Are We Ready for Sex Robots?

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***Abstract*—Sex robots are gaining a remarkable amount of attention in current discussions about technology and the future of human relationships. To help understand what kinds of relationships people will have with these robots, empirical data about people's views of sex robots is needed. We report the results of the first systematic survey that asks about the appropriateness and value of sex robots, acceptable forms they can take, and the degree to which using them counts as sex. The results show a consistent difference in the uses for which women and men found sex robots to be appropriate, with women less and men more inclined to consider them socially useful. We also found convergences on what sex robots are like and how sex with them is to be classified, suggesting that larger views about relationships and society, not just understandings of sex robots themselves, should be a matter for more research and thus frame future work on the ethics of sex robots.**

***Index Terms*—sex robots, social robots**

I. Introduction and Motivation

Sexuality, as a human need and a force by which our social fabric coheres and unravels, merits careful attention within a changing technological landscape. In the case of human-robot interaction, the emerging role of sex robots has piqued public interest and sparked discussions around robotic design, societal norms, and the status of human-robot sex vis-á-vis human relationships. Thinking through this role of sex robots does not entail sounding the alarm on a future threat, but really means recognizing "what their development shows about the society we already have" [1], i.e., our society today. A present-day portrait of society already features robots interacting with humans in a growing number of contexts, testing various conditions of intimacy and personal connection. For example, the symbolic and bodily aspects of sex may develop into the type of intense bonding responses that have led to funerals for robotic IED detectors on the battlefield [3]. However, bonds developing from human interactions with robots are not mutual and symmetrical, as can be the case with human interactions. Rather, they are unidirectional and thus asymmetrical, leaving the human with the desire and longing for an other who might be entirely oblivious to the connection. These bonds could inhabit everyday spaces in even more fraught ways than Roomba vacuums, which themselves have elicited sympathy and gifts [16]. Sex robots like *Roxxxy* (made by True Companion) are coming onto market with increasing frequency, eliciting additional alarms and appraisals of what sex robots could mean for the shape of human intimacy and social behavior. Given that the artificial intelligence requirements of sex robots could arguably be much lower than for other social robots (e.g., those working in healthcare or education), the pace of dissemination of these robots will only accelerate. And so will public attention and deliberation about their use, likely yielding heightened concerns about the impacts, foreseen and unforeseen, of sex robots on people's interactions with one another.

Unlike other spheres of social robotics like healthcare, developments around sexual behavior have proceeded without sufficient input from the HRI community. To be sure, Levy [11] has offered a pivotal summary of many issues raised by sex robots, and the intervening years have borne out his argument that love, sex, and intimacy will be imagined, sought, and designed to be offered by automated systems. Sullins [18] has surveyed the ethical terrain of principles by which sex robots might be designed and evaluated. Whitby [25] and Coeckelbergh [4] have looked at what a "robot lover" might be and the dynamic of "mirroring" by which they could elicit bonding from a human partner. As the market for sex robots has so far been tilted toward heterosexual males, critical analysis of gender of robots by Robertson [14] and Weber [22] have offered acute social insight into, to repeat, "the society we already have."

Nonetheless, recent mainstream commentaries and summaries have not engaged these insights closely. Banning certain technologies garners outsized attention, even when, as with Richardson's recent call for a campaign against sex robots, a ban is not actually advocated [13]. Instead of devolving into a staking of pro vs. anti positions on an entire context for robots, however, these important and urgent discussions desperately need empirical and conceptual HRI studies to grasp the complexity of what stakes society might have in sex robots, and by extension what their use should be.

Lacking in both journalistic treatments and HRI scholarship is a *methodical survey of what people think about robots and sex*. Casual inquiries, striking anecdotes, or vivid examples of sex robots often shape the news coverage of the issues at hand [9]. Even rather robust treatments of societal benefits or harms that might come with human-robot sexual interaction have been more suggestive futurology than empirical reports (e.g., predictions that only robot prostitutes would work in Amsterdam's red-light district in 2050 [26]). Facilitating ethical discussions about sex robots within a welter of technological change and new forms of automated systems is hardly possible without empirical grounding, especially when it comes to how people react to and conceive of the use of these robots. As both a scholarly collaboration and a means to enter into discussions

that need HRI's continuing contributions, we take the HRI conference to be a crucial, indeed central venue for introducing empirical data, sharing significant patterns that have emerged thus far, and suggesting future avenues for both HRI research and public discourse about how sex robots relate to human interests and needs.

