Let's talk about Sex Robots:
Empirical and Theoretical Investigations of Sexualized Robots

Von der Fakultät für Ingenieurwissenschaften

Abteilung Informatik und Angewandte Kognitionswissenschaft

der Universität Duisburg-Essen

zur Erlangung des akademischen Grades

Doktor der Philosophie

genehmigte Dissertation

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Tag der mündlichen Prüfung: 13. Februar 2019

"What makes you different or weird,

that's your strength."

–   Meryl Streep

Danksagung

Für mich sind es die Begegnungen mit Menschen, die den Weg formen und einen zu dem machen was man ist und somit leisten kann. Ich möchte mich an dieser Stelle bei einigen Personen bedanken, die mich unterstützt und demzufolge einen wesentlichen Beitrag zum Gelingen der vorliegenden Dissertation geleistet haben.

Ich bedanke mich bei Prof. Dr. Nicole Krämer für die Offenheit und die Unterstützung in Hinblick auf die Erforschung des durchaus kontroversen Themas. Ich weiß es zu schätzen, dass ich in der Forschung mit ihr immer meinen Interessen nachgehen und gleichzeitig auf ihre Unterstützung bauen kann. Ich danke ihr für die jahrelange Förderung, das Vertrauen in meine Fähigkeiten und die Möglichkeit über mich selbst hinauszuwachsen.

Prof. Dr. Tilo Hartmann danke ich für den Austausch den wir im Rahmen der Erstellung des theoretischen Modells hatten und die zusätzliche Perspektive die er mir dadurch auf das Thema ermöglicht hat.

Ich danke den 1163 Studienteilnehmerinnen und Studienteilnehmern für die Unterstützung, ebenso wie Stacy Leigh, Derek Emmons, Freya Lingerie, Realbotix und WM Dolls für die Erlaubnis deren Bilder als Stimulusmaterial zu nutzen.

Ich möchte mich darüber hinaus beim gesamten Team der Sozialpsychologie bedanken. Ich weiß sowohl den inhaltlichen Diskurs, als auch die soziale Unterstützung sehr zu schätzen.

Ich danke insbesondere Aike Horstmann und Carolin Straßmann für den konstruktiven Austausch in Hinblick auf die Beforschung artifizieller Interaktionspartner, die APA-Hilfe und unsere terrific Tuesdays/wicked Wednesdays/freaky Fridays etc.

Ich danke zudem Leonie Rösner und Tina Ganster nicht nur für das Korrekturlesen, sondern genau wie Sabrina Eimler und German Neubaum für das Teilen des Enthusiasmus an der Wissenschaft und die moralische Stütze, in den Momenten in denen ich ersteres mal aus dem Blick verloren habe.

Ich bedanke mich im Speziellen bei Laura Hoffmann, Vera Sauer und Lena-Marie Kniffke für die offenen Ohren, guten Worte, fürs zum-Lachen-bringen und das Wissen, dass ich immer auf euch zählen kann. Ihr seid Gold.

Ebenso möchte ich an dieser Stelle Daniela, Kathrin, Anna, Matthea, Micah und Phil vor allem für all die Ablenkung von der Dissertation danken. Moreover; Thank you, Roddy.

Ich möchte meiner Mutter dafür danken, dass sie mir meinen Lebensweg ermöglicht und dafür gekämpft hat. Ich weiß, dass du immer für mich da sein wirst.

Zu guter Letzt danke ich Raphael Penning für sein Vertrauen in mich, die Unterstützung, unsere Augenhöhe, den Halt, aber auch für die bunten Ideen, die wir für die Zukunft haben. Du und ich zusammen.

Annotation of the papers included in the cumulus

Research Paper 1:

Szczuka, J. M., & Krämer, N. C. (2017). 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. *Multimodal
  Technologies and Interaction*, *1*, 3. https://doi.org/10.3390/mti1010003

Research Paper 2:

Szczuka, J. M., & Krämer, N. C. (2019). There's More to Humanity than Meets the Eye:
  Differences in Gaze Behavior towards Women and Gynoid Robots. *Frontiers in
  Psychology, 10:693.* https://doi.org/10.3389/fpsyg.2019.00693

Research Paper 3:

Szczuka, J. M., Hartmann T., & Krämer, N. C. (Accepted). Negative and positive influences
  on the sensations evoked by artificial sex partners - A review of relevant theories, recent
  findings, and introduction of the sexual interaction illusion model. In Y. Zhou & M.
  Fischer (Eds.) *AI Love You - Developments on human-robot intimate relationships.*
  Springer

Research Paper 4:

Szczuka, J. M., & Krämer, N. C. (2018). Jealousy 4.0? An empirical study on jealousy-related
  discomfort of women evoked by other women and gynoid robots. *Paladyn, Journal of
  Behavioral Robotics*, *9*, 323–336. https://doi.org/10.1515/pjbr-2018-0023

Media Coverage (Choice of printed and online Articles)

In the following, media reports are presented which refer to parts of the present dissertation. It should be noted that the results of the included studies are reproduced correctly. This however illustrates the controversial discussion about sexualized robots.

Eine Stunde Liebe [One Hour of Love]: Liebe mit Robotern: Knutsch-Aufsätze und Sexmaschinen [Love with robots: kissing-systems and sex machines] (2017, January 06) [Television broadcast]. Deutschlandfunk Nova. Retrieved from https://www.deutschlandfunknova.de/beitrag/eine-stunde-liebe-sex-mit-robotern

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Zusammenfassung

Der technische Fortschritt im Bereich der Robotik ermöglicht vielseitige Nutzungsszenarien. Neben der Entwicklung von immer sophistizierteren Industrierobotern, gewinnt die Vermenschlichung der Technologie immer mehr an Bedeutung, was vor allem für die Interaktion mit Menschen sowohl Chancen als auch Risiken bergen kann (Bar-Cohen & Hanson, 2009). Ein Anwendungsbereich der hierbei besonders kontrovers diskutiert wird ist das Erbauen von Robotern zur Befriedung sexueller Bedürfnisse. Hierbei werden hyperrealistische Sexpuppen mit elektro- und feinmechanischen Bauelementen ausgestattet, welche auf Grundlage von Algorithmen und Datenstrukturen den Eindruck verbaler und nonverbaler Kommunikation vermitteln können (Bartneck & McMullen, 2018). Auf Grundlage der Media Equation Theory (Nass & Moon, 2000; Reeves & Nass, 1996) kann davon ausgegangen werden, dass die so entstehenden sozialen Hinweisreize der Roboter zur Aktivierung von sozialen Skripten beim Menschen führen. Es ist darüber hinaus denkbar, dass gerade der sexualisierte Kontext der Interaktion aufgrund von distinkten Motivationen einen Einfluss darauf hat, wie sozial das artifizielle Gegenüber wahrgenommen wird. Dieses Potential wird beispielsweise in Hinblick auf mögliche negative Konsequenzen für die Objektifizierung von Frauen kritisiert (Richardson, 2016). Um die Chancen und Risiken der Technologie realistisch einschätzen zu können, sind empirische Untersuchungen unabdingbar, jedoch werden sexualisierte Interaktionen im akademischen Kontext oftmals außer Acht gelassen (Brewer, Kaye, Williams, & Wyche, 2006).

Das Ziel der vorliegenden Dissertation ist es, anhand von ausgewählten methodologischen Ansätzen sich eben genau dieser entstandenen Forschungslücke anzunehmen und das soziale Potential von sexualisierten Robotern zu untersuchen. Das soziale Potential wird hierbei in Form von perzeptuellen Prozessen und Evaluationen betrachtet, da diese Prozesse die Basis für weitere Interaktionen bilden. Um eine umfassende Betrachtung zu erzielen, sollen nicht nur Evaluationen und Perzeptionen potentieller Nutzer, sondern auch potentielle negative Konsequenzen für das soziale Umfeld der Nutzer (hier in Form der Beziehungspartnerin) Betrachtung finden. Da sowohl die ersten robotischen Prototypen als auch die Verkaufszahlen bisheriger hyperrealistischer Sexpuppen darauf hindeuten, dass heterosexuelle Strukturen auch bei sexualisierten Interaktionen mit Robotern prävalent sein werden (Bartneck & McMullen, 2018), fokussieren die vorliegenden Untersuchungen

heterosexuelle Männer als Nutzergruppen und heterosexuelle Frauen als deren Partner (Studie zur technologiebasierten Eifersucht).

Die erste Schrift untersucht den Einfluss von Einsamkeit, welche potentiellen Nutzern stereotypisch unterstellt wird und fokussiert darüber hinaus Unterschiede zwischen expliziten Attraktivitätsbewertungen von Frauen und Robotern und implizit abgerufenen Assoziationen (Szczuka & Krämer, 2017). Schrift 2 befasst sich mit der Frage, ob die Darstellung von artifiziellen sekundären Sexualcharakteristika dazu führt, dass evolutionär eingeprägte Prozesse der Perzeption in Hinblick auf potentielle Partner auf Roboter übertragen werden (Szczuka & Krämer, 2019). Um dies angemessen zu untersuchen, wurde die Blickbewegung mittels Eye Tracking examiniert. Die dritte Schrift ist eine theoretische Abhandlung, welche interdisziplinäre Theorien und Befunde aus den Bereichen der Medienpsychologie, Sexualwissenschaft und Sozialwissenschaft in Hinblick auf deren hemmenden oder bestärkenden Einfluss auf eine mögliche entstehende sexuelle Illusion gegenüber einem artifiziellen Sexpartner konzeptualisiert (Szczuka, Hartmann, & Krämer, accepted). Die letzte Schrift betrachtet potentielle negative Konsequenzen für das soziale Umfeld der Nutzer in Form der Beziehungspartnerin (Szczuka & Krämer, 2018). Im Detail wurde hier untersucht, ob Roboter im gleichen Maße das Potential haben Eifersucht in Frauen auszulösen wie menschliche Kontrahentinnen.

Die Befunde der ersten Studie zeigen zum einen, dass Einsamkeit keine große Rolle in Attraktivitätsbewertungen hat und deutet darüber hinaus darauf hin, dass die schematische Darstellung sekundärer Sexualcharakteristika in Robotern ähnliche Assoziationen zum Konstrukt Attraktivität aktiviert wie menschliche Darstellungen. Die Ergebnisse der Eye Tracking Studie untermauern jedoch, dass Menschen auf einer perzeptuellen Ebene zwischen Robotern und Frauen unterscheiden, sobald klar ist, dass es sich um ein artifizielles Gegenüber handelt - ungeachtet der Menschen- oder Maschinenähnlichkeit der Roboter. In Kombination mit den in dem theoretischen Model betrachteten positiven und negativen Einflussfaktoren, welche auf die sexuale Illusion wirken, lässt sich aus den Ergebnissen ableiten, dass in initialen Rezeptionen Replikationen von Sexualcharakteristika durchaus ähnliche evaluative Assoziationen hervorrufen wie bei Frauen, dass jedoch bei Bewusstsein, dass es sich um artifizielle Gegenüber handelt unterschiedliche perzeptive Prozesse ausgelöst werden. Was jedoch bei der Betrachtung einer verantwortungsvollen Handhabung der Technologie berücksichtigt werden muss, ist das Potential der Theorie negative Konsequenzen für das soziale Umfeld zu schaffen. Die Ergebnisse der vierten Schrift zeigen, dass Frauen sich bei der Vorstellung, dass ihr Partner Sex mit einem Roboter hatte, genauso unzulänglich fühlen, als

hätte er eine sexuelle Interaktion mit einer anderen Frau gehabt. Somit darf nicht vergessen werden, dass die durch die Technologie induzierten Bewertungen des Selbst und der Beziehung negative Konsequenzen für das soziale Umfeld der Nutzer entstehen können. Die Schriften des vorliegenden Cumulus liefern neue Erkenntnisse über evaluative und perzeptive Prozesse in Hinblick auf sexualisierte Roboter im Vergleich zu Frauen und bilden somit eine empirisch untermauerte Basis für Diskussionen um eine verantwortungsvolle Handhabung der Technologie und zukünftige Untersuchungen sexualisierter Interaktionen zwischen Menschen und artifizieller Sexpartner.

Abstract

Technological advances in robotics allow a variety of use cases. While industrial robots can become increasingly sophisticated, there is a growing interest in the humanization of the technology. The implementation of human-like features might be beneficial for interactions between humans and robots but can also be accompanied by potential risks (Bar-Cohen & Hanson, 2009). One field of application that is a topic of particularly controversial debate is the construction of robots that are built to fulfil sexual needs. Hyper-realistic sex dolls are equipped with electromechanical and fine-mechanical components that can convey the impression of verbal and non-verbal communication on the basis of algorithms and data structures (Bartneck & McMullen, 2018). Based on the Media Equation Theory (Nass & Moon, 2000; Reeves & Nass, 1996) it can be assumed that these conveyed social cues may lead to the activation of social scripts within users. Furthermore, the sexualized context sex robots are used in may cause specific social reactions to the machines based on the evoked distinct motivational states that accompany sexual arousal. This social potential is criticized as it is for instance claimed to contribute to the objectification of women (Richardson, 2016). Empirical studies are indispensable in order to realistically estimate the technologies' opportunities and risks. However, academia mostly neglects sexualized usages of technologies (Brewer, Kaye, Williams, & Wyche, 2006).

The aim of the present dissertation is to address this research gap by investigating the social potential of sexualized robots by using both implicit and explicit methodological approaches. The mentioned social potential is considered by investigating evaluative and perceptional processes as both are part of initial reactions towards sexualized robots and might be influential for subsequent social reactions. In order to obtain a comprehensive view, the included works not only investigate the evaluations and perceptions of potential users, but also include an investigation of the potential negative consequences for the users' social environment (here in the form of the relationship partner). Since both, the first robotic prototypes and the sales of hyper realistic sex dolls, indicate that heterosexual structures will be prevalent in sexualized interactions with robots (Bartneck & McMullen, 2018), the included research paper focus on heterosexual males as users and their female partners (study on tech-based jealousy).

The first paper examines the influence of loneliness, which is stereotypically assumed to be prevalent for potential users, and moreover focuses on differences between explicit

attractiveness ratings of women and robots and implicitly retrieved associations (Szczuka & Krämer, 2017). The second paper addresses the question whether the presentation of artificial secondary sexual characteristics leads to the adapt of deeply rooted evolutionary processes of mate perception (Szczuka & Krämer, 2019). To investigate this appropriately, the eye movements of participants have been examined by means of eye tracking. The third manuscript introduces a theoretical model that conceptualizes interdisciplinary theories and findings in the fields of psychology, sexology, and social science in terms of their inhibitory or empowering influences on a possible emerging sexual interaction illusion towards artificial sex partners (Szczuka, Hartmann, & Krämer, accepted). The last paper considers potential negative consequences for the users' social environment in the form of the relationship partner (Szczuka & Krämer, 2018). In detail, it was examined whether robots have the potential to evoke jealousy in women to the same extent as human counterparts do.

The findings of the first study indicate that loneliness does not play a major role in attractiveness assessments, and further suggest that the schematic representation of secondary sexual characteristics in robots activates similar associations to the construct of attractiveness as human representations would do. However, the results of the eye tracking study support the assumption that humans distinguish between robots and women on a perceptual level if they are aware that the stimuli are robotic, regardless of the human-like or machine-like appearance of the robots.

In combination with the positive and negative influencing factors considered in the theoretical model, it can be deduced that robots do trigger quite similar evaluative associations as women do within initial receptions, but that the cautiousness of being confronted with an artificial entity triggers distinctive perceptive processes in comparison to human stimuli. However, in the reflection about a responsible handling of sex robots it needs to be considered that the use of the technology has the potential to negatively influence the users' social environment. The results of the fourth study showed that robots have the ability to make women feel just as inadequate as if their partner had sex with another woman. Thus, it must not be forgotten that the technology-induced evaluations of the self and the relationship can have negative consequences for the social environment of users. Taken together, the writings of the present cumulus provide new insights into evaluative and perceptual processes in relation to sexualized robots compared to women. The implications of the present dissertation are aimed to serve to contribute to a responsible handling of the technology, as a foundation for the controversial discussions about sex robots and to encourage scientific research on sexualized interactions with robots.

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I.   Introduction

Throughout the history of technological advances, humans have numerous times used technological developments to fulfill their sexual needs (Döring, 2009; Gordon, 1980). While there are a few examples of technologies that have been specifically designed to be used for sexual satisfaction (such as vibrators), often technologies that were invented for another primary purpose have been used for the fulfillment of sexual needs (e.g., telephone sex or displaying pornographic content via the Internet or TV). With the rise of robotics, machines which until now have primarily been conceptualized to assist humans with various tasks based on their robustness (e.g., lifting heavy parts, working in environments that are challenging for humans based on the temperature, Bar-Cohen & Hanson, 2009) there are more and more use cases in which robots are being employed in social contact with humans. Within the area of so-called social robots, one of the most controversially discussed fields of application are human-like robots that are built to be deployed as artificial sex partners. Here, hyper-realistic sex dolls are being equipped with electromechanical components and technologies such as motors, speakers, and databases that are aimed to convey the impression that the robots are capable of verbal and non-verbal behaviors, which in turn should enable a more lifelike interaction with the potential users (Bartneck & McMullen, 2018). Contrary to already existing sex dolls, sex robots therefore have the ability to interactively engage with the user and use natural language for communication, both of which are factors that are assumed to contribute to the social reactions people show towards technology (compare media equation theory, Reeves & Nass, 1996). The resulting new possibility to engage in intimate and sexualized interactions with machines has already raised a lot of public attention. Scholars, essayists and journalists mostly discuss sexualized robots by evaluating the emerging technology normatively. Here, on one side the technology is praised as an opportunity for humans to act out sexual needs and fantasies without being judged or being dependent on the consent of another person (Danaher, Earp, & Sandberg, 2017). Moreover, the usage of sexualized robots is predicted to positively affect people who are in some ways physically or psychologically constrained and therefore have difficulties in social and/or sexual interactions with other humans (Bartneck & McMullen, 2018; Levy, 2008). Contrary to this, sexualized robots have also been strongly criticized for the potential to negatively affect especially the societal standing of women. The concerns range from the prevalent fear of being replaced by robots (e.g., Ellen, 2017; Mackenzie, 2014) to the embracement of objectifying women and resulting changes in the conceptualization of sexuality and the cohabitation in long-lasting relationships (e.g., Richardson, 2016).

