free-text rationales for the stereotypes, we used qualitative thematic analysis to describe and interpret (but not necessarily verify or evaluate) [109] themes in how they justified their beliefs. Our goal

TABLE 2: Breakdown of participant demographics by gender, age, education, race/ethnicity, and technical background.

| Gender | | Age | | Education | | Race/Ethnicity | | Tech background | |
|---|---|---|---|---|---|---|---|---|---|
| Woman | 38.9% | 18-24 | 19.9% | High school | 13.0% | White | 59.5% | No | 58.4% |
| Man | 56.3% | 25-34 | 34.7% | Associate's or some college | 7.1% | Asian | 11.1% | Yes | 19.5% |
| Non-binary | 2.1% | 35-44 | 24.2% | Trade/technical/vocational | 1.9% | Black or African American | 5.8% | Prefer not to say | 3.2% |
| Multiple genders | 1.0% | 45-54 | 9.3% | Bachelor's | 39.6% | Hispanic, Latino, or Spanish Origin | 4.7% | | |
| Genderfluid | <1% | 55-64 | 6.8% | Master's | 16.9% | Mixed | 1.6% | | |
| Prefer not to say | 1.0% | | | Professional degree or doctorate | 3.9% | Middle Eastern or North African | | | |
| | | | | | | Other | <1% | | |

was to facilitate deeper explanations of why participants believed in gender stereotypes regarding security and privacy, beyond the choice of "biological" and "non-biological."

We followed a thematic coding process [94]. One researcher read and re-read all data, noting initial thoughts about the rationales participants gave. The researcher then generated a set of themes, applied them to the full dataset, and iteratively defined and refined each theme (full codebook in Appendix C). One member of the team performed the analysis, consistent with viewpoints from qualitative research theory and practice about the potential for multiple coders to reduce interpretive nuance [95], [96] or the semantic power of the codebook [97]. To balance researcher subjectivity with thoroughness and integrity [98], another team member reviewed the codebook, independently coded 25 randomly selected responses, and discussed and resolved differences with the main coder.

## 5.5. Ethical considerations

Our institution's IRB reviewed our study and determined it to be exempt. However, IRB review is not sufficient to guarantee ethical research. We identified the following ethics-related questions: would our research instrument cause our participants to believe (1) harmful stereotypes that they did not believe prior to participating in our study, or (2) that harmful stereotypes apply to others or themselves? We carefully constructed our survey to avoid suggesting any gender differences were true; rather, our survey was designed to be neutral and elicit the participant's unprimed responses (full survey instrument in Appendix A).

## 5.6. Positionality statement

Aligned with feminist methodology, we recognize that our position as researchers and our identities influence our research [55], [110], and discuss here identities most relevant to this paper and how they shaped our research choices. (We further discuss how our positionality limited our research perspective in Section 5.7.) Three researchers are women, and one is a man. All researchers have observed instances of gender stereotyping with respect to computer security and privacy, either directed at ourselves or via our roles as instructors of computer security courses. We have the most personal experience with gender stereotypes as it relates to people who are women or men and thus focused our study on these genders. Two researchers were born outside of the U.S.; all of us have lived in the U.S. for at least the last six years. Our work focuses on stereotypes in the U.S. cultural context for this reason.

## 5.7. Limitations

We must consider standard survey-based limitations, including survey fatigue and social desirability bias. We attempted to mitigate these concerns by pre-testing our survey to optimize its length and by explicitly stating that there were no right or wrong answers. However, our acknowledgement at the beginning of the study that there are many genders may have signaled our positionality and influenced some responses. Further, we studied only perceptions that participants were willing to report in our survey, suggesting that our results are a lower bound on gendered perceptions people consciously or subconsciously hold. In terms of fatigue, we received a large amount of free response text (24,180 words) from our 190 main study participants, suggesting that many engaged deeply with the survey.

Our results are also limited by the characteristics of our Prolific sample. Crowdworkers have more internet experience than the general U.S. population, but are still representative in terms of security and privacy experiences and knowledge [111]. Prolific has emerged as an alternative to other crowdworking platforms like Amazon Turk [112] for implementing features to improve participant recruitment specifically for scientific researchers. We studied only English-speaking U.S. participants; gender stereotypes with respect to computer security and privacy may look different in other cultures and contexts.

Finally, our work is limited by our own identities, perspectives, and experiences as researchers. We hypothesize that intersections with race or ethnicity (e.g., for Black women), gender identity (e.g., for transgender women), age, sexuality, dis/ability, and other identities would strongly modulate how gender stereotypes in security and privacy are experienced. Our research team is composed of cisgender women and men in their 40s or younger; two are white, one is Asian, and one is Asian, Native, and white. While we partially made the choice to focus our work on stereotypes of binary genders to build on existing sexism research instruments (the ASI only considers binary genders), our own identities also shaped the limited scope of this paper. Future work should investigate other critical aspects of identity in an intersectional way [56]; extending a study to a full spectrum of genders or identities will require at minimum a thoughtful redesign or even a different method entirely.

TABLE 3: Sexism scores, as mean (SD), of all participants, just women, and just men. We used the Ambivalent Sexism Inventory (ASI), measuring overall sexism, benevolent sexism, and hostile sexism from 1 (low) to 6 (high).

| | All | Women | Men |
|---|---|---|---|
| Overall sexism | 2.7 (1.0) | 2.5 (1.0) | 2.9 (1.0) |
| Benevolent sexism | 2.8 (1.1) | 2.7 (1.1) | 2.9 (1.0) |
| Hostile sexism | 2.6 (1.3) | 2.2 (1.2) | 2.9 (1.4) |

## 6. Main Study Results

First, we analyze our participants' sexism scores (Section 6.1). We then report stereotypes that our participants believed about women, men, or that were not strongly associated with either (Section 6.2), whether these differed by sexism or participant gender (Section 6.3), and the sources of these stereotypes (Section 6.4). We conclude with participants' rationales for these stereotypes (Section 6.5).

### 6.1. Sexism scores

The Ambivalent Sexism Inventory (ASI) is scored from 1 (low) to 6 (high) [14]. Overall, our participants scored an average of 2.7 (SD 1.0; range 1-4.8). Further broken down into benevolent and hostile sexism, our participants scored an average of 2.8 (SD 1.1, range 1-4.7) and 2.6 (SD 1.33; range 1-5.5), respectively. Men's overall sexism scores were higher than for women (Table 3). Additionally, both men's benevolent sexism and hostile sexism were higher than women's. Gender correlated significantly with participants' overall ASI ($Z = 3.01, p\text{-value} < .01$) and hostile sexism ($Z = 3.31, p\text{-value} < .001$), but not for benevolent sexism.

