Research Article

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Moral psychology of sex robots: An experimental study – how pathogen disgust is associated with interhuman sex but not interandroid sex

Abstract: The idea of sex with robots seems to fascinate the general public, raising both enthusiasm and revulsion. We ran two experimental studies (N_s = 172 and 260) where we compared people's reactions to variants of stories about a person visiting a bordello. Our results show that paying for the services of a sex robot is condemned less harshly than paying for the services of a human sex worker, especially if the payer is married. We have for the first time experimentally confirmed that people are somewhat unsure about whether using a sex robot while in a committed monogamous relationship should be considered as infidelity. We also shed light on the psychological factors influencing attitudes toward sex robots, including disgust sensitivity and interest in science fiction. Our results indicate that sex with a robot is indeed genuinely considered as sex, and a sex robot is genuinely seen as a robot; thus, we show that standard research methods on sexuality and robotics are also applicable in research on sex robotics.

Keywords: sex robots, disgust, sociosexuality, moral foundations questionnaire, moral judgments

1 Introduction

Many kinds of robots are introduced into society at an accelerating rate. Sex and other types of companion robots are in development and seem to fascinate the general public [1,2]. Most new robots introduced to the market attract some media attention, but only sex robots appear on tabloid front pages when their production is delayed. Where the "Campaign to Stop Killer Robots" spent several years networking with established non-governmental organizations to gain traction [3], the "Campaign Against Sex Robots" went viral in weeks.

Several surveys have measured people's attitudes toward sex robots. These surveys have focused on people's expectations and fears concerning sex robots [4], the likelihood of people themselves using or buying a sex robot (for an overview, see [5]), and whether people consider using a sex robot to be infidelity or "cheating" [6]. The range of answers is extremely wide, from less than 10% to more than 80% of subjects being ready to test a sex robot, for example. Gender and age differences have been found across studies focusing on attitudes toward robots in general. However, to our knowledge no previous study has focused on the psychological factors underlying attitudes toward sex robots.

Apart from specific scales measuring attitudes toward robots [7], studies have shown that higher education implies more positive attitudes toward robots [8] and that acculturation also plays a role (both in real-life hands-on experience [9] and through consuming fiction [10]). Recent work suggests that psychometric scales measuring values like the Schwartz Value Survey [11] and personality like HEXACO [12] are not linked to attitudes toward the usage of transhumanist technologies, while scales more strongly grounded in evolutionary theory like the Moral Foundations Questionnaire (MFQ) [13] and the Three-Domain Disgust Scale (TDDS) are [14,15]. On attitudes toward sexual themes in general, MFQ (especially the purity/sanctity factor) and TDDS (especially sexual disgust) have been useful in separating different instinctual reactions and modes of reasoning to explain variations in behavioral outcomes [16,17].

Overall, the last century has seen significant changes in attitudes toward sexual morals, but not a "tide of liberation on all fronts" as was predicted 50 years ago. In Western societies, the use of contraceptives, divorce, and premarital sex are now seen as normal, and the last few

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years have seen homosexual marriage legalized in one form or another in most industrial countries. While polyamorous relationships are slowly gaining acceptance, marital fidelity is still seen as the norm – however, since multiple relationships before marriage are common, and since divorces are widely accepted, the precise expectation nowadays is serial monogamy. Attitudes toward prostitution vary immensely between societies and change rapidly [18–20]. In most countries, a division between social liberals and traditionalists or social conservatives (to distinguish from fiscal liberals and conservatives) can be seen in most topics of sexual morals. While this division is often along religious and political lines [21], there seem to be major individual-level components also, at least partly based on intuitive reactions as measured by MFQ and TDDS. Research has shown that conservatives typically have stronger disgust reactions than liberals [22], particularly in terms of pathogen avoidance behavior [23]. Of the five moral foundations in MFQ, liberals consistently endorse the harm/care and fairness/reciprocity foundations more than the other three foundations, whereas conservatives more equally endorse all five foundations. Conservatism correlates most strongly with the purity/sanctity foundation, which, in turn, relates to adhering to religious rules and is associated with disgust and contamination sensitivity [24,25].

The results are mixed on the question of marital fidelity: among liberals, infidelity is seen as a betrayal of trust and a serious offence toward one's partner, while among conservatives it is seen as "destruction of family" and thus a crime against society (but it is typically accepted that occasionally the husband may stray). On prostitution, liberals more often blame the (typically male) customer and see the sex worker as a victim of circumstances, while conservatives tend to condemn the sex worker as a "fallen person" and attribute less blame to the customer [26]. This implies that moral cognition focuses on patients and agents differently based on in-group membership values, which suggest that the machinery that produces condemnation of sexual acts is relatively malleable and dependent on many other mechanisms.

1.1 Rationale of current studies

We chose to study people's moral judgments toward sex robots as a replacement of human sex workers. This is highly relevant, as both proponents [27] and opponents of sex robotics [28] argue widely on the topic. Sex robot prostitution is also the most likely way for most people to have first contact with sex robots, given the robots' estimated prices in excess of US$10,000, and the plans of current "doll bordellos" to expand into sex robots as soon as possible.

Additionally, this made it possible to write our vignettes in a way that avoids questions of defining love, companionship, or sex, which are philosophically challenging issues [29]. While attitudes toward sex work vary widely [20], those differences will not matter when we compare the reactions to two stories set in a bordello, where the sex worker is either a human or a robot. Having participants read and evaluate vignettes (written stories) is a common method in moral psychology and experimental philosophy. While people's reactions to a story in a controlled laboratory setting may not reflect their actual reactions in a real-life situation, they do tell us much about how people see themselves; and that self-image (as measured by responses to vignettes) has a strong effect on the public opinion and "moral climate" of societies [30]. Thus, vignette-based studies can help us understand how moral judgments form.

This was an exploratory study and we did not set up formal hypotheses. Until recently, it was common in moral psychology to focus on moral judgment toward actions committed by protagonists in different settings. However, extensive research of late has concluded that people do not just assess the *acts* of the agents present in the vignettes but also judge and condemn their *character* [31]. We therefore measured both condemnation of character and action of the protagonist in our vignettes.

Recent advancements in the development of moral psychological theory suggest that disgust reactions in particular are crucial in character condemnation that follow from witnessing someone committing an ethically relevant action [31].

2 Methods and results of the studies

2.1 Pilot study introduction

The aim of the pilot study was to test our experimental paradigm and validate our dependent variables (DVs) and our stimulus materials. We wrote a short science fiction story where the protagonist is a 30-year-old male (married or single) visiting a Western European city for work. During his downtime, he decides to try out a brothel where the workers are either humans or robots. Since this is the first study to use such stimulus materials, it was important to pilot the story carefully (see below for further details).