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Empirical research, which would help society to understand how potential users react towards the technology (also in comparison to the human counterpart) is strongly under-represented (Sharkey, van Wynsberghe, Robbins, & Hancock, 2017). On the one hand, academia neglects sexualized interactions with technologies in general (Brewer et al., 2006). Among other reasons, this may be due to the high interest of media in sex research and potential consequences. McBride et al. (2007) conducted interviews with both journalists and scientists and concluded "journalists reported that controversy sells news, whereas for sex researchers, the same controversy can threaten funding, result in restrictive policies, and lead to negative consequences for the individual or the field." (p. 354). The result of this neglect, however, is that we only gain a marginal understanding of how technologies might change the conceptualization of sexuality and relationships, which in the case of sexualized robots might be crucial in order to ensure responsible handling of the technology. On the other hand, the investigation of sex robots requires a careful consideration of the right methodological approaches, including the usage of an appropriate stimulus material (especially as in the moment there are only prototypes of sex robots available). As the process of perceiving, evaluating and lastly engaging in a sexualized interaction with a robot is likely to be influenced by aspects such as the internalization of sexual and social norms and potentially the wish to not deviate from them, user-centered research on sexualized robots needs to consider multi-methodological approaches in order to meet the requirements of this multi-dimensional topic.

Some researchers might underestimate the importance of investigating sexualized robots due to the early stage of development of this technology. However, research on sexualized robots will play a key role in estimating the potential risks and benefits of the emerging technology and here it is of special importance to early identify how people react towards a technology in order to protect society from harm. According to Danaher (2017b), sex robots are likely to be affected by the so-called Collingridge or control dilemma (Collingridge, 1981). This dilemma is constituted by the potential impact the advancement might have on society and the unknown effects it might be accompanied by. In the early stage of distribution, the effects of the technology on society might not be comprehensible; but once widespread and investigated, the influences on society might be hard to control or even impossible to change.

The goal of the present dissertation is therefore to address the resulting research gap by gaining a first understanding about the social potential of sexualized robots by investigating how people perceive and evaluate sexualized robots in comparison to humans. Here, social potential is conceptualized as the potential to evoke associations, perceptions and evaluations that are comparable to processes that are evoked by humans. For this purpose, three empirical

studies have been conducted in addition to one theoretical model that has been derived from relevant theories from the fields of media psychology, sex science and social science. In order to provide a comprehensive understanding of how humans react towards the phenomenon, two empirical studies focus on how potential users perceive and evaluate sexualized robots, while the third investigation examines potential negative consequences sex robots might have for the users' social environment. In detail, the two studies which focus on potential users of sexualized robots investigate initial reactions towards the technology in terms of how heterosexual males perceive and evaluate the technology and what kind of associations sexualized robots evoke in comparison to associations evoked by women. The factors that might influence the perception of sexualized robots, namely their ability to evoke sexual arousal along with the resulting social sensations that might contribute to an engagement in sexual activities with artificial sex partners, were summarized in the introduced sexual interaction illusion model. Furthermore, the third study addresses the potential of a sex robot to be perceived as a love rival by investigating jealousy-related discomfort caused by robots in comparison to human women.

An analysis of the market revealed that 80% of the sex dolls sold (which can be understood as a precursor for sex robots) represent the female gender and that the largest target group (80%) is composed of males (Bartneck & McMullen, 2018). As the present dissertation includes some of the first empirical studies on the topic, heterosexual males as the most likely target group of sex robots were chosen to represent the investigated user group. Consequently, the study investigating the social environment in terms of the partner focused on heterosexual women. However, the synopsis also acknowledges the need for further research on more diverse user groups (see chapter 5.6 on the outlook).

Based on the elaborations, this dissertation aims to provide a valuable contribution to the knowledge on sexualized human-robot interactions by investigating initial perceptions and evaluations of sexualized robots in comparison to females. The innovativeness of the dissertation is not only grounded on the transfer of relevant interdisciplinary theories (mainly (media) psychology and sexology) to a cutting-edge technology, but also in the carefully chosen methodological approaches (affective priming, eye tracking, thought experiment) which were chosen in order to sophisticatedly examine perceptions and evaluations with regard to sexualized robots. The results and their discussions are intended to provide valuable implementations for responsible handling of the technology and should moreover serve as a basis for the controversial discussions about sexualized robots.

The present synopsis first provides an overview of all relevant theories from the field of (media) psychology, studies on human sexuality and social science, followed by an explanation

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of the research objectives. After that, the three empirical studies and the theoretical model are explained in more detail, followed by a discussion of the results. Lastly, the dissertation contains all accepted and submitted papers which are discussed in the present synopsis.

II.   Theoretical Background

2.1   Sexualized Robots: An Overview

While the basic idea of a robot is that of a machine constructed to help people execute different kinds of tasks in which being a non-human can be of advantage (e.g., because it is more resistant towards different influences such as temperature), there are also robots that are specifically built for interactions with humans (so-called social robots). One of the most controversial applications discussed for so-called social robots are sexual interactions. Danaher (2017a) defined three aspects that need to be implemented into a machine so that it can be considered a sex robot: a) a humanoid form, b) human-like movement/behavior and c) some degree of artificial intelligence. The humanoid form implies that the machines are (in some form) equipped with cues that can be associated with the biological sex. While there are also scholars who proclaimed that robots have the potential (especially for women) to overcome gender-related boundaries and stereotypes (Haraway, 2006), sexualized robots clearly counteract this idea "as this gendering emphasizes their function." (Søraa, 2017, p.110). McMullen, who owns one of the companies that now equip sex dolls with technology, stated 80% of the dolls they produce represent the female gender (Bartneck & McMullen, 2018). The representation of the gender is one of the biggest concerns of critics of the technology. Based on existing hyper-realistic sex dolls, it can be assumed that the vast majority of sexualized robots will have a human-like appearance (also referred to as android) rather than a machine-like (also referred to as humanoid). Human-like robots are designed to be replications of humans and therefore are equipped with details ranging from human-like silicone skin to eye-brows. Sexualized robots differ from the first human-like robots that have been developed to the extent that they provide replications of sexual characteristics. Bar-Cohen and Hanson (2009) stated that it might be beneficial to have human-like robots so that they can support humans in the best possible manner and this might especially be true for sexualized robots, since humans (almost entirely) until now only participated in sexual interactions with other humans. The other two definitional aspects named by Danaher (2007), the human-like behavior in combination with artificial intelligence, will be crucial regarding the question whether it social reactions occur towards sexualized robots. According to media equation theory, machines that communicate in natural language and interact with the user and/or represent a social role have the ability to evoke social responses that are comparable to the ones that are evoked if confronted with another human being (see chapter 2.2.2 for details on media equation theory).

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Those aspects will enable social interactions which make it unnecessary to rely on the mere imagination for interactions with an inanimate entity.

The idea of artificial entities that are loved or can be used to fulfil sexual needs is not new. Some scholars see the origins of the phenomenon in the Greek mythology by referring to the love story of the sculptor Pygmalion who fell in love with his statue called Galatea that was brought to life by the goddess of love and pleasure Aphrodite (Devlin, 2015; Sullins, 2012). The idea of machines that look like and to some extent behave like humans was then shaped within fictional works such as Karel Čapek's play R.U.R. - Rossum's Universal Robots (Karel Čapek,; 1920) or I, Robot by Isaac Asimov (1950). Numerous subsequent fictional works then combined the idea of robots with one of the most prevalent topics in literature which is love and lust. Examples for this range from stories in which humans fall in love with artificial entities based on their implemented behaviors (e.g., "Ex Machina"; Garland, 2014) to narratives in which robots are portrayed that are specifically built to fulfill human sexual needs (e.g., "Westworld"; Nolan & Joy, 1973).

Even before the idea of human-shaped robots and potential relations between robots and individuals, humans have started to use technological advances to fulfil sexual needs. The intentions however were rather clinical than social. One of the first electromechanical vibrators was invented in the 1880s in order to treat women who suffered from what was called female hysteria (Maines, 1999). The positive thing about the invention was that no other person (which during that time was a physician) was needed in order to sufficiently help women to overcome symptoms such as nervousness, insomnia or sexual desire. Almost 140 years later, the usage of vibrators is widespread (Herbenick et al., 2011) and the technological developments in robotics are on the edge of bringing the science fictional idea of robotic lovers to life.

In the year 2018, the first convincing prototype (in terms of aspects such as used materials, synchronized and fluent movements and implemented non-verbal behaviors) of a sex robot was made commercially available (Realbotix, 2018). For the moment, only the head is equipped with technology in the form of basal artificial intelligence, speakers that are synchronized with the lips in order to create the impression that the robot is able to verbally communicate (interactively) and movable parts such as the neck and eyes. The body is made of silicone, can be fully customized and provides detailed replications of sexual characteristics. The robotic head can be connected to a smartphone application which makes it possible to switch between different personae (Realbotix, 2018). To stay in line with the purpose the robot was built for, the communication implemented in the robotic head system strongly emphasizes erotic aspects (e.g., if you ask it about hobbies, it will offer stereotypical answers such as

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reading, making new friends but also making love to "you", "America Inside Out," 2018). Within the next few years the developers aim to also equip the body with technology which would imply for instance warmth to replicate a body temperature and implemented verbal and non-verbal reactions based on touch. Figure 1 shows an example of a sex doll, while figure 2 shows the existing robotic head which can be pre-ordered.

Figure 1. Example of a sex doll (picture of a Realdoll taken by Stacy Leigh)
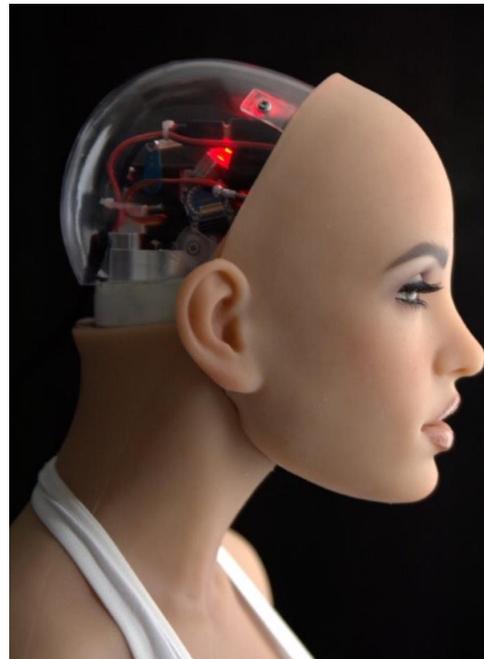
Figure 2. Robotic head system of the company Realbotix

Sexualized robots can be used to fulfil any sexual needs and can therefore be of interest for people of different gender and sexualities (including the ones in relationships; see Levy, 2008). Developers also highlight the potential therapeutic purpose by stating that robots might help "certain people overcome social anxiety or relationship phobia" (Realbotix, 2018). If asked explicitly, the number of respondents who profess to be open minded about having sexual interactions with robots strongly varies (percentages range from 16%, see Pike & EdenFatasy, 2018; to 40.3%, see Szczuka & Krämer, 2017; to 70%, see Scheutz & Arnold, 2016). However, different sources claim that the sex-technology market is worth around $30 billion with a growth of 30% per year (e.g., Kaur, 2018), which underlines the relevance of the technological development.

Robots that are built for sexual needs are controversially discussed by both scientists and journalists. Sex robots combine the topic of sex with that of robots, whereby the attitude can range from being excited and enthusiastic about it to strong rejection and even anxieties (Nomura, Kanda, Suzuki, & Kato, 2008). Sex is a topic which is on the one hand very natural

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as it is the origin of life, but, on the other hand, also a topic that can be considered a taboo to talk about (especially in specific cultures and associated religions, Morgan, Thorne, & Zurbriggen, 2010). Kate Devlin commented on the combination of both topics in an interview with the online magazine Wired:

> The taboo surrounding sexuality still hugely impacts our society, even if we'd like to consider ourselves very progressive… Add this to our in-built fear of technological change, especially when it involves a loss of agency, and there you have it: a recipe for complete moral panic. (McMullan, 2018)

Because of the described lack of empirical research, scholars, journalists and essayists elaborate on positive as well as negative futuristic scenarios and therefore discuss sex robots mostly from a normative point of view. David Levy (2008) was one of the first to write a book on the potential future about love and sex with robots in which he elaborates on several rather optimistic outcomes for different groups of users. As an example, humans who are in a relationship with another individual could use sex robots as extensions in order to fully act out their sexuality (e.g., because some sexual preferences do not match with one's partner or because one partner desires to have more frequent sexual interactions). Also, lonely individuals or those who have physical and/or psychological difficulties in social interactions could use sex robots to release sexual tensions and/or even fall in love with the human-like machines. Levy (2008), but also other scholars moreover, claim that sex robots could diminish some of the problems associated with sex work (e.g., human trafficking or transmission of (sexual) diseases; Yeoman & Mars, 2012).

Contrary to this, others argue that human-like sexualized robots might be especially problematic for the societal standing of women. Alesich and Rigby (2017) for instance argue that sex robots could contribute to the replication of optical female stereotypes especially because there is a bias of males working in the field of robotics who then decide how a robot meant to fulfill sexual needs should look. It is imaginable that costumers could be inspired by both female and male body types presented in for instance erotic magazines and pornographic movies, which in turn have been shown to negatively affect the female and male satisfaction with their own body (heterosexual women: Shaw, 1999; heterosexual and homosexual males: Peter & Valkenburg, 2014). For reasons such as this, Kathleen Richardson founded the "campaign against sex robots" in which she raises concerns that clearly advocate against the production and usage of this technology (Richardson, 2015). She for instance argues that love

and sex with robots may cause a decrease in empathic skills that can only be learned in "mutual relationships" and that sex robots contribute to the objectification of women and children as they can be used at any time for any possible sexual act. With regard to child sex dolls and robots it needs to be noted that on June 13th 2018 the United States House of Representatives just approved an act that prohibits the importation and transportation of any child sex doll or robot ("CREEPER Act of 2017," 2018). According to journalists it is likely that this decision will also be supported by the senate (Vagianos, 2018). However, this aspect underlines how complex and multi-faceted and therefore potentially controversially discussed sexualized robots can be, as there are also scientists who note that the usage of robots can potentially prevent people from being harmed sexually and that there is no clear scientific evidence that would legitimize a prohibition, which in turn would fuel a black market for dolls and robots that are prohibited (e.g., Klein, 2018; Sharkey et al., 2017; Strikwerda, 2017).

Both the optimistic future portrayed by David Levy in which humans will love robots as well as Kathleen Richardson's attempt to ban sex robots have been criticized before. Not only are both scenarios not based on any empirical investigations, they both lack some core conceptualizations in their reasoning. David Levy for instance was criticized for his behavioristic and functional conceptualizations of love that lack reflection on how robots can engage in a genuine mutual romantic love (Nyholm & Frank, 2017; Sullins, 2012). Kathleen Richardson, at the other end of the normative spectrum however, is criticized for drawing parallels between the relationship of a sex worker and a client and the relation between a sex robot and the user and the primarily negative view on sex work she refers to (e.g., generalizing that all sex workers are treated like objects, see Danaher et al., 2017). What I find important to consider is that both views have in common that especially males will automatically transfer evaluations and behaviors towards robots to women because of a human-like appearance and lifelike behaviors; still, empirical research on this is strongly under-represented.

Even though it should be unnecessary to underline, there are numerous aspects of humans that at the moment are not developed and probably will take a long time or simply will not be possible to be artificially recreated. Examples range from biological processes such as reproduction, cognitive-biological processes like facial movements that reflect on the inner state of a person to interpersonal, (social) psychological dynamics. Referring to the latter, there are theoretical constructs such as the self-determination theory (Ryan & Deci, 2000) which in terms of relationships propose that people have the tendency to integrate traits of a partner such as values and goals that have been found to positively affect romantic relationships (Patrick, Knee, Canevello, & Lonsbary, 2007). Computer scientists, however, argue that it might not be

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beneficial for humanity if machines were able to develop complex structures like this (Muehlhauser & Helm, 2012). Sullins (2012) elaborated on sexualized robots and the implementation of behaviors that evoke feelings of reciprocal affection from a philosophical and ethical perspective and concludes (by referring to Socrates): "We can only find the philosophically erotic thorough the encounter with the complexity of the beloved, complexity that not only includes passion, but may include a little pain and rejection from which we learn and grow" (p. 408).

In the following, the theoretical concepts representing the foundation for the included empirical studies and the introduced sexual interaction illusion model will be explained in more depth. In the beginning perceptional processes and resulting social reactions will be explained. This is followed by an elaboration about the importance of the match between the internalized sexual script and the displayed artificial sex partner and its behavior. I argue that this is crucial in order to get sexually aroused by an artificial entity, which as a concept is consequently explained afterwards. After this, I will elaborate why sexualized robots are a technology that might be accompanied by both reactions of approach and avoidance. Aspects that might contribute to the latter (such as the violation of social and sexual norms or the relevance of the uncanny valley) will be explained subsequently. Finally, the theoretical background will be completed by an overview of related work and an exploration of aspects that need to be considered for empirical research.

2.2 Perceptional Processes and Social Reactions towards Robots

Perceptions are the foundation of subsequent social reactions not only within humans, but also with regard to robots. For this reason, the following subchapters will explain perceptional processes followed by an elaboration of social reactions towards robots which is mainly composed of the media equation theory and the suspension of disbelief.

2.2.1 The processes of robot perception.

Before looking at social reactions towards robots, it is important to consider whether robots can evoke similar processes of perception as the gathered information shapes subsequent cognitions such as (social) reactions and evaluations (Bodenhausen, Macrae, & Hugenberg). There are first empirical investigations on perceptual processes on robots in comparison to humans based on their visual similarities (e.g., Rosenthal von der Pütten, 2014). One example would be a study by Zlotowski and Bartneck (2013) in which the authors compared the perceptional processes of robots with those of humans (and objects) by investigating the so-

called inversion effect. The theory implies that humans have more difficulties in recognizing faces when they are presented upside down, while this is not the case when objects are presented (Yin, 1969). The reason for this is that faces are processed in three steps. The first steps refer to sensitivity to first-order relations, which means that first humans recognize something as a face because of its features. Secondly, holistic processes are activated, which refer to the process of integrating facial features into a gestalt and third, a person needs to perceive the spatial distances between facial features (Maurer, Le Grand, & Mondloch, 2002). Zlotowski and Bartneck (2013) found that humans do not show the inversion effect with regard to objects, while the effect can indeed be observed regarding inverted pictures of robots (and humans). The authors therefore conclude "on the cognitive level, robots were processed more like humans than objects" (p. 370). The study provides a basis for assuming that sexualized robots have the potential to trigger perceptual processes that are similar to the ones among humans based on their shape and facial features. However, studies on individual processes of perception and connected physiological processes (such as visual perception) are needed in order to fully understand whether robots and which aspects of the robots are perceived in a similar way as humans are. Sexualized robots are equipped with details of the human body which would be unnecessary for other robots (such as replications of the breasts). It is, for instance, important to know how users perceive the replications of the sexual characteristics and whether they perceive them in the same way as they do with humans in order to gain knowledge on the robots' ability to be perceived as potential (sex-) partners.

