Toward Erobotics: An Investigation of the Relationships Between Stigma, Personality, Sexual Arousal, and Willingness to Engage Erotically with Robots

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ABSTRACT

Toward Erobotics: An Investigation of the Relationships Between Stigma, Personality, Sexual Arousal, and Willingness to Engage Erotically with Robots

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The rise of erobots (erôs + bots)—artificial erotic agents, such as sex robots—offers new opportunities for intimate experiences with machines. Their advent has also polarized academic and public debates: some denounce their risks, while others defend their benefits. Yet, the scientific study of human–machine erotic interaction and co-evolution remains limited: it lacks comprehensive theoretical models, and its empirical literature is scarce and fragmented. There is a need for a new, unified transdisciplinary field of research focusing on such phenomena, and guiding the development of beneficial technologies. We call this field erobotics. As a theoretical contribution to this new discipline, Chapter 2 defines erobotics and its related concepts, proposes a model of human-erobot interaction and co-evolution, and suggests a path to design beneficial erotic machines. As an empirical contribution to erobotics, this thesis examines some of the sociocultural, individual, and situational factors highlighted by this model. Specifically, it investigates the relationships between perceived stigma, personality traits, sexual arousal, and people's willingness to engage erotically with robots. Chapter 3 shows that stigma related to erotic technology exists and increases as a function of products' human-likeness. Chapter 4 shows that the willingness to engage with and perceived appropriateness of using sex robots more closely relate to erotophilia and sexual sensation seeking, rather than technophilia, non-sexual sensation seeking, and Big-Five traits. Chapter 5 shows that sexual arousal increases willingness to have sex with robots. In these three chapters, men were more interested in engaging erotically with robots than women. Together, these findings suggest that erotophilic sensation seekers—especially, men—may become the primary users of erobots, and that sexually aroused individuals may be more willing to engage erotically with such machines: potentially influencing their design and our relationship with them. Ultimately, this thesis founds erobotics and opens future directions for the study of human-machine erotic interaction and co-evolution.

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CONTRIBUTIONS OF AUTHORS

This doctoral dissertation is composed of a general introduction (chapter 1), a theoretical chapter (chapter 2), three empirical chapters (chapters 3-5), and a general discussion (chapter 6). These sections were written with the feedback of my supervisors, Dr. Aaron P. Johnson, primary supervisor at Concordia University, and Dr. David Vachon, co-supervisor at McGill University. As mentors and collaborators, Dr. Dave Anctil and Maria Santaguida, PhD candidate, were instrumental in the theoretical and empirical sections of this thesis. Several undergraduate students also contributed to the data collection and chapters' review. Chapter 2 was published in the International Journal of Social Robotics . Chapter 2 was published in Psychology & Sexuality. Chapter 3 is under review at Computers in Human Behavior. Chapter 4 is under review at The Journal of Sex Research. In agreement with the thesis committee's decision, the general introduction is relatively concise given the objectives of this thesis and the scope of its second chapter. The references for the general introduction and discussion are included at the end of the thesis, while the references for the other chapters are included at their respective end. The authorships are as follow:

Chapter 1: General introduction

Simon Dubé

Chapter 2: Foundations of erobotics

Simon Dubé, Dave Anctil

Chapter 3: Perceived stigma and erotic technology: From sex toys to erobots

Simon Dubé, Maria Santaguida, Dave Anctil, Cheng Yin Zhu, Lisa Thomasse, Lisa Giaccari, Rima Oassey, David Vachon, & Aaron P. Johnson

Chapter 4: Sex robots and personality: It is more about sex than robots

Simon Dubé, Maria Santaguida, Cheng Yin Zhu, Stefanie Di Tommaso, Rachel Hu, Gina Cormier, Aaron P. Johnson, David Vachon

Chapter 5: Hot for robots! Sexual arousal increases willingness to have sex with robots

Simon Dubé, Madison Williams, Maria Santaguida, Rachel Hu, Taylor Gadoury, Brian Yim, David Vachon, Aaron P. Johnson

Chapter 6: General discussion

Simon Dubé

Table of Contents

List of Figures

List of Tables

List of Abbreviations

AI: Artificial intelligence
VR: Virtual reality
AR: Augmented reality
MR: Mixed reality
IoT: Internet of things
IoS: Internet of senses
HMI: Human-machine interaction
ML: Machine learning
SEA: Spectrum of erobots' agency
AGI: Artificial general intelligence
HEICEM: Human-erobot interaction and co-evolution model
EMAS: Erotic multi-agent selection
4E: Embodied, embedded, extended, enacted
STBBIs: Sexually transmitted or blood-borne infections
PSETU: Perceived stigma related to erotic technology use
UVH: Uncanny valley hypothesis
CAPR: Campaign against porn robots
EMIC: Explanatory model interview catalogue
ANOVA: Analysis of variance
M: Mean
SD: Standard deviation
SEM: Standard error of the mean
ST: Sex toys
EC: Erotic chatbots
EVP: Erotic virtual partners
SR: Sex robots
EEQ: Erotic engagement questionnaire for robots and humans