2.2 Methods of the pilot study

2.2.1 Participants and design

One hundred and seventy-two participants were recruited through noninvasive means in a public library in Helsinki city center (N = 172; 96 females; age = 37, 18; SD = 16, 64; range 18–75). All participants were native Finnish speakers and compensated with 3 euros in cash for their time. Of the participants, 50% had completed at least a bachelor's degree, and 78% reported having mid-level income or below.

Participants were randomized into one of four conditions in a 2 × 2 experiment. The first factor had two levels, where the main character of the vignette was either (i) married or (ii) single. The second factor also had two levels where the service provider was either a (i) robot or a (ii) human being (see details of our stimulus material below).

2.2.2 Procedures and materials

Participants were recruited in the main lobby of the library by advertising the study with a sign. Participants were not approached. If they wanted to participate, they made contact with the research assistants through their own initiative. After providing informed consent, participants were escorted into one of the cubicles in our pop-up lab. Participants sat in front of a computer and put on headphones with pink noise playing on a comfortable level to block the disturbing background noise.

After being randomized into one of four conditions, participants filled in scales in the following order: MFQ, Science Fiction Hobbyism (SFH) scale, and Sociosexual Orientation Inventory (SOI). Then participants read a story where a 30-year-old male is on a business trip to a certain Western European city and decides to try out brothel services. Each participant read only a single story version, where the main character was either single or married and bought sexual services from either a robot or a human being. The story was set in the year 2035. Whether the service provider was human or robot was indicated in the story by the main character reading a sign stating either "You cannot tell our robots from real women" or "All our workers are real women". The story concluded by the main character paying in cash for the services. No details on sexual acts were included (see Appendix A for full material).

After reading the story participants filled in the DVs, which were shown on the same page as the story. Finally, participants answered demographic and other background questions, were debriefed, and were thanked for their time.

2.2.2.1 MFQ

The MFQ [13] measures individual variation in the foundations of "intuitive ethics". It is based on a model for five separate moral foundations: care/harm, fairness/cheating, loyalty/betrayal, authority/subversion, and purity/sanctity. The MFQ has two parts. In the first part, the respondent is asked to rate how relevant various considerations (16 in total) are when deciding whether something is right or wrong, on a scale from "1" (not at all relevant) to "7" (extremely relevant). Example items are "Whether or not someone suffered emotionally" (care/harm) and "Whether or not someone violated standards of purity and decency" (purity/sanctity). In the second part, the respondent rates his/her agreement with 16 statements on a scale from "1" (strongly disagree) to "7" (strongly agree). Example items are "Compassion for those who are suffering is the most crucial virtue" (care/harm) and "Chastity is an important and valuable virtue" (purity/sanctity). High (or low) scores on specific subscales indicate high (or low) relevance for the said subscale in an individual's intuitive moral foundation or "code of conduct". The Cronbach's α values for all subscales were 0.69 for harm/care, 0.64 for fairness/cheating, 0.73 for loyalty/betrayal, 0.73 for authority/subversion, and 0.80 for purity/sanctity.

2.2.2.2 Revised SOI (SOI-r)

Penke and Asendorpf [32] describe the interindividual differences in the tendency to engage in sexual relationships without deeper emotional commitment. It consists of nine items measuring *behavior* (in terms of number of casual and changing sex partners), *attitude*, and *desire* (for people not in a romantic relationship) on a scale from "1" to "9", with higher scores indicating higher sociosexuality. Example items: "With how many different partners have you had sex within the past 12 months?" (scored from "1" [zero] to "9" [more than 20]) and "I do not want to have sex with a person until I am sure that we will have a long-term, serious relationship" (reverse coded). Cronbach's α for the scale was 0.82.

2.2.2.3 SFH scale

This scale is currently under development. It consists of 12 items and measures individuals' cultural exposure to various science fiction themes. It has items such as "I consider myself a major consumer of science fiction" and "I think science fiction is an interesting topic". All the questions were anchored from "1" (strongly disagree) to "7" (strongly agree). Higher scores indicate higher SFH and

exposure to science fiction themes. In the current sample, the scale had good psychometric properties (all factor loadings >0.57; Cronbach's α 0.92) (see Appendix C for full details).

2.2.2.4 DVs

We had several DVs that aimed to measure condemnation of several aspects of the stimulus story described above (see Appendix B for full details).

2.2.2.5 Condemnation of the main character actions (DV1)

Measure of participants' disapproval toward the actions of story's main character. DV1 had 13 items (example item: "Andrew's actions made me feel sad", no reverse-coded items). All items were anchored from "1" (completely disagree) to "7" (completely agree). Higher scores indicate higher level of condemning the main character's actions. The scale had good psychometric properties (all factor loadings in a single-factor solution >0.66, Cronbach's α = 0.95).

2.2.2.6 Condemnation of purchasing sexual services (DV2)

Measure of participants' disapproval toward purchasing sexual services in general. DV2 had 10 items (example items: "Paying for the service is unethical" and "Paying for the service is normal" [reverse coded]). All items were anchored from "1" (completely disagree) to "7" (completely agree). Higher scores indicate higher level of condemning the purchase of sexual services. The scale had good psychometric properties (all factor loadings in a single-factor solution >0.48, Cronbach's α 0.92).

2.2.2.7 Condemnation of the main character (DV3)

Measure of participants' disapproval toward the essence of the story's main character. DV3 had nine items (example items: "Andrew is selfish" and "Andrew is just

curious" [reverse coded]). All items were anchored from "1" (completely disagree) to "7" (completely agree). Higher scores indicate higher level of condemning properties of the main character. The scale had acceptable psychometric properties (all factor loadings in a single-factor solution >0.35, Cronbach's α 0.75).

2.3 Results of the pilot study

We ran two-way analyses of variance (ANOVAs) separately for each of our three DVs by including both experimental factors and their interaction in the model as predictors (see Table 1 and Figure 1 for full results).

The pattern of results suggests that the main character's *actions* (DV1 and DV2) and *character* (DV3) are condemned less if he buys sexual services from a robot (DV1: $B = 0.78$; 95% CI [0.12, 1.44], $p < 0.05$; DV2: $B = 0.65$; 95% CI [−0.01, 1.30], $p = 0.054$; DV3: $B = 0.57$; 95% CI [0.11, 1.02], $p < 0.05$). The relationship status of the story's main character shows a trend for DV1 (*condemnation of the main character's actions*) and DV3 (*condemnation of the main character*): married people were condemned more for using sex work services irrespective of the service providers species (human or robot); but this effect was not statistically significant. There were no significant interaction effects in any of the models (all Fs < 2, all ps = n.s.).

We also ran the analyses by first controlling for gender and age. Age had no effect, but gender did: female subjects had higher condemnation scores than males across all DVs in all conditions.