2.2.2   The media equation theory.

The media equation theory is one of the most influential theories about social reactions towards technological devices. The theory was proposed by Reeves and Nass (1996) who argued that people have the tendency to mindlessly react in a social way if confronted with a computer that provides sufficient social cues. This definition is composed of different aspects that need to be explained in more depth: The precondition for social reactions are cues that trigger "scripts, labels, and expectations" (Nass & Moon, 2000, p. 83) which in turn shift the attention towards the aspects that are in line with them and away from information that would interrupt the activated scripts (Nass & Moon, 2000). In consequence, humans do not reflect on the question whether the entity warrants social treatments. The mindlessness and directness of the social reactions, which is also referred to as ethopoeia (Nass & Moon, 2000), is underlined by results of studies showing that people explicitly indicated that social rules should not be applied to machines (e.g., Nass, Steuer, Henriksen, & Dryer, 1994). The activation of social

scripts which humans usually apply in interactions with other people results in different social responses towards different kinds of artificial entities (e.g., robots, virtual agents or computers in general). Examples of empirically investigated social responses towards non-living entities range from politeness (e.g., Nass, Steuer, & Tauber, 1994; Hoffmann, Krämer, Lam-chi, & Kopp, 2009), engaging in mutual self-disclosure (e.g., Moon, 2000; Rosenthal von der Pütten, Hoffmann, Klatt, & Krämer, 2011), showing social reactions based on group affiliations and the usage of social categories (e.g., in terms of gender, Nass, Moon, & Green, 1997; Powers et al., 2005) to showing emotional reactions (such as showing empathy; Rosenthal von der Pütten, Krämer, Hoffmann, Sobieraj, & Eimler, 2013). Cues that are associated with humans, and therefore trigger the previously mentioned social responses in machines are natural language, interactivity and the representation of social roles. Even though Nass and Moon (2000) do not list appearance as one of the cues that are necessary to evoke social reactions, they do acknowledge that artificial entities which have a human-like appearance (they are referring specifically to robots and dolls) make it easy for people to react socially towards artificial entities. And there are multiple empirical studies which could show that human-like cues in machines, ranging from cartoonish faces to sophisticated human-like appearance can impact intended social reactions (e.g., Kim, Moon, Choi, & Kwak, 2014). However, it is important to mention that this is not always a linear relationship, especially in terms of positive and intended reactions (see chapter 2.3 for details on the theory of uncanny valley).

There is one experimental study which aimed to investigate whether humans show social responses towards machines in close interactions. In their study, Li, Ju, and Reeves (2017) investigated the evoked physiological arousal during the process of touching a humanoid robot (Nao) in more or less accessible body regions, such as the genitals or buttocks. The accessibility was varied because for humans, less accessible parts are also associated with a higher degree of closeness. The results revealed that humans do show a higher level of physiological arousal if touching low-accessibility body parts of a humanoid robot, which is a first hint that also social reactions of intimacy and closeness can be transferred to robots. However, it is important to mention that the evoked physiological arousal cannot be equaled with sexual arousal; rather the arousal reflected on discomfort as the humans would most likely also feel discomfort if a human were to ask a person to touch low-accessibility parts such as the genitals. This however, this was mis-reported in some media coverage as an empirical evidence that robots can "turn on" humans (e.g., Blakemore, 2016).

Even though related, the concept is not to be mistaken with the individual tendency to anthropomorphize non-living objects. While ethopoeia is a situational reaction towards a non-

living entity based on its provided cues, anthropomorphization is the tendency of "attributing humanlike properties, characteristics, or mental states to real or imagined non-human agents and objects" (Epley, Waytz, & Cacioppo, 2007, p. 865) and has not necessarily to do with the cues that are provided. Nass and Moon (2000) also point out that people who anthropomorphize objects might believe that the object warrants the social treatment.

To conclude, sexualized robots (even if only equipped with a robotic head) should have the technological ability to provide the required social cues named by Nass and Moon (2000) in order to activate social scripts as they have the ability to engage in conversations by using natural language, can verbally and non-verbally act and react in an dynamic, interactive way and represent the social role of a caring partner for more or less intimate interactions. However, one aspect that is crucial within social reactions towards technological devices is that they should not underline their artificialness because otherwise people would realize that the social reactions are not appropriate (Nass & Moon, 2000). One aspect that might influence the way how people approach an artificial entity might be the willingness to suspend aspects that might underline the artificialness of the partner. In line with this, the theory of suspension of disbelief will be explained in the following.

2.2.3   Suspension of disbelief.

The theory of suspension of disbelief was originally proposed by Coleridge about the enjoyment of theater and displayed fictional scenes (Coleridge, 1819). The main idea is that humans temporarily constitute what Coleridge (1819) named "poetic faith" (p. 6) if being confronted with a fictional scene in order to fully enjoy it instead of constantly questioning aspects that deviate from the real world. The acceptance of a fictional scenario as real is therefore accompanied with processes of forgetting or disregarding that the mediated content does not represent the actual world (Böcking, 2008). Consequently, this not only causes the transformation to another reality, but more importantly in the context of the present work, it is associated with the ability to react socially based on what is happening in this world. The theory has already been investigated in the context of theater plays, while reading books, during the reception of movies (Böcking, 2008) and also while playing videogames (Nowak, Krcmar, & Farrar, 2008). Duffy and Zawieska (2012) were one of the first to discuss the relevance of suspension of disbelief in the context of social robots and concluded: "(…) the very nature of human-robot social interaction is fictional rather than factual, and this fundamentally supports the idea of suspending disbelief when we socially engage with machines" (p. 489). Although both the media equation theory and the theory of willing suspension of disbelief emphasize

social reactions towards mediated contents, there are some differences between the theories. Byron Reeves, who was one of the persons to propose the media equation theory, stated that the social reactions elaborated within the media equation theory are based on automatically activated social scripts which do not require any willing suspension of disbelief (Reeves & Read, 2009). While Böcking (2008) acknowledges that this might be specifically true for the process of selection of the fictional stimuli, she however also explains (based on Cohen, J., 2006) that the acceptance of a fictional world throughout the reception is not an active decision anymore. She argues that it is rather an active decision to remember that a once accepted content is fictional. The first aspect however which states that one can willingly choose to be confronted with a fictional scene in order to perceive enjoyment is interesting in the context of sexualized robots as this could mean that a user's motivation to engage in an interaction in order to be sexually satisfied could contribute to the acceptance of the interaction as temporarily real. Böcking (2008) elaborated on the fact that not only aspects of the medium but also of the user might affect how likely one constitutes "poetic faith" in order to be entertained. Here, she states that there can be motivational, cognitive and personality traits that might influence the willingness to engage in fictional content. To name only a few examples, the motivation to be entertained or to be relaxed by the fictional content might contribute to a state in which the disbelief dominates and therefore causes a higher level of tolerance against aspects that break with the created illusion. Also, the need for cognition was named as a potentially influential variable as it is accompanied by the tendency to analyze the environment. In line with Böcking (2008), Duffy and Zawieska (2012) elaborated on aspects of the medium, which in this case were robots, that might influence the way in which humans can accept an interaction as truly social by highlighting their appearance (and here specifically eyes as an important aspect), movements and speech. This is again similar to the aspects conceptualized in the media equation theory to evoke social reactions. To conclude, the theory of suspension and disbelief also states that users can engage in social interactions with artificial entities. In contrast to media equation theory, this theory highlights that users can willingly expose themselves to the fictional content in order to satisfy specific motivations (such as being entertained or relaxed) and it is imaginable that this is therefore transferable to the motivation to fulfill sexual needs.

2.3   Relevance of the Uncanny Valley?

As an extension to the described social reactions towards robots I want to shortly elaborate on the relevance of the uncanny valley which is frequently named in the same breath as reactions of avoidance and the human-like appearance of robots. In the 1970s Masahiro Mori

proposed a model in which he interrelated the affinity towards a robot with the human-like appearance of it (see Mori, MacDorman, & Kageki, 2012). Mori refers to the experience of being confronted with a prosthesis and finding out that the prosthesis is artificial as a process which caused an "eerie sensation". This negative impression illustrates that affinity and human-likeness of a robot are not positively linearly related. Moreover, Mori hypothesizes differences between still and moving robots with moving robots to evoke more intense reactions (in both positive and negative ways, see Mori et al., 2012). Humanoid robots (or as named in the present thesis human-like robots) can be characterized as having a human shape and therefore a torso, a head, legs, hands and in some cases even facial features such as eyes. However, they can easily be recognized as non-human entities as they do not strive to be a hyper-realistic robotic replication of humans. They usually differ from humans in aspects like the size or the skin (which usually is made of materials such as plastic or metal, see Bar-Cohen & Hanson, 2009). In the uncanny valley model, these robots are located in the first segment, in which affinity and human-likeness are still positively related. Contrary to this, human-like robots (also referred to as android robots) are predicted to fall into the uncanny valley as they are designed to have a strong resemblance to humans but still are likely to be identified to be artificial. There are different approaches to explain why especially human-like robots are said to evoke reactions of eeriness. For example, some researchers argue that the negative reactions towards human-like robots are caused by conflicting human and non-human cues and the violation of expectations based on the perceived cues (e.g., MacDorman & Ishiguro, 2006). Others proposed that the eeriness might be a protective mechanism to avoid stimuli which provide cues that symbolize diseases or death (e.g., Mori et al., 2012). Especially the latter might be a strong reason to avoid sexualized robots as this would come close to the abnormal paraphilia of necrophilia, which describes a sexual tendency where the perpetrator is sexually aroused by corpses (which by law is prohibited in many countries, see Aggrawal, 2009).

However, almost 50 years after the uncanny valley theory was proposed there were numerous attempts to empirically investigate the uncanny valley. Research showed that not only characteristics of the users and their previous experiences with robots need to be considered (ranging from gender to the general negative attitude towards robots, see Destephe et al., 2015; Nomura et al., 2008), but that also methodical considerations such as the way in which participants were confronted with a stimulus (picture versus video versus a real interaction), and the robots used. Variations in these led to both confirming but also contradicting results (Rosenthal von der Pütten, 2014; Rosenthal von der Pütten & Weiss, 2015).

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As there are not that many convincing human-like robots yet, research cannot safely say whether those robots all fall into the uncanny valley. Therefore, it is questionable whether sexualized robots will be affected by the prognosed negative reactions. David Hanson (2006), who works on human-like robots (such as the robot Sophia), argues that aesthetics are central in order to avoid negative reactions. Hyper-realistic sex dolls (see chapter 2.1 for a picture) have been found to be aesthetically pleasing for their owners (Langcaster-James & Bentley, 2018). It could be imaginable that their robotic versions have the potential to overcome the uncanny valley, at least for the owners who willingly engage with them.

2.4   Sexual Response towards Sexualized Robots

While the theories on social reactions towards machines represent the basis for the assumption that machines can evoke (social) reactions that are comparable to the reactions we show towards other humans, the following chapters will elaborate on how robots might or might not evoke sexual responses in users. In the following I will therefore elaborate on the potential importance of the matching between internalized sexual scripts and how sexual arousal might be manifested in the interactions with robots.

2.4.1   Sexual script (goodness-of-fit).

During their lifetime, every human develops a set of rules which define how sexually relevant stimuli are processed. Gagnon and Simon (1973), who proposed the sexual script theory, noted on this: "Scripts are involved in learning the meaning of internal states, organizing the sequencing of specifically sexual acts, decoding novel situations, setting the limits on sexual responses and linking meanings from nonsexual aspects of life to specifically sexual experience" (Gagnon & Simon, 1973, p. 19). Those scripts include influences from the culture one lives in, personal experiences but also intrapsychic reflections such as sexual fantasies (Gagnon & Simon, 1973, cf. Wiederman, 2015). Mosher (1988) was one of the first to link the consumption of pornographic videos to this theory and argued that fantasy which is stimulated by pornography provides a safe space for "the exploration in erotic reality of a range of fantasied variations around the core of a preferred sexual path" (p. 71-72). The coherence between one's own sexual script and the content of the displayed sexual scene, which includes the sexual behavior itself but also the roles of the actors, was labeled as goodness-of-fit. Because sex with non-living entities such as robots can be categorized as a fetish (see chapter 2.5.1 for details on sexual norms) and might therefore not be included in the vast majority of sexual scripts at first glance, they have even more potential to be used to

act out sexual fantasies in comparison to static presentations of sexuality such as pornographic videos. Not only can the appearance of sexualized robots be fully customized, ranging from body proportions to the hairstyle and eye color, but the representation of sexual characteristics can also be implemented on an individual basis. A robot is moreover theoretically able to execute all movements (in accordance with the technologies' degrees of freedom), which means that a robot is able to perform a wide range of sexual behaviors. In combination this means that users are able to try and act out all their sexual fantasies.

2.4.2 Sexual arousal.

If not influenced by diseases of dysfunction or medical influences, sexually relevant stimuli (e.g., in the form of visual sensations, touch, sounds, smell) can cause physiological and cognitive changes that contribute to sexual arousal (Lehmiller, 2014; Spiering & Everaerd, 2007). One of the aspects that are important for the evaluation of sexual relevance of the stimuli is the gender of the presented person/s. Here, different studies using a variety of measures (e.g., eye tracking or genital responses) could show that males tend to be sexually aroused by one preferred gender, while women are considered to be "non-specific" (Chivers, 2010; Fromberger et al., 2011). Sexual arousal is moreover also affected by associations and memories individuals have formed through personal experiences, but also with regard to societal and sexual norms (Spiering & Everaerd, 2007). Research could show that the resulting sexual arousal has an influence on decision making and evaluations. Ariely and Loewenstein (2006) referred to Rolls (1999) and argued that just as with hunger and thirst, humans have an increased motivation to engage in a sexual interaction once a person has an opportunity which includes the state of sexual arousal. In their experiments, they were able to show that individuals agreed significantly more often to different sexually-related activities/questions, such as "Are women's shoes erotic?" or "Would you find it exciting to have anal sex?" if they were sexually aroused (which was manipulated by asking the participants to masturbate and answer the questions at a high level of arousal but before experiencing an orgasm) compared to if not sexually aroused. In another empirical investigation, Skakoon-Sparling, Cramer, and Shuper (2016) were able to show that humans tend to make more risky decisions if sexually aroused (e.g., participating in unprotected sexual intercourse) and concluded

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[…] sexual arousal incites a form of myopia, or tunnel vision, where attentional focus is placed on the object of desire, in this case, sexual gratification, and on the self (i.e., one's own enjoyment/pleasure), rather than being placed on more distal factors such as concern for others or on future considerations. (p. 34)

Transferred to human-robot interactions, this could mean that once sexually aroused, individuals may have a higher motivation to participate in the sexual interaction with robots without reflecting on aspects that could negatively impact the illusion (such as the influence of sexual and societal norms or see chapter 2.5.1). The resulting powerful sensation of sexual interaction illusion (see chapter 4.3 for details on the sexual interaction illusion model) may cause the users to accept the artificial partner as a present social interaction partner, rather than focusing on the robot as non-living entity. The robots' potential to evoke sexual arousal might therefore cause other social reactions compared to less arousing interactions one can have with robots (such as getting assistance in scheduling the week).

2.5 Approach and Avoidance with regard to Sexualized Robots (and Aspects that might cause the Avoidance of interactions with Sex Robots)

While the latter chapters elaborated on how sexualized robots might cause not only social but also sexual responses, the following chapters will address aspects that are specific for artificial entities and could therefore negatively impact the evoked sexual responses towards sex robots. The basis for this is the assumption that sexualized robots might cause a conflict of approach and avoidance reactions which will be explained in the following.

Whenever a decision and/or a behavior is simultaneously associated with both, positive/desired as well as negative/undesired consequences, humans have to face an approach-avoidance conflict (Ehrlich & Fasbender, 2017; Lewin, 1935). The two competing systems are the motivation to approach a certain decision or behavior, which in neuropsychology is associated with the pursuit of reward, while the other motivational system counteracts this, as it tries to inhibit the associated punishment (Gray, 1987). According to Lewin (1935), the approach or avoidance of a specific behavior is influenced by its a) magnitude of valence (e.g., if the approach appraisals are strong enough to counterbalance the avoidance-related undesired consequences, the conflict is likely to result in approach behavior) and b) the distance (e.g., the closer one gets to a behavior which one aims to approach, the more the tendencies to avoid the specific behavior decrease) (cf. Heckhausen & Heckhausen, 2010). The main idea of such intra-personal conflicts between pleasure and pain concerned humans throughout history, as it was

discussed even in Greek philosophy in the context of ethical hedonism, which legitimizes human behavior based on the premise that humans should strive to maximize happiness and pleasure and minimize pain (Elliot & Thrash, 2002). One might intuitively think that sexual interactions strongly represent the hedonistic view, as sex is associated with pleasure, but research shows that sexual interactions can evoke an approach-avoidance conflict (Impett, Peplau, & Gable, 2005).

With regard to sex robots, it is likely that reflections of norms may play an important role that could even cause reactions of avoidance towards the technology. Therefore, in the following, I will elaborate on the violation of sexual norms and the importance of social desirability as a reaction on the violation of norms. The role of the users' social environment and associated social norms will be explained in a separate chapter afterwards.

2.5.1 Violation of sexual norm and associated stigmata.

Even though it is not easy to define which sexual behaviors deviate from sexual norms, as a) norms have different frameworks (e.g., statistical norms which are based on frequency or clinical norms which are shaped by clinical assumptions about deviant sexual behavior that is categorized as medical issue) and b) they are highly influenced by the spirit of the age and cultural backgrounds, it is safe to say that sexual interactions with inanimate objects can be categorized as paraphilic sexual behavior or more precisely as a fetish and therefore deviate from at least statistical sexual norms (Motschenbacher, 2014; Briken & Berner, 2013; Worthen, 2016). In the latest version of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) those paraphilic sexual behaviors have been additionally marked as disorders that are not necessarily problematic or require treatment as long as they do not cause problems for the person him or herself or the person's social environment (Lehmiller, 2013; Mackenzie, 2014). For the moment it is questionable whether sexual interactions with robots that have the potential to evoke social sensations within a user can be equaled as a sexual act with an inanimate object. However, deviations (as it can be understood with regard to sex with robots) from norms are often accompanied by negative social stigmata (Worthen, 2016).