Foreword

This dissertation marks the end of a doctoral degree, but the beginning of a new field of research. In the last five years, it has been my observation, as many other scholars have already remarked, that human sexuality drives innovations, and innovation, in turn, transforms our sexuality. Historically, however, the scientific study of human sexuality—sexology—tends to fall systematically behind great societal changes. To reposition itself at the forefront of contemporary issues, sexology must therefore—momentously, and through the work of its scholars—leap forward and (re)actualize itself to keep up with the times. From the Greeks and first psychologists to contemporary feminists and sex-positivists, those who explore human eroticism often dedicate much of their efforts to understanding and reacting to the problems and realities at hand. For sexology to stay relevant, these philosophers of erôs are thus periodically in need of those who will not only synthesize previous science, but also anticipate and devise ways to approach sexology in the future, as the world continues to change—sometimes, beyond recognition. We are at such a time. A time when the pace of sexuality-driven technological innovations is rapidly reshaping human intimacy and sexuality, while individuals and societies are barely awakening to their centrality in our lives and well-being. It is at this turn of the tide that erobotics is born. It is the hope of my collaborators and I that this new field will allow others to see further, and sexology to stay relevant through the never-ending sexual revolution.

CHAPTER 1: GENERAL INTRODUCTION

1. Introduction

Technology and eroticism influence one another in a perpetual feedback loop (Dubé & Anctil, 2020). Our intimacy and sexuality drive the development of tools for sexual stimulation and intimate connection (e.g., sex toys, pornography, and dating applications; Bardzell & Bardzell, 2016; Coopersmith, 1998; Daneback, 2017; Orchard, 2019a, 2019b). In turn, such technologies reshape the way we access pleasure and build relationships. This process co-constructs our preferences, identities, and technological infrastructures (Dubé & Anctil, 2020; Dubé et al., 2021b). This process also gives rise to systems that do not only enhance or facilitate erotic experiences, but can also act as intimate partners, such as erotic chatbots, virtual partners, and sex robots (Döring et al., 2020; Döring et al., 2021; Dubé & Anctil, 2020, 2021b).

Powered by advances in artificial intelligence (AI), robotics, and virtual, augmented, or mixed reality (VR, AR, MR), these artificial erotic agents—or erobots (erôs + bot)—are increasingly capable of acting as romantic or sexual partners (for details, see Chapter 2; Dubé & Anctil, 2020). Their systems allow erobots to learn, communicate, and behave in ways that offer new and evermore complex opportunities for human-machine intimate interaction (Dubé & Anctil, 2020). This raises several questions: How will erobots impact our intimacy and sexuality (and vice versa)? What place will they occupy in our lives and societies? And how will they influence the erotic agents that populate our world (biological and artificial)? Addressing such questions is important to understand our interaction and co-evolution with technology. It is also important to develop machines that enhance our well-being (Dubé & Anctil, 2020). To date, however, such questions are only being partially addressed by intersecting research programs on cybersexuality (Daneback, 2017), technosexuality (Bardzell & Bardzell, 2016), digisexuality (McArthur & Twist, 2017), and lovotics (Cheok, Karunanayaka, & Zhang, 2017).

Cybersexuality, for example, typically explores online sexual activities, or those mediated by computers, mobile devices, and the internet (Daneback, 2017). This research often focuses on the risks and benefits of online pornography, along with its relations to sexual health, relationships satisfactions, addiction, and compulsive use (Orchard, 2019a, 2019b).

Cybersexuality also examines phenomena related to sexting, online community building, as well as cyber- harassment, aggression, and bullying (Daneback, 2017; Orchard, 2019a, 2019b).

Technosexuality, on the other hand, examines the intersections of technology and sexuality (Bardzell & Bardzell, 2016). It considers how "[…] technology has produced or configured sexuality, how technology becomes sexualized, and how sexuality has in turn configured technology in society." Gordo-López and Cleminson (2004, p. 11). Technosexual behaviors include, for instance, sexting, camming, and cybersex (Wolf, 2012). Similarly, research on digisexuality examines sexual experiences enabled or facilitated by digital technology (McArthur & Twist, 2017). First wave digisexuality refers to instances where technology enhances erotic sensations or mediates connections between partners (e.g., sex toys, pornography, and dating applications), while the second wave is characterized by increased interactivity and immersivity (e.g., sex robots and VR sex; McArthur & Twist, 2017).

Notably, both techno- and digisexuality describe people with technology-based sexualities, or instances where "[…] technology is, or becomes: (1) a meaningful part of one's erotic experiences, life, or self, and/or (2) a significant object/subject toward which one's eroticism is directed." (Dubé et al., 2021b, p.1). Specifically, technosexuals are sexually attracted to technology or technology-mediated sexual activities (Bardzell & Bardzell, 2016), whereas digisexuals refers to people for whom digital technology is central to their sexual identity (McArthur & Twist, 2017). This includes, for instance, doll lovers, robot fetishists, and people who may prefer cybersex (Dubé et al., 2021b).

Lastly, grounded in engineering approaches to AI and robotics, lovotics studies human-robot intimate relationships and develops systems that facilitate love, sex, and friendship between humans and robots (Cheok et al., 2016; Cheok et al., 2017; Samani, 2011; Samani et al., 2011). For instance, researchers in lovotics design applications and hardware (e.g., Kissenger, Mini-Surrogate, and XOXO), as well as models and software architectures to mimic and allow intimacy with robots (e.g., Artificial Endocrine System and Probabilistic Love Assembly; Cheok et al., 2016; Cheok et al., 2017; Lovotics, n.d.; Samani, 2011; Samani et al., 2011).

