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Not Only the Lonely—How Men Explicitly and Implicitly Evaluate the Attractiveness of Sex Robots in Comparison to the Attractiveness of Women, and Personal Characteristics Influencing This Evaluation

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Abstract: While some theories, such as the Media Equation, suggest that men will evaluate sex robots to be attractive, other assumptions (e.g., biases of norm adherence) would contradict this hypothesis. Therefore, the present study aimed at empirically comparing men's explicit and implicit evaluation of the (sexual) attractiveness of sex robots and women. At the same time, personal characteristics of the observer that might affect this evaluation were considered. An online survey (n = 229) and an affective priming experiment (n = 41) revealed that men rate women to be more attractive than robots if asked explicitly (=self-reported). However, this effect is not present when attractiveness is assessed implicitly (unbiased, directly). Moreover, affiliation-related traits such as loneliness, which have been assumed to be associated with the usage of sex dolls, are not related to the evaluation of attractiveness. Instead, a negative attitude towards robots is an important predictor.

Keywords: sex robot; explicit and implicit measure; personality traits; attractiveness; HRI

1. Introduction

Although sex robots represent an emerging field of application for humanoid robots, research on the sexual aspects of human–robot interaction is almost non-existent. With the rise of humanoid robots, more and more companies are focusing on building android robots (robotic replications of humans). As the adult industry is known for driving technological developments, such as Internet applications or virtual reality [1], it can be expected that the use of robots for the satisfaction of sexual needs will soon be rendered possible due to the technological progress in the field of sex robots. Sex dolls already have a hyper-realistic outward appearance [2]. Companies such as True Companion or Abyss Creations are already working on different robotic solutions to enable the human replications to move and talk. David Levy, one of the first researchers to discuss love and sex with robots in detail, predicted that by the year 2050 robots will be capable of being "perceived as being similar to biological creatures" [3] (p. 303) and that this will make robots appealing in terms of sexual and affectional purposes. While the media coverage often associates the usage of sex dolls or sex robots with being lonely (e.g., "Lonely men to get guide on building a sex robot" [4]), a first study by Schuetz and Arnold, with a relatively small male sample size, revealed that more than two-thirds of the male participants could imagine using a sex robot [5]. This demonstrates that, as futuristic as it might seem, the topic might be of interest to more than merely a fringe group. Indeed, theoretical considerations based on social psychological insights into the mechanisms of physical attractiveness as well as assumptions from communication science, such as the Media Equation (the process of applying social rules to computers [6]), would suggest that attraction to sex robots could be a universal phenomenon. However,

other concepts, such as the uncanny valley (a negative reaction if robots are too human-like [7]) or sexual and social norms would predict that sex robots would not be appealing to the masses [2].

While research in different fields of human–robot interaction is on the rise (e.g., human–robot interaction in healthcare), empirical research on the sexual aspects of human–robot interaction is almost completely lacking. Although there are some scientific papers on sex robots, they mostly discuss ethical concerns (e.g., [8,9]). While such considerations are indeed highly valuable, as the development of sex robots might be related to various negative societal outcomes (e.g., objectification of people), empirical studies focusing on the user's perception and evaluation are nevertheless necessary to gain a deeper understanding of sexual aspects in human–robot interaction.

In this vein, the present study aimed not only to investigate how men evaluate sex robots if asked explicitly (=self-reported) and the influence of personality traits on this explicit evaluation, but also whether the same results emerge if an immediate, and therefore unbiased, reaction is used to measure the attractiveness perception (affective priming). This multi-methodological perspective enables a more profound understanding of the evaluation of sex robots. Moreover, it allows for an empirical investigation into the importance of different aspects, such as bias of sexual and societal norm adherence, the evolutionary principles of attractiveness, or the influence of certain personal characteristics. It is important to gain in-depth knowledge about the influence of personality traits, as research in the context of human–robot interaction has already shown that the way humans think about and act towards robots is influenced by personal characteristics and previous experiences. Taking into account personal characteristics is particularly crucial with regard to sex robots as there is a stereotypical claim that lonely people, who have a hard time getting in touch with real people, could be particularly attracted to sex robots in order to fulfill their sexual and affectional needs [4].

The study is separated into two parts: Study 1a (n = 229) comprises an online questionnaire assessing men's explicit evaluations of women and robots, and the personal characteristics that might have an influence on the rating. In Study 1b, 41 additional participants took part in an affective priming paradigm to access the subliminal attractiveness ratings of women and robots. This was important as we aimed to investigate the immediate reaction to sex robots. To enable a comparison of the results, the two studies used the same stimulus material.

1.1. Sex Robots

Sex robots can be understood as android robots (robotic replications of the appearances of women or men) that are built to satisfy sexual needs. For this purpose, the robots provide not only replications of some secondary sexual characteristics (e.g., breasts), but also external genitals (e.g., labia). As this description could also apply to hyper-realistic sex dolls, sex robots are also able to move (which is particularly important with regard to the fulfillment of sexual needs) and speak. Affective computing will be an important aspect of sex robots, since having sex is one of the most intimate interactions possible, in which reacting and acting like a human will be perceived as quality attributes. At present, there is no sex robot available that is suitable for the masses and that provides all of the features listed above. However, there are first approaches, such as the sex robot Roxxxy by the company True Companion or the first moving body parts created by the company Abyss Creations. David Levy predicts that, by 2050, technological achievements will make it possible to fall in love with, have sex with, and even get married to a robot [3]. On the other hand, as mentioned above, these new developments have given way to ethical concerns. Among other aspects, the possible process of objectification (especially with respect to prostitutes) needs to be kept in mind, as well as the illusion of love (caused by the illusion of interaction with a person), which can lead to various ramifications [8,9].