Erving Goffman (1986) extensively elaborated on humans who deviate from what others define as norms. He proposed that "unnatural passions" (p. 4) are a form of character stigma and explained that once the stigma is attached, the person is "reduced in our minds from a whole and usual person to a tainted, discounted one" (p.3). Goffman further explained that once a stigma is attached, it can cause discrepancies between the virtual social identity, which is mainly composed of stereotypes, and the actual social identity. People who are identified as choosing

a sex doll (which can be considered as the precursor of robots) for intimate interactions are frequently portrayed as not being capable of having intimate interactions with humans and/or being lonely by, for example, the media (e.g., Taves, 2016) and the movie industry (e.g., "Lars and the Real Girl," 2007). The stereotype of the "social misfit" was also encouraged by David Levy (2008) who stated on this "Many who would otherwise have become social misfits, social outcasts, or even worse will instead be better-balanced human beings." (p. 304). Moreover, the usage of sexualized robots is sometimes depicted as being especially suitable for people who are in some way constrained for instance because of their physical abilities but also because of their age (e.g., Cox-George & Bewley, 2018). The company Realbotix which developed the first prototype of a robot one can have sex with, explicitly states on their website "We also believe that this technology will prove to be a very effective way of helping certain people overcome social anxiety or relationship phobia." (Realbotix, 2018). Langcaster-James and Bentley (2018) conducted interviews with 83 sex doll owners and found that there are indeed some people who claim to own sex dolls (which represent the preliminary stage of sex robots) because they have difficulties with contact to other people. In a study about sexualized robots and their usage, Scheutz and Arnold (2017) asked subjects to indicate to what degree they find different cases of usage of sex robots appropriate and the results revealed that the statement "for disabled people" was one of the two highest scoring items (for more details on the study see chapter 2.7). Consequently, it needs to be acknowledged that people who are in some way socially constrained might benefit from the interactions with robots, especially as they provide a controllable safe space. It therefore needs to be considered that this stereotype could also play a role in the decision to initially approach a sex robot.

2.5.2 Social desirability.

As already explained, sexualized robots are a controversial topic. The technology combines human-like robots with sexuality, both of which are topics that are accompanied by questions of morality and norms (e.g., see Veruggio & Operto, 2008 for robotics; Worthen, 2016 for sexuality and Bendel, 2017 for sexualized robots). Based on the influences of norms, there are sometimes discrepancies between attitudes and behaviors (e.g., in terms of explicit evaluations). Research on topics such as virginity (Antonovsky, Shoham, Kavenocki, Modan, & Lancet, 1978) or extramarital sexual relations (Maykovich, 1976) has already shown that incongruences between attitudes and behaviors exist in sexuality. Based on the wish to be in line with social norms and therefore enjoy societal approval rather than stating the "actual truth" which might be socially unacceptable (Krumpal, 2013), topics like sexualized robots are likely

to be affected by social desirability. Even though it is imaginable that heterosexual males overestimate their openness towards sexualized robots and evaluate them more positively in order to demonstrate their masculinity (as frequent sexual interactions are part of the male sexual script; Byers, 1996), it is more likely that attitudes towards sexualized robots are negatively biased because of the elaborated violations of sexual norms and social stigmata.

2.6   Social Environment

In line with violated norms and the wish to be in line with the opinion that is accepted by the majority, the present chapter will elaborate on the how the social environment of a user might react towards a sex robot but also on the fact that these reactions may affect the user her or himself.

While the majority of scientific work and coverage in the media primarily focus on how potential users react towards sexualized robots, there might be a very important influence which has been mostly neglected so far; the social environment of the user. In the aforementioned elaborations on stigmata, Goffman (1986) argued that different forms of stigmata are more or less easy to manage as they are more or less concealable. Therefore, it is possible to hide some stigmata in order to avoid negative social consequences. Because there are no visual signs of sexual preferences, humans do not necessarily need to disclose them to others. However, research showed that it might be stressful to hide important aspects of their own personality, like sexual preferences. In a recently published review by Hall (2018) which included 35 studies, the author was able to show that, among people from the LGBTQ (Lesbian, Gay, Bisexual, Trans, Queer) community, hiding, managing sexuality and thoughts about coming out are influential stressors. Research was also able to show that having a secret can even intensify the thoughts around the secret (Lane & Wegner, 1995). Langcaster-James and Bentley (2018) conducted an interview study with sex doll owners and found that one of the disadvantages of them quoted are that they have to be a secret. Unfortunately, the paper does not elaborate on that in more detail; but transferred to sexualized robots, the fear of peer rejection and the question whether the user's social environment would accept sexual interaction with a robot (once it if freely communicated or once a secret interaction is revealed) could affect the initial decision to approach a sexualized robot. Because robots that are built for sexual needs are not the size of, for instance, a vibrator, it might not be easy to hide them. Persons who are part of the household might therefore sooner or later be confronted with the truth.

The person who would be most affected by the purchase of a sexualized robot is the partner in an existing relationship. Levy (2008) is convinced that sexualized robots might be beneficial for couples who have problems in sexual interactions as the robots might not only be used to act out sexuality whenever and however a person wants, but more importantly, they might be able to teach the art of sex. However, Levy also acknowledges that there might be partners in relationships who might get jealous of a robotic lover. A market survey which was conducted by an online sex shop found that 30% of the 2000 Americans asked indicated that they considered sex with a robot as cheating (Pike & EdenFatasy, 2018). Moreover, research on the attitude towards vibrators showed that 29.6 % of the 1047 males asked indicated that they would feel intimidated by the female partner using a vibrator for sexual fulfillment (Herbenick et al., 2011). As robots will provide significantly more social cues and might be programmed to represent specific personae over time, jealousy is an issue that needs to be addressed in research in order to raise the awareness that not only might the user her or himself be affected by the usage, but that, by implication, the negative reactions of the user's partner might backfire on the user by affecting her or his relationship in a negative way.

With regard to the social environment (e.g., parents or friends), it remains unclear whether the user's intimate interaction with a robot might negatively influence the relationship and therefore might be accompanied by negative consequences for the user. The fictional movie "Lars and the real girl" portrays how hard it can be for a social environment if a sex doll is understood as a companion who should take part in activities of daily life (for instance a family dinner, "Lars and the Real Girl," 2007). Future studies need to include users' social environments in order to understand how the usage of a sex robot might affect the users' social life (Bendel, 2017).

2.7   Related Work on Sexualized Robots

Even though there is an extensive body of research about the usage of robots in several fields of applications (such as health care or learning), sexual interactions with robots have been mostly neglected in academia (see chapter 2.1 for details on the underrepresentation of sex research in human-computer interaction, also compare Döring & Pöschl, 2018). In 2015, the scientific conference on Love and Sex with robots was shut down by the Malaysian police by explaining that "there is nothing scientific about sex with robots" (Welsh, 2015). This does not only underline that sexualized robots evoke controversial reactions, but it does demonstrate that for some people scientific research on sex robots is not as accepted as research on other fields

of application in robotics and that it has a rather filthy image. However, it is important to include sexual interactions with technology in the research agenda, as it is crucial to understand how such technological advances might shape our society and the understanding of connected concepts such as sexuality and commitment (Sharkey et al., 2017). This is the only way academia can contribute to a responsible handling of technologies like sexualized robots.

Since empirical research on sexualized robots is scare, the present chapter outlines first attempts to encounter the topic from an empirical perspective. Subsequently, aspects will be discussed that are needed to be considered within research on sexualized robots.

Richards, Coss, and Quinn (2017) empirically investigated predictors for a hypothetical sexual interaction with a robot. de Graaf and Allouch (2016) compared the likelihood and potential positive and negative outcomes of different fields of applications of robots (including robots as sex partners). Lastly, a study by Scheutz and Arnold (2017) will be introduced in which ethical ramifications of sexualized robots have been evaluated. This overview is not only helpful in order to see which aspects have been investigated but also to see what kind of methodological approaches have been used so far.

The first study which was presented at the Love and Sex with Robots conference 2016 by Richards et al. (2017). They asked 133 participants, of which 63 were males and 70 females, how likely they would engage in a sexual interaction with a robot. The investigated predictors were relationship satisfaction, sexual satisfaction, fear of intimacy, sexual sensation seeking, sex drive, sexual fantasies and the negative attitude towards robots. The results showed that sexual sensation seeking, which is the openness towards novel and even risky sexual behaviors, and the tendency to have sexual fantasies positively predicted the likelihood to engage in sexual interactions with a robot while the negative attitude towards robots was a negative predictor. All the other included variables did not show any significant correlation. Unfortunately, the analysis did not include a comparison of the participants' gender. Even though the study can be criticized because there was no stimulus such as a picture, video or written scenario that would make sure that the participants had a mutual understanding of what a sex robot can look like or what abilities the robot has, the study is the only one that investigate the participants' own intention to use a sex robot.

In the study by de Graaf and Allouch (2016), potential positive and negative societal consequences of specific fields of applications for robots have been investigated. 1162 Dutch participants between the age of 18 to over 60 took part in the online survey of which 51.1% were male and 48.9% female. The participants had to answer a questionnaire online in which they were not only asked to answer questions about their demographics and their associations

with the concept of robots, but more importantly for the context of the present dissertations, they were asked to respond to five different written scenarios which introduced different fields of application. The written scenarios were chosen in order to ensure that the participants were not influenced by the appearance of the robots. With regard to robots as sex partners the results showed that the participants rated the likelihood of a robot to be a sex partner to be less realistic than for instance a robot being used as a butler, soldier or teacher, but more realistic than the scenario of robots being a romantic partner or nanny. This result is especially interesting as it shows that the most individuals might not be able to realistically estimate how far the technological advances are. The three mostly indicated positive consequences of sex robots were "none", to "decrease casualties" and "for special target groups". With regard to the negative consequences the participants most often indicated again "none", followed by "changed norms/values" and "impersonal". In combination with the estimation of what kind of fields of applications for robots would be most realistic, the high number of "none" indications with regard to both, the positive as well as negative consequences could be understood as a hint that people have not engaged with the idea of sexualized robots yet, which could not only be due to a lack of information but more importantly because of the missing personal relevance.

The most elaborated study on the acceptance of sexualized robots was conducted by Scheutz and Arnold (2017) (earlier version; Scheutz & Arnold, 2016). In their study they investigated the expected capabilities a sex robot should have, how appropriate different use cases are, the expected physical form, advantages, disadvantages and general views on sexualized robots. The questions were answered by 198 participants (114 males and 84 females) from the US, in the age between 18 and 63. Similarly to the study by Richards et al. (2017), the questions were asked without providing any stimulus material. Regarding the attributes the robots should be capable of, the three highest ratings were that it should be capable of "being instructed", that it "obeys orders", that it "moves by itself". It has to be noted that the item "it is specifically designed to satisfy human desire" showed the highest ratings ofagreement but as this is no particular capability, I did not list it. The results further revealed that the top three of the most appropriate forms of usage are "for disabled people", "instead of prostitutes" and "to reduce the risks of transmitted disease". Regarding the most appropriate form of an sexualized robot, Scheutz and Arnold (2017) found that "an adult human" was the most agreed form, followed by "any recognizable life form" and "one's current partner". The three highest rated advantages of sex robots that have been identified by the study are "no disease transmission", "sex is available anytime" and "no psychological impact on the partner (i.e., the robot)". On the other hand, the three disadvantages the participants agreed on the most were that sexualized

robots "might harm relationships with other humans (e.g., abusive, controlling, hatred for other humans)", "sex with the robot will become addictive" and "transfer unrealistic expectations to humans, leading to disappointment and abuse". The last finding of the study refers to general opinions on sex robots. Again, the three items that most people agreed to were "having sex with a robot does not violate any law", "one cannot rape sex robot" and "people could fall in love with sex robots". In needs to be noted that the earlier vision of the paper (Scheutz & Arnold, 2016) does include differences between men and women, but I chose to report on the revised version of the study.

In general, it needs to be highlighted that studies like the one from de Graaf and Allouch (2016) and Scheutz and Arnold (2017) are an important first approach to understand how society conceptualized sexualized robots. However, it needs to be discussed that in both studies people were asked to normatively evaluate a technology that they maybe have not heard of (which would explain the low ratings regarding how realistic the technology is) but also that there are some items that the participants simply cannot evaluate. For instance, there are no studies which show whether sexualized robots are a good way for disabled people to have sex with and yet it was one of the most agreed on appropriate usages. Moreover, it needs to be highlighted that previous studies showed that the lack of personal involvement might influence the way how information is processed which in turn affects the resulting attitude (Petty, Cacioppo, & Goldman, 1981). Therefore, asking individuals to normatively judge something that has not even a high relevance for themselves, holds the danger of participants reproducing the knowledge, respectively the associated stereotype they know, instead of reflecting on their attitudes. Taken together, the studies do provide valuable first indications of what society thinks about sexualized robots, but they do not provide concrete information about the acceptance of potential user and moreover do not include any potential other groups of people that could be affected by the usage of sex robots (e.g., the users social environment). Moreover, all studies gathered their data based on explicit evaluations and did not used any pictures or videos as stimulus materials. In the following I will discuss the importance of the latter aspects by elaborating on the challenges of empirical investigations on sex robots.

2.8   Challenges of Empirical Investigations on Sexualized Robots

Empirical research on the topic of sexualized robots is particularly challenging because the chosen methodology needs to reflect on the danger of a low validity of the data. There are two aspects that can particularly influence the informative value of a result of an empirical study on sexualized robots: (1) the usage of an appropriate stimulus material and (2) considerations

concerning the influence of social desirability (see chapter 2.5.2 on details about social desirability in the context of sexualized robots).

2.8.1 Stimulus choice.

Because at the moment there are only first prototypes of sexualized robots (which are not fully equipped with technology, see chapter 2.1 for details), it is not possible to investigate actual interactions with sexualized robots. Therefore, it needs to be carefully considered which stimulus can be chosen in order to ensure that all participants have a mutual understanding of what state-of-the art robots are able to execute (e.g., show implemented facial expressions and first attempts to make robots walk) and how they can look like (Devlin, 2018). This is especially important as subjects can be influenced by their prior knowledge about robots which is frequently shaped by science fiction movies (Bruckenberger et al., 2013).

2.8.2 Control for social desirability effects: implicit vs implicit measurements.

Chapter 2.5.1 already elaborated on how the violation of sexual norms and the associated stereotype of being lonely or not capable of finding intimacy with another human could potentially influence the social desirability of attitudes towards sexualized robots. Sexuality is considered to be a so-called sensitive topic because answering questions related to this requires self-disclosure and can be accompanied with feelings of shame, embarrassment or even social sanctions (Bradburn & Sudman, 1979; Lee & Renzetti, 1990; Tourangeau & Yan, 2007). Therefore, it needs to be considered whether user-centered research questions on sexualized robots can be addressed by asking participants explicit questions or whether it can rather be beneficial to use implicit and/or physiological measures.

Implicit measurements "aim to capture psychological attributes (e.g., attitudes, stereotypes, self-esteem) without requiring participants to report a subjective assessment of these attributes." (p. 283, Gawronski & Houwer, 2014). One commonly used way to quantify implicit reactions are response latencies and/or error rates in assignment tasks. For example, in the affective priming task by Fazio, Sanbonmatsu, Powell, and Kardes (1986), individuals are confronted with primes (e.g., words or pictures) right before they should assign words to a category (e.g., positive or negative). The associate strength between the prime and a category of words can then be assigned based on how fast the individuals perform the task and how many mistakes they make. Another form of gathering information without explicitly asking subjects about it are physiological measures. Here, reactions of the body are quantified and afterwards correlated with psychological states (Hewstone, Stroebe, & Jonas, 2015). Examples for this could be the assessment of the heartrate, or salivary cortisol levels in order to access individual

levels of stress (e.g., Ditzen et al., 2007) or the tracking of eye movements in order to quantify visual attention (e.g., Fromberger et al., 2011).

Implicit and physiological approaches can be particularly helpful in situations in which respondents could have difficulties in verbalizing/stating an specific attitude and/or attitudes are likely to be influenced by social desirability (Hewstone et al., 2015). Therefore, they have been used successfully in numerous studies in which attitudes related to sexuality were investigated, that in some way could have been biased by sexual or societal norms. For instance, implicit measurements (here implicit association test and priming tasks) and physiological measures (pupil dilation) can be used to identify a person's sexual orientation (especially with regard to heterosexual males) without the need to rely on the person's self-report (e.g., Rieger & Savin-Williams, 2012; Snowden, Wichter, & Gray, 2008).

Based on these elaborations, implicit and physiological measurements are considered to be helpful (compared to explicit measurements) in order to gain a more unbiased knowledge on how people perceive and evaluate sexualized robots. However, the only few empirical studies that aim to investigate how people evaluate the technology of sexualized robots all represent surveys that explicitly ask for the participants opinions. Indeed, there are also advantages of explicit evaluations. With online surveys it is possible to reach a larger and more diverse audience as the method does not rely on people who come into the lab. Moreover, it is possible to collect the data faster compared to experimental settings in which usually only one person can be tested at the same time. Sue and Ritter (2012) who also elaborated on the advantages named before, mentioned that because online surveys are anonymous and usually filled out at home, they provide a save space to answer sensitive questions.

To conclude on the importance of methodological considerations, future research on sexualized robots should aim to incorporate a wider range of methodological approaches in order to provide a more overarching understanding of how people evaluate, perceive and react towards sexualized robots. In line with this, the subsequent chapter presents the research objectives of the present dissertation witch among other aspects emphasize the usage of different methodological approaches.

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III.   Research Objectives

As already elaborated, the field of human-computer interactions has the tendency to neglect sexual aspects in the usage of technology (Brewer et al., 2006). In consequence, there is a lack of knowledge that could be gained not only with regard to interactions itself, but also about the influence technologies might have on the conceptualization of sex and relationships. However, this could be of special importance with regard to sexualized robots, as different scientist and scholars have raised concerns that might affect the societal standing of women and the cohabitation in relationships. Therefore, scientists have highlighted that empirical research is needed in order to realistically estimate positive and negative consequences the technology might have (Sharkey et al., 2017). It might be of special importance to investigate the perceptions of sexualized robots in an early stage of the technological development in order to advice a responsible handling. Otherwise, societal consequences might be hard to control once the technology is widespread (Collingridge, 1981; Danaher, 2017b).

The aim of the present dissertation is therefore to contribute to a more profound understanding on perceptual and evaluative processes of both potential users and the social environment (here in form of the users' partners) with regard sexualized robots. This reflects on the two overarching goals of the present dissertation, which is to provide insights on the social potential of sex robots in terms of the question whether sexualized robots evoke similar perceptual and evaluative processes as human counterparts do, while at the same time this knowledge is intended to serve as a needed basis to the discussions about sexualized robots. As sexualized robots represent replications of humans that are intended to be used in interactions which until now have been predominantly practiced among humans, the investigation of differences and similarities in the perceptions and evaluations of humans and robots is essential in order to realistically estimate the technologies social potential. This will be crucial in the estimation of potential risks and benefits of the technology and might help to provide a foundation for the discussions of various concerns (e.g., the fear of being replaced, Mackenzie, 2014).

In order to innovatively investigate this, the present doctoral thesis is composed of three empirical studies and one theoretical consideration which aim to investigate the following overarching questions:

- Are there differences in the perception of sex robots in comparison to women?
- Are there differences in the evaluations of sex robots in comparison to women?