In this paper, we present results from the first exploratory survey study of public opinions on the basic capabilities of sex robots, how to classify sexual interaction with a robot, and what reasons or circumstances would make their use appropriate. We begin with a brief overview of how sex robots have garnered increasing public attention and debate, while pointing out connections to HRI research that could inform these deliberations. Noting the need for more data about how people think about sex robots, we report results from a broad Amazon Mechanical Turk survey about sex robots and their use. Finding some consistent differences between male and female responses around the appropriateness of sex robots, we conclude that attitudes toward using sex robots have less to do with *what a sex robot is*, or *how sex with a robot is categorized*, than they do with *different takes on the conditions and purposes of both personal relationships and society's interests*. On that basis, we submit that HRI must continue to direct public and scholarly considerations of sex robots far beyond the questions of design or technological innovation, with further fine-grained looks into how gender, culture, and economy inform the lives those robots would touch.

The scholarly treatment of sex robots in HRI has yielded forward-looking insights, arguing for a wider horizon of possible intimate relationships and classifying them in ethical terms toward the end of informing design. Levy [11] remains the most thorough exploration to date of how human-robot interaction could aim toward forms of sexuality, intimate companionship, and even love, and it extrapolates from current sexual practices and devices to more advanced robots that meet several criteria for human bonds. Bendel [2] recently has placed sex robots squarely within the horizon of medical ethics, situating them alongside surgical, nursing, and domestic roles. Whitby [25] considers the real possibilities of the robot as "lover" and what means the robot would have to facilitate ideal connection. Coeckelbergh [4] similarly foresees the efficacy of the "vulnerability mirroring" by which a robot might elicit bonding with a partner.

Yet to be integrated fully in these discussions are the many theoretical approaches to sexuality, aimed at sorting out how sexual behavior is learned, modeled, and explained [23]. This admittedly renders efforts to explain the sexual aspects of human-robot interaction even more inchoate and exploratory. More recent work at the intersection of sex and social ethics (e.g., Nussbaum's discussion of sex, sex work, and dignity [12]) shows how challenging it will be to determine what sex robots mean for society and how they should function therein.

Nonetheless, this general direction of considerations can usefully draw upon empirical work in HRI. Kahn et al. [10] explore "emotional intimacy" via children's interaction with *Robovie*. Young et al. [27] include a sex robot in their tests of acceptability in domestic robots, drawing on some common qualities that could sustain human attention and concern. When it comes to where robotic designs might be headed as they try to meet more and more demanding standards of bonding, sexual and otherwise, scholars like Robertson [14] and Weber [22] both point out pitfalls of gender roles and prioritizing of male desire.

So far, however, such scholarly contributions are not adequately circulating through rapidly developing discussions around the newest sex robots introduced to market, stark predictions about the future of robot sex [8], and provocative public debates about technology and the changing qualities of human communication and social relationships. Products like *Roxxxy* (and male counterpart *Rocky*) have sought to transcend the sex-doll level of interaction, instead of having robot companionship solely conjured through science fiction (*A.I.*, more recently *Ex Machina*) or literature (Margaret Atwood's "The Heart Goes Last"). Richardson's paper [13] on the "asymmetrical relationship" between humans and robots mirroring and exacerbating the abusive dynamic of prostitution, which offers a *manifesto* of sorts against their further development, has done better at capturing the media's attention. On the broader question of personal relationships in the age of the smartphone, Turkle's new book has garnered serious consideration for its many relevant observations about where communication and intimacy may be undergoing dramatic refiguring through computer interface [20]. With increased media scrutiny have come counter-arguments and pushback against a restrictively negative take on sex robots, not to mention smartphones. Devlin raises the possibility of "new approaches to artificial sexuality" that open up insights in "inclusivity, legal theory, and social change" [6]. On this view, sex work, not to mention expectations around sexuality in general, are too varied to warrant banning or even strict limitation of sex robots – sex robots need not be "coming for our relationships" [1].

What persists throughout these discussions, and what calls even more pressingly for the HRI community's presence therein, is that we do not know enough about what the broader public's opinions and reactions to the idea of sex robots — moral, social, and personal — say about what sex robots are, what they could be, and what they should do. It is not surprising that HRI has not found ways to test sexually inflected (and inherently fraught) human-robot interactions in a lab setting (aside from the challenges involved in recruiting a representative subject population, and the highly charged nature of such interaction, the dearth of appropriately representative sex robots makes such investigations premature). But there are not the same obstacles to surveying what people generally think about sex robots in terms of use, value, or overall status as partner. Questions must be focused, deliberate, and sensitive, of course, rather than provoking subjects with salacious or triggering material. But within those parameters there remains a great deal to learn. It is time to paint a fuller picture of where people's intuitions lie, along different axes of evaluation (single individual vs. partnership or relationship, personal effects vs. large-scale social dynamics, judging by

effects vs. fundamental dignity or norms about sex and relationships). These can feed into the way larger social and ethical discussions frame the relevant issues, so that the complex textures of human relationships can have a voice in the way sex robots are forecast, warned against, or advocated.