1.2. Sex and Attraction

Sexual intercourse between humans is one of the most intimate interactions people can have [10,11]. Although the concept of sex is often associated with long-lasting romantic relationships, sexual experiences can manifest themselves in different ways. Studies have demonstrated

that, for men, there are different positive psychological and physiological effects of sexual experiences, caused, for instance, by masturbation (e.g., [12]) or by sexual intercourse in short-term relationships (e.g., [13]). Despite the lack of consensus regarding whether sex drive is based on psychological or physiological processes or an integrated process, every human experiences sexual tension [14–16]. In this respect, research has shown that men have a higher need for sex compared to women, who tend to have a stronger need for affiliation [17].

The precondition for sexual activities (especially with regard to intercourse) is attraction. Research on evolutionary principles of mate selection shows that, in particular, waist-to-hip ratio (WHR) plays an important role in this regard [18,19]. The WHR represents the body fat distribution between the upper and lower body, which is influenced by sex hormones that cause the visual difference between women and men after puberty. Singh further argues that "WHR appears to be the most accurate signal of female reproductive capability" [19] (p. 315), which is a main factor in mate selection. Besides the WHR, breast size also plays an important role in the evaluation of attractiveness. In an eye-tracking study, Dixson et al. found that men's initial visual fixation is either on the breasts or the waist, not on the face or lower body—at least when a naked woman is shown [20]. In a similar study conducted by Hewig et al., in which participants were presented with pictures of dressed women and men, the male participants' initial look was at the face of women, followed by fixation on the breasts [21]. The face is another important influence on attractiveness ratings, as it transmits a variety of information including sociodemographic information such as gender or age, but also information on emotions and physical health [22–24]. Familiarity has been shown to be another important aspect for attractiveness ratings, as we react positively to known things [25].

Ratings on how people evaluate an individual or a category of people (e.g., men or women) to be (physically) attractive are usually measured by explicit ratings, such as self-reporting questionnaires. However, there are first studies using subliminal measurements to assess the strength of the relationship between the concept of attractiveness and categories of stimulus material. This could be of special interest in cases in which attractiveness ratings might be influenced by biases of norm adherence, which might lead to socially desired behavior. For instance, Snowden et al. used subliminal measurements to show that sexual orientation and erotic preference can be captured using implicit measurements [26].

1.3. Media Equation

Reeves et al. demonstrated in various studies that people behave the same way in interactions with computers as they would with humans (e.g., they are polite, they apply gender stereotypes) (e.g., [6,27]). The effect of this so-called Media Equation (media equals real life) has also already been shown with regard to robots (e.g., experiencing empathy, keeping interpersonal distance) [28,29]. In terms of intimate interactions with robots, Li et al. conducted a study in which the humanoid robot NAO told the participants to either touch or point to different body parts (with low and high accessibility) [30]. The results showed that people experienced an increased physiological arousal and an increased reaction time when touching regions of the robot's body with lower accessibility (e.g., buttocks or genitals). The authors discussed this finding in the context of the Media Equation. As the study did not focus on the question of why the arousal increased, the authors assumed (among other reasons) that touching low-accessible body parts of a human-like robot might evoke a feeling of discomfort, based on social norms or the increased intimacy. Although the authors did not discuss this in particular, it can be assumed that the increased arousal cannot be compared to sexual arousal, as the humanoid NAO is 57.3 cm/22.6" tall, made of white plastic, and is sometimes even described as being cute in a childlike way [30,31]. Nevertheless, their finding is important, as it shows that touching even remotely human- shaped robots evokes arousal. It is therefore conceivable that androids might evoke even stronger reactions, in the sense of actual sexual arousal, since anthropomorphism (in design and behavior) is an important aspect in the Media Equation. Ferrari stated that human appearance in robots is not only relevant on a functional level (some things can simply be done better with human features, e.g., raising a glass), but also on a physiological level, as we tend to interpret anthropomorphic

features as "human" features [32]. For instance, Bartneck et al. demonstrated that the degree of anthropomorphism (in their study: moving lips, eyes, and eyebrows) had an influence on feelings of embarrassment in an interaction with a medical robot [33]. The authors discussed this finding in the context of Media Equation assumptions. They pointed out that there are certain situations in which a less human-like appearance could be helpful, but also noted that highly anthropomorphic robots could have benefits with regard to human–robot interaction. One aspect that could have an influence on the perceived human likeness is salient mechanical body parts. These come with the consequence that humans can instantly categorize them as robots, as their human-like outward appearance is disturbed, for instance, by plastic or metallic components, and this in turn could trigger negative pre-existing attitudes towards robots. However, if robots have no visual robotic components at all, it is possible that they might evoke feelings of eeriness, as described in the context of the uncanny valley phenomenon [7].

1.4. Uncanny Valley

The theory of the uncanny valley states that robots evoke more positive feelings of acceptance the more human-like they become, until their evaluation is influenced by the so-called uncanny valley. The current generation of android robots often triggers this effect, as they are built to copy human beings but fail to achieve complete humanness due to restrictions in appearance and/or behavior. This misguided representation of humans is accompanied by negative evaluations/feelings [7]. The model predicts that the human likeness of a robot and its acceptance by the user are not related in a linear manner. One frequently suggested explanation is the perception-oriented approach, which suggests that very human-looking robots often do not meet people's expectations (e.g., with regard to haptic aspects or social norms). The resulting uncertainty (in the sense of difficulty in categorizing the entity) leads to negative evaluations [34,35].

Referring to the original uncanny valley model, robots without any salient mechanical body parts should be located somewhere on the upper-right of the curve after the dip, representing nearly perfect humanness [7]. In contrast, robots with visual cues (e.g., buttons or wire) allow an instant classification and therefore reduce uncertainties due to their salient mechanical body parts. Therefore, they should be located somewhere on the left of the curve, before the uncanniness starts. Theoretically, both positions in the model could lead to an average likeability [7]. However, Bartneck et al. found that there was no difference between the likeability of a human and his android doppelgänger, which demonstrates that the uncanny valley is not always empirically supported [36]. Moreover, it should be emphasized that research on the phenomenon is strongly influenced by the measures and stimuli used. In particular, the movement can have an important influence on results with regard to the uncanny valley hypothesis [28].