- Can Sex Robots have negative consequences for the social environment in terms of the partner of a user? If so, are the negative consequences as strong as with other humans?
- Does the human-likeness of the sex robots affect the perceptions, evaluations and the evoked negative consequences for the partner?

Figure 3 shows a graphical representation of the included works and their emphasis.

	Explicit Measurments	Implicit Measurments	Theoretical Model
User-centered Perceptions and Evaluations	Evaluation of Attractivness	Implicit Association with Concept of Attractivness (Affective Priming Paradigm) *Research Paper 1*	Sexual Interaction Illusion Model *Research Paper 3*
		Processes of visual Perception (Eye Tracking) *Research Paper 2*	
Consequences for the Users' Social Environment	Jealousy-related Discomfort in Female Partners *Research Paper 4*	*Empirical Studies*	

Figure 3. Overview of the included works

Research on human-robot interaction from a psychological perspective might help humans to gain a more profound understanding of our social nature (Feil-Seifer & Matarić, 2009). In order to implement this rationale in the present dissertation, the first two overarching research questions were formulated. Because at the moment social reactions cannot be examined within real interactions between humans and sexualized robots (as for the moment there is only a prototype of a robotic head system), it was not possible to investigate actual reactions. As perceptions and evaluations strongly affect resulting social reactions (Bodenhausen & Hugenberg, 2009), these aspects were focused on in the present dissertation. Both processes but especially perceptions represent processes that are activated in the initial phase of contact. Perceptions are strongly affiliated with the concept of social cognition which explains how people do construct a meaningful understanding of the social world (Bodenhausen & Morales, 2012). Evaluations are based on the perception we have and are influenced by schemata we individuals internalized. By investigating both processes with regard to sexualized robots in comparison to women, the present dissertation aims to provide information on the question whether sexualized robots are perceived in similar ways as humans in the initial phase.

In order to achieve a sufficient investigation of these research objectives, the first two studies were composed of implicit as well as explicit methodological approaches. As elaborated in chapter 2.8.2, explicit evaluations on sex robots might be influenced by social desirability, lack of personal relevance and also knowledge (if not considered in the study design) and may therefore not be ideal in order to assess potential users' evaluations about robots. For this reason, the first study represents an multimethodological approach which aimed to combine explicit and implicit reactions towards sexualized robots. This was important in order to investigate how attractive potential users evaluate sex robots to be, but also to assess whether social desirability might play an important role in the evaluation of robots. The study therefore contains two parts; one in which the explicit attractiveness evaluations of heterosexual men with regard to sexualized robots were compared to women, while the other used an implicit method in order to access the associative strength between the concept of attractiveness and robots, respectively the associative strength between the concept of attractiveness and women. Because evaluations are accompanied with the disadvantage that they rely on self-report which cannot cover unconscious processes, perceptional processes have been included in the investigation about the social potential of sexualized robots. With the help of eye tracking, the second study (Szczuka & Krämer, 2019) aimed to investigate whether deeply rooted processes of mate perception would be transferred to sexualized robots.

Another goal of the present dissertation is to provide an elaborated overview of relevant interdisciplinary theories and empirical findings which help to explain the penitential reactions people show when confronted with a sexualized robot. As research on sexualized robots is strongly underrepresented, relevant theories from the field of media psychology but also findings from social science and sexology have been transferred to the usage of sexualized robots. In line with this, the third paper is a theoretical model which structures influence factors that can positively and negatively affect sexual illusion, a powerful sensation that causes the user to experience an artificial sex partner (such as a sex robot) to be present, embodied and human (if it is intended to display one). Apart from the conceptualization of which aspects might influence the perception of sexualized robots, this model was constructed in order to guide future research on sexualized robots, which is an overarching goal of the whole dissertation.

In line with the third main research objective, this dissertation aims to provide a comprehensive view on the topic of sexualized robots as it provides empirical data from a user-centered perspective but also includes elaborations on potential consequences the technology might have in the users' social environment (here with a focus on the female partners).

Therefore, the fourth paper investigates whether sexualized robots have the same potential to evoke jealousy related-discomfort as women do. This again underlines the innovativeness of the present dissertation, as it is the first study to transfer the interpersonal theory of jealousy to the human-robot context. The study was conducted as online survey in which the participants were asked to enter in a thought experiment. In detail, the subjects were asked to imagine that they found out that their partner either had sex with another woman or a sex robot before answering associated questions. The study therefore contributes to the investigation on the social potential of sex robots as it questions whether robots will be accepted as a threat to existing relationships.

The final research objective targets the human-likeness of sexualized robots as a factor that might influence the social potential of a sexualized robot. While it can be argued that the human-likeness contributes to the similarity and might therefore be more accessible for humans in intimate interactions, researchers do question whether sex robots need to have a human-like appearance (Devlin, 2015). In order to investigate the impact of the appearance on evoked associations, explicit evaluations and perceptions all studies investigated reactions towards human-like robots as well as machine-like robots. By varying this, we moreover aimed to gain a more profound understanding of the influence the presented human-like sexual characteristics might have on the reactions of males. Referring to the uncanny valley (Mori et al., 2012, see chapter 2.3) it also might be possible that the human-like resemblance in robots causes strong differences in evaluations and perceptions in contrast to humans.

In general, one of the overarching aims of the present dissertation is to use sufficient methodological approaches in the investigation of sexualized robots. Therefore, it is important to mention that the gathered data is not only based on different implicit and explicit methodological approaches, but that the participants were confronted with suitable stimulus materials in the form of not only pictures but also videos in order to provide a mutual understanding of the concept of robots. This methodological approach had been acknowledged by Devlin (2018) in reference to the used methodology in the first study included in the cumulus (Szczuka & Krämer, 2017).

Taken together, the present dissertation aims to investigate the social potentials of sex robots in comparison to humans by investigating evoked associations, evaluations and perceptions. The dissertation therefore does not only aim to contribute to the knowledge on a cutting-edge technology but aims to provide a basis for controversial discussions about sex robots. The results are moreover intended to spark further knowledge on how a responsible handling of the technology can be realized. Because sexual aspects of human-computer

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interaction are often neglected by academia, the present dissertation moreover aims to encourage new research on sexualized robots.

In the following, the four papers which constitute the present dissertation will be explained in more depth. Afterwards they will be discussed against the background of research objectives and theoretical background. Please note that the three included empirical studies meet the principles of ethical research of the American psychological association (Smith, 2003) and have been approved by the university's ethics committee prior to data collection.

4.1   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 (Research Paper 1; Szczuka & Krämer, 2017)

Based on the underrepresentation of empirical investigations on sex robots, the knowledge on the technology is mainly shaped by already elaborated ethical considerations about sexualized robots (see chapter 2.1 for an overview). The controversial discussions, especially in the media, moreover frequently addressed reactions and evaluations towards sex robots in comparison to female counterparts (e.g., Ellen, 2017 published an article headlining "Female sex robots, feel free to replace us if you want to") without reference to any empirical investigations of the topic (which are currently not existent). Moreover, the discussions on sex robots is dominated by a stereotypical representation of users who are lonely and/or have difficulties in finding a relationship with another human (e.g., Taves, 2016 published an article heading "Can a robot mend a lonely heart? AI-equipped sex toys could either make human contact unnecessary or help the socially awkward learn intimacy", see also Levy, 2008 about social misfits).

Based on these elaborations the study had two main goals. Firstly, the study aimed to investigate potential differences in the evaluation of the attractiveness of sexualized robots in comparison to woman. To consider potential influences of social desirability, both, implicit and explicit measurements have been used. An online survey was carried out to gather self-reported attractiveness evaluations, while an affective priming paradigm (Fazio et al., 1986) was used to gain unbiased data. The affective priming paradigm was chosen as it allows to explore the "activation of evaluative information" (Hermans, Houwer, & Eelen, 1994, p. 515) with regard to two target groups (in this case women and female looking robots). The task for the participants is that they have to assign positive and negative words associated with the concept of attractiveness (examples for positive target words: affectionate, beautiful; examples for negative target words: unappealing, rejection) after they have been confronted with a picture

showing either a woman or a female looking robot (with salient mechanical body parts in order to assure that the participants would recognize the difference). The main idea is that the associative strength can be quantified in terms of reaction times in which words can be assigned after a prime is presented. Fazio et al. (1986) argue that if target words and primes have the same valence participants are able to assign them faster.

Attractiveness was chosen as main concept of both parts of the study as it is an important concept in interpersonal relations which is not only used to evaluate a person's appearance, but also to ascribe whether one is drawn to another person.

Secondly, the study aimed to empirically investigate the frequently portrayed stereotype of a lonely person who is drawn to sexualized robots. Therefore, affiliation-related variables and pre-existing negative attitudes about robots in general (NARS; Nomura, Suzuki, Kanda, & Kato, 2006) were used as predictors for both assessments of attractiveness. Because affiliation is a multidimensional construct, the following different concepts have been included which from different angles investigate the social status of a person; loneliness (UCLA loneliness scale; Russell, Peplau, & Cutrona, 1980), the importance of social contracts (Need to belong scale; Krämer et al., 2013), fear of rejection and whether the person has interaction deficits (SASKO Scale of Social Anxiety; Kolbeck, 2008). The anthropomorphic tendency was included as research could show that lonely people do anthropomorphize robots more strongly (Eyssel & Reich, 2013).

Because of the used multimethodological approach, the two parts of the study were conducted separately, with separate samples of heterosexual males.

In the online (self-report) study, 229 heterosexual males between the age of 18 to 67 years were first confronted with a video which showed how state of the art robots can look like and what their abilities are. Afterwards, they were asked to fill in different questionnaires assessing the different relevant personal characteristics used as predictors. Finally, they were asked to rate how (sexually) attractive they found the stimulus material which was composed of four women, four human-like female looking robots and four machine-like female looking robots. Since a within-subjects design was chosen, all participants were confronted with all stimuli in a randomized order.

41 additional heterosexual males between the age of 18 to 52 participated in the second part of the study in which an affective priming paradigm was used to implicitly access whether there are in attractiveness of women in comparison to robots. This study also was divided into three parts; first the participants were confronted with the same video showing state of the art robots as the subjects in the online study, then they completed the affective priming paradigm

and were afterwards asked to also answer the questionnaires accessing the personal characteristics.

The results showed that there were significant differences between the stimuli group with regard to the explicit evaluations of their attractiveness. The heterosexual males rated the women to be the most sexually attractive, followed by the human-like robots and the machine-like female looking robots. However, the used implicit measurement showed that there was no significant difference in the time the subjects needed to correctly assign the positive target words (which represented the concept of attractiveness) after they have been primed with either pictures of women or robots with salient mechanical body parts. Consequently, the concept of attractiveness was equally accessible when the heterosexual males were confronted with a female, as when they were confronted with the pictures displaying robots with salient mechanical body parts.

With regard to the stereotype of the social misfit, the results of the online study showed that when looking at the human-like robots, the negative attitude towards robots and the fear of rejection were the only significant predictors of the robots' attractiveness ratings. However, one has to note that the beta coefficients revealed that the influence of the fear of rejection was weaker than for the negative attitude towards robots. When rating the attractiveness of the machine-like robots, the negative attitude towards robots was the only significant predictor. With regard to the implicit measurement, none of the included predictors could predict the time it took the participants to assign the positive words to after being primed with a picture displaying a robot.

Taken together, the study aimed to gather knowledge on how heterosexual males evaluate the attractiveness of sexualized robots in comparison to woman, to investigate the potential influence of social desirability on this evaluation and to investigate the stereotype of the social misfit by testing whether the data would support the importance of loneliness-related variables as predictors for the attractiveness ratings. The results show differences in the explicit evaluation of attractiveness, while this was not the case for the implicit measurement. It is imaginable that the priming of a human-like sexualized entity was enough to trigger scripts which would usually only be activated when confronted with a female. This would underline the impact that human-like sexual characteristics can have on initial perceptions and associated evaluations. Moreover, the differences in the attractiveness ratings between the stimuli groups in the online study could be a first empirical hint to the relevance of norm adherence, social desirability and the general preference of the own species. The fact that the various affiliation-related variables did not serve as significant predictors of neither the implicit nor the explicit

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attractiveness ratings underline that the stereotype of the social misfit might be more complex than just to highlight the loneliness.

4.2   There's More to Humanity Than Meets the Eye: Differences in Gaze Behavior Toward Women and Gynoid Robots (Research Paper 2; Szczuka & Krämer, 2019)

The first study of the present dissertation could empirically show that there was no difference in the affective priming task based on the human or robot stimuli which were presented. In the discussion of the findings we (Szczuka & Krämer, 2017) argued that the within the initial process of perception, the human-like sexual characteristics might trigger evolutionary based perceptual and evaluative reactions that could explain the missing difference. In order to gain a more profound understanding about how female looking robots are processed in comparison to humans and to understand whether the presentation of replications of sexual characteristics would contribute to similarities in the processing of a stimulus, the present study was conceptualized.

One process among humans in which deeply rooted evolutionary processes of perception are crucial is mating. According to evolutionary psychologists, such as David Buss (1999), humans have developed strategies to efficiently estimate a person's mate value in the initial phase of confrontation by processing the person's visual information (cf. Buss & Schmitt, 1993; Symons, 1995). The mentioned mate value is composed of traits that contribute to a potential reproductive success, such as genetic quality and/or fitness (Buss, 1999). Numerous eye-tracking studies could show that for heterosexual males, the head of a woman, the breasts and the torso with an emphasis on the waist-to-hip ratio provide valuable visual information in order to efficiently estimate her mate value (e.g., Lykins, Meana, & Kambe, 2006; Nummenmaa, Hietanen, Santtila, & Hyönä, 2012; Rupp & Wallen, 2007).

The head is of special importance as it provides information on the genetical status of a person (e.g., humans who are affected by the down syndrome, also referred to as trisomy 21, have characteristic facial features, see Cohen, M. Michael & Winer, 1965) and about the person's health (e.g., some diseases can be visually detected by the tone of the skin, e.g., missing redness; Lefevre, Ewbank, Calder, dem Hagen, & Perrett, 2013) and age (number and deepness of wrinkles). What makes the face so important with regard to visual attention is that humans encode emotions and motivations from it (Ekman, Friesen, & Ellsworth, 1972). Facial impressions are important information as humans need to know whether the opposite has a friendly attitude or wants to harm the person (cf. Ohman, Lundqvist, & Esteves, 2001).

The fertility of a woman can be visually estimated by changes of the body fat distribution which occur due to hormonal changes during puberty. Therefore, the size and shape of the breasts and the deposit of fat in the area of the upper tights and buttocks can help to estimate a woman's reproductive status. The resulting gynoid fat distribution which is also referred to as hourglass figure is quantified by the so-called waist-to-hip ratio. According to Singh (1993), this is an important optical point of reference for heterosexual men as it serves as "first-pass filter, which would automatically exclude women who are unhealthy or who have low reproductive capacity" (p. 304). Therefore, the breasts and the pelvic area are relevant body areas in their perception of a potential mate.

While the elaborated body areas all provide authentic information on some of the person's biological status and/or the inner state, this would not be the case with robots as they simply do not have any biological and/or psychological states to represent. However, as the previously mentioned study (Szczuka & Krämer, 2017) showed, similar body structures in robots and humans could have the potential to evoke similar perceptual processes. Therefore, we aimed to investigate whether humans would apply evolutionary psychological processes of mating on human-like and machine-like robots. To appropriately investigate the perceptual processes, eye tracking was used as method. This methodological approach is in line with the goals of the present dissertation (see chapter 3 for details on the research objectives), as it quantifies perceptual processes without relying on self-report (Garza, Heredia, & Cieslicka, 2016). The manipulation of the human-likeness was important in order to see whether the visual resemblance would contribute to similar processes of perception or whether a female silhouette would be enough to trigger perceptual processes observed among humans. Furthermore, we were interested in the need for exploration if confronted with human and non-human sexualized stimuli and therefore incorporated the revisits (quantification of times the participants switched from one body area to another and back) of different areas of interest into the analysis. Lastly, the anthropomorphic tendency (Neave, Jackson, Saxton, & Hönekopp, 2015), the negative attitude towards robots (Nomura et al., 2006) and the attractiveness ratings of the stimuli were included as predictors of the time spent looking at the different body parts in order to include potential personal characteristics that might influence the visual attention.

The sample consisted of 45 participants of which 15 were heterosexual men, 12 males were homosexual, and 18 women identified themselves as heterosexual. The heterosexual women and the homosexual males were not only included to gather first data on how people perceive sexualized robots in general, but more importantly they were included in order to investigate the gaze pattern in contrast to a different gender (heterosexual women) but also in

contrast to another sexuality (homosexual males), as both aspects might cause different perceptual processes. The experiment was divided into three parts: First the participants were asked to fill out questionnaires accessing personal information (e.g., age), their individual tendency to anthropomorphize objects and questions about their negative attitude towards robots. Then the participants were (just as in the previous study) exposed to the video about state of the art robots in order to ensure a mutual understanding of the concept robot. Afterwards, the eye tracking session took part. Here, first the dominant eye was determined, then the vision was calibrated and finally the participants were asked to look at the presented pictures as if they would be exposed to it in a magazine. The stimulus material consisted of 6 highly standardized relevant pictures (two different pictures of women in plain underwear, two different pictures showed human-like robots in underwear and two different pictures showing machine-like female looking robots). Additionally, 13 irrelevant pictures were incorporated in order to cover that we were mainly interested in the perception of the female and female-looking stimuli. As the study was composed as a within-subjects design, all participants were confronted with all stimuli. Each presentation of a picture was accompanied by a fixation cross in the middle of the screen, followed by an information which informed the participants whether they would see a robot or a human, followed by the actual picture which was looked at for 8000 ms. The eye tracking task could be controlled by the eye movements of the subjects which was important as this made it possible for the experimenter to leave the room. Afterwards the participants were asked to rate the attractiveness of the previously viewed stimuli explicitly.

The results underline that humans and especially heterosexual males have different perceptual processes if confronted with human and non-human stimuli, regardless of their visual resemblance. The viewing times towards the head revealed the most interesting result; regardless of the participants' gender and sexuality, they spent significantly more time looking at the human head compared to the human-like and machine-like robotic heads. This is peculiar, as especially the human-like robotic head provides numerous details which could have gained visual attention. However, it is highly imaginable that humans have a deeply rooted drawn to human faces as they are able to encode emotions and motivations from it (which is important in order to estimate the person's attitude and emotional state), which cannot be conveyed by robotic faces. This also raises the attention towards the fact that strategies of encoding inner states cannot be applied to robots as their actions are reasoned by algorithms that are not observable in the initial contact phase.