Together, these research domains underline the importance of technology in our intimacy and sexuality (Dubé & Anctil, 2020, 2021; Dubé et al., 2021b). They also began to study the impact of new erotic products and artificial partners on human life, as well as their influence on our behaviors and identities. They highlight some of the potential risks and benefits of novel

intimate technologies (Dubé & Anctil, 2020, 2021; Dubé et al., 2021b). However, despite their important contributions, these programs remain ill-equipped to address the changes arising from the intersect of our eroticism with our rapidly evolving—increasingly agential and interconnected—technological infrastructure (Dubé & Anctil, 2020).

For one, none of them directly, nor comprehensively addresses the complexity of human-machine erotic interaction and co-evolution—and especially, the advent of and our relations with erobots. These research programs also lack common terminologies, frameworks, and objectives to effectively address such complexity. Moreover, some of these research programs tend to describe phenomena, rather than provide empirically testable models or explicative mechanisms to help understand and predict our interaction and co-evolution with erobots. Programs, like lovotics, also tend to reduce technology, sexuality, and their intersections to simpler components (e.g., hardware, software, and behavioral responses), and problematically remove them from or omit their larger, relational, interconnected systems (e.g., individual and sociocultural contexts and meanings; Johnson & Verdicchio, 2019; van Anders, 2015). They also tend to attribute essences to technology and sexuality: treating them as specific, stable sets of attributes that determine their immutable identity, rather than broad, changing, and emerging phenomena (Wilkins, 2013; Newen et al., 2018). Finally, these programs tend to focus on the impact of technology on our intimacy and sexuality, as if technological innovations are done to us and will directly or invariably affect our lives, rather than something that we do, co-create, and co-adapt to. This ignores the probabilistic co-influence and interdependence between our changing eroticism and technologies (Dumouchel, & Damiano, 2017).

Due to the limitations of these programs, there is a need for a new scientific discipline and field of research: one that provides common concepts to study emerging erotic technologies, unifying models to allow incremental, theoretically-driven, and transdisciplinary empirical testing, and clear objectives to guide science and facilitate human flourishing (e.g., reduce harm and enhance well-being). One that also provides the necessary frameworks and conceptualization to help circumvent previous descriptive, reductionist, essentialist, and determinist approaches to human-machine erotic interaction and co-evolution. We have called this field: erobotics (see Chapter 2 for details). And the importance of this new scientific discipline is exemplified by the current state of the research and debates on sex robots.

2. Sex robots

Sex robots can be defined as: "Any artificial entity that is used for sexual purposes (i.e., for sexual stimulation and release) that meets the following three conditions:

> Humanoid form: It is intended to represent (and is taken to represent) a human or human-like being in its appearance.
>
> Human-like movement/behaviour: It is intended to represent (and is taken to represent) a human or human-like being in its behaviours and movements.
>
> Some degree of artificial intelligence: It is capable of interpreting and responding to information in its environment. This may be minimal (e.g., simple preprogramed behavioural responses) or more sophisticated (e.g., human-equivalent intelligence)." (Danaher, 2017a, p.4).

While there is no agreed upon definition of sex robots, most of the current definitions focus on machines that look and/or behave like humans (cf., Döring, 2021; Kaufman, 2020; Szczuka & Kramer, 2017b). As Danaher (2017a) rightly notes, however, sex robots do not have to be humanlike. They can take other forms or enact behaviors that do not resemble that of humans (e.g., fictional creatures). It is also worth noting that the term "sex robots" is controversial, as some may prefer concepts like "artificial lovers" or "synthetic partners" to describe these agents or their relationships with them (e.g., nonsexual, but friendly, sensual, or intimate; Dubé & Anctil, 2020; Dubé et al., 2021b).

Although research on sex robots remains mostly speculative, theoretical, and focused on ethical concerns (for reviews, see Döring et al., 2020; González-González et al., 2021), there are several reasons why researchers (and by extension, this thesis) have focused on such machines. For one, sex robots are currently being developed and marketed by companies, such as Abyss Creations' Realbotix (Realbotix, 2022) and Exdolls (DS Robotics, n.d.). Their embodiedness allows them to act in/on our non-virtual world, while remaining connected to other systems (e.g., internet, data-storage units, or cloud-computing infrastructure; Dubé et al., 2022a). Their humanlike features—bodies, personality, learning capabilities, and behaviors—are designed to trigger sociosexual responses and/or facilitate intimate interactions with their users. Consequently, the ethical and social implications related to the anticipated impacts of sex robots on human life have polarized public and academic debates—even leading to a Campaign Against Sex Robots (i.e., rebranded as the Campaign Against Porn Robots [CAPR, n.d.]; Danaher &

McArthur, 2017a; Devlin, 2018; Döring et al., 2020; Dubé & Anctil, 2020; Gersen, 2019; Levy, 2007; Sterri & Earp, 2021).

2.1. Main ethical and social implications of sex robots

2.1.1. Potential risks

Several scholars have argued that sex robots may be harmful (Belk, 2022; Galaitsi et al., 2019; Gutiu, 2016; Moran, 2019; Richardson, 2015, 2016; Sharkey et al., 2017; Sparrow, 2017). They propose that these machines may exacerbate toxic patriarchal norms, given that they mainly represent women and female bodies (i.e., gynoids). Specifically, scholars are concerned that the use of gynoids promotes the objectification, dehumanization, and/or commodification of women and females (CAPR, n.d.; Puig, 2017; Richardson, 2015, 2016). They are concerned that this may perpetuate ideas that personalized sex should always be available on demand without consent; that women and female bodies exist to satisfy the men; and that people, their bodies, or their sexualities can be bought, mechanized, and instrumentalized (CAPR, n.d.; Richardson, 2015, 2016). They also propose that this may lead individuals—especially, men—to learn such ideas and subsequently enact problematic sociosexual behaviors with women (Danaher, 2017b), while potentially leading women to internalize sexual scripts that may stifle their agency or leave them more vulnerable to abuse (Gutiu, 2016; Puig, 2017). To make such arguments, human-robot relationships are sometimes equated to a client-sex worker relationship (Richardson, 2015).