Finally, we also added SFH and SOI-r scores into our model as covariates. The pattern of results stayed the same. SOI-r had a consistent effect: across all DVs and conditions, higher SOI-r scores were associated with less severe condemnation. SFH had a significant effect on DV1 and a weak conditional effect on DV2: higher scores on SFH were associated with lesser condemnation in the married × robot condition. Controlling for SFH and SOI-r removed the effect of gender.

Table 1: Results of the pilot study

Pilot	Marital status	Species of service provider	Interaction marital status × species of service provider
DV1	−0.14 [−0.79, 0.52]	0.78 [0.12, 1.44]*	−0.60 [−1.48, 0.29]
DV2	−0.01 [−0.65, 0.65]	0.65 [−0.01, 1.30]*t*	−0.40 [−1.28, 0.47]
DV3	−0.29 [−0.74, 0.16]	0.57 [0.11, 1.02]*	−0.25 [−0.85, 0.36]

B [95% confidence interval] (DV1: condemnation of the main characters actions, DV2: condemnation of purchasing sexual services, and DV3: condemnation of the main character). Notes: *t*: $p < 0.1$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
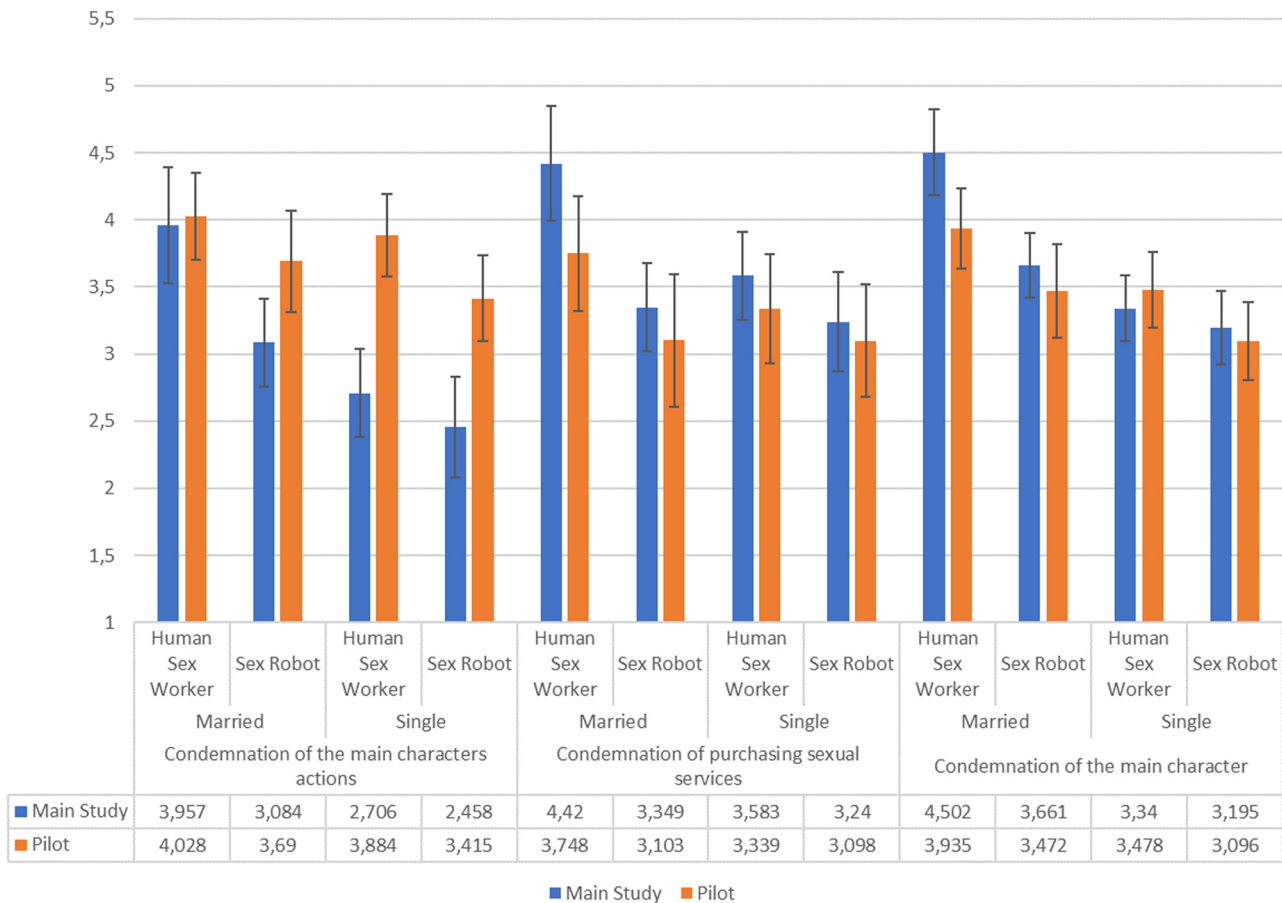
Figure 1: Mean values of DVs in different conditions in both studies.

2.3.1 Exploratory analyses

We ran an analysis of covariance (ANCOVA) predicting each DV separately, with both treatment variables and their interactions as fixed factors, and all of the MFQ variables as independent variables without any interaction terms; then we reran the analysis by dropping nonsignificant variables.

For DV1, we found that the model stayed essentially the same for experimental factors (treatment variables) compared to the analysis presented above; however, we found that higher scores in the harm/care and purity/sanctity dimensions of the MFQ were associated with increased levels of condemnation toward the client's actions ($B = 0.43$; 95% CI [0.21, 0.65], $p < 0.001$ and $B = 0.25$; 95% CI [0.06, 0.43], $p < 0.01$, for harm/care and purity/sanctity, respectively). We did not find any interactions between the MFQ variables and the experimental factors.

For DV2, we ran the same analysis and found the same pattern of results; the main effects for harm/care and purity/sanctity ($B = 0.37$; 95% CI [0.16, 0.59], $p = 0.001$ and $B = 0.34$; 95% CI [0.16, 0.52], $p < 0.001$,

respectively); with no essential change for experimental factors. We observed a weak interaction effect between purity/sanctity and the species of the service provider ($B = 0.30$; 95% CI [−0.03, 0.63], $p = 0.07$), which was mostly driven by the slope for robots ($B = 0.64$; 95% CI [0.39, 0.89], $p = 0.001$); Figure 2. For DV3, no effects were found regarding the MFQ variables.