The survey for this paper is the first to probe people's intuitions about what qualities people imagine a sex robot to possess, as well as appropriate uses, social functions, and physical forms for sex robots. Our questions specifically tackle 1) what person-like qualities subjects associate with sex robots, 2) what kinds of uses (both individual and social) would make the role of a sex robot appropriate or inappropriate, 3) what form a sex robot would permissibly take, and 4) what "sex" with a sex robot really constitutes compared to sex with another person. Although we also included participant age in our analyses, we looked with particular comparative interest at male and female responses. In light of the many social and historical complexities of gender that have permeated the issue of sex and robotics, this proved a fitting start for introducing empirical results into scholarly consideration. From this initial study we call for future HRI investigations into the many cultural and demographic aspects of views about sex robots, the better to discern what social roles, if any, such robots should play going forward.

II. Methods

To investigate the above questions about sex robots, we developed an online questionnaire that could probe people's attitudes and intuitions about sex robots as well as their intuitions about what appropriate forms and uses of sex robots might be. While survey questions may be theoretical, at this point a questionnaire promises a more open space for subject reflection than highly charged lab interactions (or even in-person interviews) would on this topic. In terms of the type of survey employed, we decided to use Amazon Mechanical Turk (AMT) for two reasons: (1) we did not feel that the standard college student population would be either appropriate or representative for the study, and (2) we aimed at reaching a larger demographic; for both aspects AMT studies have been demonstrated to be appropriate (e.g., [5]).

Materials: The survey consisted of four parts. Part 1 consisted of 16 background questions about possible capabilities of sex robots to get a sense of what people thought sex robots are capable of. Part 2 consisted of 15 questions on what subjects took to be appropriate uses of sex robots. Part 3 consisted of 10 questions on what subjects took to be allowable physical forms for sex robots. Part 4 consisted of three questions about what subjects thought it would be like to have sex with a sex robot. And part 5 consisted of three questions about the effect the survey had on subjects with respect to their views on sex robots and their interest in using them. We specifically refrained from including images of sex robots, just as we did a definition of "sex", in order to avoid unduly narrowing or biasing how subjects could personally relate to the questions. The purpose of relative vagueness was to allow highly personal associations (e.g., what one thought a sexual relationship looked like, what one's own sex life was like, what goods it served, etc.) to find application toward the questions.

Participants: We recruited 103 US subjects from AMT; 3 were eliminated due to incomplete data, leaving 57 males and 43 females.[1] Their overall mean age was 33.42 years, with male mean age being 33.07 and female mean age being 33.88. The minimum age was 20, the maximum age 61 years. None of the participants had participated in the study before.

Procedure: Participants were informed that the purpose of the study was to investigate their views about sex robots and they were warned that they might find some questions emotionally disturbing. Upon informed consent and completion of a basic demographic questionnaire about their age and gender, participants were shown the above described five parts in order, with questions within each part randomly arranged to avoid order effects, one question at a time.

Attribute	%Agree	%Males	%Females
Can hear	38	32	47
Can see	36	25	36
Can recognize objects	44	46	42
Can understand language	49	44	56
Can talk	53	51	51
Can remember past interactions	37	39	35
Can be instructed	78	72	86
Can learn new behaviors	49	46	53
Moves by itself	79	79	79
Adapts to human behavior	53	51	56
Recognizes human emotions	20	19	21
Specifically designed to satisfy human sexual desire	86	86	86
Can take initiative	27	26	28
Has feelings	11	11	12
Responds to touch	64	68	58
Obeys order	69	65	74

TABLE I
BACKGROUND QUESTIONS ABOUT THE SUBJECTS' VIEWS ON WHAT SEX ROBOTS ARE CAPABLE OF AND PERCENTAGES OF SUBJECTS WHO AGREED WITH THE CAPABILITIES.

III. Results

In the following, we use *gender* and *age* as the main independent variables and where appropriate, we will consider two age groups split by the mean age of the participants: "younger than 34" as well as "34 and over", roughly corresponding to "Millennials" and "Generation X and Baby Boomers".

A. Expected capabilities of sex robots

No significant gender or age differences were found on any of the background questions about subjects' views of the sex robot capabilities (see Table I).

[1]Based on the differences in means and standard deviations between males and females in a pilot study with 50 subjects and an expected larger male than female subject pool by about 20%, we performed a power analysis on the anticipated mean differences of around 1 with standard deviations of around 1.8 and determined that for a power level of 80% given α of .05 roughly 100 subjects would be sufficient.