### 6.2. What stereotypes exist about how women and men protect their security and privacy?

**Stereotypes about women.** Out of nineteen stereotypes we investigated, we found five regarding security and privacy characteristics or behaviors about women. Participants expressed that women would be more likely than men to:

- Share sensitive information on social media (-)
- Be emotional (-)
- Fall for shopping scams (-)
- Ask for help if they have questions (+)
- Be gullible (-)

For these stereotypes, 37%-68% of participants responded women would definitely or probably be more likely to be or do so, compared to men (Figure 1). One cluster of these stereotypes about women regard their personal characteristics, i.e., that they are more likely to be emotional or gullible. Another cluster regards specific behaviors, but none of the stereotypes about women included positive stereotypes from the category of general engagement with security and privacy. From our original interpretations (of participants' responses in the pre-study, or of related work we referenced) about potential "positive" or "negative" stereotypes, four of

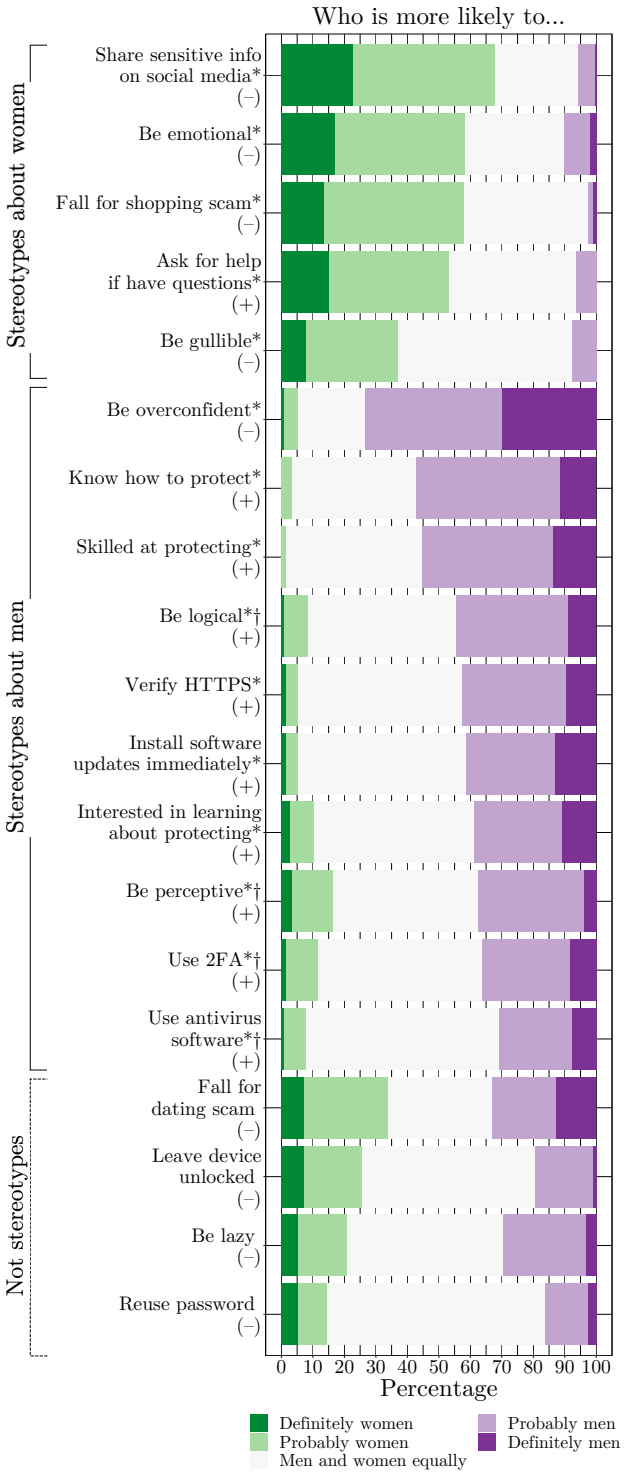


Figure 1: Stereotypes in security and privacy. * represents stereotypes we found, defined by a significant difference ($p$-value $< .001$) in proportion of participants who selected either "Definitely women" / "Probably women" compared to "Definitely men" / "Probably men". † represents stereotypes believed more by men; see further detail in Figure 2. (+) represents positive stereotypes, and (–) negative stereotypes.

these five were negative stereotypes about women, with only one positive stereotype: asking for help.

**Stereotypes about men.** For ten stereotypes, significantly more participants associated the characteristic or behavior with men over women. We found that at least 30% of participants associated ten security and privacy stereotypes with men (Figure 1), i.e., that men would be more likely to:

- Be overconfident (-)
- Know how to protect their security & privacy (+)
- Be skilled at protecting their security & privacy (+)
- Be logical (+)
- Verify HTTPS (+)
- Install software updates immediately (+)
- Be interested in learning about protecting security & privacy (+)
- Be perceptive (+)
- Enable 2FA (+)
- Use antivirus software (+)

These stereotypes about men include all three of our potential stereotypes about general engagement with security and privacy, as well as three personal characteristics (i.e., overconfident, logical, and perceptive). Another cluster of these stereotypes regarding men are about a range of protective security and privacy behaviors, including verifying HTTPS, installing software updates, and enabling 2FA. From our original hypothesis about the stereotypes being "positive" or "negative", all stereotypes about men were positive except overconfidence.

Our finding that men are more logical contradicts prior work (in STEM broadly, not security and privacy specifically) that logical thinking was perceived to be a gender-neutral personality trait, i.e., not a gender stereotype [64].

**Stereotypes not strongly held about women or men.** There were no statistically significant differences in the proportion of participants who believed gender was associated with four characteristics or behaviors:

- Being lazy (-)
- Falling for dating scams (-)
- Leaving devices unlocked (-)
- Reusing passwords (-)

Given that differences in the proportion of responses were not significant, these characteristics or behaviors could be described as gendered prejudices that are held by a minority.

## 6.3. How do stereotyped beliefs vary by participants' gender and sexism level?

**Stereotype beliefs by participant gender.** Building on the identification of stereotypes in the prior section, we now turn to whether the beliefs in stereotypes were correlated with participants' gender. We find four stereotypes about men that men believed but women did not:

- Be logical (men: $p$-value $< .001$, women: $n.s.$)
- Be perceptive (men: $p$-value $< .001$, women: $n.s.$)
- Use 2FA (men: $p$-value $< .001$, women: $n.s.$)
- Use antivirus software (men: $p$-value $< .001$, women: $n.s.$)

Figure 2 shows participant responses to these stereotypes, comparing women and men in our sample. We found no stereotypes that women believed but men did not, indicating that — of the stereotypes we studied — men held more gender stereotypes regarding security and privacy than women.

Men and women alike held the 11 remaining stereotypes in Section 6.2. This suggests that most stereotypes are widespread; however, select stereotypes are only held by men, which, further, are positive stereotypes about men.

**Stereotype beliefs by participant sexism.** In addition to participants' gender, we wanted to know whether higher levels of participant sexism, measured via Ambivalent Sexism Inventory (ASI) scores [14], correlated with having (or not having) belief in gender stereotypes.

Overall, we found that as sexism scores increased, so too did the belief in fifteen of the stereotypes we studied: seven about women, and eight about men (see Appendix, Table 5). Participants who the test identified as more sexist were significantly more likely to believe that women would be emotional (estimate $= 1.00$, $p$-value $< .001$), gullible (estimate $= 0.85$, $p$-value $< .001$), lazy (estimate $= 1.32$, $p$-value $< .001$), fall for shopping scams (estimate $= 0.89$, $p$-value $< .001$), ask for help (estimate $= 0.80$, $p$-value $< .01$), reuse passwords (estimate $= 0.86$, $p$-value $< .05$), and leave devices unlocked (estimate $= 0.95$, $p$-value $< .001$). Note that beliefs about women being lazy, reusing passwords, and leaving devices unlocked were not found to be stereotypes overall but were views more likely to be held by participants who scored higher on the sexism scale.