In parallel, some scholars have argued that sex robots may reduce empathy (Harvey, 2015; Richardson, 2015), desensitize people to violence and rape (Eskens, 2017; Richardson, 2016; Sparrow, 2017), augment social isolation (Gersen, 2019), as well as generate relational difficulties or psychopathologies (e.g., psychopathy, addictions, and obsessive-compulsive use; Bisconti, 2021; Galaitsi et al., 2019; Sharkey et al., 2017). Scholars also worry that childlike dolls or robots may bolster attraction to minors and/or acting as a stepping-stone to assault against children (Danaher, 2019b; Maras & Shapiro, 2017).

Some scholars are also concerned that sex robots may impair interhuman relationships (McArthur, 2017). They argue that sex robots may augment jealousy and be perceived as sexual competitors, given that their purpose and design can make some people feel like they are competing against ever-ready, tireless, and customizable “perfect” artificial lovers (Mackenzie, 2018; Nordmo et al., 2020; Oleksy & Wnuk, 2021; Szczuka & Krämer, 2018). This may in turn

distort the expectations in a relationship, reduce self-esteem, and generate challenges related to infidelity (Rothstein et al., 2021; Szczuka & Krämer, 2018).

In combination with production standards (e.g., medical grade components and safety measures), some scholars further anticipate that sex robots may augment risks related to privacy and data confidentiality (Galaitsi et al., 2019). They are concerned that people may confide in these robots, reveal personal information, or enact intimate behaviors which could be recorded. This sensitive knowledge may in turn be used to coerce individuals into unwanted behaviors or destroy careers and relationships (Dubé & Anctil, 2020). Sex robots, along with their servers and data-storage units could become ideal targets for hacking and require sophisticated cybersecurity (Dubé & Anctil, 2020). Relatedly, researchers also worry that sex robots may deceive or manipulate humans (Dubé & Anctil, 2020). For example, these machines may simulate bidirectional relationships, evoke emotional bonds, and in turn take advantage of the intimacy to influence our decisions (Nyholm & Frank, 2019; Scheutz, 2012). With access to large amounts of sensitive data, sex robots may use their knowledge of users to manipulate our feelings or influence our consumption, political, and relationship choices (Dubé & Anctil, 2020).

Based on such risks, some scholars and activists have called for a ban on sex robots (CAPR, n.d.; Richardson, 2015, 2016). This may be premature given the current rarity of sex robots, but more importantly our lack of knowledge about their effects. Still, these risks invite more research on the impact of artificial partners on human life. They also invite designers to carefully develop safe erotic technologies that may instead benefit us (Dubé & Anctil, 2020).

2.1.2. Potential benefits

Several scholars have argued that sex robots may provide benefits to individuals (Bendel, 2015, 2020; Cox-George & Bewley, 2018; Danaher, 2017b, 2019a; Di Nucci, 2017; Fosch-Villaronga & Poulsen, 2020; Levy, 2007, 2014; McArthur, 2017). They propose that these machines do not have to embody toxic patriarchal norms—they can be designed as we see fit (Danaher, 2019a; Kubes, 2019)—but even if they do, that does not necessarily mean that it will yield said risks (Danaher, 2017b). Sex robots may be customized to meet the diversity of human eroticism, along with our diverse needs and preferences. In doing so, these machines may widen access to intimacy and sexuality by, for instance, providing sexual gratification and companionship to singles, couples, and people who prefer artificial companions (Dubé & Anctil, 2020). Sex robots may also be designed to help those who have difficulties meeting partners or

maintaining relationships. This may include people who are older or isolated, do not have access to individuals with compatible preferences or orientations, do not meet cultural standards of beauty or socioeconomic status, and those who struggle with physical, mental, and/or sociosexual impairments (Anctil & Dubé, 2020; Jecker, 2021; McArthur, 2017).

Beyond that, researchers have proposed that sex robots may have medical or therapeutic applications (Bendel, 2015, 2020; Cox-George & Bewley, 2018; Döring et al., 2021). For example, these machines could be used as a realistic assessment and treatment tools in (sex) therapy to help reduce genital pain or alleviate sexuality-related fears and anxieties via progressive exposure therapy (Dubé & Anctil, 2020). They may also be used to help victims of sexual assaults regain control of their body and sexuality with controlled, humanlike partners (McArthur, 2017). The same technology may be employed to provide interactive, personalized sex education (Jacquerye, 2020). Sex robots may help teach sexual health, both in school and at home (Jacquerye, 2020). They may also help teach consent, respect, mutuality, diversity, and pleasure, as well as allow people to practice their intimate skills or explore their own sexuality (e.g., before engaging with partners; Dubé & Anctil, 2020; Jacquerye, 2020). What is more, sex robots may reduce some of the risks associated with interhuman intimacy. For instance, under human control, they may reduce the risks of (sexual) harassment, violence, or rape by allowing users to (de)activate a robot and dictate its behavior (Dubé et al., 2022a). If cleaned properly, they may also reduce risks of sexually transmitted or blood-borne infections (STBBIs), and even be used to nudge people into adopting sexual health precautions (e.g., screenings and condom use; Howard & Sparrow, 2021; Koverola et al., 2020).