QN	Question	Mean$_T$	Std$_T$	Mean$_M$	Std$_M$	Mean$_F$	Std$_F$
U1	**...instead of cheating on a partner?**	4.97	2.06	5.42	1.61	4.37	2.43
U2	**...instead of prostitutes?**	6.01	1.70	6.40	1.19	5.49	2.12
U3	**...for sex education?**	5.50	1.91	5.98	1.58	4.86	2.13
U4	**...for disabled people?**	5.95	1.78	6.46	1.12	5.28	2.24
U5	**...for sex offenders?**	4.38	2.25	4.88	1.96	3.72	2.45
U6	**...to improve hormone levels of people with infrequent sex lives?**	5.46	1.90	5.84	1.54	4.95	2.21
U7	**...to improve self-esteem and and overall psychological health?**	5.37	1.90	5.89	1.57	4.67	2.10
U8	**...for group sex such as mixed human-robot group sex?**	5.16	2.02	5.79	1.50	4.33	2.32
U9	**...for pornographic movies?**	5.53	1.95	5.96	1.50	4.95	2.31
U10	**...to engage in unusual sex practice such as rough sex or sadistic behavior?**	5.23	1.96	5.70	1.61	4.60	2.22
U11	*...to maintain a relationship?*	4.51	1.98	4.80	1.74	4.11	2.23
U12	...to demonstrate forms of sexual harassment for training and prevention?	5.65	1.71	5.84	1.50	5.40	1.94
U13	*...in isolated environments?*	5.59	1.83	5.86	1.57	5.23	2.07
U14	*...to practice abstinence?*	4.30	2.07	4.61	1.90	3.88	2.23
U15	**...to reduce the risk of sexually transmitted diseases?**	5.73	1.90	6.14	1.48	5.19	2.24

TABLE II

QUESTIONS AND RATING RESULTS (MEANS AND STANDARD DEVIATIONS) FOR APPROPRIATE USES OF SEX ROBOTS (THE SUBSCRIPTS T, M, AND F IN "MEAN" AND "STD" REFER TO "ALL SUBJECTS", "MALES", AND "FEMALES", RESPECTIVELY). ALL QUESTIONS START WITH "WOULD IT BE APPROPRIATE TO USE SEX ROBOTS ...". ALL ANSWERS ARE ON A 7-POINT LIKERT SCALE WITH "1 = COMPLETELY INAPPROPRIATE" AND "7 = COMPLETELY APPROPRIATE". GENDER DIFFERENCES ARE SIGNIFICANT FOR BOLD-FACED QUESTIONS, MARGINALLY SIGNIFICANT FOR ITALICIZED QUESTIONS, AND NON-SIGNIFICANT FOR QUESTION U12.

B. Appropriate uses of sex robots

Table II shows the questions and overall rating results on questions pertaining to appropriate uses of sex robots on a 7-point Likert scale with "1 = completely inappropriate" and "7 = completely appropriate". As can been from the table, overall all uses are rated more or less strongly as appropriate, from the lowest being sex robots used for practicing abstinence to the highest of using sex robots instead of prostitutes. However, almost all answers show distinct gender differences where men and women differ on their appropriateness ratings, with men overall finding uses more appropriate than women (in some cases, such as U5 and U14, women find the use even slightly inappropriate while men still find them appropriate).

In the following we will report the detailed results from ANOVA analyses with subject gender and subject age as independent and the above questions as dependent variables that showed significant main effects for gender or age (none of the analyses showed any significant interactions).

For question U1 we find that men agree more ($M = 5.42, SD = 1.61$) than women ($M = 4.37, SD = 2.43$) that sex robots could be appropriately used instead of cheating on their partner ($F(1, 96) = 6.60, p = .01$).

For question U2, we find that men view it completely appropriate ($M = 6.4, SD = 1.19$) and so do women, but less so ($M = 5.49, SD = 2.12$), to use sex robots instead of prostitutes ($F(1, 96) = 7.94, p = .006$). For this question we also find a somewhat surprising age effect, namely that Millennials seem to find it less appropriate ($M = 5.67, DS = 1.93$) than older generations ($M = 6.59, SD = 1.04$) to use sex robots instead of prostitutes ($F(1, 96) = 7.20, p = .006$); we will briefly return to this point in the Discussion section.

For question U3, we observe that men find it more appropriate ($M = 5.98, SD = 1.58$) than women ($M = 4.86, SD = 2.13$) to use sex robots for sex education ($F(1, 96) = 9.14, p = .003$), e.g., in movies.

For question U4, we determined that men find it completely appropriate ($M = 6.46, SD = 1.12$) more so than women ($M = 5.28, SD = 2.24$) to use sex robots for disabled people who cannot easily have sex ($F(1, 96) = 11.69, p < .001$).

For question U5, we see that men find using sex robots for sex offenders to satisfy their drives more appropriate ($M = 4.88, SD = 1.96$) than women ($M = 3.72, SD = 2.45$) who are borderline on this issue ($F(1, 96) = 6.75, p = .01$).