The viewing times towards the human and non-human chest area revealed that compared to heterosexual woman and homosexual males, the heterosexual males spent

significantly more time looking at the breasts of the females in comparison to the robotic replications of this body area. This result for the heterosexual males is therefore again in accordance with the evolutionary psychological importance of authentic information and might also point out to a lack of interest in sexualized robots as mating partners.

The results of the viewing times towards the pelvic area were rather unexpected. All participants spent less time looking at the pelvic area of the women in comparison to the human-like and machine-like robotic pelvic regions. The analysis further revealed that all participants took more time to look at the pelvic area of the machine-like robotic pelvic region compared to the human-like robotic one (this difference was however not significant for the heterosexual males only). It is likely that the novelty of the stimuli and the observable mechanical parts raised the visual attention towards this area.

With regard to the predictors, the negative attitude towards robots was the only marginally significant negative predictor of the time the heterosexual males spent looking at the human-like robotic chests.

The analysis of the revisits revealed that the participants needed significantly more visual exploration of the pictures displaying non-human stimuli in comparison to those displaying human stimuli as the revisits which represent the process of switching back and forth to one particular area of interest were significantly higher for the robotic stimuli than for the human stimuli.

Taken together, the present study shows empirical evidence that heterosexual males do not simply adapt deeply rooted processes of mate perception to robots. As the results showed, heterosexual males spent significantly more time looking at the human head and chest in comparison to the same body areas of the presented robotic stimuli, regardless whether these were human-like or machine-like. While those results might indicate general preferences within the sample of heterosexual males, it is also important to highlight that the robotic body areas do not provide any authentic information on the robot mate value as they do not have any authentic biological and psychological information. The missing differences between the human-like and machine-like robots underline that humans do not simply react in the same way if confronted with a human-like stimulus than they would towards other humans, as there is *more to humanity than meets the eye*.

4.3 Negative and Positive Influences on the Sensations Evoked by Artificial Sex Partners - A Review of Relevant Theories, Recent Findings, and Introduction of the Sexual interaction illusion model (Research Paper 3; Szczuka, Hartmann, & Krämer, Accepted)

As indicated earlier, the present dissertation contains a theoretical model which aims to conceptualize positive as well as negative influences on a robot's potential to evoke social sensations based on relevant theories form the fields of (media) psychology, sexual science and social science.

The introduced sexual interaction illusion model aims to explain under which conditions sex robots might evoke a state of what we (Szczuka et al., accepted) defined "sexual illusion", a state in which users accept the machines as real social and sexual interaction partners (without questioning their artificiality).

As already elaborated in chapter 2.4.2 on sexual arousal, we argue that this state might be accompanied with motivational, evaluative and perceptual changes that might have a profound effect on the "users' subjective (illusionary) experience that the interaction with an artificial partner feels like a sexual interaction with an existing, living social being" (p. 4). Figure 4 displays the sexual interaction illusion model.
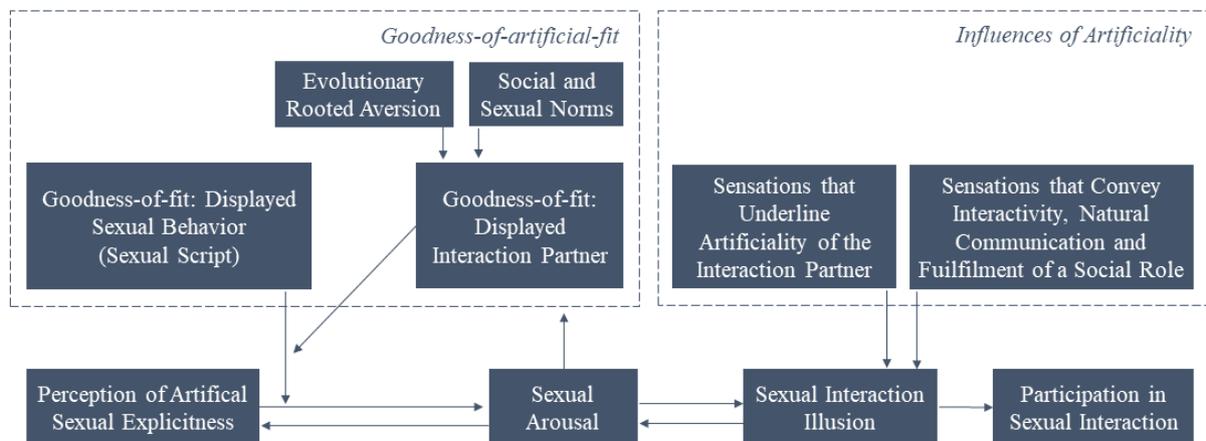
Figure 4. The sexual interaction illusion model

The starting point of a process in which sexual interaction illusionis evoked is the perception of artificial sexual explicitness. As sexualized robots have an appearance that strongly resembles that of humans and are moreover equipped wth sexual characteristics, their physiognomy may have the potential to be sexually appealing for humans. This can moreover be enhanced by a robot's ability to verbally and nonverbaly engage in a sexualized interaction.

The dashed box presents a core element of the sexual interaction illusion model which represents what we called goodness-of-artificial-fit. The label points out that the processes

conceptualized within that box are strongly related to the main ideal of the goodnes-of-fit proposed by Mosher (1988). He argued that the content with regard to both the actors and the displayed behavior of a displayed pornographic scene must match the sexual script which is composed of different sociteal influences, personal experiences and reflections on sexuality (see chapter 2.4.1 for details on sexual script theory). While a robot behavior will be based on algorithms that can be controlled and matched with one's preferences, we argue that the artificiality of a robot might also influence the goodnes-of-fit and consequently the evoked sexual arousal. Based on an extensive literature review we argue that evolutionary rooted aversion against artifial sex partners but also societal and sexual norms (see chapter 2.5.1 for details on social stereotypes and the violation of sexual norms) might play a role with regard to a robot's potential to evoke sexual arousal. If a person for instance was highly concerned with what their social environemnt might think if he or she owned and used a sexualized robot and therefore violated social and sexual norms, this might negatively influence the goodness-of-artificial fit. The evolutionarily rooted processes of aversion is included based of an explanatory approach of the uncanny valley in which MacDorman and Ishiguro (2006) highlighted that people might avoid contact with too human-like robots based on the fact that they are genetically inadequate partners (see chapter 2.3 for details on the relevance of he uncanny valley).

If the goodness-of-artificial fit matched the user's preferences it might evoke sexual arousal, a state which, as already explained in chapter 2.4.1, is acompanied with an destinctive motivation state to engage in sexual behavior (Ariely & Loewenstein, 2006). This in turn may also influence the perception of the stimulus and the goodness-of.artificial-fit, as research could show that when aroused, humans rated different sexuality acts as more arousing than they would do when not aroused. The sexual arousal might then result in sexual interaction illusionas a state in which a user does ot question the artificialness of the sexual partner anymore.

When sexually aroused, we argue that aspects of the artificiality might positively and negatively affect the evoked sensation, just as proposed in the media equation theory (see chapter 2.2.2 for details). In line with the relevant literature we regard the conveyed social cues such as interactivity, natural language and the fulfillment of social roles as positive influences, while interactions with technology might also convey signals that underline the artificiality of a partner and therefore the inappropriateness of the evoked sensation (e.g., the need to reboot the system, see Nass & Moon, 2000; Reeves & Nass, 1996).

Finally, the resulting sexual interaction illusion might then lead to the sexual interaction itself. It is however important to mention that the model is merely based on theoretical considerations and is aimed to serve as a guideline for future research on sexualized robots.

4.4 Jealousy 4.0? An empirical study on jealousy-related discomfort of women evoked by other women and gynoid robots (Research Paper 4; Szczuka & Krämer, 2018)

An aspect that has been neglected in the discussions about sexualized robots is the social environment of the user (see chapter 2.6). While there are first theoretical considerations about how robotic replications might change the societal standing of women, there is no data and also almost no theoretical discussions about what individual consequences it had for women if their partner decided to buy and/or use a sex robot. While this decision can theoretically have positive implications for the relationship, such as that that the partner can act out any sexual fantasies without relying on consent of the woman or that the robot might teach the partner to become a better lover (Levy, 2008), there is also the possibility that females will get jealous about the robotic love rival (Bendel, 2017). Referring to media equation theory (Reeves & Nass, 1996) and the resulting social reactions (see chapter 2.2.2) it is likely that not only the owner will treat sex robots as social entities, but that also the partners might react socially and therefore perceive them as threat to the own relationship. Past research on the acceptance of vibrators could show that 29.6% out of 1047 males stated to feel intimidated by their partner's usage of a vibrator (Herbenick et al., 2011). This finding indicates that intimate interactions with technology might cause jealousy-related discomfort in some individuals even if the technology does not provide any social cues. Further, jealousy-related discomfort might not merely be dependent on the question whether the opponent is human or non-human. However, what would speak against jealousy towards robotic replications of women is the deeply rooted evolutionary psychological perspective on jealousy. According to Buss (1999, 2013) jealousy within women is a complex of emotion that motivates behavior in order to fend off a potential threat to a relationship. According to evolutionary psychology, emotional bonds with other women are especially debilitating because of shared resources (such as emotional resources, time resources but also in some cases financial resources). As the other woman might moreover get pregnant as a result of an affair, the resulting offspring would not only mean even more shared resources, but it can also strengthen the bond between the partner and the other woman. However, as robots cannot get pregnant, the evolutional psychological perspective cannot fully be applied to sexualized robots.

In order to gain knowledge about potential effects sexualized robots might have on existing relationships and therefore the users' social environment, the present study aimed to understand whether there would be differences in jealousy-related discomfort based on whether the opponent is human or robotic and potential personal characteristics and technology-related attitudes influencing the jealousy related discomfort towards robots. Because jealousy is strongly associated with processes of social comparison which in turn is influenced by similarities to the individual a person is comparing/him/herself to (Festinger, 1954), the study incorporated human-like robots which therefore have a high (optical) resemblance to the subjects and machine-like robots which instinctively can be recognized as non-humans.

To investigate the jealousy-related discomfort evoked by women and robots, an online survey was conducted. As previously discussed (see chapter 2.8.2), explicit methods that aim to gather knowledge connected to sensitive topics are accompanied with problems of social desirability. However, as the questions did not concern the concrete usage and therefore might not be accompanied with social stigmata, the advantages of an online survey were made use of, such as the opportunity to gain data from a more diverse and bigger sample (Sue & Ritter, 2012). Even though an online study was used, the participants were not only asked to answer questionnaires. The centerpiece of the present study is a thought experiment in which the participants had to imagine that their partner had sex with either another woman, a human-like robot or a machine-like robot. Furthermore, a picture was presented which showed four different love rivals in accordance with the category described in the thought experiment in order to ensure that the people all had a similar love rival in the mind. This was especially important for the robot condition, as it is imaginable that not all participants had heard about this technology before. It is moreover noteworthy to mention that thought experiments have been used in the research on jealousy before (e.g, Buss, Larsen, Westen, & Semmelroth, 1992).

As jealousy can be considered to be multidimensional construct, a questionnaire was self-derived based on relevant literature (especially the romantic jealousy model by White & Mullen, 1989) which could be applied for both human and robotic love rivals. To structure the items, an exploratory factor analysis with principal component analysis and varimax rotation was computed, followed by Horn's parallel analysis. The results revealed the following jealousy-related discomfort subdimensions: discomfort regarding sexual contact, discomfort based on shared time and emotional resources and discomfort based on shared financial resources. Moreover, the analysis revealed items contributing to the factor feeling of inadequacy and negative emotional consequences. The variables which were included as potential personal characteristics influencing jealousy towards the robots were self-esteem

(Rosenberg, 1965), physical attractiveness (Stiller, Würth, & Alfermann, 2004) and attitude towards sexual non-exclusivity (Boekhout, 2000). The technology-related variables we assumed to have an influence on jealousy towards robots were negative attitude towards robots (Nomura et al., 2006), tendency to anthropomorphize objects (Neave et al., 2015) and a self-derived questionnaire on the openness to the usage of technology in sexual interactions.

The study consisted of three parts; First the subjects were asked to answer questions about their person. Then they participated in the thought experiment followed by questions regarding the evoked jealousy-related discomfort. Right before being confronted with the thought experiment, the women in the condition which imagined a robotic love rival were confronted with the video about state of the art robots in order to create a mutual understanding of what robots are capable of and what they can look like. Lastly, all participants were asked to fill out questionnaires accessing the potential predictors.

In sum, 848 heterosexual female participants (mainly from Germany and very occasionally from German speaking countries, e.g., Switzerland) between the age of 18-63 years participated in the study. In order to avoid carry-over effects of the different stimuli groups, a between-subjects design was chosen. Consequently, 287 heterosexual female participants were confronted with the scenario that their partner had sex with another woman, 287 participants imagined that their partner had a sexual interaction with a human-like robot and 274 females were asked to indicate how they feel after they imagined that their partner had sex with a human-like robot.

The results revealed that women and robots indeed differed in the evoked levels of jealousy-related discomfort, although there were no differences between the human-like and machine-like robots across all jealousy-related subdimensions. In detail, women evoked stronger feelings of jealousy-related discomfort with regard to the negative emotional consequences (such as being angry or sad), the discomfort based on shared financial resources and the discomfort based on the sexual interaction itself. With regard to the negative emotional consequences it is imaginable that participants indicated stronger emotional reactions compared to the robotic love rivals because they have been in a situation before in which they had a female as love rival. The discomfort based on shared financial resources might be higher for women in comparison to the robotic opponents as the things the male could spend money on (such as gifts like flowers) could also be spent on the partner while the expense for a robot might be too abstract (such as warranty) in order to contribute to discomfort. The last aspect in which the female competitors had higher ratings was the sexual interaction itself. We aimed to explain the higher level of discomfort evoked by the sexual interaction by referring to the evolutionary

psychological perspective on jealousy which means that the discomfort was higher for the women in comparison to the robots as the intercourse was not only likely to result in an emotional bond (which is rather unlikely with robots) but more importantly, women can have an offspring while this is not possible for robots.

The results moreover showed that there was one subdimension of jealousy related discomfort in which the robots evoked higher levels of discomfort compared to the women, which was the discomfort caused by shared emotional and time resources. It is likely that this result is due to the fact that it would violate social norms if one would spend time with a robot and invest emotions in it, which in turn might cause processes of questioning the partner.

Finally, there was also one subdimension in which there was no difference at all with regard to the species of the love rival which was the feeling of inadequacy. This result was surprising as it shows that robots do have the potential to be perceived as a threat to the self and therefore can have an influence on the social environment of the user which is comparable to another woman. One reason for this result might be that robots cannot only be programmed and therefore controlled but also that their appearance might be fully customized in accordance to the user which might cause feelings of inadequacy if the robot differed from oneself.

The analysis of the predictors showed that only the attitude towards non-exclusivity in relationships, the negative attitude towards robots and the openness to technology explained variance in the discomfort based on a partner's sexual interaction with a robot. The strongest predictor which was the attitude towards non-exclusivity in relationships shows that values of traditional relationships can be transferred to intimate interactions with machines.

Taken together, the present study provides first empirical insights which underline that robots do have the potential to evoke negative reactions (especially with regard to the self-evaluation) similarly to other women. The fact that results showed no difference between the human-like and machine-like robot moreover underlines that social reactions and therefore the perception of a robot as a threat to an existing relationship is not necessarily dependent on the human-likeness but that basic cues can trigger social processes of comparison.

V. Discussion

The aim of the present dissertation was to extend the knowledge on how humans perceive and evaluate sexualized robots (in comparison to their human counterparts). To provide an overarching perspective on the phenomenon the empirical and theoretical investigations presented in this dissertation do not only emphasize user-centered elaborations, but also include reactions of the users' social environment.

As sex robots represent a multifaceted phenomenon that requires an interdisciplinary theoretical foundation, the dissertation provides a first conceptualization of relevant theories from the field of (media) psychology, sexual science, and social science. In the following, the results of the empirical studies will not only be discussed against the background of discrete theories to underline the theoretical implications of this work but also based on the sexual interaction illusion model, introduced in chapter 4.3, which provides a first conceptualization of psychological mechanisms that enhance or interfere with a robot's potential to evoke sexual arousal and (social) sensations. In addition, starting points for future research will be discussed. Afterwards, the results serve as a foundation for theoretical, practical and ethical considerations that can contribute to a responsible handling of the technology and enhance the controversial discussions about the technology.

5.1 Perception of Artificial Sexual Explicitness (Research Paper 3)

In order to get an understanding about how people evaluate or react towards sexualized robots, it is important to consider the initial perceptions if confronted with the technology. The perceptions built the basis for how we process and interpret information, which in turn guide following (social) reactions (Bodenhausen & Hugenberg, 2009, see also chapter 2.2.1 for details on perceptual processes with regard to robots). The following figure illustrates the starting point of the process, which, in the end, might lead to a participation in sexual interactions.
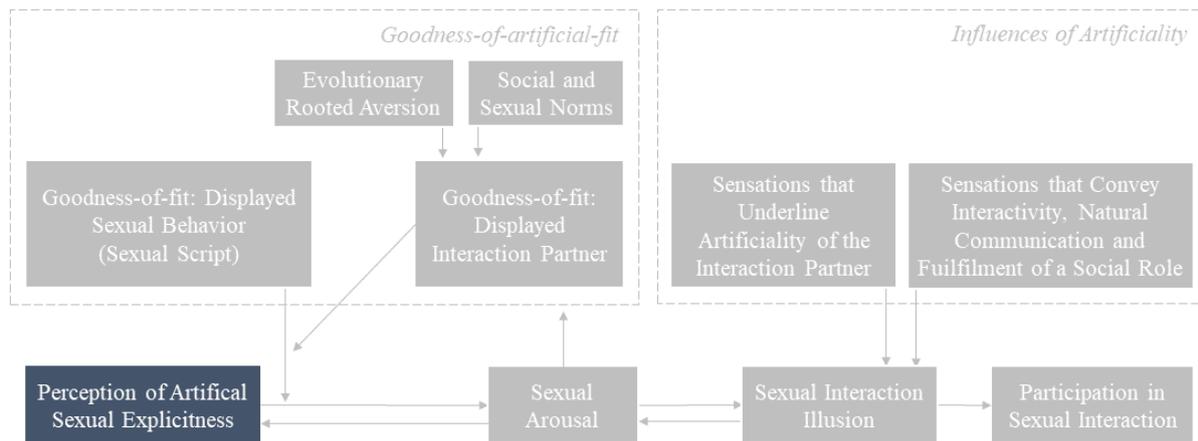
Figure 5. Perception of artificial sexual explicitness as starting point of interactions with sexualized robots

Perceptions can be categorized in bottom up processes that occur on the very initial perception of stimuli and more thorough perceptions that aim to create a basis of information that can be used to create a meaningful interpretation of a stimuli (Bodenhausen & Hugenberg, 2009; Couronné, Guérin-Dugué, Dubois, Faye, & Marendaz, 2010). To properly investigate perceptional processes towards robots in comparison to humans, the first two user-centered studies were based on methods that allow the examination of both, very initial perceptions and more thorough perceptions. The initial reactions have been investigated by accessing automatically activated attractiveness evaluations based on human and robotic stimuli, while eye movements have been examined to see what information is thoroughly processed within human and robotic stimuli.