2.4 Discussion of pilot study results

The main character's *actions* (DV1 and DV2) and *character* (DV3) were both condemned less if he buys sexual services from a robot compared with a human. Married people were condemned more for using sex work services irrespective of the service provider's species (human or robot). SOI-r had a consistent effect across all DVs and conditions: higher SOI-r scores were linked to less severe condemnation. SFH had a significant effect on DV1 and a marginal effect on DV2: higher scores on SFH were associated with lesser condemnation in the married × robot condition. Including the SOI-r and SFH variables removed the effect of gender. The MFQ dimensions
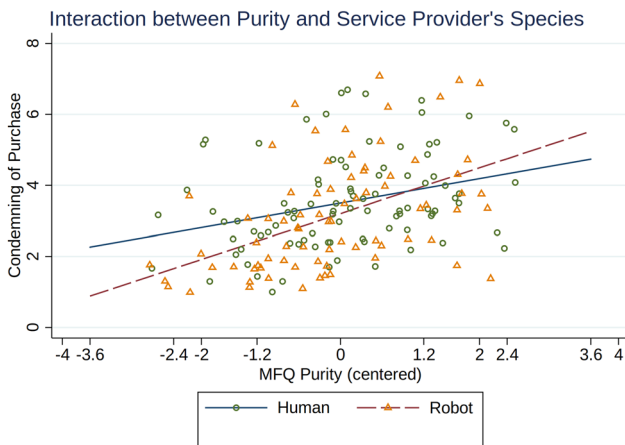
Figure 2: Interaction between MFQ purity/sanctity and species of service provider on condemning of purchase (DV2) in the pilot study.

harm/care and purity/sanctity were both statistically significantly associated with increased levels of condemnation toward the client's actions (DV1) across all conditions. We observed the same pattern of results for DV2 (the main effects for harm/care and purity/sanctity) with no essential change for experimental factors. Only with purity/sanctity and the species of the service provider did we find a marginal interaction effect, which was mostly driven by the slope for robots.

2.5 Main study introduction

After establishing the basic functionality of our vignette, study design, and variables in the pilot study, we sought to confirm our results in a larger sample. We introduced a third experimental factor, *gender of main character*, and modified the story accordingly, to test for a possible moral dual standard. We also added the TDDS to measure the effects of different kinds of disgust reactions.

2.6 Methods of the main study

2.6.1 Participants and design

Two hundred and sixty-one participants were recruited through noninvasive means in a public university library in Helsinki city center ($N = 261$; 137 females). Of the participants, one was excluded due to incomplete data. The final sample size was 260 participants (137 females; age = 28.93; SD = 9.72; range 18–75). All participants were native Finnish speakers and compensated with 3 euros in cash for their time. Of the

participants, 55% had completed at least a bachelor's degree and 92% reported having mid-level income or below.

Participants were randomized into one of eight conditions in a $2 \times 2 \times 2$ experiment. All factors had two levels. The main character of the story vignette was either *married* or *single* (first factor), either *female* or *male* (second factor), and the service provider was either a *robot* or a *human* (third factor).

2.6.2 Procedures and materials

The procedure was the same as in the pilot study. A third factor was introduced in the story: the gender of the main character was now female or male and the text describing the sign in the story was changed into "You cannot tell our robots from real humans" or "All our workers are real humans".

2.6.2.1 MFQ

The Cronbach's α values were 0.69 for harm/care, 0.64 for fairness/cheating, 0.73 for loyalty/betrayal, 0.73 for authority/subversion, and 0.80 for purity/sanctity.

2.6.2.2 TDDS [14]

This scale was created by Tybur and colleagues based on an evolutionary theoretical framework. The scale has 21 items and measures three different aspects of disgust sensitivity. The items are divided into three subscales of seven items each, labeled (1) moral disgust, (2) sexual disgust, and (3) pathogen disgust. Participants are instructed to think about how disgusted they would feel by specific statements. The items are anchored from "1" (not at all disgusting) to "7" (very disgusting). Example items for moral, sexual, and pathogen disgust, respectively, are (1) "Shoplifting a candy bar from a convenience store"; (2) "Hearing two strangers having sex"; (3) "Stepping on dog poop". Higher scores on all of the subscales indicate pronounced disgust sensitivity. There are no reverse-coded items. The subscale-specific Cronbach's α values were 0.88, 0.83, and 0.83 for moral disgust, sexual disgust, and pathogen disgust, respectively.

2.6.2.3 SOI-r

In the current sample, Cronbach's α was 0.85.

2.6.2.4 SFH scale

In the current sample, the scale had good psychometric properties (all factor loadings >0.55; Cronbach's $\alpha = 0.91$).

2.6.2.5 Condemnation of the main characters actions (DV1)

The scale had good psychometric properties (all factor loadings in a single-factor solution >0.60, Cronbach's $\alpha = 0.96$).

2.6.2.6 Condemnation of purchasing sexual services (DV2)

The scale had good psychometric properties (all factor loadings in a single-factor solution >0.59, Cronbach's $\alpha = 0.94$).

2.6.2.7 Condemnation of the main character (DV3)

The scale had acceptable psychometric properties (all factor loadings in a single-factor solution >0.48, Cronbach's $\alpha = 0.84$).

2.7 Results of the main study

The newly introduced third factor, gender of the client, had only a single effect on our DV3, where male clients' character in general was less condemned for the use of sex services compared to female clients (this effect was robust against controlling for gender effects: $B = -0.30$; 95% CI [−0.10. 0.49], $p < 0.01$); however, in a full factorial three-way ANOVA there were no interesting interaction effects, so the client gender factor was collapsed and only the other two original factors (marital status and species of service provider) were analyzed fully.

We thus repeated the analysis we ran it in our pilot study, and we ran a two-way ANOVA for each of our DVs by including both experimental factors and their interaction in the model as predictors (see Table 2 and Figure 1 for full results).

For all our DVs, we replicated the most important finding of our pilot study; namely, that the clients of robot sex workers were condemned much less than clients of human sex workers both for their actions and their character. Furthermore, we also replicated the main effect of marital status on DV1 and DV3: single people were condemned less than married people whether they have sex with robot or human sex workers.

In contrast with our pilot study, there was a marginally significant interaction effect in each of our models (Table 2); for DV1 and DV3 the interaction was driven by the fact that a married person having sex with a robot was condemned more than a single person having sex with a human sex worker ($B = -0.62$; 95% CI [−1.36, 0.11], $p < 0.1$ and $B = -0.70$; 95% CI [−1.24, −0.15], $p < 0.05$). For DV2, the interaction was driven by the fact that a single person's character was condemned more harshly if he/she had sex with a human sex worker compared with having sex with a robot ($B = -0.73$; 95% CI [−1.46, 0.00], $p < 0.05$). These results are interesting in the light of recent theoretical developments in moral psychology on the differences in character and action condemnation. Our results and their interpretations remained the same after controlling age, gender, SFH, and sociosexuality. We also investigated whether there was interaction between the story's character's sex and the respondents' own sex, but found no effects.