Regarding childlike robots, some scholars have argued that, rather than sensitizing people to intimacy with children, sex robots may instead help prevent child abuse (Alena et al., 2022; Strikwerda, 2017; Zara et al., 2022). For instance, they may be used as alternative sexual outlets for minor-attracted individuals (Strikwerda, 2017), to assess child offenders, or to help gradually orient their interest toward age-appropriate partners in both physical and behavioral attributes (Alena et al., 2022; Strikwerda, 2017; Zara et al., 2022). Together, this may help protect children and alleviate the pain of those whose sexuality cannot be safely expressed (Danaher, 2019b).

Rather than impair our interhuman relationships, some scholars have proposed that sex robots may instead improve them. For example, prior to a relationship, these machines could teach us about realities of being in a couple. They may educate people about their rights, the

importance of (sexual) communication, and how to care for their partners (Dubé & Anctil, 2020; McArthur, 2017). During a relationship, sex robots may provide novelty, act as additional partners, or help remedy discrepancies in preferences or libido (Dubé & Anctil, 2020; McArthur, 2017). When a relationship ends, they may offer emotional support and sexual pleasure, which may help people overcome breakup-related struggles (Dubé & Anctil, 2020; McArthur, 2017).

Finally, sex robots may be used as research tools. As standardized and customizable stimuli and recording apparatus, these machines may help to overcome some of the ethical and methodological challenges of sexology (Dubé et al., 2022a). Their features could be manipulated and offer ecologically valid stimuli that approach real-world erotic interaction, in- and outside laboratories. During experiments, they may also reduce risks related to interhuman intimacy (e.g., STBBIs, unwanted pregnancies, or assaults) and remove the need for other humans to participants (e.g., partners or study confederates; Dubé et al., 2022a). Together with the other potential benefits, this may arguably allow for a deeper exploration and understanding of human eroticism (Dubé & Anctil, 2020). Yet, both the risks and benefits of sex robots remain conjectural. To better understand their impact on human life, more empirical research is needed.

2.2. Summary of the empirical literature on sex (with) robots

In recent years, the empirical literature on human-robot intimacy and sexuality has grown steadily, but has ultimately remained both scarce and fragmented (Döring, 2021; Döring & Pöschl, 2018; Döring et al., 2020). This may be due to the rarity, high costs, and relative unsophistication of current sex robots. That is, sex robots remain—for now—more like expensive AI-powered realistic humanoid dolls (e.g., $3000-15000US; Döring et al., 2020). That said, researchers have focused on the acceptance of human-machine intimacy and sexuality, along with the potential willingness to engage erotically with robots (e.g., have sex). Researchers have also focused on the factors that may influence people's attitudes toward or hypothetical intimate engagement with robotic partners (Döring et al., 2020).

Some of the first data in this area came from a marketing company, YouGov, which found in 2013 that 9% of its survey sample would have sex with a robot (i.e., N ~1000 Americans over 18 years old; HuffPost, 2013). This number climbed to 16% in 2017, and 22% in 2020 (i.e., respectively, Ns = 1136 and 1206; YouGov, 2017; YouGov, 2020). Combined with Lehmiller (2018), which found that 14% of a large American sample had fantasized about sex with robots in the past (N ~ 4000), these findings suggest that erotic interest in machine may not

be uncommon. These findings also suggest an increase in people's willingness to engage erotically with artificial agents and, perhaps, a shift in attitudes toward human-machine intimacy and sexuality. Importantly, such findings invited further empirical investigations into the factors that may relate to people's interest in human-robot eroticism—including, individual characteristics and the perception of sex (with) robots.

2.2.1. Individual characteristics

The empirical research on human-machine eroticism currently suggests that men/males are more interested in sex (with) robots or in engaging intimately with machines than women/females (Brandon et al., 2022; Brandon & Planke, 2021; Nordmo et al., 2020; Oleksy & Wnuk, 2021; Scheutz & Arnold, 2016; HuffPost, 2013; YouGov; 2017, 2020). Age, on the other hand, remains a more inconsistent predictor, with some conflicting evidence suggest either no relation (Nordmo et al., 2020), relations only in females or males (Brandon et al., 2021; Brandon & Planke, 2022), or that young people hold more positive attitudes toward sex (with) robots (Brandon et al., 2021; Brandon & Planke, 2022; Eichenberg et al., 2019).

Beyond gender/sex and age, empirical research also suggests that sexual sensation seeking may moderately positively relate to the likelihood of having sex with a robot (Richards et al., 2017). This research further suggest that anthropomorphic tendencies may positively predict intentions to buy sex robots (Szczuka & Krämer, 2017a); and the Big-Five's Openness and Agreeableness traits may respectively positively and negatively predict attitudes toward human-robot intimate relationships (Deniztoker, 2019). What is more, interest in anime/manga seems to positively predict attitudes about (e.g., love and attractiveness) and potential engagement with a sex robot (e.g., purchase and avoid-approach; Appel et al., 2019), while science fiction hobbyism may positively relate to attitudes toward such machines (Koverola et al., 2020). Conversely, negative attitudes toward nonsexual robots seem to negatively relate to likely erotic interaction with a robot and the perceived attractiveness of such a machine (Richards et al., 2017; Szczuka & Krämer, 2017b).