5.1.1 Automatically activated attractiveness evaluations of sex robots and human based on initial perceptions (Research Paper 1).

The results of the first study showed that there was no difference in the associative strength of the concept of attractiveness to both, women and robots. It likely that the initial perception of human-like visual cues, such as the hourglass-shape and female breasts, independent of whether they were perceived in human or robotic stimuli, cause the activation of deeply rooted evaluative processes. Therefore, the results show that when participants were unbiased by reflective processes, robots, in the very initial phase of confrontation, activate evaluative processes that are similar to the processes their human counterparts evoke and it is likely that this is due to the similarity in the visual cues (e.g., the posture and face, cf. Zlotowski & Bartneck, 2013. Because the used affective priming task quantified reactions (based on a priming of pictures showing female-looking robots and humans), which on average took less

than one second, it can be assumed that participants did not have the time to reflect on the violation of sexual and social norms and therefore social desirability. These results would be in favor of a very strong effect of the provided human-cues on perceptional processes. However, a more thorough perception of stimuli is needed to create a meaning of the visual information. In order to better understand how human-like visual cues within robots affect the perception of robots and whether human-like characteristics would cause similar processes of perception among humans and robots, an eye tracking study was conducted (research paper 2).

5.1.2 Processes of (mate) perception within humans and robots (Research Paper 2).

The investigation of how humans gather visual information from a potential mate allows to understand whether humans would apply deep processes of mate perception on robots. This would be a crucial finding in the controversial discussions on sex robots as it might help to understand whether heterosexual males perceive robotic replications of women as potential mates in the same way they perceive women. The results for the heterosexual males' gaze behavior towards robotic and human stimuli yield that the chest and the head, two very important areas in mating, gained more visual attention among the human stimuli in comparison to the robotic stimuli. This result shows that heterosexual males do not simply adapt evolutionary rooted processes of mate perception towards sexualized robots. It is likely that the missing authenticity of the cues might be a reason for this. For example, a human head might be more interesting than a robot's head, because it allows to encode important information regarding the emotional and motivational state of a person (e.g., Ekman et al., 1972). Because the nonverbal cues which humans usually use to express their inner states are mere motions related to activations of specific algorithms within robots, it is likely that robotic heads do not convey as valuable information as human heads. In contrast to human bodies, robotic bodies do not provide any visual information that could help a person to gain valuable authentic information; hence, it seems likely that humans in general have not developed a strategy yet on how to visually process robots.

This kind of confusion or at least the deeper need for visual exploration is also visible in the results, which showed that participants switched significantly more often between the body parts when confronted with robotic stimuli than with human stimuli. This need for exploration illustrates that people might still be unsure what information might be important.

Moreover, the results indicate that the novelty of the technology might influence perceptional processes. The results concerning the viewing time of the pelvic areas of the stimuli showed that surprisingly, this was the only area which males looked at longer in

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comparison to the human counterparts. It is not only possible that this was due to the presented mechanical components (e.g., hinges) but it is also imaginable that participants needed a deeper exploration to process the possibility for a robot to be equipped with a primary sexual characteristic.

5.1.3 Comparison of automatically activated evaluations based on initial perceptions and more thorough (mate) perception (Research Paper 1 & 2).

While one may intuitively argue that the results of the affective priming paradigm, showing similar reactions towards robots and humans based on the presentation of human-like cues, and the eye tracking study, showing that males do look differently towards human and robotic stimuli, might contradict each other, this is not the case based on two considerations: First, the two approaches looked at different measures. While the affective priming paradigm looked at associations between the stimulus category and the concept of attractiveness, the eye tracking study looked at the visual attention towards specific body parts. More importantly, however, both measurements address different levels of depth in the procession of a stimulus. The results of the affective priming study (Research Paper 1) are in line with the results of the study by Zlotowski and Bartneck (2013). The researchers also found that during very initial perceptions (less than one second), humans cognitively process robots similar to humans based on human-like features of their appearance (such as a face or human posture). The results of the first study therefore rather investigated bottom-up processes and associated activations, while the eye tracking study investigated top down processes in the perception of robotic stimuli. These top down processes are characterized by the aim to interpret and create a meaning of the sensory input based on, for example, prior knowledge or the semantic context (e.g., Bodenhausen & Hugenberg, 2009; Couronné et al., 2010). Hence, the differences in the gaze behavior towards the robotic and human stimuli might have been influenced by participants' activated knowledge based on the fact that they knew whether they would look at human or non-human stimuli.

5.2 Goodness-of-Artificial Fit (Research Paper 3)

The goodness-of-artificial-fit was introduced in the sexual interaction illusion model (see chapter 4.3) as a collection of variables that represent the matching between a user's internalized sexual scripts and the properties of a presented sex robot. Within the model, this goodness of the matching is conceptualized to influence a sex robot's potential to evoke sexual arousal and, therefore, plays an important aspect in social sensations a robot might evoke and also the intention to participate in a sexual interaction with an artificial sex partner. This

influence was inspired by work from Mosher (1988), who argued that, in order to get sexually aroused by pornographic movies, the role the actors are representing and the displayed sexual behavior have to match a person's sexual script. These scripts are shaped by the culture one lives in, personal experiences, inner reflections and sexual fantasies (Gagnon & Simon, 1973). In the introduced sexual interaction illusion model, we (Szczuka et al, accepted) argued that this mechanism can also be adapted to sex robots. On one side, robots also engage in a specific sexual behavior that can or cannot meet a user's preferences. On the other side, whether one can get sexually aroused by a machine might be influenced by aspects related to the artificialness of the robot. We proposed not only social and societal norms to play an important role but also deeply rooted processes of aversion (see chapter 2.3 for details on the relevance of the uncanny valley as one explanatory approach concerning the assumed negative reactions towards human-like robots; cf. MacDorman & Ishiguro, 2006) to play an important role in the reactions towards an artificial sex partner. In contrast to the elaborated perceptual mechanisms of the artificial sexual explicitness, the goodness-of-artificial fit is therefore strongly characterized by reflective mechanisms. The following figure highlights the elaborated conceptualization.
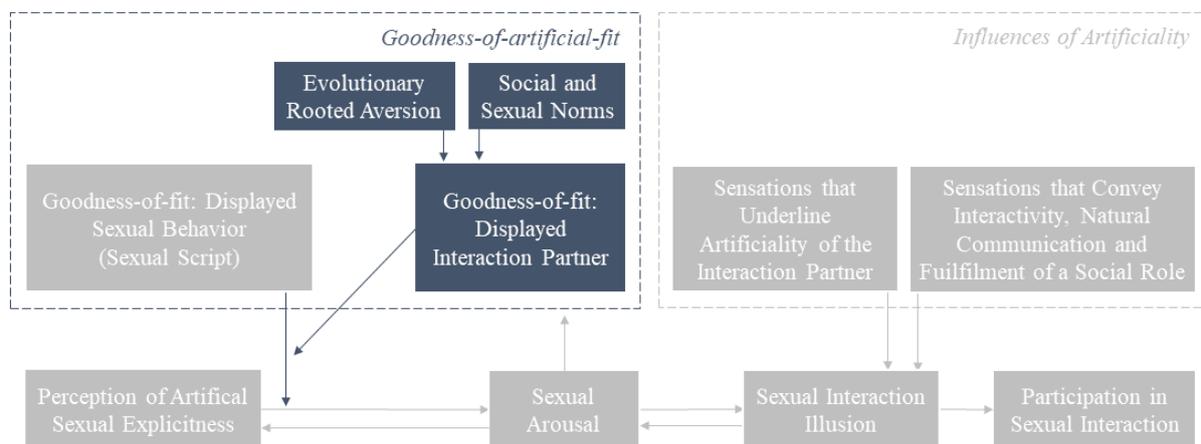
Figure 6. Conceptualization of the goodness-of-artificial-fit

While the sexual interaction illusion model itself represents one of the theoretical implications of the present dissertation, the empirical studies also provide first empirical findings concerning the goodness-of-artificial-fit. In this regard, it needs to be mentioned that the goodness-of-fit of the displayed sexual behavior was not addressed by the studies, which is why this aspect is not highlighted in Figure above.

5.2.1 Explicit attractiveness evaluations: evolutionary rooted aversion versus societal and sexual norms (Research Paper 1 & 2).

Because attractiveness is not only a concept that is used to describe a person's appearance but also whether one is sexually drawn to another person, the concept was evaluated in the first two studies. We explicitly asked for the attractiveness ratings of the human and robotic stimuli to investigate whether the results differ from the findings based on the automatically activated evaluative information that we measured in the first study via affective priming. The results showed that contrary to the implicitly evaluated activations of information related to attractiveness, which showed no difference between humans and robots, the explicit attractiveness ratings of the both first studies found that heterosexual males rated women more attractive in comparison to human-like and machine-like robots. It is likely that the differences in the explicit evaluations are caused by the influences conceptualized within the goodness-of-artificial-fit.

Even though the studies did not cover a systematic investigation of the potential influencing factors, there is a first empirical hint that needs to be discussed: The gradation in the explicit attractiveness ratings of the human-like and machine-like robot suggests that the difference in the ratings is not only based on the mere artificialness of the partner but could also be explained by deeply rooted processes of aversion against machines. Otherwise the data would not have shown that the human-like robots were rated to be more attractive in comparison to the machine-like robots, but rather that both robotic kinds were rated to be equally less attractive in comparison to the human stimuli. Therefore, it might be more likely that the results are influenced by reflections about a potential violation of sexual and social norms and/or the wish to answer the question regarding the attractiveness of the robots in line with the socially accepted opinion (see chapter 2.5.2 on social desirability).

Future studies need to systematically investigate the distinctive influences of sexual and social norms and evolutionary rooted mechanisms of aversion. In a first step, an investigation is needed which provides information about whether potential users are aware of the violation of social and sexual norms. Although sexualized interactions with a robot could be categorized as fetish and, therefore, represent a deviation from sexual norms (see chapter 2.5.1 on the violation of sexual norms, Worthen, 2016), it needs to be investigated how prevalent the knowledge on sexual and societal norms regarding sex robots are. In addition, the investigation of evolutionary rooted processes of aversion based on the genetic inadequateness of an robotic partner, as proposed by MacDorman and Ishiguro (2006), will only be examinable in interactions with actual robots.

5.2.2 Differences in goodness-of-fit based on personality traits? (Research Paper 1).

Sexualized robots are frequently portrayed to be specifically appealing to humans who are lonely or who have some difficulties in (social) relations with other humans. This is not only proclaimed by media (e.g., Das, 2017) and some scholars (Levy, 2008) but also identified as one particularly important use case by companies that produce sex robot prototypes (Realbotix, 2018). In order to investigate whether loneliness predicts the perceived attractiveness of sex robots, various affiliation-related variables were included in the first study in order to find out whether this stereotype would be confirmed in the data. The results yield no support of the stereotypically assumed connection between loneliness and the drawn towards sex robots. While it is plausible that people who are somewhat physically or psychologically constraint might benefit from the usage of a sex robot in order to fulfil their sexual needs, the results did not show a positive relation between greater loneliness and the attractiveness ratings of the sexualized robots. This finding should be stronger accentuated in the discussion about sexualized robots to prevent potential users of being stereotypically labeled.

5.2.3 Sexual norms: influence of the users' social environment with an emphasis on jealousy related discomfort of the partner (Research Paper 4).

Because the sexual interaction illusion model is user-centered it does not particularly show how a user's social environment might be affected by the usage of a sex robots. However, it provides a connection to the socioenvironment's reactions in terms of the social norms that might affect the potential to evoke sexual arousal and consequently sexual interaction illusion. As elaborated, one of the peer groups that might be affected the most the usage of a sex robot is a users' partner. While the stereotypic user of sex robots is portrayed as being lonely and having difficulties in relationships with other humans (Levy, 2008), there are also considerations which assume that sex robots might be used by people in relationships, for example, to fulfil sexual needs the partner might not want to engage in (Danaher et al., 2017) or to learn something from the interactions with a robot (Levy, 2008). However, it needs to be questioned whether the robots could also have negative consequences for a partner, for example, in terms of jealousy, or whether robots are "just machines" that pose no threat to romantic relationships (Bendel, 2017). For this reason, an online study was conducted, in which heterosexual males were asked to participate in a thought experiment which asked them to imagine that they found out that their partner either had sex with another woman, a human-like, or a machine-like robot.

The result, which showed that the female antagonists compared to the robots induced a higher level of discomfort at the thought that the partner had a sexual interaction with them, may seem, at first glance, to be an indication that robots do not have the potential to be regarded as equal opponents. However, it is more likely that the aspects influencing the discomfort were not focused on the social potential of the robots but rather on aspects related to the robot's artificialness. Firstly, the idea of the own partner having sex might be very abstract. Whereby it is highly realistic that women have been confronted with the concept of a man who cheated with another woman before (e.g., own experience, experiences of peers or media) which could have contributed to a higher level of discomfort evoked by the human competitors. This is in line with the fact that, to this point, most humans did not engage in any interaction with a robot yet (Bruckenberger et al., 2013). Therefore, it is realistic that most humans have not yet been confronted with the concept of a robot that is built to fulfil sexual needs. Closely related to this, it is imaginable that the participants in the condition in which they were asked to imagine that their partner had sex with a robot could not imagine that the connection would be something that could turn in an emotional, ongoing relationship, other than the females in the condition in which they were confronted with a human competitor. It is therefore imaginable that females categorized the sexual interaction with a robot more as something like a meaningless one-night stand, which, according to evolutionary psychology, can be overcome more easily in comparison to a potential emotional bond to a competitor (Buss, 1999). These two reasons are also likely to be the explanation for the result showing that the female participants who were confronted with a human love rival indicated the highest levels of jealousy-induced negative emotions (e.g., being sad or angry). However, the third explanatory approach for why the sexual interaction with a woman caused more discomfort compared to the imagined sexual interaction with a robot may be due to the fact that males cannot have a baby with a robot, which automatically reduced the chances of shared resources and a future emotional bond to the mother. It is important to mention that it is unknown to which degree the participants considered the elaborated explanatory approaches throughout the process of answering the questions. Here, more research is needed to gain a more profound understanding of underlying psychological mechanisms. In addition, the study aimed to investigate factors that would predict the distress caused by the imagined sexual interaction with a robot. Here, the general negative attitude towards the technology was the most important predictor, which shows that the general negative attitude also transfers to the discomfort caused by the partners' sexual interaction with the technology.

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The study could moreover show that females indicated higher levels of discomfort based on shared emotional and time resources with a robot. This might be connected to the violation of social norms, because it could be perceived as odd if a partner falls asleep next to a robot or gives the robot a nickname t (which was operationalized in the items covering this dimension). Moreover, because sexualized robots are produced to fulfill sexual needs, especially the sharing of emotions and time with a robot might have caused negative reactions by the participants in the robotic conditions based on the fact that they were overruled by an object that is not intended to be used that way.

The results showing that shared financial resources caused higher levels of discomfort in the condition in which the imagined love rival was human could be due to the higher comparability between humans. Here, the financial resources, for example in form of gifts could be equally spend to the human partner, which is not the case for robots as this would include money spend on items such as a warranty.

One of the most interesting results of the study, however, is that robots evoked the same levels of inadequacy as the human competitor did. This dimension included items that covered whether women blamed themselves for the sexual interaction of the partner with another woman or the robots and assessed whether the imagined interaction would cause them to doubt their attractiveness. This is a first empirical result showing that females do compare themselves with the technology of sex robots and that this evaluation does not necessarily lead to positive outcomes for the women. What could be of special importance with regard to artificial love rivals is the fact that they can be customized in terms of appearance and programmed with regard to their behavior. This might cause women to think of robots as problem-free partners. It is imaginable that a better understanding of the technology and its boundaries would cause a more favorable evaluation of the self. This result also points to a paradox: While the women seemed to reflect on the boundaries of the technology in the questions asking about the discomfort caused by the sexual interaction (e.g., not being capable of providing children), it seems that if referring to the self, the technology has the potential to be perceived as an equally strong competition in comparison to other women. Based on this elaboration, the results of the fourth work need to be considered in a responsible handling of the technology. Humans who buy the technology need to be aware that this might have negative consequences for their partners and in consequence for their relationship and ultimately for themselves.

As already elaborated, this study may not be user-centered but was conceptualized to provide a new perspective on the importance of the user's social environment. It needs, moreover, be kept in mind that negative consequences for the user's social environment are

likely to affect social norms, which in turn might negatively affect the users goodness-of-artificial fit. The importance of the study results will, moreover, be discussed in chapter 5.5 in which contributions to the responsible handling of the technology will be provided.

With regard to future studies that can be derived from the discussed study, I want to emphasize two aspects: the stronger need for research on technology-based jealousy and the inclusion of different peers that can be part of the user's social environment.

With regard to the first aspect, it needs to be mentioned that this is the first study to transfer theories of jealousy to the context of human-robot interaction. The only other investigation which emphasized the potential of technology to cause negative reactions based on the usage of it in sexual interactions has been published by Herbenick et al. (2011) and asked women and men about their attitudes towards the usage of vibrators. As jealousy is a multidimensional construct which cannot only cause negative emotional consequences but can also initiate the reflection about the love rival, the self, and the partner, research on jealousy in human-robot interaction might add an important perspective on the social potential of technologies. In a replication of the discussed forth work (Szczuka & Krämer, 2018), it would be interesting to see whether robots that do not represent a replication of a human can also evoke similar jealousy related discomfort. Because we did not find any differences in the jealousy related discomfort between the human-like and machine-like robot it would be interesting to see whether there is a threshold of jealousy towards different kinds of machines and whether, for instance, vibrators, a technology which does not have the ability to evoke social reactions as defined in the media equation theory (e.g. by acting interactively by communicating in language, Nass & Moon, 2000). Future studies should moreover investigate whether the effects of jealousy-related discomfort evoked by an artificial sex partner are based on the persons' gender and/or sexuality. This is of special importance as jealousy is also driven by evolutionary psychological mechanisms, which heavily differ between women and males (Buss et al., 1992).

Future research on the potential consequences for the users' social environment should moreover include different groups of peers. While the partner of a user might be the person most strongly affected, because the robot potentially affects the users' habits in terms of sexuality, the users' parents need also be included in future considerations. Even if it sounds futuristic, a child's decision to have an exclusive relationship with a robot might affect them in terms of having or not having grandchildren. For reasons like this, it is unknown whether parents will accept a (sexual) relationship to a robot and this, in turn, might affect a user's

perception of social norms that might interfere with the wish to have an exclusive relationship to a robot.