1.5. Social and Sexual Norms

Concerning aspects that might influence the evaluation of sex robots, sexual norms could be of particular importance. Nowadays, technology plays an important role in sexuality [37,38]. The term technosexuality describes sexual activities that are combined with technology. Some technosexual behaviors, such as Internet pornography, are more common than others. So far, sexual activities involving robots have been described as deviant and termed robot fetishism, being defined as a "fetish attraction to humanoid or non-humanoid robots, or to people behaving like robots, or to people dressed in robot costumes" [37] (p. 66/67). Although possible users might be unaware of the fact that such sexual behavior could be labeled as fetishism, it is clear that sexual activities with an object deviate from statistical sexual norms [2], which in turn could be evaluated negatively. Moreover, these sexual norms could lead to difficulties in the context of empirical research, as participants have the tendency to respond in ways they believe to be socially acceptable (social desirability).

Another aspect that could lead to negative attitudes towards sex robots is that having sex with a doll, instead of a human, is associated with being lonely or desperate [37]. Although a robot is more

lifelike than a doll, it is still a machine, and it can therefore be assumed that this stereotype could transfer to sex robots, as both are non-human. However, it should be stressed that sex dolls (ranging from cheap inflatable versions to expensive ones made of silicone) and also technology used for sexual stimulation are already part of the present sex toy industry [37,39].

1.6. Influence of Personal Characteristics on Human–Robot Interaction

As already briefly mentioned in the context of uncanny valley, the perception of robots can be influenced by different personality traits and pre-existing biases towards robots. In the following, personality traits and their influence on robots and the evaluation of attractiveness will be discussed.

1.6.1. Affiliation-Related Variables in the Context of (Sex) Robots

When thinking about sex doll or future sex robot owners, the stereotype prevails (often portrayed by the media, e.g., in the news such as an article in the *Times* with the headline "Lonely men to get guide on building a sex robot" or in the film *Lars and the Real Girl*) that people who are attracted by artificial entities suffer from loneliness or are unable to get in touch with other people [4,40]. David Levy also addressed this topic in his book *Love and Sex with Robots*, stating in his conclusion that "Many who would otherwise have become social misfits, social outcasts, or even worse will instead be better-balanced human beings." [3] (p. 304). In the documentary *Love Me, Love My Doll/Guys and Dolls* produced by Holt, who looked at owners of life-sized sex dolls called "Real Dolls", one 32-year-old man confirmed Levy's conclusion, stating that: "I can tolerate being alone, but not loneliness" [3,41]. Although there are no empirical results regarding sex robots, research has shown that lonely people do benefit from contact with humanoid robots. For instance, Eyssel and Reich demonstrated that lonely people tend to anthropomorphize humanoid robots more strongly (with respect to their characteristics) [42]. This is a highly relevant finding because people have a fundamental motivation to affiliate with others [43], which in turn might be satisfied by interactions with humanoid robots. Moreover, it is conceivable that people who have problems satisfying this need to belong, such as people with social anxieties, might especially benefit from interactions with humanoid robots. Such interactions might provide a feeling of safety with respect to aspects or behaviors that could be controlled in a robot, such as fear of rejection [44]. This aspect might be of special importance for sex robots, as people suffering from social anxieties often have problems engaging in interactions with the opposite sex and consequently have fewer sexual experiences in their lives [45]. A first empirical hint that people suffering from social anxieties can benefit from interactions with robots was provided by Suzuki et al., who examined persons scoring highly on social avoidance and distress [46]. Such individuals indicated that they would prefer robots over humans as communication partners in various situations (e.g., asking for directions at a station or on a street).

1.6.2. Pre-Existing Attitudes

Another aspect that needs to be kept in mind with regard to attractiveness in robots is that robots, as a concept, are associated with certain pre-existing positive and negative biases [47]. In this context, Nomura et al. investigated the anxieties people have towards robots with regard to situations of interaction with robots, the social influence of robots, and emotions robots might have [48]. They developed the Negative Attitudes towards Robots Scale (NARS), which is an important instrument in research on human–robot interaction. Different studies showed that the attitudes measured by the NARS have an influence on various evaluations in human–robot interactions. For instance, the attitudes have an influence on the distance people keep between robots and themselves and the willingness to engage in physical contact with robots [49]. As important as this latter aspect is, it has to be noted that this state of anxiety (evoked in certain situations) is strongly linked to a robot's appearance (e.g., human-sized or small humanoids) [48]. In this regard, no research has been conducted so far that focuses on sex robots and pre-existing attitudes.

1.7. Hypotheses

The aim of the present study is not only to examine whether men evaluate female android robots to be attractive, especially in comparison to how they rate women, but also whether this evaluation is influenced by certain personality traits and biases of norm adherence or social desirability. Based on the presented literature review, the following hypotheses were derived:

There are different theoretical approaches (especially the Media Equation and evolution-based mechanisms of attractiveness) that would suggest that men evaluate female androids (with or without salient mechanical body parts) to be as attractive as women. However, there are also visual differences between women and robots, especially with respect to robots with salient mechanical body parts that might disturb the impression of human likeness. Moreover, the influences of social norms, as well as the possibility that female android robots with and without salient mechanical body parts might give rise to feelings of uncanniness, would speak against this hypothesis. Research on the evaluation of attractiveness showed that erotic preferences can be measured using subliminal measurements. This might be particularly relevant for attractiveness ratings that could be biased by norm adherence and social desirability [26]. Since no study has yet empirically investigated differences in attractiveness ratings among different forms of robots and between robots and women, the following research question is posed:

Research Question 1 (RQ1). *Is there a difference in men´s explicit evaluation of the (sexual) attractiveness of women, female androids with salient mechanical body parts, and female androids without salient body parts?*