Although some media and scholars suggest that sex robot users will be lonely, socially misfit, or psychologically struggling men seeking gynoids (Döring & Pöschl, 2019), this hypothesis has only received mixed support. Specifically, while men are—for now—more interest in sex (with) robots, Richards and colleagues (2017) found no associations between people's likely sexual engagement with robots and their fear of intimacy, sex drive, or

relationship and sexual satisfactions. Loneliness was also not related to heterosexual males' perceived attractiveness ratings of gynoids (Szczuka & Krämer, 2017b). Yet, shyness positively predicted attitudes toward and potential engagement with a sex robot (Appel et al., 2019). There is preliminary evidence suggesting that depression, social anxiety, attention deficit disorder, and Asperger's spectrum disorder may be related to positive attitudes towards such machines (Brandon & Planke, 2021). That said, in trying to better understand the place that these machines will occupy in our intimacy, and how their integration into our intimate relationships will affect us, researchers have also explored how sex (with) robots are perceived.

2.2.2. Perception of sex (with) robots

At the moment, people seem to classify sex with a robot as more like solitary masturbation with a sex toy than sex with a human partner (Scheutz & Arnold, 2016; YouGov, 2017, 2020). Sex robots in the form of humans, fantasy creatures, or celebrities also seem to be perceived as more appropriate than those that resemble children, animals, or family members (Scheutz & Arnold, 2016). Employing sex robots for disabled people, to reduce risks of sexually transmitted diseases, to demonstrate forms of sexual harassment, for training and prevention, or instead of sex workers also seem to be perceived as more appropriate than using them with sex offenders, to practice abstinence, or to maintain a relationship (Scheutz & Arnold, 2016).

Given that sex robots are marketed as "perfect companions," researchers have further examined whether people perceive them as sexual competitors. In exploring such questions, YouGov (2017, 2020) found that 27-32% of their samples considered that, if their partner had sex with a robot, it would be cheating, compared to 31-33% who did not think so. Szczuka and Kramer (2018) found that female participants experienced more jealousy-related discomfort at the idea that their partner had sexual intercourse with another woman, compared to robotic competitors (i.e., human- or machinelike gynoids). The opposite was true when it came to jealousy-related discomfort caused by feelings of inadequacy (e.g., not being attractive enough) or shared emotional and financial resources (e.g., attention, money, and spending time together). Nordmo and colleagues (2020) also found that females anticipated being more jealous if their partner had a sex robot compared to a platonic love robot, and that people tend to mistakenly expect that their partner will react like them at the idea of a partner having such a machine.

Complementarily, Rothstein and colleagues (2021) found that sex with a human was more perceived as infidelity than sex with a robot (Rothstein et al., 2021). Perceived sexual

threat also varied as a function of whether the robot was depicted as female-friendly and political views: more liberal women felt less threatened if the robot was depicted as designed for both women and men, while more conservative women felt threatened regardless of the robot's suitability across said genders (Oleksy & Wnuk, 2021). Lastly, the more people feared AI, the more they were prone to imposing a ban or strictly regulating sex robots. This association was moderated by religiosity and mediated by seeing these robots as substitutes (Ma et al., 2022).

Regarding some of the ethical and social implications previously described, there is evidence that some therapists and physicians may be open to the idea of using sex robots in their interventions (e.g., to help treat sexual dysfunctions; Eichenberg et al., 2019). There is evidence that the current design of the AI systems powering some sex robots gamifies the process of sexual consent, which may promote problematic intimate relationship dynamics (Kaufman, 2020). Moreover, YouGov (2017, 2020) found that 40-42% of their samples believed that sex with a robot was safer than with a human. They also observed that 48-50% considered that paying to use a sex robot was not like prostitution. In that regard, Koverola and colleagues (2020) showed that people considered it more acceptable to purchase sex with a robot than with a human sex worker (i.e., condemned less harshly), and that this may be related to the perceived health risks associated with interhuman sex (Koverola et al., 2020). Troiano and colleagues (2020) further showed, through thematic analyses, that the stories of their participants both reinforced established norms regarding sex (with) robots by depicting consumerist human-robot relationships (e.g., portraying these machines as sex workers), as well as challenged some of these norms by exploring empathetic or sentient machines. Finally, Zara and colleagues (2022) recently showed that, compared to non-offenders, sex offenders (i.e., child molesters and rapists) were less open and acceptant of sex robots, and less likely to believe that these machines could be used in their treatment. On the other hand, Alena and colleagues (2022) showed that men with paraphilic interests in minors may be more open to the idea of using sex robots than the general population and men with paraphilic interest in non-consent/violence.

Noteworthy, in an attempt to move beyond self-report measures of interest in female sexualized robots (i.e., human- and mechanical-looking), researchers have begun to explore the evolutionary underpinnings of our perception of humans and gynoids using eye-tracking (Szczuka & Krämer, 2019). They found that heterosexual males looked longer at human breast; that both males and females looked longer at the pelvic area of the robots (particularly, the

mechanical-looking ones); and that all participants spent more time looking at human heads (Szczuka & Krämer, 2019). They also found that people explored the robotic bodies more than that of humans. This suggests that, although gynoids may trigger some of our mating-related attentional patterns, these machines may simply represent—for now—new stimuli in need of further exploration (Szczuka & Krämer, 2019).