2.7.1 Exploratory analyses

2.7.1.1 Gender differences

There was a consistent difference in how female subjects showed slightly stronger condemnation than male subjects across all DVs (see Table 3 and Figure 3 for full results). The overall difference was statistically significant for DV1 and DV2 ($t = -2.68$, $p < 0.05$ and $t = -2.94$, $p < 0.05$, respectively). There were no interesting interactions.

2.7.1.2 MFQ

For DV1, we ran an ANCOVA by entering both experimental factors and their interaction as fixed factors, and all the MFQ variables as covariates (without interactions between the covariates and fixed factors). The results for the experimental factors remained essentially the same. Of the MFQ dimensions, only purity/sanctity was statistically significant ($B = 0.51$, 95% CI [0.33, 0.69], $p < 0.001$). Further probing of potential interaction effects produced no results. For DV2 and DV3, we

Table 2: Results of the main study

	Marital status	Species of service provider	Interaction (marital status × species of service provider)
DV1	−0.63 [−1.12, −0.13]*	0.87 [0.33, 1.41]**	−0.62 [−1.36, 0.11]t
DV2	−0.11 [−0.60, 0.38]	1.07 [0.54, 1.61]***	−0.73 [−1.46, 0.00]*
DV3	−0.47 [−0.83, −0.10]*	0.84 [0.44, 1.24]***	−0.70 [−1.24, −0.15]*

B [95% confidence interval] (DV1: condemnation of the main characters actions, DV2: condemnation of purchasing sexual services, DV3: condemnation of the main character). Notes: t: $p < 0.1$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Table 3: Consistent gender difference in rating DVs in different conditions

|	DV3	DV2	DV1
Female married human	4.5257	4.768	4.1385
Male married human	4.4714	3.985	3.7308
Female married robot	3.7738	3.5972	3.4423
Male married robot	3.5646	3.1357	2.7766
Female single human	3.4762	3.8133	2.906
Male single human	3.1473	3.2594	2.4255
Female single robot	3.3143	3.38	2.6615
Male single robot	3.0762	3.1	2.2538
Female average	3.7122	3.836	3.2206
Male average	3.485	3.296	2.7134

DV1: condemnation of the main characters actions,
DV2: condemnation of purchasing sexual services,
DV3: condemnation of the main character.

observed the exactly same pattern of results, finding only the main effect of purity/sanctity ($B = 0.47$; 95% CI [0.29, 65], $p < 0.001$ and $B = 0.33$; 95% CI [0.19, 0.47], $p < 0.001$; respectively).

2.7.1.3 TDDS

For all DVs, we ran an ANCOVA by entering both experimental factors and their interaction as fixed factors, and all the TDDS variables as covariates (without interaction terms). The results for the experimental factors remained essentially the same for all DVs; and for each DV, the main effects were found only for sexual disgust (DV1: $B = 0.53$; 95% CI [0.40, 0.66], $p < 0.001$; DV2: $B = 0.54$; 95% CI [0.42, 0.67], $p < 0.001$; DV3: $B = 0.28$; 95% CI [0.18, 0.38], $p < 0.001$). We then probed each TDDS subscale independently in a three-way ANCOVA with all

Interaction between Pathogen Disgust and Experimental Conditions
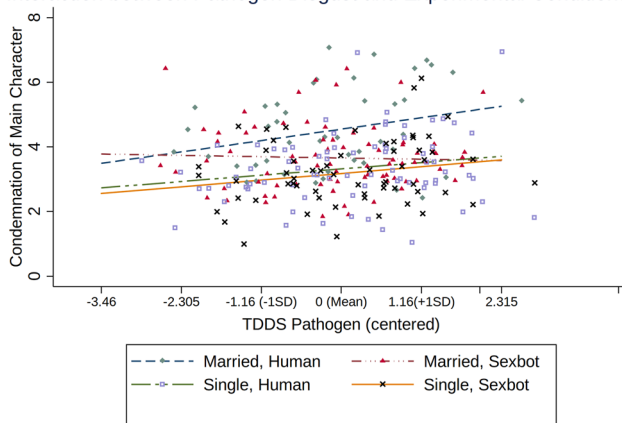
Figure 3: Interaction between pathogen disgust and experimental conditions in the main study.

interaction effects between covariates and fixed factors included.

Surprisingly, we found two significant interactions between *pathogen disgust* and the species of the service provider. This was the case for DV2 (interaction term: $B = -0.58$; 95% CI [−1.06, −0.10], $p = 0.02$) and DV3 (interaction term: $B = -0.34$; 95% CI [−0.69, 0.01], $p = 0.06$). In both cases, the interactions were very similar; therefore, we only present one of them here. In both cases, it is very clear that the effect is driven by the slope for married people who have sex with a human sex worker (DV1: $B = 0.48$; 95% CI [0.10, 0.87], $p < 0.05$; DV3: $B = 0.30$; 95% CI [0.02, 0.59], $p < 0.05$; all other slopes $p =$ n.s., for DV2 and DV3; see Figure 4 for results regarding DV3).

2.8 Discussion of the main study findings

Across all DVs, we replicated the most important finding of our pilot study, namely, that the clients of the robots were condemned much less than clients of human sex workers, with respect to both their actions and their character. Furthermore, we also replicated the main effect of marital status across all DVs: single people are condemned less than married people across all conditions.

In contrast with our pilot study, there was a marginally significant interaction effect present in each of our models. For DV1 and DV3, the interaction was driven by the fact that married person having sex with a robot was condemned more than a single person having sex with a human sex worker. For DV2, the interaction was driven by the fact that a single person's character was condemned more harshly if he/she had sex with a human sex worker compared with having sex with a robot.

Across all DVs, there was the main effect of purity/sanctity and sexual disgust. For DV2 and DV3, we found a significant interaction between pathogen disgust and the species of the service provider. In both cases, the effect was clearly driven by the slope for married people who have sex with a human sex worker.