For stereotypes about men, participants who the test identified as more sexist were more likely to believe that men would be more likely to know how to protect (estimate $= 0.71$, $p$-value $< .01$) and be skilled at protecting their security and privacy (estimate $= 0.70$, $p$-value $< .01$), be perceptive (estimate $= 0.76$, $p$-value $< .01$), be logical (estimate $= 1.26$, $p$-value $< .001$), verify HTTPS (estimate $= 0.70$, $p$-value $< .01$), install software updates immediately (estimate $= 0.78$, $p$-value $< .01$), use 2FA (estimate $= 0.62$, $p$-value $< .05$), and use antivirus software (estimate $= 1.10$, $p$-value $< .001$).

## 6.4. Personal exposures to stereotype beliefs

We asked participants to select all sources (not mutually exclusive) where they had heard about people of one gender being better than others at performing security and privacy behaviors. 82 participants reported not hearing about gender differences from any source. Social media was the most commonly cited source (31), followed by friends (25), TV/movies (23), family (20), work or job (20), or the news (16). For the 10 "other" responses, participants mentioned hearing about stereotypes from teachers, co-workers, the military, their own experiences, nowhere in particular, and "ambient cultural osmosis" (P116). One participant wrote, "of course i have heard, what a silly question to ask." [sic]

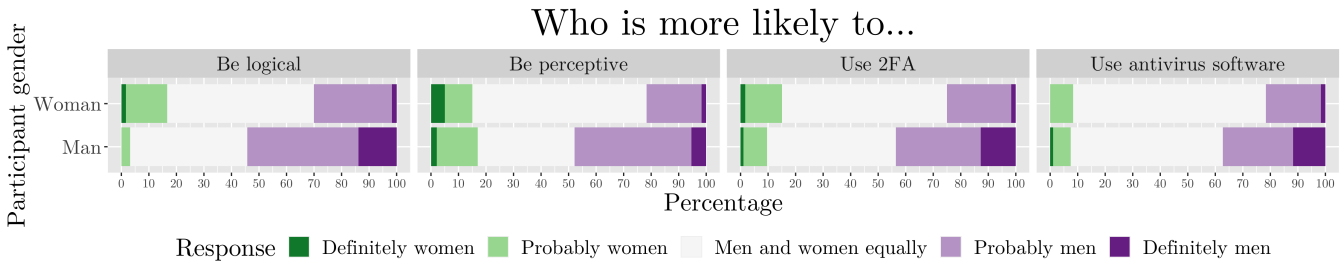


Figure 2: Four stereotypes held by men, but not by women, in our sample (all other stereotypes were held by both men and women). Differences in proportions of participants who selected either "Definitely men" / "Probably men" compared to "Definitely women" / "Probably women" were statistically significant ($p$-value $< .001$) for men but not for women.

## 6.5. What are participants' rationales for their stereotype beliefs?

We now turn to our second major research question: What are participants' rationales for gendered stereotypes? Towards the end of combating gender stereotypes, we sought to understand what types of evidence are used to rationalize the stereotype beliefs. Table 4 summarizes these results.

### 6.5.1. Closed-response rationales

As a first pass, we asked participants to select whether they believed gender differences were due to biological or non-biological factors, replicating prior work [105].

For stereotypes about women, significantly more participants believed that non-biological reasons explained why women would be more likely to share sensitive information on social media ($t(45) = -4.12, p$-value $< .001$), fall for shopping scams ($t(58) = -6.77, p$-value $< .001$), and ask for help ($t(26) = -3.84, p$-value $< .001$). On the other hand, stereotypes about women's personal characteristics – being more emotional and gullible – were attributed by more participants to biological reasons (75% and 62%, respectively), although this difference was only significant for being emotional ($t(62) = 4.46, p$-value $< .001$). Participants may have perceived *actions* to be more related to societal expectations (non-biological factors), e.g., that women use social media and shop more and thus would fall for more shopping scams, while *personal characteristics* were seen as biologically determined. Further, participants with higher sexism scores were more likely to consider women to be emotional (estimate $= 0.57, p$-value $< .01$) or gullible (estimate $= 0.72, p$-value $< .01$) as a result of biological reasons, while participants with lower sexism scores were more likely to attribute women being more emotional (estimate $= -0.47, p$-value $< .05$) or sharing sensitive information on social media (estimate $= -0.77, p$-value $< .001$) to non-biological reasons.

Regarding stereotypes about men, significantly more participants attributed nine of the ten to non-biological reasons: being overconfident ($t(53) = -4.42, p$-value $< .001$), knowing how to protect ($t(70) = -3.76, p$-value $< .001$), being skilled at protecting ($t(65) = -4.33, p$-value $< .001$), verifying HTTPS ($t(59) = -5.89, p$-value $< .001$), installing software updates immediately ($t(59) = -4.14, p$-value $< .001$), being interested in learning about protecting ($t(47) = -4.30, p$-value $< .001$), being perceptive ($t(44) = 4.55, p$-value $< .001$), using 2FA ($t(52) = -3.19, p$-value $< .05$), and using antivirus software ($t(47) = -3.47, p$-value $< .05$).

### 6.5.2. Open-response rationales: Sources of and evidence for stereotype beliefs

Participants were also asked to explain their rationales for holding stereotypes; we collected a total of 1,159 free-text rationalizations from 150 participants and now present results of thematically analyzing these responses. Aligned with qualitative methods, our analysis is intended to be generative, surfacing themes about the sources of and evidence for participants' beliefs, rather than measuring pervasiveness. As such, we report whether themes were expressed by a few (less than 25%), some (25%-49%), or many (more than 50%) of the 150 participants that provided free-text rationales. We also apply our own interpretive lens to develop shared themes across participants' responses that build on, but ultimately rise above and enrich, the closed-response rationales.

**Other stereotypes.** Many rationales for stereotypes were based on other stereotypes. P117 explained that women were more likely to be gullible because:

> *"Women have a tendency to be compassionate...and listen to others and that often gives scammers the opportunity to fool them."*

Often, participants rationalized their beliefs for who would be more likely to reuse passwords based on which gender they perceived to be more lazy, e.g.,

> *"women are naturally lazy in issues of internet matters and always tend to seek the easy way out" (P189).*

**"Science".** A few participants' rationales referenced biologically essentialist effects of estrogen, testosterone, and hormones. These also spanned scientific disciplines including biology, psychology, and anthropology:

> *"Women are biologically programmed in many ways over thousands of years to trust their in-*

TABLE 4: Participants' rationales for gender stereotypes. For stereotypes about women or men, closed-response rationales are shown for participants who believed that stereotype and whether there was a significant difference between participants selecting biological or non-biological reasons (% do not sum to 100% because choices were not mutually exclusive and "other" is not shown here). For example, 26% of participants who believed women would be more likely to share sensitive information on social media believed so for biological reasons; this choice was significantly less than the 72% that selected non-biological ($t(45) = -4.12, p < .001$). Selected quotes from participants are shown for open-response rationales. For not gender stereotypes, rationale data is reported from all participants. *Note:* * $p < .05$, ** $p < .01$, *** $p < .001$.