For question U6, we observe that men find it more appropriate ($M = 5.84, SD = 1.54$) than woman ($M = 4.95, SD = 2.21$) to use sex robots to improve hormone levels of people with infrequent sex lives ($F(1, 96) = 5.51, p = .02$).

For question U7, we get that men find it more appropriate ($M = 5.89, SD = 1.57$) than women ($M = 4.67, SD = 2.1$) to use sex robots for improving self-esteem and overall psychological health ($F(1, 96) = 10.87, p = .001$).

For question U8, we see that men find sex robots more appropriate ($M = 5.79, SD = 1.5$) than women ($M = 4.33, SD = 2.32$) for group sex such as mixed human-robot group sex ($F(1, 96) = 14.81, p < .001$).

For question U9, we discover that men ($M = 5.96, SD = 1.5$) compared to women ($M = 4.95, SD = 2.31$) find sex robots more appropriate for movies such as porn movies ($F(1, 96) = 6.99, p < .01$).

For question U10, we find that men ($M = 5.7, SD = 1.61$) compared to women ($M = 4.6, SD = 2.22$) find it more appropriate for for sex robots to engage in unusual sex practices such as rough sex or sadistic behavior ($F(1, 96) = 6.99, p = .005$).

For question U11, whether it would be appropriate to use sex robots to maintain a relationship (e.g., when partners have different preferences about the type of sex) we only obtain a marginally significant gender effect ($F(1, 96) = 2.97, p = .087$), with men finding it slightly more appropriate ($M = 4.80, SD = 1.74$) than women ($M = 4.11, SD = 2.23$).

For question U12, whether it would be appropriate to use

sex robots to demonstrate forms of sexual harassment for training and prevention we find no significant difference. Note that this is the only question without any differences between males and females.

For question U13, whether it would be appropriate to use sex robots in isolated environments such as space missions, arctic research station, etc. we find again a marginally significant gender effect ($F(1, 96) = 2.97, p = .09$), with men finding it slightly more appropriate ($M = 5.86, SD = 1.57$) than women ($M = 5.23, SD = 2.07$).

For question U14, whether sex robots can be appropriately used for abstinence, we also find a marginally significant gender effect ($F(1, 96) = 3.07, p = .08$), with men finding it slightly more appropriate ($M = 4.61, SD = 1.90$) than women ($M = 3.88, SD = 2.23$) who are on the fence.

For question U15, we get that men ($M = 6.14, SD = 1.48$) more so than women ($M = 5.19, SD = 2.24$) find sex robots appropriate for reducing risk of sexually transmitted diseases ($F(1, 96) = 6.57, p = .01$).

Overall, men find sex robots more appropriate than women in all examined categories and the differences are significant or marginally significant in all but one (question U12).

C. Appropriate forms of sex robots

Table III summarizes the overall rating results on questions pertaining to appropriate physical forms of sex robots. As can been seen from the table, most forms are rated as appropriate except for child-like forms which subjects find very inappropriate, family members which subjects find inappropriate, as well as animal forms which subjects find slightly inappropriate. As with the appropriate uses for sex robots, almost all answers about appropriate physical forms show distinct gender differences. We again performed ANOVA analyses with subject gender and subject age as independent and the above questions as dependent variables to investigate these effects.

For question F1, we find that men strongly agree ($M = 6.47, SD = 1.14$) and women less so ($M = 5.19, SD = 2.24$) that sex robots should be allowed to have an adult form ($F(1, 96) = 14.12, p < .001$).

For question F2, there is no significant difference between men and women in their strong rejection of child-like forms for sex robots ($F(1, 96) = 1.10, p = .30$). Note that this is the only question about robot forms where male and female answers show no significant difference.

For question F3, we find that men are slightly against animal forms of sex robots ($M = 3.7, SD = 2.13$), while women ($M = 2.6, SD = 2.08$) are strongly against animal forms ($F(1, 96) = 6.58, p = .01$).

For question F4, we find that men are more in favor ($M = 5.6, SD = 1.56$) than women ($M = 4.42, SD = 2.39$) of allowing sex robots in the form of fantasy figures that do not resemble any known human or animal form ($F(1, 96) = 8.98, p = .003$).

For question F5, men are more in favor ($M = 5.42, SD = 1.18$) compared to women ($M = 4.23, S = 2.36$) of allowing shapes different from any recognizable life form ($F(1, 96) = 8.22, p = .005$).

For question F6, men are less strongly against ($M = 3.32, SD = 2.2$), compared to women ($M = 2.16, SD = 1.8$), allowing sex robots in the form of family members ($F(1, 96) = 7.71, p = .007$).

For question F7, men are in favor ($M = 5.51, SD = 1.61$), while women are on the fence ($M = 3.98, SD = 2.24$), on whether celebrity forms should be allowed for sex robots ($F(1, 96) = 17.01, p < .0001$).