3 Discussion

In two experimental studies, we consistently show that (a) having sex with robots is less condemned as an action than having sex with human sex workers and (b) people who have paid sex with robots rather than paid sex with human sex workers are condemned less harshly as people (i.e., they are perceived as less deplorable as characters). Furthermore, we also consistently show that
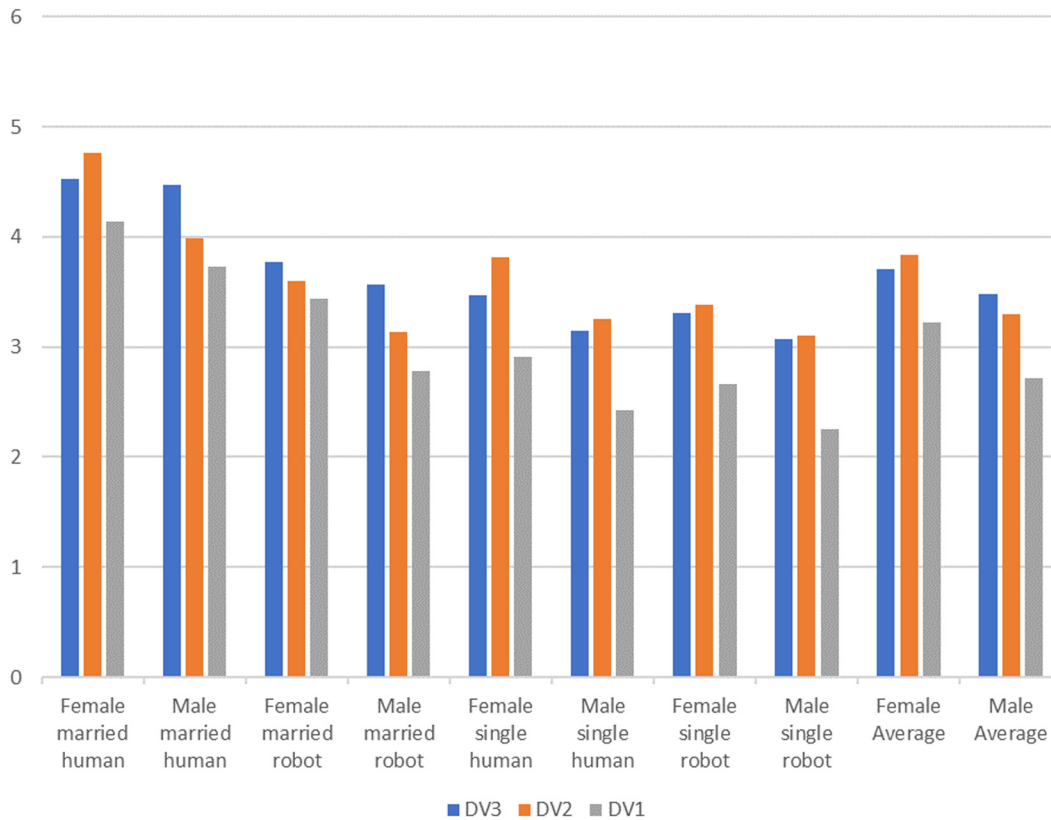
Figure 4: Gender difference in rating DVs in all conditions in the main study. Notice how the level of condemnation by female subjects is always slightly higher than by male subjects but the pattern stays remarkably similar (DV1: condemnation of the main characters actions, DV2: condemnation of purchasing sexual services, DV3: condemnation of the main character).

(c) married people who have sex with human sex workers are most harshly condemned both for their actions and for their characters.

In our main study, we further refined these findings by showing that the gender or the biological sex of the client does not seem to matter: Whether the client was a male or a female, our participants condemned their actions equally, albeit both men and women condemned men slightly less as users of sex work services.

All of our three DVs yielded similar results in both studies: married people visiting a bordello were condemned more harshly than single people; and regardless of marital status, paying for a human sex worker was condemned more harshly than paying for a sex robot. Thus, a married person paying for a human sex worker was always condemned most harshly, while a single person paying for a sex robot was condemned least harshly; and for the most part, this difference was statistically significant. Across all DVs, condemnation was stronger among female than male subjects. This is in line with the general expectation that males have a more positive view on sex trade [20]. There was no gender

difference in the differences in condemnation between married vs single or human sex worker vs sex robot.

We were surprised to observe only a slight double moral standard for the gender of the customer in the vignette. We expected higher levels of condemnation of at least married women paying for human sex workers compared with males. This might be explained by our subject population being relatively young, highly educated, and urban in a country among the most liberal and gender equal in the world [33].

In both our studies, we also found hints that disgust-related emotions might be relevant for future moral psychological research on sex robots and prostitution. The MFQ purity subscale was associated with harsher condemnation of having sex with robots only in our first study. However, we nonetheless found consistent effects in both studies wherein purity concerns influenced condemnation of *all* types of prostitution, irrespective of the service provider's species. Probing these effects further revealed that pathogen disgust strongly predicted condemning the use of paid human sex services. Interestingly, this effect was clearly driven by condemnation

associated with *married* clients but not *single* clients. In line with previous research, this suggests that pathogen disgust sensitivity is somehow related to moral condemnation, but how, exactly, is still a mystery [34–36]. At the same time, it is striking that pathogen disgust effects were not implicated in people having sex with robots. One explanation for this is the strong association between sex work and sexually transmitted diseases on the one hand, and robots and "cleanlinesss" on the other; but this does not explain the difference in condemnation between married and single clients. There seems to be some elusive component of purity in a married couple that needs to be protected from pathogens in a way that is not necessary for single people – some kind of idealized bond or trust that is somehow associated but not directly related to physical health or cleanliness. However, the MFQ purity/sanctity effect found in our first study suggests that moral condemnation with respect to the use of sex robots could be a more complex and nuanced issue: even if the use of sex robots is less condemned than having paid sex with other people, concerns of purity might still be associated with condemning sex robots and their use. Perhaps those campaigning against sex robots are particularly sensitive to purity-related moral issues. This would be an interesting avenue of future research, that is, finding the relevant individual difference measures that explain opposition toward sex robots.

In exploratory analyses, we also made some novel findings with respect to SFH. In the science fiction scale, we included measures for both consumption of science fiction in various forms and involvement in science fiction fandom; this enabled us to analyze the effect science fiction familiarity has on condemnation of sex robots. The results implied that familiarity indeed breeds acceptance, in approximately the same way as in our previous studies on acceptance of mind upload technologies [15]. While our studies show that the more our subjects consumed science fiction in its various forms, the more positive attitude they had toward sex robots, we do not know the exact causal cascade. It is possible that certain personality types are more inclined to enjoy both science fiction and robots; but it is also possible that consuming science fiction familiarizes people with the idea of sex robots and results in a positive attitude toward them. Research on how attitudes change toward positive when people get used to something (e.g., robots in elderly care [9]) supports the latter interpretation, while there seem to also be some specific psychological traits that are much more common among science fiction fandom than in the general population [37]. As in most "nature vs nurture" comparisons, it is likely that both

play a role. Still, our results imply that advertising sex robots on science fiction shows would likely be more productive than on historical dramas.

The scores on the SOI-r showed a simple pattern: the higher the SOI-r score, the more permissive attitudes toward visiting a bordello, regardless of the marital status or species of the service provider. This was not surprising, given some previous studies showing that high SOI-r scores are associated with more relaxed attitudes toward many forms of casual sex among consenting adults (homosexual, heterosexual, multipartner, BDSM, etc.) [38].