5.3   Overarching Discussion: Effects of Human-like Appearance

In line with the research objectives, the empirical studies included in the present dissertation all investigated potential differences in users' perceptional and evaluative processes as well as possible negative consequences for users' partners based on the human-like or machine-like appearance of the female looking robots. While the human-like robots represent a perfect replication of humans, machine-like robots can instantly be recognized as machines. Bar-Cohen and Hanson (2009) stated on the importance of human-likeness within robots: "… if we want to develop robots that would best support us, it would be better to make them as much as possible a replica of our shape, average size, and ability" (p. 15-16). Based on this statement, it was assumed that a human-like robot would be more suitable for sexualized interactions in comparison to something that does not look human-like and that might even be unpleasant to interact with (e.g., touching cold metal, danger of getting injured). Moreover, the investigation of the robots' appearance was used to get a first empirical hint to the question whether the basic premise of the uncanny valley (Mori et al., 2012), which states that human-like robots would cause more negative evaluations in comparison to robots that can instinctively be categorized as robots, would also apply to sexualized robots. Table 1 provides an overview of the results found in the studies of the present dissertation that concern differences between the robots' appearance.

Table 1 Overview of the results of the empirical works with regard to the robotic appearance

Study/Research Paper	Measure and Variable	Difference in Appearance?
Research Paper 1 on User-centered Perceptions and Evaluations (Explicit Evaluations and Affective Priming)	Explicit Evaluation: Attractiveness	Human-like > Machine-like Robots
Research Paper 2 on User-centered Perceptions and Evaluations (Eye Tracking)	Explicit Evaluation: Attractiveness	Human-like > Machine-like Robots
	Implicit Measures: Viewing Times towards the robotic Heads	x
	Viewing Times towards the robotic Chests	x
	Viewing Times towards the robotic Pelvic Areas	x
Research Paper 4 on consequences for the Users' Social Environment (Thought experiment: Jealousy)	Explicit Evaluations: Discomfort caused by idea of sexual intercourse	x
	Discomfort caused by shared emotional and time resources	x
	Discomfort caused by shared financial resources	x
	Feeling of inadequacy	x
	Negative emotional consequences	x

Note. Because the affective priming paradigm relied on fast reaction times towards the stimuli we decided to only include robots with salient mechanical body parts in order to ensure that the participants would understand the difference. Therefore, the first study did contain a variation between human-like and machine-like robots. Moreover, the third work of the study is a theoretical model which is why it is not listed in the table.

The overview illustrates that there are different patterns of results in the user-centered evaluations and perceptions and the study in which the evaluations of the users' social environment with regard to jealousy have been investigated. The first two studies illustrate that male users when asked to explicitly rate the attractiveness of sexualized robots, evaluate human-like robots as more attractive as machine-like robots. On one side, it is imaginable that this has to do with the fact that humans associate the concept of attractiveness more strongly with humans (as they are used to apply this concept rather to humans compared to robots) and therefore more with human-like robots in comparison to machine-like robots. However, it is also very likely that the lower attractiveness ratings of the machine-like robots are influenced by what we conceptualized in the sexual interaction illusion model as goodness-of-fit with the displayed interaction partner. People might be affected by the potential violation of social and sexual norms or evolutionary rooted aversions. It is, however, interesting that we did not find any differences in the way how males looked at the body regions of the human-like and machine-like robots that are typically important regions of the human body for mating (see

chapter 4.2 for details on the second paper). In line with this, the results of the eye tracking study do not show that the males were particularly repelled by the presented robotic stimuli as there the viewing times towards the robotic stimuli that showed that one stimuli group was particularly avoided. The fact that here also no differences could be found between human-like and machine-like robots could again be a first hint that the uncanny valley hypothesis cannot simply be applied to sexualized robots.

The fact that the results of the study investigating jealousy-related discomfort in women caused by robots did not show any effect of the robots' appearance was somewhat surprising. Because jealousy is strongly associated with processes of social comparison (Festinger, 1954; White & Mullen, 1989), we assumed that the human-like robots would cause stronger reactions of discomfort compared to a love rival which, could be categorized as a machine. The results, however, indicate that even machine-like robots have a potential to be perceived as a social entity (here in form of a love rival and threat to the relationship). For instance, the results showed that the thought experiment involving a machine-like robot as love rival caused similar feelings of inadequacy in participants as a human competitor.

5.4   Theoretical Contributions

The present dissertation did not only aim to gather empirical data on how people perceive and evaluate sexualized robots, it further aimed to provide a theoretical model that can foster systematic research on sexualized technologies in the future. As elaborated before, the phenomenon of sex robots needs to be encountered considering the users as well as their social environment. Thus, the sexual interaction illusion model (see chapter 4.3) and the transfer of the romantic jealousy model (White & Mullen, 1989) from interpersonal- to human–robot interaction present the major theoretical contribution of the present thesis. Moreover, the importance of evolutionary psychological theories in the context of sex robots will be highlighted

Because interactions with sex robots are a phenomenon that combine aspects of human-robot interactions, media psychology but also sex science and social science, theories on sex robots must reflect on the subject from an interdisciplinary perspective. The proposed sexual interaction illusion model represents a first attempt to structure negative as well as positive effects observed in different disciplines with regard to their influence on a robot's potential to evoke, what we defined as, sexual illusion. The model was inspired by the media equation theory which proposes that machines can evoke social reactions from users based on social cues they possess (Reeves & Nass, 1996). While the model is not focused on what kind of social

reactions users show towards sexualized robots, it does provide a first overview of influences that might affect the social sensations the users might have towards a robotic sex partner. The model, therefore, provides a new theoretical perspective on social sensations evoked by machines by highlighting the importance sexual arousal (which among humans is associated with distinctive motivations, perceptions and evaluations: Skakoon-Sparling et al., 2016). Also the transfer of the theory of goodness-of-fit to interactions with sexualized robots, which originally was proposed in the context of pornography (Mosher, 1988), can be helpful to investigate approach- and avoidance-related reactions in the context of sex robots. This points out to the last theoretical contribution of the sexual interaction illusion model I want to address; the general awareness that reactions towards sex robots are related to perceptions (e.g., of artificial explicitness) and cognitions (e.g., violation of norms), which might cause the wish to approach and avoid the technology at the same time. This idea is based on the approach-avoidance conflict theory by Lewin (1935) which was further introduced as a relevant theory that could guide future research on sexualized robots. While the starting port of the model which is the perception of artificial explicitness, and the goodness-of-artificial-fit have partly been empirically approached in the present dissertation (see chapter 5.1 and 5.2 on the discussions of the findings), the model is aimed to serve as a framework for the systematical investigation of users' reactions towards sexualized robots.

Above that, the transfer of the theory of jealousy to machines resembles another theoretical contribution of the present dissertation. The fourth study of this dissertation (Szczuka & Krämer, 2018) shed first light on what is I considered as tech-based jealousy. Because jealousy is a multidimensional construct, it is accompanied with different emotions and cognitions (White & Mullen, 1989). Therefore, the theoretical background of the fourth study aimed to transfer different aspects that cause jealousy-related discomfort among humans to machines, ranging from their ability to evoke discomfort based on shared emotional, time or financial resources to processes of social comparison. Because the results of the investigation showed that robots do have the potential to evoke, for instance, similar levels of the feeling of inadequacy, the elaborated transfer of the romantic jealousy model might be a helpful first approach to further investigate tech-based jealousy.

The last theoretical contribution for future investigations of sex robots is that I generally advocate to consider evolutionary psychological mechanisms in the investigation of sexualized robots. In the present dissertation, the transfer of mate perception and the evolutionary psychological origin of jealousy with regard to sexualized robots have been investigated. This subdiscipline might be of special importance in the investigation of sexualized robots because

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sex and mating plays an prevalent role in evolution (Buss, 1999). Results regarding the transfer of evolutionary rooted mechanisms, moreover, provide knowledge on internalized psychological mechanisms that humans do or do not transfer to machines, and therefore what kind of social reactions machines can evoke.

5.5   Contribution to the Controversial Discussions on Sex Robots in Reference to a Responsible Handling of the Technology

As discussed in the overview on sex robots, the technology is controversially discussed. The combination of the taboo topic sex and a technology which causes negative evaluations in some people per se contributes to what Kate Devlin calls "moral panic" (McMullan, 2018). In reference to the media coverage about the present dissertation (see first pages of the present dissertation), media has a high interest on reporting results from sex research in order to sell their news (McBride et al., 2007). Based on how headlines and the content of the articles are framed, the fears regarding sex robots are comprehensible. One fear that is strongly connected to robots in general is the fear of being replaced. This is not only due to the fact that some robots indeed do perform some of the work for humans, but might also be enhanced by the fact that some robots are conceptualized to replicate humans in terms of their behavior and appearance. Bruckenberger et al. (2013) concluded: "Robots that look like humans arouse a strong feeling of fear of being replaced in terms of personal relationships" (p. 305). And indeed different sources already mentioned the fear of being replaced by sex robots, ranging from news headlines such as "Female sex robots, feel free to replace us if you want to" Levy (2008) who, without referring to any studies or emphasizing the uniqueness of human contacts forecasted that robots might be so good in sexual interactions that they might be preferred in sexual interactions in comparison to their human counterpart.

However, I would like to highlight that the results of the studies presented in this dissertation do not reveal that especially heterosexual males perceive or evaluate sex robots in a similar manner as they would perceive or evaluate humans. Even though the first study showed that in the very initial contact phase (under one second) pictures of robots activate similar evaluative information than pictures of humans, the eye tracking study did show that a thorough perception of humans and robots caused different perceptional processes. On the one hand, this may be caused by the uniqueness of presented information within humans. The fact that all participants spend more time looking at the head of the humans compared to the robotic counterparts might underline the importance of emotional and motivational information that cannot be conveyed by robots as they do not have any emotional or motivational states that

might refer to their inner states. On the other hand, the results of the eye tracking study could be a first hint to the fact that males simply do not perceive robots to be potential mates.

Nevertheless, the results of the study investigating potential negative consequences for the partner of users (Szczuka & Krämer, 2018) underlined that women indeed compare themselves to the technology, as we found that robotic sex partners evoked the same level of discomfort based on feelings of inadequacy as their human counterparts did. In reflection to a responsible handling of the sex robots, we have to ask ourselves whether it is reasonable to produce a technology that might have a negative impact on human relationships (cf. Bendel, 2017). I argue that we have to sensitize especially users in relationships that the technology might cause negative consequences for the relationship. Moreover, I plead that we have to emphasize results such as from the presented eye tracking study more strongly, which show that males do not simply adapt reactions and perceptions to robots only because they look human like. This also needs to be made more salient in media coverage in comparison to speculations that might contribute to concerns that are unsubstantiated. In fact, the discussion of the results with regard to the appearance (see chapter 5.3) showed that the human-likeness did not had a major influence on the process of users' perception and the potential to evoke jealousy-related discomfort. While humans might be likely to think about robots as problem-free partners based on the fact that their behavior can be programmed, and their appearance can be customized (also in accordance to the representation of sex robots in science fiction, e.g., "Westworld"; Nolan & Joy, 1973), we as scientists (but also journalists reporting on technological developments) have to raise the awareness on the uniqueness of humans and the limits of technology. The presented sexual interaction illusion model includes different aspects which might negatively affect the potential of robots to evoke arousal and a sexual illusion. This, moreover, illustrates that the reactions towards sex robots may not be binary (being drawn to it or not), but that there might be different influential aspects that need to be considered when elaborating on the potential risks of the technologies.

In line with Danaher et al. (2017), I therefore argue that there is no need to ban sex robots as advocated by Richardson (2016), but that we need more research in order to avoid negative societal consequences that cannot easily be controlled once the technology is widespread (Collingridge, 1981). I, however, would like to emphasize that the present dissertation did show that explicit evaluations and perceptional processes do underline that *humanity is more than meets the eye*.

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5.6   General Outlook and Limitations

While I already provided outlooks to future research at the end of the discussions of the different results (see chapters above), this chapter elaborates on general aspects that should be included in the future research. Especially because the present dissertation represents a first attempt to empirically investigate sexualized robots, not all aspects could be included. The following chapter will address some of these aspects.

5.6.1   Inclusion of a wider range of user groups.

One of the most urgently needs for research is the inclusion of a wider range of user groups. Even though most of the produced and sold sex dolls, which represent the preliminary stage of sex robots, are female looking, this does not mean that heterosexual females might not also be interested in sexual interactions with robots. David Levy (2008), for instance, assumes that (heterosexual) females would be more interested in an emotional relationship with a robot in comparisons to males and that they might appreciate the commitment of a sex robot. Even though the author did not refer to it, this would be in line with research by the evolutionary psychologist David Buss, who, together with colleagues, found that females across different cultures rated emotional stability and dependability to be among the three most important characteristics in mate selection (Buss et al., 1990). However, to fully access this potential of sexualized robots, more research is needed on the social potential sexualized robots might have for women. A study following the main ideas of the first study, investigating implicit and explicit attractiveness evaluations of males and male-looking robots would be helpful to get a first impression of whether the presentation of male robotic characteristics also evokes similar evaluative reactions compared to their human counterparts.

In addition, research guided by the sexual interaction illusion model needs to investigate whether the influencing factors differ between gender and/or sexual orientation. Even though the model was conceptualized without being tailored to one specific gender and/or sexual orientation, it is imaginable that the quality and content of the effects might differ. It is, for example, unknown whether the stereotype of the social misfit and the associated stigmata of being lonely and not capable of having a relationship with a human also applies to women because, so far, the elaborations on this only focus on male users.

Moreover, I plead to include research on user groups that belong to the LGBTQ (Lesbian, Gay, Bisexual, Transsexual and Queer) community. I believe that this group of potential users is strongly underrepresented in considerations about sex robots. Within the elaborations on the sexual interaction illusion model, we aimed to emphasize the potential

artificial sex partners can provide to test what one thought to be a sexual boundary (based on work by Mosher, 1988). Especially because the process of understanding and accepting that one has a sexual orientation that deviates from the statistical norm might be accompanied with the wish to explore the own sexuality, interactions with artificial representations of humans might (for some people) provide a save space to explore the own sexuality.

In reference to user groups that should be addressed in future studies, it needs to be highlighted that also a user's cultural background might play an important role for perceptual and evaluative processes with regard to sexualized robots. The Japanese culture, for instance, is known to have a different conceptualization of artificial entities. Here, individuals are not only more frequently exposed to robots (in their daily lives and the media) but also are raised in a culture where some people believe that objects, such as robots, can have a spirit (MacDorman, Vasudevan, & Ho, 2009). In 2009, Nintendo released a dating simulation called LovePlus, in which one can engage in interactions with one of three artificial women and which is quite popular among Japanese males (Lowry, 2015). With regard to the sexual interaction illusion model it is likely that a person's cultural background shapes, for instance, the understanding of social and sexual norms. Cross-cultural studies are needed to investigate how culture might affect the aspects conceptualized in the sexual interaction illusion model.

5.6.2   Stimulus material.

In general, it needs to be acknowledged that the studies investigating individuals' perceptions and evaluations are focused on the initial phase of contact with a sexualized robot only and, therefore, do not allow any final statement of how users might actually interact with the robots. The investigation of actual interactions with sexualized robots would depends on the possibility to use robots that are able to engage in intimate interactions for academic research. In this regard, it is important to mention that the social potential of a sexualized robot can be investigated without focusing on the sexual interaction itself but rather on how people behave in intimate interactions, such as engagement in flirtatious communication, proximity or physiological reactions, or touch on highly accessible body parts, such as the hand. Those investigations will be crucial for the estimation of the potential chances and risks associated with the technology as research in the context of the uncanny valley could show that research results can differ based on the provided stimuli (e.g., picture versus film versus interaction, Rosenthal von der Pütten & Weiss, 2015). Nevertheless, the methodological approaches used in the studies investigating perceptional and evaluative processes in the initial contact with sexualized robots justify the used videos and pictures as stimulus material. Future studies

should, however, aim to investigate actual interactions to provide a more comprehensive understanding of the technology's social potential.

5.6.3   Change of time.

The investigation of sexualized robots will be an ongoing process as attitudes towards sex robots are likely to change over time. This might affect the reactions of potential users as well as its social environment. It is likely that some of the aspects conceptualized in the sexual interaction illusion model might be more affected than others, such as the change of sexual and social norms, which both have dramatically changed over time (Worthen, 2016). Moreover, research could show that the acceptance and the attitude towards robots in general changes over time and it is likely that, once robots will be commercially available and more affordable, this will also strongly influence the way how we as a society perceive robots (Gnambs & Appel, 2018). Nevertheless, it is very important to start studying reactions towards, perceptions, and evaluations of sex robots in an early stage of technological development. In accordance with the control dilemma proposed by Collingridge (1981) and the controversial discussions on sex robots' ability to influence the conceptualizations of sexuality, relationships and the societal standing of women (Richardson, 2016), sex robots can be one of the technologies that have profound effects on society that can hardly be controlled once the technology is widespread (Danaher, 2017b). Therefore, a responsible handling of the technology can only be achieved if the development of the technology is influenced by implications that are based on research. In this regard, the present dissertation provides first implications and aims to inspire researchers for future investigations on the perceptions, evaluations, and reactions towards sexualized robots with a scope on not only users but also their social environment.

5.7   Conclusion

To conclude, the present dissertation aimed to expand the knowledge on the emerging technology of sexualized robots, which is so far strongly underrepresented in academia, by investigating evaluative and perceptional processes of both, potential male users and potentially affected female partners in relationships. The results of the conducted empirical studies showed that perceptional processes with regard to sex robots do differ based on the depth of perception: While very initial perceptions of sex robots activate similar evaluative information with regard to robots and humans, more thorough processes of mate perception, however, showed that there are differences in the importance of visual information. The result is likely to be based on the importance of authentic information (such as the representation of emotional and motivational

inner states that can be encoded in the face of humans) and, therefore, underline the uniqueness of humans. Moreover, the provided sexual interaction illusion model presents distinct influences on a robot's potential to evoke sexual arousal and therefore sexual illusion. While these results underline that humans and especially males will not simply react towards sexualized robots in the same way as they do with women based on the visual resemblance, the results of a study investigating jealousy-related discomfort showed that robots had the same potential to evoke jealousy-related discomfort if confronted with the idea that their partner had an sexual interaction with another human or a robot. This highlights that we need to include the social environment (e.g., partners) into considerations about a responsible handling of sexualized robots. Taken together, the present dissertation provided empirical investigations with an emphasize on carefully chosen multi-methodological approaches, as well as theoretical considerations that are aimed so serve as a guideline and inspiration for future research on sexualized robots.

VI.   References

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