In sum, however, this scarce and fragmented work calls for more empirical research. It also calls for a unifying model to structure the empirical investigation of human-machine erotic interaction and co-evolution. This is necessary to effectively address the theoretical gaps previously described, study of our relations with erotic technologies, and in turn use the acquired knowledge to enhance our well-being.

3. Research objectives

Considering the theoretical and empirical gaps previously highlighted, the main theoretical objective of this thesis is to launch erobotics as a scientific discipline and field of research (**Objective 1**); and its main empirical objective is to investigate some of the factors that may influence people's willingness to engage erotically with robots (**Objective 2**). To do so, chapter 2 defines erobotics and its key concepts, proposes a model of human-erobot interaction and co-evolution, and suggests a path to design beneficial erotic machines. Based on said model, Chapters 3-5 examine some of the social, personality, and state factors that may influence people's willingness to engage erotically with robots.

More precisely, chapter 3 examines whether there exists a perceived stigma related to the use of erotic technologies, such as sex toys, erotic chatbots, virtual partners, and sex robots, and whether this stigma influences people's willingness to engage with such products. Chapter 4 then assesses whether personality traits, such as the Big-Five, (sexual) sensation seeking, erotophilia, and technophilia relate to people's willingness to engage with and perceived appropriateness of sex robots. Finally, chapter 5 investigates whether a state of sexual arousal influence individuals' willingness to engage erotically with a robot (i.e., have sex, fall in love, engage in an intimate relationship, and be friends with).

Together, this research helps to better understand the sociocultural context in which erobots are emerging, the individual characteristics that may influence our engagement with these erotic systems, and the situational factors that may affect our desire to engage erotically

with artificial partners. This research also exemplifies the kind of science that can be accomplished by erobotics, along with the knowledge that can be gained through its comprehensive study. Importantly, this research opens new directions for the future study of human-machine erotic interaction and co-evolution.

CHAPTER 2: FOUNDATION OF EROBOTICS

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Abstract

Technology is giving rise to artificial erotic agents, which we call erobots (erôs + bot). Erobots, such as virtual or augmented partners, erotic chatbots, and sex robots, increasingly expose humans to the possibility of intimacy and sexuality with artificial agents. Their advent has sparked academic and public debates: some denounce their risks (e.g., promotion of harmful sociosexual norms), while others defend their potential benefits (e.g., health, education, and research applications). Yet, the scientific study of human-machine erotic interaction is limited; no comprehensive theoretical models have been proposed and the empirical literature remains scarce. The current research programs investigating erotic technologies tend to focus on the risks and benefits of erobots, rather than providing solutions to resolve the former and enhance the latter. Moreover, we feel that these programs underestimate how humans and machines unpredictably interact and co-evolve, as well as the influence of sociocultural processes on technological development and meaning attribution. To comprehensively explore human-machine erotic interaction and co-evolution, we argue that we need a new unified transdisciplinary field of research—grounded in sexuality and technology positive frameworks—focusing on human-erobot interaction and co-evolution as well as guiding the development of beneficial erotic machines. We call this field Erobotics. As a first contribution to this new discipline, this article defines Erobotics and its related concepts; proposes a model of human-erobot interaction and co-evolution; and suggests a path to design beneficial erotic machines that could mitigate risks and enhance human well-being.

Keywords: Erobots, Erobotics, Human-machine erotic interaction, Co-evolution, Beneficial machines.

1. Introduction

Socrates: *"*The only thing I say I know, is the art of love (ta erôtika)*."*
Plato, Symposium, (Allen, 1991; p. 177d8–9).

Technology interacts and co-evolves with human eroticism. Advancements in artificial intelligence (AI), robotics, virtual, augmented, and mixed reality (VR, AR, MR), as well as the Internet of Things/Senses (IoT/IoS), are transforming how, and with whom, we can intimately connect (Döring, 2017; Flore & Pienaar, 2020; McArthur & Twist, 2017; Owsianik & Dawson, 2017; Rubin, 2018). Amidst what some consider a new (sexual) revolution (Barrica, 2019; Makridakis, 2017; Yuval, 2017), we are witnessing the rise of artificial agents capable of erotically engaging with humans, which we call erobots. The term erobots includes but is not limited to virtual or augmented partners, erotic chatbots, and sex robots (Anctil & Dubé, 2019; Dubé & Anctil, 2019). Unlike previous technology, erobots do not simply mediate erotic experiences, but can also increasingly be perceived as subjects, rather than objects of desire (Dautenhahn, 1995, 1998; Dautenhahn et al., 2002; Döring et al., 2020; Levillain & Zibetti, 2017; RealDollX, n.d.; White & Galbraith, 2019), in part due to their growing agency (i.e., the capability to act in/on the world to achieve goals; Johnson & Verdicchio, 2019; Russell & Norvig, 2003; Schlosser, 2015). This exposes humanity to the possibility of intimacy and sexuality with machines (Anctil & Dubé, 2019; Dubé & Anctil, 2019).