Altogether, our results indicate that sex with robots is generally seen as sexual conduct, albeit it is considered to be somewhat more acceptable than sex with a human sex worker. Our results on gender, disgust, and moral foundations are in line with research on attitudes toward interhuman sex. Thus, it seems that sex with a sex robot is seen to be closer to sex with another human than masturbation. Also, attitudes toward sex robots seem to be influenced by the same factors as attitudes toward robots in general. In summary, sex with a robot is considered to be sex and a sex robot is seen as a robot.

It needs to be stated that our results cannot be interpreted as "this many people from country X have this opinion on sex robotics".

Like all studies, ours had some limitations. Our samples did not fully represent the general population, although we still achieved better representativeness than most psychological studies. In standard psychological laboratory experiments, most of the participants are undergraduate female psychology students, while our participants were recruited in large public libraries. Still, our subjects went through a self-selection process by choosing to take part in a scientific study in their spare time, though we also made an attempt to recruit participants who had no preplanned intentions of participating in a study. This has likely resulted in a sample that is more open-minded, curious, and interested in science than the general population, although some participants also showed anti-science sentiment.

Moreover, our vignettes described a very humanlike sex robot in a bordello setting. It is more than likely that the results partly reflect attitudes toward sex work in general. Thus, our results for the most part cannot be generalized to nonhumanoid sex robots or to a long-term companion robot in private use.

The use of vignettes is not without problems in moral psychology. The reactions elicited by the stories are partly influenced by the immersion the subject experiences while reading the vignette. Thus, minor

disturbances can have large effects, and as vividness of imagination is presumably not entirely independent of empathy and social intelligence, the results may be somewhat biased. Also, reading a vignette, especially one describing a fictitious character, does not elicit as strong reactions as actual real-life situations would [39]. Thus, our results are not necessarily directly applicable to real-life situations. However, vignettes make it possible to study taboo subjects with only minor ethical concerns [30]. Vignette-based studies are also a cost-effective method and thus especially suitable for exploratory studies in emerging fields.

Attitudes toward robots, sex work, and sex are currently changing at an accelerated rate and thus any survey results should be interpreted and compared cautiously. We looked for associations between attitudes toward sex robots and psychometric measurements on various scales. Arguably, these associations are more likely to stay constant in the near future (e.g., people with highest scores on the purity/sanctity subscale of MFQ will likely be the most condemning of sex robots, regardless of the general baseline of approval).

Future studies should attempt to replicate our results across cultures and populations and with other methods than vignettes (especially, psychophysical or neuropsychological measurements of disgust reactions would tell us much). As soon as sex robots become available on open markets, buyers and/or users could be polled online or otherwise and different kinds of real-world reaction tests could be done. Also, hard data on sales can yield results on typical buyers, which can be informative, as can data on customer satisfaction and complaints. Additionally, as there really is no practical reason to build sex robots only as replications of either the human female or male form, it will be interesting to see what kind of machinery really makes it on the market, and whether attitudes toward less humanoid sex robots will differ – it is possible that sex with an "oddity", for example, a six-legged machine with three tentacles, six orifices, an electrostimulator, and two dildos, might not be considered as infidelity or "cheating" in the same sense as sex with something that simulates one's spouse forms – but such robotic oddities might also evoke other types of (negative) responses.

We have for the first time experimentally confirmed that people are somewhat unsure about whether using a sex robot while in a committed monogamous relationship should be considered as infidelity or not. We have also shed some light on the psychological factors influencing attitudes toward sex robots. As our results indicate that sex with a robot is indeed considered to be sex and a sex robot is seen as a robot, we feel that we have shown that standard methods of research on sexuality and robotics are applicable in research on sex robotics.

4 Conclusion

Our results successfully show that people condemn a married person less harshly if they pay for a robot sex worker than for a human sex worker. This likely reflects the fact that many people do not consider sex with a robot as infidelity or consider it as "cheating, but less so than with a human person" [6]. These results therefore function as a stepping-stone into new avenues of interesting research that might be appealing to evolutionary and moral psychologists alike. Most likely, sociologists and market researchers will also be interested in increasing our understanding regarding the complex relations between humans and members of new ontological categories (robots, artificial intelligences (AIs), etc.). Future research will offer new possibilities to understand both human sexual and moral cognition by focusing on how humans relate to sexual relationships with androids beyond mere fantasies produced by science fiction like Westworld or Blade Runner. As sex robots in the near future enter mass production, public opinion will presumably stabilize regarding moral attitudes toward sex with robots.

Author contributions: The study idea was conceived by MD and ML. The first study and stimulus materials and study design were prepared by MK, JP, MD, and ML. Dependent variables were first designed by MD and then improved upon by MK and JP. Both experiments were programmed by ML. The data were collected by JP, MK, AK, JH, NL, and MR. The data were analyzed by ML, MK,

and AK. The first draft of the manuscript was prepared by MK and ML and then improved upon and proofread by JP.

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Appendix A: example of the vignette used (variation female customer × married × sex robot)

"The year is 2035. Various independent humanlike robots are common but still lacking any kind of consciousness or self-awareness. The advance of robotics has not caused much societal change. Anna is a 35-year-old civil servant. She is married and in her free time she enjoys trekking in nature and playing a piano. Anna is on a weeklong work trip in a city in Central Europe. The days are full of work but the evenings in a foreign city are dull and lonely. Curiosity draws her to explore the so-called Red Lights District, where sex work is visible and fully legal, though firmly controlled and regulated. For example, bordellos are required by law to clearly state whether the companions are human or robotic. A sign stating 'You can't tell our companion robots from real humans' encourages her to step into a bordello. After checking that the place follows impeccable hygienic standards and all official regulations she reserves a room and a robot companion for an hour and pays for the service in cash."

Appendix B: psychometric properties of DVs

DV1 Condemnation of the main characters actions Item	Pilot Mean	$N = 172$ SD	Factor loading
Anna's actions made me feel angry	2.44	1.741	0.771
Anna's actions made me feel sad	3.11	2.007	0.681
Anna's actions made me feel offended	2.34	1.694	0.804
Anna's actions made me feel afraid	2.3	1.578	0.664
Anna's actions made me feel concerned	2.97	1.937	0.739
Anna's actions made me feel anxious	2.73	1.851	0.789
Anna's actions made me feel nervous	2.47	1.785	0.682
Anna's action was immoral	3.31	1.936	0.837
Anna's action was wrong	3.26	2.098	0.851
Anna's action was reprehensible	2.69	1.85	0.846
Anna's action was punishable	2.31	1.667	0.785
Anna's action was abominable	2.87	1.837	0.849
Anna's action was disgusting	3.09	1.995	0.835
	Cronbach's α	0.953	
	Variance explained	64.392	
	Extraction method: maximum likelihood		
	1 factor extracted. 5 iterations required		