| | Stereotype | Closed-response rationales | | | | | Participant quote |
|---|---|---|---|---|---|---|---|
| | | Reasons | % | *t* | *df* | *p-value* | |
| Stereotypes about women | Share sensitive info on social media | Biological | 26 | -4.12 | 45 | ** | "Women are less biologically driven to use technology, and thus may not be as aware of the risks of sharing too much information online." |
| | | Non-biological | 72 | | | | "[Women] like more of the attention" |
| | Be emotional | Biological | 75 | 4.46 | 62 | *** | "Due to their genetics, women tend to be much more emotional, their brains are created in such a way that emotions are much more intense in them" |
| | | Non-biological | 29 | | | | "it's more socially acceptable for women to be more emotional... Therefore I'd expect women to be more emotional over computer security than men" |
| | Fall for shopping scam | Biological | 19 | -6.77 | 58 | *** | "Women gather and make clothes/food for there families, to clothe their children...over time these things leave biological signatures for survival." |
| | | Non-biological | 78 | | | | "There are more shopping-related scams targeting women." |
| | Ask for help if have questions | Biological | 19 | -3.84 | 26 | ** | "Women's brains generally do not think that way and they don't have a problem asking for help." |
| | | Non-biological | 74 | | | | "[women are] more familiar with and more culturally comfortable with asking for answers." |
| | Be gullible | Biological | 40 | -1.67 | 51 | $(n.s.)$ | "Women are biologically programmed in many ways over thousands of years to trust their intuition over logic... Once they feel something is right.. they take that path repeatedly and incautiously... and as such can easily be manipulated" |
| | | Non-biological | 62 | | | | "[Women] give someone the benefit of doubt mostly. We don't mean to be gullible just polite" |
| Stereotypes about men | Be overconfident | Biological | 30 | -4.42 | 53 | *** | "I think men think that they are just stronger and incapable of someone coning them even when it is in a technology situation." |
| | | Non-biological | 76 | | | | "Men are generally socialized to have more confidence than women, especially about technology. They are much more likely to be overconfident." |
| | Know how to protect | Biological | 28 | -3.76 | 70 | ** | "Men are just protectors in general. Its just in their blood." |
| | | Non-biological | 66 | | | | "Culturally men have been the ones more responsible for protection for any sort, so I would think it would extend to this as well" |
| | Skilled at protecting | Biological | 26 | -4.33 | 65 | *** | "[men are] more biologically driven to use computers" |
| | | Non-biological | 70 | | | | "women generally have less access to computer security and privacy... career choices... lesser participation in STEM categories and it's no fault on their part" |
| | Be logical | Biological | 54 | 0.85 | 55 | $(n.s.)$ | "I feel men are more likely to be more logical when it comes to computer security and privacy because men are natural born problem solver and always try to explore the best possible means to fix a problem" |
| | | Non-biological | 43 | | | | "Men have been at the forefront of technological advancement" |
| | Verify HTTPS | Biological | 25 | -5.89 | 59 | *** | "Men probably use those sites that need to be protected than women, so they are more used to what it is" |
| | | Non-biological | 82 | | | | "There are more men that are into computers, thus they would be more likely to know to look for this." |
| | Install software updates immediately | Biological | 25 | -4.14 | 59 | ** | "Men due to their natural skepticism are more likely to recognize the danger of not keeping software up to date." |
| | | Non-biological | 68 | | | | "Men have time - they aren't as busy with children or taking care of the household. They like to take care of their 'toys' and tech." |
| | Interested in learning about protecting | Biological | 21 | -4.30 | 47 | ** | "Men have been wired... cognitively to be protectors, of themselves first and foremost, [if they] sense threat they deal with it way thoroughly than women." |
| | | Non-biological | 69 | | | | "Men tend to be more interested in things whereas women like to learn and study people" |
| | Be perceptive | Biological | 22 | -4.55 | 44 | *** | "that's just the way guys are, nerdy and techy, Women are careless on the computer, not as much knowledge about geeky stuff as men" |
| | | Non-biological | 76 | | | | "Because of societal factors, men are given more training and confidence in computer-related fields... hence why they are more perceptive." |
| | Use 2FA | Biological | 32 | -3.19 | 52 | * | "[2FA] is too complex for women" |
| | | Non-biological | 70 | | | | "Men are more likely to be targeted by technology news and are more likely to have been informed of the benefits of two-factor authentication." |
| | Use antivirus software | Biological | 27 | -3.47 | 47 | ** | "naturally men are always security conscious and can go the extra length to secure their devices" |
| | | Non-biological | 71 | | | | "[men] seem more like the type to download more sketchy items from the internet." |
| Not gender stereotypes | Fall for dating scam | Biological | 47 | 0.15 | 57 | $(n.s.)$ | "women more subject to being swayed by their emotions"; "[mens'] testosterone may temporarily inhibit sound decision when it comes to dating-related financial scams" |
| | | Non-biological | 45 | | | | "Women are seen as softer targets by scammers" |
| | Leave device unlocked | Biological | 32 | -3.01 | 59 | * | "Women tend to be more trusting and less skeptical"; "Men tend to be more careless" |
| | | Non-biological | 65 | | | | "Women rarely have things to hide"; "Men more likely to take risks" |
| | Be lazy | Biological | 26 | -3.91 | 57 | ** | "Women more concerned about posting a photo and how many likes they get" |
| | | Non-biological | 69 | | | | "A lot of men think they should have things done for them due to personal and societal standards" |
| | Reuse password | Biological | 40 | -1.15 | 46 | $(n.s.)$ | "Women is more likely to use the same password for multiple accounts. Because it is easy to remember for women" |
| | | Non-biological | 55 | | | | "Men want things to be as simple as possible" |

*tuition over logic" (P170).*

*"Men might have a certain drive to explore, and so often venture into new territory like technology" (P142).*

*"Men seem to be the protectors in anthropological terms" (P108).*

**Societal expectations.** Some participants rationalized their beliefs by referencing social discourses about the ways that women or men should be. The most common was that men were expected to understand and enjoy technical topics and were provided support and encouragement to have interests in STEM — in P122's words:

*"the social coding of those hobbies as 'masculine' "*

which led to participants deducing that men would be more likely to verify HTTPS, use 2FA, install software updates, and more. On the other hand, we observed stereotype rationales about societal expectations that women be family-oriented, e.g., that women would be more likely to fall for shopping scams because:

*"Women gather and make clothes/food for their families, to clothe their children, as these responsibilities often fall on women" (P142).*

**Personal observations and experiences.** Many participants' rationales came from their observations that women or men in their lives tended to have certain traits, e.g.,

*"With the way social media is, women are known to 'overshare' information about their lives. I don't see too many men doing this" (P159).*

or take certain actions, e.g.,

*"From all my friends the male ones concern more about their privacy and security, so they look it up about it more" [sic] (P43).*

**Assumptions of knowledge, level of experience, and interest.** Many participants wrote that men likely had more knowledge, experience, or interest in technical topics, which then influenced stereotypes they held about men. Participants assumed that men were more interested in software, gaming, and the internet, and thus would be more knowledgeable about computers, security, and privacy. Some commented on women's apparent lack of interest, e.g.,