To date, no research has been conducted on the influence of biases of norm adherence on the evaluation of sex robots. However, it seems likely that the evaluation of attractiveness, which is usually an aspect that would only be rated with regard to humans, is influenced by aspects that need time for reflection (such as social or sexual norms). In the present study, a subliminal measurement (affective priming) is used in order to access the implicit, that is, subliminal evaluation of the attractiveness of women and robots. This could have the consequence that the participants are unable to retrieve social norms or social desirability. In turn, this would mean that participants rely on the first visual impressions they get. Although the robots used in the affective priming paradigm do have salient mechanical body parts that allow an instant categorization, it can be assumed that the evolution-based mechanisms of attractiveness trigger the same reactions as would pictures of women. Therefore, the following hypothesis is formulated:

Hypothesis 1 (H1). *The affective priming paradigm (implicit measurement) will show no difference between women and robots in the associative strength with regard to the concept of attractiveness.*

Sex robots are built to fulfill sexual needs. Among humans, this need is most often fulfilled by physical contact with other human beings and is therefore connected to affiliation-related personal characteristics, such as fear of rejection or loneliness. Therefore, we aim to investigate the influence of affiliation-related personality traits on the evaluation of sex robots. Moreover, it is important to empirically investigate the stereotypical claim that users of sex robots suffer from loneliness or are unable to get in touch with other people [4,40].

In particular, men suffering from loneliness, fear of rejection, or interaction deficits and men who rate social contacts to be unimportant might benefit from interactions with female robots, as they might, for instance, be able to control their fears in human–robot interaction. The anthropomorphic tendency was already shown to be important for lonely people in human–robot interaction, as lonely people tend to anthropomorphize humanoid robots more strongly [42], and research in the field of human–robot interaction showed that a negative attitude towards robots has an influence on how people behave towards them (e.g., with regard to the willingness to engage in physical contact [49]).

In line with this and the literature review in Section 1.6, two hypotheses are derived, which explicitly (H2) and implicitly (H3) test the importance of the mentioned personality traits:

Hypothesis 2 (H2). *Loneliness, importance of social contacts, fear of rejection, the individual degree of interaction deficits, anthropomorphic tendency, and a negative attitude towards robots are predictors of the evaluation of attractiveness of robots with and without salient mechanical body parts.*

As already mentioned in the context of Hypothesis 1, implicit measurements allow a direct, unbiased insight into the associative strength between concepts. Based on this method, we wanted to empirically test whether affiliation-related personal characteristics can serve as predictors of the direct, unbiased reaction regarding the attractiveness of robots. In other words, it is conceivable that (for instance) loneliness and fear of rejection predict how strongly the concept of attractiveness is connected to sex robots, meaning how quickly the participants react in the affective priming paradigm. Therefore, Hypothesis 3 extends Hypothesis 2 by using a subliminal measurement (like in H1) to examine the influence of affiliation-related personality traits on the evaluation of attractiveness of robots.

Hypothesis 3 (H3). *Loneliness, importance of social contacts, fear of rejection, the individual degree of interaction deficits, anthropomorphic tendency, and a negative attitude towards robots are all predictors of the associative strength of the concept of attractiveness and robots (measured by reaction time between the pictures of robots and a positive/attractive word).*

To test the research question and the hypotheses, this study is separated into two parts; Study 1a is an online survey (n = 229) that aims to investigate the explicit evaluations (=self-reported) of attractiveness with regard to women and sex robots (with and without salient mechanical body parts) (RQ1) and the influences of personality traits on this evaluation (H2). Study 1b, on the other hand, is an experiment that uses the affective priming paradigm to gain unbiased insights into the associative strength of attractiveness of women compared to the associative strength of attractiveness of sex robots (H1), and again, the influence of personal characteristics on this implicit evaluation (H3). This method forces an immediate, direct reaction of the participants without any bias of norm adherence or influence of social desirability. Although both samples filled in the same questionnaire, to ensure that the data of Study 1a were not biased by the additional affective priming paradigm completed by the participants of Study 1b, the data were kept separate.

2. Materials and Methods for Study 1a (Explicit Measure of Perceived Attractiveness of Robots and Women)

2.1. Sample and Procedure

To investigate the explicit evaluations of sex robots, a total of 229 heterosexual male participants aged from 18 to 67 (M = 25.82, SD = 6.85) took part in an online survey; 53.3% (n = 122) of the participants indicated that they were in a relationship, while 107 (46.7%) were single.

The present study focused on male participants only, which is based on three important aspects: (1) Attitudes relating to sexual activities differ strongly between men and women (e.g., [17]); (2) an empirical study conducted by Schuetz and Arnold showed that men were significantly more in favor of sex robots, or the idea of using one, compared to women; and (3) the product sector focuses more on the male consumer by producing mainly female sex dolls or (first) sex robots [5].

The survey was composed of three parts. First, the participants were asked to watch a two-minute video showing female robots, such as Sophia (by Hanson Robotics) and HRP-4C (Miim; by the National Institute of Advanced Industrial Science and Technology (AIST)). We aimed to create an understanding of what state-of-the-art robots look like (e.g., facial expressions, secondary sexual characteristics), what their abilities are (e.g., standing and walking), and in which fields of application they can be used (e.g., domestic worker or training object for dentists). The second part comprised different personality measures, which will be explained in more detail in the next section. In the third part, the participants rated the (sexual) attractiveness of four women in underwear, four female robots in underwear with

salient mechanical body parts, and four female androids (biologically correct replication of women) in underwear, presented in pictures. There was a note under every picture clarifying whether the picture displayed a woman or a robot in order to ensure that the participants would understand the different concepts, especially with respect to the robots without any salient mechanical body parts. To prevent the three kinds of pictures from influencing each other, we pre-structured them such that the participants first had to rate a picture of a woman, followed by a picture of a female robot with salient mechanical body parts, and then a picture displaying a female robot without salient mechanical body parts. This process was repeated four times with different pictures in order to minimize the influence based on the appearance of a single picture and in order to reduce possible effects of randomization (e.g., cognition on one category if, for instance, three pictures of women were shown in a row instead of providing a new category in each picture in order to foster the focus on the perception of the picture and not the category).