For question F8, men are in favor ($M = 5.04, SD = 1.85$), while women are slightly against ($M = 3.7, SD = 2.4$), allowing sex robots in the form of a deceased spouse ($F(1, 96) = 7.71, p = .002$).

For question F9, men are more in favor ($M = 5.25, SD = 1.87$) while women are on the fence ($M = 4.02, SD = 2.24$), of allowing sex robots that look like one's partner ($F(1, 96) = 8.63, p = .004$).

For question F10, we find a very strong main difference in views with men being in favor of ($M = 5.09, SD = 1.84$), while women being against ($M = 3.19, SD = 2.16$), allowing sex robots in the form of friends ($F(1, 96) = 22.15, p < .0001$).

D. What is it like to have sex with a sex robot?

We also asked subjects three questions about what it is like to have sex with a sex robot: (1) "Would having sex with a robot cause you to lose your virginity?" (40 no and 17 yes for males, 30 no and 13 yes for females, with no significant differences in proportions between males and females); (2) "Is having intercourse with a robot more like masturbation or more like sex?" ($M = 3.16, SD = 1.87$) and (3) "Is having intercourse with a robot more like using a vibrator or more like having sex with a human?" ($M = 3.06, SD = 1.78$). Similar to question 1, we do not find any significant difference between men and women for questions 2 and 3 either ($F(1, 96) = 0.93, p = .34$ and $F(1, 96) = 0.39, p = .53$, respectively), with lower ratings indicating vibrator use or masturbation and higher ratings indicating sex with a human. Overall subjects view sex with a sex robot as somewhat more like masturbation or using a vibrator than having sex with a human.

E. What subjects think of sex robots as a result of having completed the survey

In the last set of questions, we asked subjects (1) whether this survey changed any of their views about sex robots, (2) whether they, as a result of the survey, might be more open to the idea of having sex robots, and (3) whether they would use a sex robot. We found no difference with respect to question 1 with most men and women denying that the survey changed their views (50 vs. 7 men, 34 vs. 9 women).

For the second question, we found a marginal effect with men being more open to the idea of having sex robots (36 men in favor vs. 21 against) as a result of filling out the survey, while women being more against it (19 women in favor vs. 24 against) using Fisher's exact test for count data ($p = .07$).

QN	Question	Mean$_T$	Std$_T$	Mean$_M$	Std$_M$	Mean$_F$	Std$_F$
F1	**an adult human**	5.92	1.81	6.47	1.14	5.19	2.24
F2	a human child	1.89	1.58	2.04	1.60	1.70	1.54
F3	**an animal**	3.23	2.17	3.70	2.13	2.60	2.08
F4	**a fantasy creature**	5.09	2.04	5.60	1.56	4.42	2.39
F5	**any recognizable life form**	4.91	2.14	5.42	1.18	4.23	2.36
F6	**one's family member**	2.82	2.11	3.32	2.20	2.16	1.80
F7	**a celebrity**	4.89	2.06	5.51	1.61	3.98	2.24
F8	**one's deceased spouse**	4.46	2.19	5.04	1.85	3.70	2.40
F9	**one's current partner**	4.72	2.12	5.25	1.87	4.02	2.24
F10	**one's friend**	4.27	2.19	5.09	1.84	3.19	2.16

TABLE III

QUESTIONS AND RATING RESULTS (MEANS AND STANDARD DEVIATIONS) FOR APPROPRIATE PHYSICAL FORMS OF SEX ROBOTS (THE SUBSCRIPTS T, M, AND F IN "MEAN" AND "STD" REFER TO "ALL SUBJECTS", "MALES", AND "FEMALES", RESPECTIVELY). ALL QUESTIONS ARE OF THE FORM "SHOULD A ROBOT WITH THE FORM OF $\langle form \rangle$ BE ALLOWED?" WHERE ON OF THE ABOVE FORMS IS SUBSTITUTED FOR $\langle form \rangle$. ALL ANSWERS ARE ON A 7-POINT LIKERT SCALE WITH "1 = COMPLETELY INAPPROPRIATE" AND "7 =COMPLETELY APPROPRIATE". GENDER DIFFERENCES ARE SIGNIFICANT FOR BOLD-FACED QUESTIONS AND NON-SIGNIFICANT FOR QUESTION F2.

Finally, we found a strong gender difference between men and women regarding whether they would use a sex robot: more than two thirds of all men are in favor (40 men in favor vs. 17 against) while almost two thirds of all women ae against (16 women in favor vs. 27 against), again using Fisher's exact test for count data ($p = .001$).

IV. DISCUSSION

It is somewhat surprising that we only found one significant age effect in this study (although we also obtained several marginal effects that we did not specifically report). For it would be natural to assume that the younger generation's acquaintance with and openness to technology should also manifest itself in different attitudes towards sex robots. The particular result about Millennials finding it less appropriate than older generations to use sex robots instead of prostitutes points to the need for a more thorough follow-up investigation focued on age effects to tease out potential differences in attitudes and expectations among the different generations.