*"Women consider technology a tool, something to use but not spend too much time on" (P129).*

*"Women have more things on their mind than computers, ie: home life, kids, errands, friends. Most leave it up to their husbands to take care of the techy geeky stuff" (P132).*

**Threat models.** The development (or lack thereof) of three aspects of threat models contributed to participants' stereotype rationales. First, some participants referred to innate valuations of security and privacy, e.g.,

*"men value security more [so they will use 2FA]" (P21).*

*"women may care less about this topic than do men [so they will be more gullible]" (P144).*

A range of assets contributed to valuing security, e.g., women's personal information that could be abused to harass, or men's financial information or browsing activities:

*"men probably have more to hide on their devices, honestly, ...to lock up porn history" (P142).*

Second, a few participants believed one gender had a better understanding of threats, e.g.,

*"men tend to... understand how security plays a role and the consequences that come if you are not protected" (P72).*

Other participants highlighted negative experiences that contribute to threat awareness, e.g.,

*"Women are more often targets of cyber stalking, doxxing campaigns, and scams than men, so they have a more obvious reason to avoid sharing sensitive information and probably learn more quickly how to do so effectively" (P186).*

Third, a few participants observed threats external to individuals, e.g., scammers target women on shopping sites or men on dating sites.

**"Just because".** Finally, a few participants did not rationalize the stereotypes they held with a unique reason, e.g., P186's rationale for why men were more likely to leave devices unlocked:

*"That was just a gut feeling, I have no reasoning to back it up."*

In another example, P130 uses explicit and non-inclusive language to explain why men reuse passwords more:

*"Their bodies are different, women have [slang term for body part], men have [slang term for body part]! isnt that enough." [sic]*

We find the lack of rationales meaningful because they reflect internalized biases; people may not have thought consciously about gender stereotypes in security and privacy, and yet, they exist.

# 7. Discussion

## 7.1. Summary and key findings

Using two surveys, we studied the beliefs that Prolific crowdworkers in the U.S. hold with respect to gender and computer security and privacy. To answer our initial research questions:

*What gender stereotypes (about women or men) do members of the general U.S. public hold that concern everyday computer security and privacy issues?* Participants in our study believed that men are more likely or more able to protect their computer security and privacy than women, e.g., that men are more interested in and more skilled at computer security and privacy, or that women are more emotional and likely to fall for scams (see Section 6.2). Because these beliefs were held by statistically significant proportions of our sample, we identify these as gender stereotypes. Additionally, we find that gender stereotypes

are held by both women and men (see Section 6.3). More sexist participants, based on their responses to the ASI [14], are more likely to believe these stereotypes (see Section 6.3).

*What explanations or rationales do people give to justify gender stereotypes?* A sizeable proportion of participants rationalized gender stereotypes about security and privacy topics by either reiterating gender stereotypes from outside of computing or invoking essentialist claims. Many participants also reflected on societal gender expectations and personal experiences or assumptions as contributors to the existence of gender stereotypes. Overall, rationales for gender stereotypes spanned the spectrum from biological to non-biological and were deeply entrenched in participants' perceptions of others (see Section 6.5).

## 7.2. Guidelines for the future

Though the existence of gender stereotypes with respect to computer security and privacy is not surprising, given the documentation of stereotypes in other contexts, our work uniquely captures the existence of specific gender stereotypes in the field of security and privacy. We hope this work inspires other researchers to explicitly consider the impact of stereotypes on the design and evaluation of future computing systems, and to further investigate the relationships between gender or other identities and computer security and privacy. Building on the implications of our work, we suggest ten guidelines for future work.

### 7.2.1. Familiarize research and design teams with the principle that stereotypes and facts are related but separate concepts

Stereotypes, or reductive beliefs about a population, are distinct from facts, or empirical measurements of that population. For example, we found a stereotype held by our participants that men would be more likely to use 2FA. This stereotype is distinct from empirical measurements suggesting more men may use 2FA than women [17]. This distinction distinguishes our work from prior work making empirical measurements because whether or not stereotypes align with empirical measurements of a population, stereotypes can cause harm. Even if multiple studies corroborate that men are indeed more likely to use 2FA than women, thereby ostensibly providing "evidence" for this gender stereotype, the stereotype may discourage scores of women from even attempting to set up 2FA for their accounts. We recommend that future researchers be mindful the distinction between stereotypes and empirical measurements, and study the relationship between the two.

### 7.2.2. Investigate the potential role of stereotypes when gender gaps are uncovered

Our work demonstrates that individuals' gender can have significant impact on their likelihood of believing stereotypes. Thus, we suggest that when gender gaps are uncovered in security and privacy (e.g., in adoption rates, in preferences, in attitudes), researchers explore whether gender stereotypes contributed to those gaps. Gender stereotypes may have also contributed to prior work that found gendered differences, such as in individuals' password choices [15] or susceptibility to phishing [20]. Keeping in mind guideline 7.2.1, gendered differences in individuals' behaviors could be a result of gendered stereotypes or other types of gender discrimination.

### 7.2.3. Familiarize research and design teams with the potential harms of stereotypes

We investigated the existence of specific gender stereotypes in our realm of computer security and privacy to create a foundation for studying the potential harms of these stereotypes. While we look forward to a multitude of future research examining what and how harms manifest in security and privacy, we recommend that research and design teams familiarize themselves with the harms of gender stereotypes in other domains, e.g., on self-efficacy [70], [8] or interest [33] in STEM, as well as feminist primers [44] that provide contextual theory.

### 7.2.4. Explore harms arising from people believing gender stereotypes about themselves

We encourage future research to explore the gender stereotypes' harms that arise for *experiencers*, or members of the stereotyped group. For example, we discovered stereotypes that women would be more likely to fall for shopping scams. Does this stereotype then contribute to women developing learned helplessness in avoiding such scams? Prior research on stereotype threat suggests that this could be the case; equally qualified women performed worse on a math test after being reminded of negative stereotypes about women and math [31]. We urge future work to explore the harms of the specific stereotypes identified in this work.

### 7.2.5. Explore harms arising from people believing gender stereotypes about others

We encourage future research to also explore gender stereotypes' harms that arise from *perceivers*, or people who hold stereotypes that distort their perceptions of others. For example, we found stereotypes that men would be more likely to use 2FA and other common security tools. Does this contribute added barriers for women who seek to use such tools, in opposition to the stereotype? Additionally, we urge future researchers to consider potential harms from gender stereotypes for people of non-binary genders. Gender is multiplicitous in its "many meanings and relations to individuals and communities" [11], and study of gender stereotypes and non-binary genders may necessitate research approaches and methods beyond those used in this work, which were intended as an initial investigation and does not adequately contend with gender's multiplicity.

### 7.2.6. Combat gender stereotypes that reduce adoption of positive security and privacy behaviors

Gender stereotypes are well-documented to present barriers to participation, e.g., in the field of STEM [67], [68]. The gender stereotypes identified in this paper suggest that they may also have negative effects on the adoption of positive security and privacy behaviors, e.g., using 2FA, being

interesting in learning about security and privacy. Especially for (but not limited to) topics where stereotype belief or individual sexism correlate with disproportionate adoption by gender, we call for the combating of those stereotypes. These efforts may align with a growing playbook to increase representation in computing and STEM, such as through outreach campaigns, diversity in marketing, and much more.