All participants were able to look at the pictures for as long as they wished. They were then asked (with regard to the robot pictures) whether they would buy such a robot for themselves now or within the next five years and to indicate why. In an open question, they were asked what they evaluated to be attractive and unattractive with regard to the female robots in underwear with salient mechanical body parts and the female androids (biologically correct replication of women) in underwear. Finally, each participant was debriefed and had the chance to win one of three gift certificates (€50).

In total, 238 participants were recruited, but nine had to be excluded from the analysis as the corresponding box plot identified these participants as outliers.

2.2. Stimulus Material

An example of the pictures of the women is shown in Figure 1 (left). Pictures of sex dolls were used to represent the robots without any mechanical body parts (Figure 1, middle) and the pictures showing the robots with salient mechanical body parts were edited by merging heads of sex dolls with computer-generated bodies that have obvious visual distortions of the skin (salient mechanical body parts; Figure 1, right).

Figure 1. Examples of the stimulus material of the women (**left**); the robots without salient mechanical body parts (**middle**); and the robots with salient mechanical body parts (**right**). Please note that these three categories were used in Study 1a. In Study 1b (affective priming), only pictures of women (**left**) and the robots with salient mechanical body parts (**right**) were shown.

Several aspects were taken into account to ensure comparability of the pictures of the female robots with salient mechanical body parts, the female androids, and the pictures of the women: All of the robots and women wore black or white basic underwear (underpants and bra or something similar to cover secondary sex characteristics), they were all shown against a white background, all of the

pictures showed the same image section, and they all had a neutral to sexy expression on their faces (to control for likeability, for instance, none of them had an extreme smile). All 12 pictures shown were selected based on a pretest (n = 10). In this pretest, seven pictures of women, six pictures of robots with salient mechanical body parts and six pictures of robots without salient mechanical body parts were evaluated regarding attractiveness and likeability on a five-point Likert scale. Moreover, the participants had to indicate on a five-point Likert scale whether the shown robots were realistic or unrealistic to them. Based on this pretest, the pictures (four in each category) were selected that had a similar mean regarding firstly, attractiveness and secondly, likeability. In addition, the means of the robots' perceived realism were computed to exclude pictures of robots that look highly unrealistic. Figure 1 shows examples of the final stimulus material.

2.3. Measures

In the following, all relevant variables are explained. Please note that all measures had to be answered on a five-point Likert scale (1 = "disagree strongly" to 5 = "agree strongly"). Moreover, two additional measures (a self-developed scale measuring the concept of suspension of disbelief and a self-developed scale measuring the importance of the social aspects of sex) could not be used in further analyses due to an unsatisfactory internal consistency ($\alpha \geq 0.5$).

2.3.1. (Sexual) Attractiveness

Each participant evaluated the pictures of the female robots and women by means of seven semantic differentials (e.g., "sexually unattractive vs. sexually attractive"). Although the pairs of words were pretested to ensure that they covered the concept of (sexual) attractiveness, 12 exploratory factor analyses with principal component analysis and varimax rotation were computed, followed by Horn's parallel analyses [50]. For every calculation of each picture of the robots and women, one factor was suggested based on the eigenvalue criteria. Instead of only computing one factor analysis, we decided to run one for all pictures to explore possible differences between the items if robots or women were rated. The 12 exploratory factor analyses with principal axis analysis and promax rotation revealed that overall, the items "appealing", "sexually attractive", "beautiful", "exciting", and "likeable" had the highest factor loadings regardless of whether women or robots were shown. Therefore, these items were summed up to measure attractiveness with an overall internal consistency of α = 0.954.

2.3.2. Anthropomorphic Tendency

To assess whether the participants have the "tendency to ascribe human characteristics to non-human objects" (p. 214), the Anthropomorphism Questionnaire by Neave et al. was used [51]. The scale was originally developed to measure the influence of anthropomorphic tendencies on hoarding. However, the 20 items, such as "As a child I sometimes said 'hello' and 'good night' to some of my favorite toys" are worded neutrally and could therefore be used in the present study. The internal consistency was α = 0.877.

2.3.3. Negative Attitudes towards Robots

The NARS scale by Syrdal et al. is based on work by Nomura et al. and covers negative attitudes towards social/future implications, emotional attitudes and action interactions [9,48]. The 11 items (e.g., "I would feel uneasy if robots really had emotions") had an internal consistency (Cronbach's alpha) of α = 0.824. As the internal consistency of the subscales was unsatisfactory ($\alpha \geq 0.5$), the overall score was used.

2.3.4. Loneliness

The revised UCLA Loneliness scale by Russel et al. was used to assess participants' subjective feelings of loneliness [52]. The 20 items (e.g., "People are around me but not with me") had an internal consistency of $\alpha = 0.912$.

2.3.5. Need to Belong (Importance of Social Contacts)

The subscale "importance of social contacts" of the Need to Belong Scale by Krämer et al. was used to measure the importance of the contact with others in everyday life [53]. The subscale consists of five items (e.g., "I frequently think of my loved ones"). The internal consistency (Cronbach's alpha) was $\alpha = 0.772$.

2.3.6. Social Anxiety (Fear of Rejection and Interaction Deficit)

The SASKO Scale of Social Anxiety by Sabine Kolbeck contains the subscales "fear of rejection" and "interaction deficit" [44]. Each subscale contains five items, such as "I am afraid of situations in which I could get rejected by somebody of the opposite gender." and "I feel uneasy at parties because I don't know how to behave". The subscale "fear of rejection" had a Cronbach's alpha of $\alpha = 0.816$, while the subscale "interaction deficit" reached an internal consistency of $\alpha = 0.756$.