In terms of methodology, our survey's results show the importance of soliciting people's opinions on sex robots, most demonstratively through findings related to how women and men responded. Responses from both sexes evidenced a generally shared understanding about what sex robots were, as well as agreement about how sex with a robot should be classified (i.e., more like masturbation not sex between people), but a striking discrepancy in what conclusions were drawn about the appropriateness of sex robots in society. Those differences were much greater than slight differences about what abilities the sex robot would have, for example, whether the sex robot would respond to touch (with women less willing to grant such an ability). Women consistently rated each respective use and possible robotic form as less appropriate than men did, and were much less likely to see using a sex robot in the future. Whether framed more individually (one's own sex life) or socially (substitution for prostitution, prevention of sexually transmitted diseases), men clearly were more open to sex robots as appropriate and to using them in the future. It does not seem to be the case, then, that men and women differ because they think (or fantasize) of robots as having markedly different natures, or that sex with a robot is thought of as personal sex by one and just masturbation by the other. The difference has to be located elsewhere, a point that clearly calls for further research.

One possible approach to explaining that general difference may lie in the few areas of "appropriate use" where women and men came close to converging in opinion. There was rough agreement that the use of sex robots was relatively permissible 1) to maintain a relationship between people, 2) to assist training for the sake of preventing sexual harassment, and 3) for use in places extremely isolated from the rest of society (e.g., outer space, research station). One could describe the first two conditions of use as involving the maintenance and protection of personal relationships, and the third being a context where personal relationships are not available to be threatened. This could suggest how particular outlooks and values about personal relationships may be lenses through which the environment of sex robots is framed, with the result that shared conceptions of sex robots may still lead to different judgments about their proper roles.

When one considers the capabilities that both men and women attribute to a sex robot, the forms they find impermissible, and their sense of what sex with a robot constitutes, it becomes clearer that the sex robot as an isolated object of consideration does not capture their divergence of opinion. One might hypothesize that different judgments about appropriateness stem from market and media forces that privilege heterosexual males as customer and user, which could lend a backdrop to how sex robots are imagined and anticipated (e.g., with the male as "active" and the robot as more submissive – part of Richardson's concern over asymmetrical, objectifying relationships). There may be a greater recognition on the part of those whose sexuality is societally rendered "pornographic" to recognize a dysfunctional dynamic repeated with robots [21]. If more scenarios and purposes for sex robots were cast relationally than those described here (i.e., uses that promised mutual benefits for those in a relationship, or a community), then their appropriateness and prospective use might be rated differently. What this survey suggests, however, is that no simple "view" about sex with robots or the essence of sex robots accounts for why women find robots less appropriate generally speaking. Women and men largely share attributions

of what agent-like qualities they take it a sex robot would have (in responses to the capabilities questions), with both projecting social capabilities beyond current sex dolls or other well-publicized devices. Moreover, when it comes to what sex with a robot resembles, there is a shared sense that it is more like masturbation than sex with a human as well as more like using a vibrator than sex with a human. Examples of "pygmalionism," doll relationships, and hopes for "Gynoids" notwithstanding (e.g., in the documentary "Guys and Dolls" [17]), the survey suggests men are not attributing comparatively heightened personhood or more consummate intimacy to a sexual robotic interaction. The differences in judgment about appropriateness would rather seem to lie in a larger context of social outlook and values.

One research imperative for treating those contexts through HRI will be to draw upon theories of sexuality and sexual ethics as they have developed over the past several decades of scholarship. A theme strongly tied to matters of HRI will be how sex satisfies desire [15], particularly reciprocation and pleasing another versus simply one's own physical satisfaction. Though increasingly sophisticated conversation algorithms may reproduce dialogue and even statements of desire, robots still only offer a unidirectional bond [16] in terms of vulnerability and genuine desire. Given that the objectified nature of the robot does not, strictly speaking, represent the basic difference in male and female responses, there may be more to investigate around reciprocity and patiency (including the ability to be pleased) by way of explaining the survey's results [24]. On a more explicitly ethical level, the relationship between sex and dignity – and how "love" may refer to their relation [18] – could also be a key complement to understanding the implications for sex robots. General agreement that a sex robot is an object does not dictate whether sexual interaction with it is a loss of dignity (and whose dignity is lost, in a relationship context), nor why a shared sense of an objectionable robot form may exist alongside deep disparity in what uses of sex robots are thought valid. Tying these themes together, this survey offers an initial empirical push to examine conceptions of intimacy to explain more fully what could shape reactions to sex in the HRI context.