#### 7.2.7. Acknowledge that participants in security and privacy user studies may hold gender stereotypes with respect to security and privacy

Our study finds that U.S. participants on Prolific, a commonly used crowdsourcing platform, believe gender stereotypes with respect to security and privacy; it is imperative that future researchers and designers take this into consideration. Specifically, researchers or designers making gendered assumptions (e.g., using gendered personas, embedding assumptions about users' aptitude or knowledge), could trigger gender stereotypes about who is more likely to fall for scams, have security and privacy interest and knowledge, or adopt security tools. We recommend avoiding gendered assumptions that could bias resulting outcomes.

#### 7.2.8. Develop tools for measuring individual belief in gender stereotypes in security and privacy

Tools to quantify belief in gender stereotypes in computer security and privacy could be a significant resource for researchers and practitioners working with users. Such tools could include validated scales, similar to SeBIS [113] or SA-6 [22], as well as experimental procedures, similar to the Implicit Association Test (IAT) [114]. Ideally, these validated scales or experimental procedures could be easily incorporated into a range of future research, including surveys, interviews, or other user study methods. The development of such tools is an essential long-term goal requiring extensive effort from researchers in our field. In the meantime, our work indicates that ASI [14] or other sexism measures can proxy belief in gender stereotypes.

#### 7.2.9. Request identity information as late as possible

To minimize the risk of stereotype threat, designers should ask for user identity information as late as possible in a security- or privacy-related UI flow. Otherwise, asking for a user's gender could contribute to the negatively stereotyped groups making poorer decisions. For example, if women were asked for their gender prior to an option to sign up for 2FA, given our finding that men are perceived as more likely to use 2FA, women might feel discouraged from doing so. Designers should also first ensure that collecting users' gender is actually necessary for their design's functionality.

#### 7.2.10. Consider gender stereotypes throughout research and design processes

Though the mitigation of gender stereotypes for research and design resists simple solutions, we advocate for the consideration of gender stereotypes throughout security- and privacy-related processes and design flows. To promote such consideration, we advocate for researchers, designers, and practitioners to reflect on the following categories of questions.

- Laying context: How does gender appear in each part of the process? What kinds of impact will gender have in each of those places? If gender is not explicitly considered, what assumptions could be going unsaid?
- Setting goals: What is the ideal outcome, with respect to gender, for your process? How will this ideal outcome support people of all genders, not just one gender or people of binary genders?
- Heeding stereotypes: How might your process relate to gender stereotypes found in this work? Do they trigger or accidentally reinforce them? How can your process combat stereotypes?

These questions are intended as a guide and not a comprehensive list of requirements. For further background on incorporating gender analysis into research, we refer readers to Tannenbaum et al. [10].

**Stepping back.** We hope that this work (a) serves to validate the experiences of people who have been at the receiving end of harmful stereotypes in computer security and privacy, and (b) serves as a call to action for researchers and technology creators in security and privacy to actively combat these stereotypes as we create and discuss products, research results, and future technologies.

## 8. Conclusion

We conducted two studies with U.S. participants on the Prolific platform to surface specific gender stereotypes regarding security and privacy characteristics and behavior. We focused on binary genders as a first investigation and empirically measured beliefs in stereotypes. We found that participants believed women were more likely to be emotional and gullible, and to take poor security and privacy actions, while men were more likely to be engaged with security and privacy topics and take protective actions. While a significant minority of participants attribute various stereotypes to biological reasons, overall, many participants believed in the validity of stereotypes for non-biological reasons. This work suggests a new direction for security and privacy research, which centers gender and other identities as critical factors in how people manage security and privacy on their computers.

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# Appendix A.
# Survey Instrument

[Consent form] We are researchers at the University of Washington (UW) studying security and privacy in human contexts.

This study was reviewed by the UW Institutional Review Board (IRB) and deemed exempt because it involves no more than minimal risk and meets other criteria. Your responses to this survey will be anonymized. Data from this survey will be stored securely and kept confidential. Your participation in this study is voluntary. You may withdraw your participation at any time. If you have questions about this study, you may contact Miranda Wei (PhD student at UW) at weimf@cs.washington.edu. You may also contact the UW Human Subjects Division (HSD), which manages IRB review, at hsdinfo@uw.edu.

I am at least 18 years old, I have read and understood this consent form, and I agree to participate in this online research study. ◯ Yes ◯ No

[Introduction] This survey has five sections. While we understand there are many genders, for the purposes of this study, we will ask about specifically women and men.

- Sections 1-3: Rate whether men or women are more likely to do certain things
- Section 4: Elaborate on a few answers you gave in Sections 1-3
- Section 5: Answer general questions about your experiences

The survey will conclude with demographics questions.

Your survey responses are anonymous. We will not ask for identifying information. In this survey, we are interested in your honest thoughts and opinions. There are no right or wrong answers, and your responses have no impact on your compensation.

[General trends] Section [number] contains questions about 3 trends in people's lives. Trend [number] (out of 3):

Based on your personal beliefs and experiences, who is more likely to [[be more interested in learning how to protect their own computer security and privacy; know more about how to protect their own computer security and privacy; be better at protecting their own computer security and privacy]]? ◯ Definitely men ◯ Probably men ◯ Men and women equally ◯ Probably women ◯ Definitely women ◯ Another gender, please specify: _____ ◯ Don't know or not sure

[Personal characteristics] Section [number] contains questions about 6 characteristics that people might have. Characteristic [number] (out of 6):

Based on your personal beliefs and experiences, who is more likely to be more [[logical; lazy; overconfident; perceptive; emotional; gullible]] when it comes to computer security and privacy? ◯ Definitely men ◯ Probably men ◯ Men and women equally ◯ Probably women ◯ Definitely women ◯ Another gender, please specify: _____ ◯ Don't know or not sure

[Specific tasks] Section [number] contains questions about 10 actions that people could take. Action [number] (out of 10):

Based on your personal beliefs and experiences, who is more likely to [[be a victim of online shopping-related scams; be a victim of dating-related financial scams; verify that a site is using HTTPS when submitting sensitive information online; keep software up-to-date; leave personal devices (e.g., smartphones, computers) unlocked and/or unattended; use anti-virus or anti-malware software on personal computers; use the same password for multiple accounts; use two-factor authentication for personal accounts (by connecting an account to a trusted phone number, backup email address, or phone app); share sensitive information on social media; ask for help if they have questions about protecting their security or privacy]]? ◯ Definitely men ◯ Probably men ◯ Men and women equally ◯ Probably women ◯ Definitely women ◯ Another gender, please specify: _____ ◯ Don't know or not sure

[Selected follow-up questions] In Section 4, you will be asked to elaborate on some of the answers you gave in Sections 1-3.

Previous question: [Previous question text]
Your answer: [Previous question answer]

Why do you believe men and women are different in this way? Select all that apply. ◯ Biological reasons ◯ Non-biological reasons ◯ Other reasons, please specify: _____ ◯ Don't know or not sure

People believe that men and women are different for many reasons. For each reason you selected above, briefly explain or give an example why you believe that reason was relevant. _____

[Open-ended questions] Section 5 contains questions about your general experiences and beliefs.