3. Results of Study 1a

3.1. Differences in Attractiveness between Robots and Women (RQ1)

To investigate whether there is a difference in men's explicit evaluation of the (sexual) attractiveness of women compared to female robots with salient mechanical body parts and female androids (biologically correct replication of women), a one-way repeated measures ANOVA with a Greenhouse–Geisser correction was computed. It should be noted that the ratings for each group (robots with salient mechanical body parts, female androids, and all women) were summed up. The results showed a significant difference between the ratings of (sexual) attractiveness between the female types ($F(1.94, 442.95) = 370.30$, $p \leq 0.01$). The Bonferroni post hoc test revealed that all of the pairwise comparisons differed significantly from another. The results showed that women (M = 3.82, SD = 0.54) had the highest attractiveness score, followed by female androids (biologically correct replication of women) (M = 2.80, SD = 0.81) ($p = 0.01$), and female robots with salient mechanical body parts (M = 2.66, SD = 0.74) ($p \leq 0.01$).

3.2. Influence of Personality Traits for the Explicit Measurement (H2)

To test whether negative attitude towards robots, perceived loneliness, the importance of social contacts, fear of rejection, interaction deficits, or anthropomorphic tendencies would significantly predict the ratings of attractiveness of robots with and without salient mechanical body parts, two linear regression analyses were computed.

The results of the linear regression for the attractiveness of robots without salient mechanical body parts showed that the regression model explained 14.4% of the variance ($F(6222) = 7.38$, $p < 0.01$), with the negative attitude towards robots (Beta = -0.40, $t(222) = -6.34$, $p < 0.01$) and fear of rejection (Beta = 0.18, $t(263) = 2.54$, $p = 0.01$) as the only two significant predictors.

The linear regression for the attractiveness of robots with salient mechanical body parts showed that 23.5% of the variance could be explained by the model ($F(6222) = 12.70$, $p < 0.01$). However, a more detailed look at the coefficients revealed that the negative attitude towards robots was the only significant predictor (Beta = -0.48, $t(222) = -8.03$, $p < 0.01$).

4. Materials and Methods for Study 1b (Implicit Measure of Attraction towards Robots and Women (Affective Priming))

The second study aimed to investigate the implicit evaluation of sex robots. The main idea of the affective priming paradigm is that the participants have to react as quickly as possible to words representing attractiveness presented for 500 ms. This enabled us to investigate the immediate reaction to sex robots, without any biases of norm adherence. Using this affective priming paradigm [54], the associative strength between women and attractiveness/unattractiveness and robots and attractiveness/unattractiveness was assessed with the help of reaction times. The basic idea is that participants are able to assign a word (positive or negative) more quickly to its category (positive or negative) if the prime (shown picture) and the target category are congruent (have a stronger associative strength) compared to incongruent trials.

Twenty-four pictures of women in underwear and 24 pictures of robots in underwear with salient mechanical body parts were used as primes. It should be noted that the displayed robots all had salient mechanical body parts to ensure that the participants would recognize the robots, as they were only shown for 500 ms. Moreover, 24 words connected to the concept of (sexual) attractiveness (positive; e.g., "affectionate", "beautiful", "gentle") and 24 words associated with the concept of (sexual) unattractiveness (negative; e.g., "unappealing", "rejection", "unfeeling") represented the targets.

Each participant performed 48 practice trials and 48 prime-target test trials. Within the practice trials, the participants had to assign each target word, which was presented in the middle of the screen, to the category attractive or unattractive. The categorization was realized by clicking on the "E" key of the keyboard for the attractive category or "I" for the unattractive category. For instance, if the word "beautiful" appeared, the participants had to click on the "E" key as quickly as possible. The category names "positive/attractive" and "negative/unattractive" were permanently displayed in the right and left corner of the screen and did not change between the trials. Within the actual test trial, the primes, pictures of women and robots, were displayed for 500 ms, followed by 100 ms black screen (Interstimulus Interval (ISI)), before the target word appeared. Affective priming paradigms often have a Stimulus Onset Asynchrony (SOA) of less than 500 ms in order to ensure that participants are not able to respond intentionally [54]. However, we consciously chose a slightly longer SOA of 600 ms to ensure that the participants were able to perceive the visual difference between the displayed women and the female robots (recognizable by the obvious mechanical body parts). The participants were instructed to focus on the assignment of the words, but also to look at the pictures. Both the practice and the test trials contained all target words (positive and negative) in a random order (without any duplicates).

4.1. Procedure

The experiment was separated into three phases. After entering the room, all participants first watched the same video (2 min) as the participants in Study 1a, displaying state-of-art female robots, in order to achieve an understanding of what robots look like, what their abilities are and in which fields of application they can be used. Following this, the examiner entered the room again in order to explain the affective priming paradigm. If no further question arose, the participants started the affective priming task. All participants received additional standardized instructions from the computer. It is important to mention that the examiner highlighted that the pictures used in the paradigm displayed women and robots. After the affective priming task, the participants took part in Study 1a. (The analyses of Study 1a do not contain these 41 participants.)

4.2. Stimulus Material

The 24 pictures of the robots and the 24 pictures of the women were composed of 12 different pictures each, which were simply mirrored because, especially with regard to the robot pictures, there were not as many pictures that could be easily aligned/retouched. All of the pictures were pretested to ensure that they would be realistic and to exclude outliers with regard to attractiveness. Some of the pictures were used in Study 1a as stimulus material for the explicit attractiveness ratings. Examples

are shown in Figure 1. The words used in the affective priming paradigm were also pretested to ensure that they could be assigned to one category (positive/negative) without any ambiguities.

4.3. Sample

The analyses were based on the data of 41 heterosexual male participants aged between 18 and 52 (M = 25.41, SD = 6.43) who participated in the affective priming task. Twenty-four participants (58.5%) indicated that they were single, while 17 (41.5%) were in a relationship. The reaction times varied between 555.79 ms and 1372.33 ms (M = 791.03, SD = 180.61). An a priori power analysis was conducted with a power coefficient of 0.80 and an effect size of 0.40, which was also found in a study by Avero and Calvo, who used a paradigm similar to that in the present study [55]. The analysis showed that 40 participants would represent a good sample size.