DV1 Condemnation of the main characters actions item	Main study Mean	$N = 260$ SD	Factor loading
Anna's actions made me feel angry	2.64	1.809	0.841
Anna's actions made me feel sad	3.13	1.962	0.716
Anna's actions made me feel offended	2.43	1.768	0.745
Anna's actions made me feel afraid	2.57	1.655	0.603
Anna's actions made me feel concerned	3.53	1.962	0.733
Anna's actions made me feel anxious	3.1	1.932	0.784

	Mean	SD	Factor loading
Anna's actions made me feel nervous	2.61	1.719	0.657
Anna's action was immoral	3.43	1.982	0.895
Anna's action was wrong	3.48	2.088	0.893
Anna's action was reprehensible	3.03	1.913	0.88
Anna's action was punishable	2.5	1.783	0.811
Anna's action was abominable	3.02	1.917	0.895
Anna's action was disgusting	3.23	1.946	0.897
	Cronbach's α	0.959	
	Variance explained	67.479	
	Extraction method: maximum likelihood		
	1 factor extracted. 4 iterations required		

DV2

Condemnation of purchasing sexual services	Pilot	$N = 172$	
Item	Mean	SD	Factor loading
Paying for the service should be illegal	2.69	1.905	0.822
Paying for the service is unethical	3.49	1.951	0.825
Paying for the service is imprudent	3.6	1.796	0.61
Paying for the service is offensive toward the companion	3.06	1.831	0.545
Offering the service should be illegal	2.83	1.963	0.871
Offering the service is unethical	3.31	1.921	0.813
Paying for the service is appropriate	3.9012	1.78905	0.829
Paying for the service is neither right nor wrong	2.936	1.9471	0.486
Paying for the service is normal	3.936	1.75768	0.722
Paying for the service is acceptable	3.5814	2.04605	0.856
	Cronbach's α	0.923	
Items in italics were scored in reverse	Variance explained	60.055	
	Extraction method: maximum likelihood		
	1 factor extracted. 4 iterations required		

DV2

Condemnation of purchasing sexual services	Main study	$N = 260$	
Item	Mean	SD	Factor loading
Paying for the service should be illegal	3.12	2.006	0.875
Paying for the service is unethical	3.62	1.929	0.852
Paying for the service is imprudent	3.92	1.743	0.703
Paying for the service is offensive toward the companion	3.05	1.848	0.691
Offering the service should be illegal	3.17	1.96	0.849
Offering the service is unethical	3.55	1.951	0.807
Paying for the service is appropriate	4.2731	1.73273	0.817
Paying for the service is neither right nor wrong	3.2885	2.05086	0.586
Paying for the service is normal	4.1462	1.72473	0.678
Paying for the service is acceptable	3.6538	1.84207	0.878
	Cronbach's α	0.937	
Items in cursive were scored in reverse	Variance explained	64.479	
	Extraction method: maximum likelihood		
	1 factor extracted. 4 iterations required		

DV3

Condemnation of the main character	Pilot	$N = 172$	
Item	Mean	SD	Factor loading
Anna is a good person	3.6628	1.3817	0.632
Anna is just curious	3.9186	1.6417	0.441
Anna is just having fun	3.3779	1.7107	0.604
Anna used the service just to test it	3.8953	1.5373	0.348
Anna is selfish	3.9186	1.9085	0.627
Anna is immature	3.4826	1.7588	0.611
Anna should be punished	2.186	1.6005	0.563
	Cronbach's α	0.75	
	Variance explained	40.486	

Items in italics were scored in reverse

Extraction method: maximum likelihood
1 factor extracted. 6 iterations required

DV3

Condemnation of the main character	Main study	$N = 260$	
item	Mean	SD	Factor loading
Anna is a good person	3.9	1.2324	0.725
Anna is just curious	3.8038	1.508	0.692
Anna is just having fun	3.5346	1.6704	0.725
Anna used the service just to test it	3.9577	1.4894	0.478
Anna is selfish	4.14	1.911	0.619
Anna is immature	3.57	1.809	0.71
Anna should be punished	2.32	1.667	0.716
	Cronbach's α	0.843	
	Variance explained	52.661	

Items in italics were scored in reverse

Extraction method: maximum likelihood
1 factor extracted. 4 iterations required

Appendix C: psychometric properties of the Science Fiction Hobbyism scale

Science Fiction Hobbyism	Pilot	$N = 172$	
Item	Mean	SD	Factor loading
For me, science fiction is an interesting topic	4.18	2.043	0.779
I have spent a lot of time on SF movies, literature, games, TV shows and/ or comics	3.09	1.995	0.816
I tend to notice scientific or technological inaccuracies in movies and books	3.66	2.076	0.637
I consider myself a big science fiction fan	2.2	1.647	0.799

I have actively participated in conventions and gatherings related to science fiction	1.7	1.275	0.546
I am active in an organization, club, or society related to SF	1.63	1.402	0.568
I try to keep up to date on technological and scientific advances	4.37	1.761	0.603
Fiction set in the future is often more interesting than other kinds of fiction	3.9	1.888	0.541
Transhumanism is a familiar topic to me	2.29	1.756	0.687
I often think about things related to artificial intelligence	3.7	1.941	0.674
I spend a lot of time finding out more about space and space technology	2.6	1.766	0.635
I often think about what machines are going to be like in the future	4.44	1.81	0.591
	Cronbach's α	0.901	
	Variance explained	48.5	
		Extraction method: maximum likelihood 1 factor extracted. 5 iterations required	

Science Fiction Hobbyism Item	Main study Mean	$N = 260$ SD	 Factor loading
For me, science fiction is an interesting topic	4.71	2.054	0.726
I have spent a lot of time on SF movies, literature, games, TV shows, and/or comics	3.55	2.174	0.813
I tend to notice scientific or technological inaccuracies in movies and books	3.62	1.957	0.63
I consider myself a big science fiction fan	2.54	1.803	0.803
I have actively participated in conventions and gatherings related to science fiction	1.91	1.539	0.549
I am active in an organization, club, or society related to SF	1.8	1.459	0.575
I try to keep up to date on technological and scientific advances	4.06	1.795	0.599
Fiction set in the future is often more interesting than other kinds of fiction	3.9	1.842	0.561
Transhumanism is a familiar topic to me	3.03	2.041	0.62
I often think about things related to artificial intelligence	4.25	1.934	0.721
I spend a lot of time finding out more about space and space technology	2.66	1.667	0.733
I often think about what machines are going to be like in the future	4.44	1.761	0.685
	Cronbach's α	0.906	
	Variance explained	49.79	
		Extraction method: maximum likelihood 1 factor extracted. 4 iterations required	