*Idea:* "People of one gender are better than others at doing security- or privacy-related tasks." Prior to taking this survey, had you heard the idea above or something similar? If so, from where? Select all that apply. ◯ Heard from friends ◯ Heard from family ◯ Heard from the news ◯ Heard from social media ◯ Heard from TV shows or movies ◯ Heard from work or job ◯ Heard from other, please specify: _____ ◯ Never heard of differences among genders when it comes to security or privacy tasks

Have **you** ever been personally affected by a gender stereotype related to computer security or privacy? ◯ Yes ◯ No ◯ Don't know or not sure

[If yes] Please describe (as much as you can) who made the assumption, what the stereotype was, and how you felt or reacted. _____

Do you know **anyone else** who has been personally affected gender stereotype related to computer security or privacy? ◯ Yes ◯ No ◯ Don't know or not sure

[If yes] Please describe (as much as you can) who made the assumption, what the stereotype was, and how they felt or reacted. _____

[Ambivalent Sexism Inventory Questions, see Appendix B]

[Demographics] Almost done! This final page contains some demographic questions.

What is your gender? ◯ Woman ◯ Man ◯ Non-binary ◯ Prefer to self-describe _____ ◯ Prefer not to say

Would you describe yourself as transgender? ◯ Yes ◯ No ◯ Prefer not to say

What is your age? ◯ 18-24 ◯ 25-34 ◯ 35-44 ◯ 45-54 ◯ 55-64 ◯ 65 or older ◯ Prefer not to say

How do you identify? Select all that apply, you may select more than one. ◯ White ◯ Hispanic, Latino, or Spanish origin ◯ Black or African American ◯ Asian ◯ American Indian or Alaska Native ◯ Middle Eastern or North African ◯ Native Hawaiian or Other Pacific Islander ◯ Some other race, ethnicity, or origin _____ ◯ Prefer not to say

What is the highest degree or level of school you have completed? ◯ High school or less ◯ Some college ◯ Trade/technical/vocational training ◯ Associate's degree ◯ Bachelor's degree ◯ Master's degree ◯ Professional degree or doctorate ◯ Prefer not to say

Which of the following best describes your educational background or job field? ◯ I have an education in, or work in the field of computer science, computer engineering, or IT ◯ I do not have an education in, or work in the field of computer science, computer engineering, or IT ◯ Prefer not to say

Which of the following best describes your educational background or job field? ◯ I have an education in, or work in the field of **computer security and privacy in particular** ◯ I do not have an education in, or work in the field of **computer security and privacy in particular** ◯ Prefer not to say

How important is it to you that you be considered good at computer security or privacy tasks? ◯ Not at all important ◯ Somewhat important ◯ Moderately important ◯ Very important ◯ Extremely important

What is your annual individual income? ◯ Less than $20,000 ◯ $20,000 to $49,999 ◯ $50,000 to $99,999 ◯ $100,000 to $250,000 ◯ Over $250,000 ◯ Prefer not to say

What is your annual household income? ◯ Less than $20,000 ◯ $20,000 to $49,999 ◯ $50,000 to $99,999 ◯ $100,000 to $250,000 ◯ Over $250,000 ◯ Prefer not to say

How comfortable did you feel while answering the questions in this survey? ◯ Very comfortable ◯ Comfortable ◯ Neutral ◯ Uncomfortable ◯ Very uncomfortable

Thank you so much for your participation in our study! Do you have any final comments or questions? _____

# Appendix B.
# Ambivalent Sexism Inventory (ASI)

Reproduced here from Glick & Fiske [14].

Below is a series of statements concerning men and women and their relationships in contemporary society. Please indicate the degree to which you agree or disagree with each statement.

Response options: ◯ Disagree strongly ◯ Disagree somewhat ◯ Disagree slightly ◯ Agree slightly ◯ Agree somewhat ◯ Agree strongly

1) No matter how accomplished he is, a man is not truly complete as a person unless he has the love of a woman.
2) Many women are actually seeking special favors, such as hiring policies that favor them over men, under the guise of asking for "equality."
3) In a disaster, women ought not necessarily to be rescued before men.
4) Most women interpret innocent remarks or acts as being sexist.
5) Women are too easily offended.
6) People are often truly happy in life without being romantically involved with a member of the other sex.
7) Feminists are not seeking for women to have more power than men.
8) Many women have a quality of purity that few men possess.
9) Women should be cherished and protected by men.
10) Most women fail to appreciate fully all that men do for them.
11) Women seek to gain power by getting control over men.
12) Every man ought to have a woman whom he adores.
13) Men are complete without women.
14) Women exaggerate problems they have at work.
15) Once a woman gets a man to commit to her, she usually tries to put him on a tight leash.
16) When women lose to men in a fair competition, they typically complain about being discriminated against.
17) A good woman should be set on a pedestal by her man.
18) There are actually very few women who get a kick out of teasing men by seeming sexually available and then refusing male advances.
19) Women, compared to men, tend to have a superior moral sensibility.
20) Men should be willing to sacrifice their own well being in order to provide financially for the women in their lives.
21) Feminists are making entirely reasonable demands of men.
22) Women, as compared to men, tend to have a more refined sense of culture and good taste.

Scoring instructions: Reverse the following items (1 = 6, 2 = 5, 3 = 4, 4 = 3, 5 = 2, 6 = 1): 3, 6, 7, 13, 18, 21. Hostile Sexism Score = average of the following items: 2, 4, 5, 7, 10, 11, 14, 15, 16, 18, 21. Benevolent Sexism Score = average of the following items: 1, 3, 6, 8, 9, 12, 13, 17, 19, 20, 22.

# Appendix C.
# Main Study Qualitative Codebook

The full codebook, with themes and subthemes, from qualitatively analyzing free-text stereotype rationales in the main study. Codes were not mutually exclusive.

**Other stereotypes**

- Separate stereotypes: a separate stereotype than the question (e.g., forgetful, lazy, taking shortcuts, protective)
- Stereotypes outside of security and privacy

**'Science"**: justified with science terms, e.g., "proven" "studies" "naturally" "wired"

**Observations**

- Self: something they do themselves
- Others: something they have observed others doing; incl. actions, habits, hobbies, traits, e.g., women shop more, men use online dating more; "in my experience" "noticed that" "women or men I know"

**Threat model**

- Assets: having (or not having) assets; e.g., "care", "concerned", "nothing to hide"; general valuations of SP, i.e., "want to protect info"
- Threats: recognition (or or not) of threats, e.g., prior experiences that inform what threats they are aware of; more "vulnerable" or "unsafe"
- External threats: external threat, e.g., scammers target this gender more

**Assumptions**

- About aptitude: assumptions about one gender's knowledge, experience, interest, or usage (or lack thereof), e.g., pay attention more, more capable ("better"); use the internet more, more interested in gaming or social media
- About background: assumptions made about one gender's education or career tendencies