In total, 46 participants took part in the affective priming paradigm, but two participants had to be excluded due to misstatements given by the examiner concerning the affective priming paradigm, and three participants had to be excluded based on too long average reaction times (more than 1500 ms on average, which were probably caused by performance problems of the computer).

The participants received a payment of €5 and were recruited via social media sites and the local newspaper.

5. Results of Study 1b

Overall, the mean latencies were 792.00 ms (SD = 191.30) for the incongruent pairs and 790.06 ms (SD = 187.35) for the congruent pairs, which leads to a priming effect of 1.94 ms. A paired *t*-test on the latencies showed no significant differences ($t(40) = 0.10$, $p = 0.92$).

5.1. Difference in Reaction Times between Pictures of Women and Robots with Regard to Attractive/Positive Words (H1)

To test whether the attractive/positive target words could be assigned faster if a picture of a woman was shown compared to a picture of a female robot, which would represent the associative strength between each of those concepts, again, a paired *t*-test was computed. The descriptive data show that there was almost no difference in the time taken to assign the word to the attractive category when comparing the presentation of robot pictures (M = 766.21, SD = 188.41) and the pictures of women (M = 770.98, SD = 254.17). Accordingly, no significant difference was found ($t(40) = -0.14$, $p = 0.89$). Therefore, Hypothesis 1 was confirmed. The concept of attractiveness was not more accessible when seeing pictures of women compared to seeing pictures of robots.

5.2. Personality Traits as Predictors (H3)

To test whether the negative attitude towards robots, the perceived loneliness, the importance of social contacts, fear of rejection, interaction deficits, or anthropomorphic tendencies were significant predictors of the reaction time with regard to pictures of robots followed by a positive/attractive word, a linear regression analysis was computed. The results showed that none of the aforementioned personality traits significantly predicted the reaction time between robots and attractive/positive words ($F(6) = 0.86$, $p = 0.54$). Therefore, Hypothesis 3 needs to be rejected.

6. Discussion

With the rise of companies working on humanoid robots, sex robots will enter the market very soon. However, the topic is biased by societal stereotypes and norm adherence. The main purpose of the present study was to investigate not only whether men perceive women to be more sexually attractive compared to robots, but also whether this evaluation would differ if the men were asked explicitly and implicitly. Moreover, we aimed to gain more insights into possible personal characteristics that would influence this evaluation. We found that the explicit rating differed from the implicit rating insofar as the differences in the attractiveness ratings between women and robots were not present when the

men were asked implicitly. Moreover, we found that personal characteristics related to social life had no influence on the sexual attractiveness ratings.

6.1. Explicit Rating of Attractiveness with Regard to Women and Robots (RQ1)

The present study showed that when asked explicitly, men evaluate women to be more attractive than robots without salient mechanical body parts and robots with salient mechanical body parts. This finding should be discussed in the context of two aspects: familiarity and norm adherence. Firstly, the grading is important, as it shows that women, representing the most familiar stimulus category, were evaluated as more attractive than both kinds of robots. This is in line with the argument that humans react more positively towards things or people with whom they are familiar, because we cannot tell whether unknown objects or people are associated with danger [25,26]. Such an argument is underlined by the fact that it is very likely that the participants had not previously interacted with sex robots, leading them to rate the women as more attractive. This can also be transferred to both kinds of robots tested, as those without salient mechanical body parts were evaluated to be more attractive than those with salient mechanical body parts. The mechanical body parts, represented by wires or obvious plastic or metallic material components, not only distract the visual impression of human likeness, but might also play an important role with regard to sexual interactions people may have with them, as physical contact could be associated with a risk of injury or unpleasantness of touch. However, it should be mentioned that the descriptive statistics of the (sexual) attractiveness ratings of the robots indicated that the mean values were medium rather than low, possibly due to the fact that the (mechanical) robots also show different physical aspects that are known to be important in attractiveness evaluations, such as a low WHR or large breast size [19,20]. The other aspect that needs to be highlighted is that the participants were aware that they were rating robots (especially in comparison with women) and that this, in turn, may have influenced the evaluations. Sexual interactions with non-humans are seen as sexually deviant, and users of sex robots or sex dolls are frequently associated by the media with being desperate and lonely [37]. As they had sufficient time to think about the concept of robots in general and society's evaluation of them in particular, it can be assumed that participants reflected not only on social norms but also on the social desirability of their answers within the empirical setting.

In general, it has to be noted that 40.3% of the present sample indicated that they could imagine buying a sex robot now or within the next five years. This is fully in line with the results of Schuetz and Arnold, who showed that more than two-thirds of their male participants could imagine using a sex robot [5]. However, this willingness of so many participants to indicate such an interest speaks against the importance of social desirability.

Overall, as we did not investigate the motivations for the ratings, more research is required on stereotypes of sex robot users and the effect of salient mechanical body parts for robots in the field of applications with physical contact between human and robots.

6.2. Influence of Personal Characteristics on Explicit Attractiveness Evaluation (H2)

With regard to the influence of personal characteristics on the attractiveness ratings, the results showed that the negative attitude towards robots was the only significant predictor for both the robots with and without salient mechanical body parts. Moreover, fear of rejection was a significant predictor for the robots without salient body parts.

First of all, it should be highlighted that the post hoc test revealed that the negative attitude towards robots is a strong negative predictor for both robot versions. This is fully in line with research by Nomura et al., who showed that the negative attitude towards robots has an important impact on the evaluations of situations in which robots and humans get closer, meaning that it influences the allowed distance between robots and humans and the willingness to engage in touch with robots [49]. As these are aspects that play a huge role in the context of sexual interactions, the predictor is plausible.