Concerning appropriate physical forms for sex robots, we found small, but notable differences that are not generally as sharp as those around use. Child forms are opposed strongly by both, yet the form of a friend is much more acceptable to men than women. Women also are more on the fence about family members, including a deceased spouse, being an acceptable form, whereas men responded with more acceptance to both. Again, these might suggest not a difference in what the sexual act with a robot itself resembles so much as what it means when set against other relationships (families, friends). As the market for sex robot develops going forward, of course, there may be alternative forms that alter what is imagined as acceptable (especially for those excluded from a dominant, usually male "sexbot script" [19]).

Further research should certainly help tease out what conditions and contexts seem to inform such relational framing for sex with robots, and on what terms (other forms of isolation, for instance) they might avoid adverse impact on human relationships or society at large. This includes determining in a more fine-grained manner what reasons and dynamics are at work in men being more willing to try sex robots as women are less so. No doubt part of this task will be enhanced by exploring complexities of gender identity and expression. Testing these questions across larger cultural complexes and demographics will provide more insight into what kinds of lifeworlds sex robots will continue to enter.

Our results not only suggest ways where relationships are assumed or imagined in connection with sex robots, but they also indicate the need to spell out what social goods are being sought by their use. Focusing on individual satisfaction (even under conditions of a physical disability) or the social concern for avoidance of sexually transmitted diseases may not be sufficient to dispel a sense of norm violation or social harm. So, too, these results suggest that the function of a sex robot, whether in terms of performance, satisfaction of desire, or even the redirection of otherwise abusive or anti-social humans, may well not make some specific forms of robots more permissible. While some have argued that sex robots could keep sexual predators from preying on humans, clearly not every form or appearance of a robot seems to be acceptable for doing so (most saliently, a child form for pedophiles). Broader discussions of sex and robotics will have to recognize that there is ethics in the aesthetics, so to speak, and draw out the embedded norms and moral impulses that the robot's body and operation as a whole present.

Finally, we would also like to recognize an experiential limitation to the survey's format, in that actual sexual interaction with a robot could alter subjects' opinions of what uses or qualities sex robots do and should have.

V. Conclusions and Future Work

The task of HRI research and robotic design is not just to ask where things stand now but also, from the vantage point of those results, to imagine where they could be as robots are increasingly brought to market and introduced to wider society. This study is one step directed toward a much longer journey of research and discussion into where sex and robotics should best meet human needs, expectations, and interests. Without developing and refining more of this kind of empirical outreach, anecdotes and attention-grabbing products will disproportionately guide ethical debates about HRI and the direction of robotic design and use.

Looking back at the developments in HRI since Levy's initial foray into the subject [11], it is certainly time for systematic surveys like the one presented in this paper to be pursued and extended. The results gathered break some initial empirical ground for integrating the data of people's views into how the stakes of sex and robotics within society might best be understood and advocated. Issues of gender and objectification that have arisen with forms connected to robotics and sexuality (movies like *Ex Machina*, video

games, online abuse) intersect with some interesting empirical material gleaned in this survey: a broad gender divide seems to run through the judgment of what uses of sex robot would be appropriate. But the results also show some areas of common expectation and understanding between women and men, such that the ethics of sex robots does not seem to rest on conflicted ideas about what a sex robot is or what sex itself with such a robot resembles. Consequently, discussions in "Moral HRI" should take care not to construct dilemmas and challenges of sex robots that too narrowly focus on one-on-one sexual interaction, to the exclusion of important disagreements about the larger environments in which that interaction takes place.

Will design be able to change some of the ideas and opinions reflected in these results, or will these conceptions determine the fate of proceeding without further ado to actuate sexual performance in a relatively autonomous system? What kind of sex, with what activity or initiation on the part of the robot, is being assumed? What other kinds might be desired and sought from the market, and how should robotics designers respond to that? For whom can robots be designed, and with what acknowledgment of what hesitations, fantasies, and liabilities users will bring to the interactions? These questions will continue to press upon commentators, companies, and ultimately lawmakers alike, and without sufficient empirical feedback the resulting designs and policies may leave out important values and principles.

These results also open out onto the concern of some (e.g., [7]) that more empirical investigation is needed to spell out where technology at large may be changing the nature of human relationships. The tension in technology between social distancing and achieved intimacy requires closer empirical study into exactly what conditions and contexts make autonomous systems more harmful than helpful. This is especially important for the design and use of robots in sexual contexts, given the intricate and powerful norms, expectations, and associations that sex carries with it.

Beyond advocacy, futurology, and anecdote, the empirically-informed guidance of HRI research can discern and map the network of associations, reactions, and values around sex and robots that are too important to remain implicit. Without these integrating efforts there will be an intolerable divide between, on the one hand, what sex robots are produced and what purpose they are programmed to fulfill, and, on the other hand, the real, human lives, individual and collective, those robots are meant to enhance.

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