**Society**: societal or cultural expectations, socialization, or conditioning; including how they want to be perceived

**"Just because"**: no meaningful reason given

TABLE 5: Results of multinomial logistic regression models belief in stereotypes by participants' ASIs. DV compares belief towards women and towards men with belief towards neither. (Int.) = Intercept. *Note:* * $p < .05$, ** $p < .01$, *** $p < .001$

| Stereotype | DV level | Term | *Estimate* | *Std. Err.* | *Statistic* | *p-value* |
|---|---|---|---|---|---|---|
| **Higher sexism scores correlated with beliefs towards women** | | | | | | |
| Be emotional | men | (Int.) | -2.20 | 0.80 | -2.69 | $(n.s.)$ |
| | men | ASI | 0.46 | 0.31 | 1.47 | $(n.s.)$ |
| | women | (Int.) | -1.96 | 0.56 | -3.50 | * |
| | women | ASI | 1.00 | 0.22 | 4.65 | *** |
| Be gullible | men | (Int.) | -4.02 | 1.01 | -3.99 | ** |
| | men | ASI | 0.76 | 0.32 | 2.37 | $(n.s.)$ |
| | women | (Int.) | -2.74 | 0.57 | -4.80 | *** |
| | women | ASI | 0.85 | 0.19 | 4.43 | *** |
| Be lazy | men | (Int.) | -1.18 | 0.53 | -2.21 | $(n.s.)$ |
| | men | ASI | 0.27 | 0.20 | 1.37 | $(n.s.)$ |
| | women | (Int.) | -4.84 | 0.92 | -5.29 | *** |
| | women | ASI | 1.32 | 0.27 | 4.85 | *** |
| Fall for shopping scam | men | (Int.) | -6.89 | 2.14 | -3.23 | * |
| | men | ASI | 1.45 | 0.60 | 2.42 | $(n.s.)$ |
| | women | (Int.) | -1.94 | 0.52 | -3.73 | ** |
| | women | ASI | 0.89 | 0.19 | 4.58 | *** |
| Ask for help if needed | men | (Int.) | -2.91 | 0.97 | -3.00 | $(n.s.)$ |
| | men | ASI | 0.44 | 0.35 | 1.26 | $(n.s.)$ |
| | women | (Int.) | -1.84 | 0.52 | -3.55 | * |
| | women | ASI | 0.80 | 0.19 | 4.25 | *** |
| Reuse passwords | men | (Int.) | -3.56 | 0.76 | -4.70 | *** |
| | men | ASI | 0.74 | 0.24 | 3.15 | $(n.s.)$ |
| | women | (Int.) | -4.07 | 0.85 | -4.82 | *** |
| | women | ASI | 0.86 | 0.26 | 3.36 | * |
| Leave device unlocked | men | (Int.) | -1.75 | 0.60 | -2.90 | $(n.s.)$ |
| | men | ASI | 0.28 | 0.22 | 1.29 | $(n.s.)$ |
| | women | (Int.) | -3.54 | 0.70 | -5.02 | *** |
| | women | ASI | 0.95 | 0.22 | 4.33 | *** |
| **Higher sexism scores correlated with beliefs towards men** | | | | | | |
| Know how to protect | men | (Int.) | -1.48 | 0.50 | -2.96 | $(n.s.)$ |
| | men | ASI | 0.71 | 0.18 | 3.83 | ** |
| | women | (Int.) | -8.82 | 2.67 | -3.30 | * |
| | women | ASI | 1.99 | 0.69 | 2.89 | $(n.s.)$ |
| Skilled at protecting | men | (Int.) | -1.63 | 0.50 | -3.29 | * |
| | men | ASI | 0.7 | 0.18 | 3.95 | ** |
| | women | (Int.) | -4.99 | 2.16 | -2.31 | $(n.s.)$ |
| | women | ASI | 0.57 | 0.71 | 0.80 | $(n.s.)$ |
| Be perceptive | men | (Int.) | -2.26 | 0.56 | -4.07 | ** |
| | men | ASI | 0.76 | 0.19 | 3.97 | ** |
| | women | (Int.) | -2.74 | 0.71 | -3.86 | ** |
| | women | ASI | 0.64 | 0.24 | 2.67 | $(n.s.)$ |
| Be logical | men | (Int.) | -3.46 | 0.62 | -5.55 | *** |
| | men | ASI | 1.26 | 0.22 | 5.75 | *** |
| | women | (Int.) | -3.56 | 0.92 | -3.86 | ** |
| | women | ASI | 0.75 | 0.32 | 2.30 | $(n.s.)$ |
| Verify HTTTPS | men | (Int.) | -2.12 | 0.52 | -4.05 | ** |
| | men | ASI | 0.70 | 0.18 | 3.94 | ** |
| | women | (Int.) | -3.81 | 1.14 | -3.36 | * |
| | women | ASI | 0.57 | 0.37 | 1.53 | $(n.s.)$ |
| Install software updates immediately | men | (Int.) | -2.42 | 0.55 | -4.43 | *** |
| | men | ASI | 0.78 | 0.18 | 4.27 | ** |
| | women | (Int.) | -2.55 | 1.01 | -2.52 | $(n.s.)$ |
| | women | ASI | 0.09 | 0.38 | 0.24 | $(n.s.)$ |
| Use 2FA | men | (Int.) | -2.07 | 0.54 | -3.82 | ** |
| | men | ASI | 0.62 | 0.18 | 3.41 | * |
| | women | (Int.) | -2.24 | 0.74 | -3.01 | $(n.s.)$ |
| | women | ASI | 0.29 | 0.26 | 1.11 | $(n.s.)$ |
| Use antivirus software | men | (Int.) | -3.85 | 0.68 | -5.64 | *** |
| | men | ASI | 1.10 | 0.22 | 5.11 | *** |
| | women | (Int.) | -3.36 | 0.93 | -3.63 | * |
| | women | ASI | 0.50 | 0.32 | 1.60 | $(n.s.)$ |
| **Beliefs not correlated with sexism scores** | | | | | | |
| Be overconfident | men | (Int.) | 0.27 | 0.54 | 0.50 | $(n.s.)$ |
| | men | ASI | 0.37 | 0.20 | 1.83 | $(n.s.)$ |
| | women | (Int.) | -4.86 | 1.52 | -3.19 | $(n.s.)$ |
| | women | ASI | 1.16 | 0.44 | 2.63 | $(n.s.)$ |
| Interested in learning about protecting | men | (Int.) | -1.07 | 0.50 | -2.12 | $(n.s.)$ |
| | men | ASI | 0.29 | 0.17 | 1.72 | $(n.s.)$ |
| | women | (Int.) | -0.88 | 0.73 | -1.20 | $(n.s.)$ |
| | women | ASI | -0.28 | 0.28 | -1.00 | $(n.s.)$ |
| Share sensitive info on social media | men | (Int.) | -3.8 | 1.35 | -2.82 | $(n.s.)$ |
| | men | ASI | 0.74 | 0.39 | 1.91 | $(n.s.)$ |
| | women | (Int.) | 0.94 | 0.51 | 1.82 | $(n.s.)$ |
| | women | ASI | 0.00 | 0.18 | -0.01 | $(n.s.)$ |
| Fall for dating scam | men | (Int.) | -0.45 | 0.55 | -0.81 | $(n.s.)$ |
| | men | ASI | 0.17 | 0.19 | 0.87 | $(n.s.)$ |
| | women | (Int.) | -0.80 | 0.56 | -1.43 | $(n.s.)$ |
| | women | ASI | 0.30 | 0.19 | 1.56 | $(n.s.)$ |