The finding of a positive association between the indicated fear of rejection and the attractiveness rating of the robots without salient mechanical body parts may point to the importance of control of sex robots. In contrast to the robots without salient mechanical body parts, they look the same as women, but in contrast to women, they can be expected to not reject the user. However, it is important to keep in mind that we did not investigate underlying reasons for the importance of specific personal characteristics. Therefore, this is an aspect that needs to be investigated in more detail in future studies.

Nevertheless, both calculations reflect the title of the present study, meaning that the affiliation-related characteristics of perceived loneliness, the importance of social contacts and interaction deficits, all failed to significantly predict the attractiveness ratings of the robots with and without salient mechanical body parts. This result shows that the picture of a lonely user who is not capable of bonding with real people and instead uses a sex doll or robot was not confirmed empirically (e.g., [4,37]).

6.3. Implicit Rating of Attractiveness with Regard to Women and Robots (H1)

Another main finding is that the previously discussed finding of differences in the explicit attractiveness ratings between women and robots was not present in the implicit ratings, meaning that for the present sample there was no difference in the associative strength between the concept of attractiveness with regard to women and robots. The main difference between the two methods lies in the time which the participants had to reflect on their attractiveness ratings. First, this could have the consequence that the men had to rely on their first visual perceptions of the robots. Dixson et al. showed that men's initial visual fixation focuses either on the breasts or the waist, and as the shown robots do provide these features, it can be assumed that our participants—on an immediate and subliminal basis—reacted in a similar way to how they would react with regard to women [20]. This is in line with assumptions from evolutionary psychology that men are predisposed to attend and react to these cues as they are associated with, for instance, female reproductive capability [19]. Therefore, the result highlights the possible importance of human-like visual cues in sex robots. Second, the instant reaction forced the participants not to reflect on social or sexual norms, which might have led to more negative reactions (as discussed in the context of the explicit evaluations (RQ1)).

6.4. Influence of Personal Characteristics on Implicit Attractiveness Evaluation (H3)

The results regarding the influence of personal characteristics (negative attitude towards robots, perceived loneliness, importance of social contacts, fear of rejection, interaction deficits, or anthropomorphic tendencies) showed that none of the mentioned traits serves as a significant predictor of the reaction time with regard to pictures of robots followed by a positive/attractive word. This needs to be discussed by taking into account the results of the regression of the explicit attractiveness ratings. Here, the negative attitude towards robots was the only predictor that was significant for both the attractiveness ratings of the robots with and without salient mechanical body parts. It is possible that the instant reaction forced the participants to focus on the information provided in the short duration time (500 ms). As it is possible that the first impressions are simply based on the basic visual information (waist, breast size; see discussion of H1) and do not take into account the (recognizable) fact that the female-looking figure is a robot, it is possible that the negative attitude towards robots did not play such a large role and therefore did not serve as a significant predictor of the reaction times. On the one hand, this raises the question of whether the participants really perceived the difference between the shown robots and the women in the context of the implicit measurement. On the other hand, it highlights the importance of research on human-like visual cues in the context of sex robots.

6.5. Limitations and Future Research

One limitation of the present study is that the affective priming paradigm had a Stimulus Onset Asynchrony (SOA) of 600 ms, which is 100 ms more than suggested by Fazio et al. [54]. It could therefore be argued that the stimulus material was presented for too long and that the results could

have been based on intentional response. As the visual differences between the pictures of the women and the robots were mainly based on the salient mechanical body parts, we nevertheless deemed it more important to ensure that the participants would perceive the difference between the categories. The non-significant results, which differ from the explicit ratings, indeed support this decision. A further limitation might be seen in the selection of the participants, as we recruited them as a convenience sample on social networking sites and newspaper ads, in which we stated that the study would be about the evaluation of robots and the sexual aspects of human–robot interaction. We considered this to be important information, as the evaluation included data on intimate topics. However, it is possible that mainly men who were already interested in the topic of sex robots took part in the study.

Future empirical studies should consider previous experiences with android robots and technology that was used to fulfill sexual needs (e.g., vibrator) as possibly important variables. It is imaginable that those aspects will have an impact on the evaluation of sex robots. Moreover, it could be interesting to investigate how people would react towards sex robots if they do know for sure whether they were seeing hyper-realistic sex robots or women. The reaction towards the missing label could provide more information on the importance of uncertainties in the evaluation of sex robots.

From a more general perspective, we argue that there is a strong need for future research focusing on the user and his or her evaluation of sex robots. A long-term goal should be to investigate real interactions between humans and sex robots, as research in the context of the uncanny valley phenomenon has already demonstrated that results differ based on the form of stimulus material [28]. Since sex robots are mainly built by the adult industry, researchers rely on their technological developments in order to improve the quality of research. However, first empirical approaches using different kinds of stimulus material, such as pictures, videos, or virtual reality, and different forms of qualitative or quantitative measures should be encouraged in order to gain new insights into users' acceptance of sex robots as well as their effects.

7. Conclusions

The present paper found that, on the one hand, women are rated as more (sexually) attractive than robots (with and without salient mechanical body parts) by men if asked explicitly. On the other hand, the implicit measure did not yield any differences in the associative strength for the concept of attractiveness between women and robots. This highlights the importance of human-like visual cues for sex robots, as they have been found to play an important role in (sexual) attractiveness ratings (breast size, hips) between humans. Moreover, we demonstrated that personal characteristics related to social life, such as loneliness, do not play a significant role in influencing the ratings of attractiveness of sex robots. Instead, we found that the negative attitude towards robots is the main user characteristic that predicts the attractiveness ratings of sex robots. Taken together, the present study contributes to the almost non-existent empirical research on sexual aspects of human–robot interaction and offers many further research questions that need to be addressed in the future in order to gain a deeper understanding of users' acceptance of sex robots.

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Abbreviations

The following abbreviations are used in this manuscript:

MDPI	Multidisciplinary Digital Publishing Institute
DOAJ	Directory of open access journals
TLA	Three-letter acronym
LD	linear dichroism

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