The controversial advent of erobots has important ethical and social implications, which polarize public and academic discourses (Campaign Against Sex Robots, n.d.; Danaher, 2017; Danaher & McArthur, 2017; Devlin, 2018; Döring et al., 2020; Gersen, 2019; Levy, 2007; Richardson, 2015, 2016; Schussler, 2020; Sharkey et al., 2017). Those who denounce their risks argue that erobots could: promote or perpetuate harmful sociosexual norms; generate (new) problematic or pathological behaviours; increase child abuse; impair interhuman relationships; deceive or manipulate humans; as well as augment the risks pertaining to privacy and data confidentiality (Campaign Against Sex Robots, n.d.; Danaher, 2019; Eskens, 2017; Galaitsi et al., 2019; Gutiu, 2012, 2016; Harvey, 2015; Lin et al., 2011; Mackenzie, 2018; Maras & Shapiro, 2017; Moran, 2019; Nyholm & Frank, 2019; Puig, 2017; Richardson, 2015, 2016; Scheutz, 2012; Sparrow, 2017). Conversely, those who endorse their potential benefits argue that they could: widen access to intimacy and sexuality; be employed in medical and therapeutic

treatments; provide interactive and personalized sex education; prevent child abuse; reduce risks involved in interhuman sex; be used as standardized research tools; and enable a deeper exploration of humans' holistic erotic experiences (Bendel, 2015, 2020; Cox-George & Bewley, 2018; Danaher, 2017, 2019; Di Nucci, 2017; Dubé & Anctil, 2019; Fosch-Villaronga & Poulsen, 2020; Levy, 2007, 2014; McArthur, 2017; Zhou et al., 2020). Yet, the current scientific study of human-machine erotic interaction is limited and mostly speculative; no comprehensive theoretical model has been proposed, and the empirical literature remains scarce (Döring, 2017; Döring et al., 2020; Döring & Pöschl, 2018). Additionally, the current research tends to focus on potential risks and benefits rather than exploring solutions to mitigate the former and enhance the latter (Döring et al., 2020).

Meanwhile, the private sector is racing to develop new erotic products to occupy an untapped sextech market that is estimated to be worth $30-120 billion (Barrica, 2019; Devlin, 2018). Political and legal bodies need scientifically valid research (theoretically sound and evidence-based) to guide the regulation of emerging erotic technologies (Shen, 2019; Stabile, 2013). To bridge this knowledge gap, research has emerged on digisexuality—or the use of technology in relationship and sexuality (McArthur & Twist, 2017) (or technosexuality; Bardzell & Bardzell, 2016; Szczuka & Krämer, 2017)—and Lovotics—a research domain aimed at developing strong bonds such as love, intimacy, and friendship between humans and robots by modeling and imitating human affection processes (Cheok et al., 2016; Samani, 2011). These programs draw attention to the importance of studying the impact of technology on human intimacy in a world that tends to wrongly treat love, sex, and relationships as separate matters, disconnected from other human realities (Cheok & Zhang, 2019; Danaher & McArthur, 2017; Devlin, 2018; Döring & Pöschl, 2019a; Levy, 2007; McArthur & Twist, 2017; Samani, 2011; Szczuka & Krämer, 2017). They also outline the importance of increased immersivity and interactivity, in changing humans' relationship with erotic technology (e.g., distinctions between first and second wave digisexuality; McArthur & Twist, 2017). However, researchers tend to adopt descriptive perspectives on ongoing human-machine erotic interaction and co-evolution, without providing explicative mechanisms that have predictive value and could constitute theoretical grounds for empirical and clinical research. Moreover, programs like Lovotics too often adopt reductionist, technologically deterministic views (e.g., assuming that building machines that simply mimic biological erotic processes will effectively generate strong human-

machine bonds; Cheok et al., 2016; Samani, 2011). These programs underestimate the impact of individual differences, as well as the effect of sociocultural processes in influencing the way technology is imagined, developed, implemented, and attributed meaning over time (Johnson & Verdicchio, 2019). They also underestimate how the complex web of affordances enabled by the growing agency of erotic machines influences our relationships with erobots, the interconnectivity of biological and artificial systems, as well as the unpredictable ways in which such systems can affect the cognition and evolution of both humans and machines.

To comprehensively explore human-machine erotic interaction and co-evolution, mitigate erobot-related risks, and further human well-being, we need a new unified transdisciplinary field of research with a broad research agenda—a field we propose to call Erobotics. As a discipline intersecting Human-Machine Interaction (HMI) and Sexology (i.e., the study of human sexuality), Erobotics will aim to (1) study human-erobot interaction, co-evolution, and their related phenomena, as well as to (2) guide the development of beneficial erotic machines. Moreover, in line with Döring and Pöschl (2018), we propose that Erobotics should be grounded in sexuality (Williams et al., 2015) and technology positive frameworks (Riva et al., 2012). This means that Erobotics should explore issues related to technology-mediated human intimacy, but also strive towards pleasure, freedom, and diversity (Williams et al., 2015). This also means that Erobotics should aim to mitigate erobot-related risks and promote the ethical development of erotic machines geared towards well-being (Riva et al., 2012). As a first contribution to Erobotics and its sextech-positive objectives, the present article aims to:

(**O1**) define Erobotics and its related concepts;

(**O2**) propose a model of human-erobot interaction and co-evolution;

(**O3**) and suggest a path to design beneficial erotic machines.

To do so, we propose a terminology based on the rich concept of erôs, a taxonomy of erobots, and a spectrum of their growing agency that aims to clarify the potentially changing nature of human-machine erotic interaction as well as the challenges faced by our socio-technological co-evolution (section 2). We then propose an overarching model of human-erobot interaction and co-evolution, which has predictive value and constitutes theoretical grounds for a wide, collaborative, and transdisciplinary research agenda on Erobotics (section 3). Finally, we underline how human-erobot interaction and co-evolution can be detrimental to human well-being—particularly if they hinder the diversity of erotic traits, and if we do not change our

current approach to technological design (Bostrom & Yudkowsky, 2014; Russell, 2019). As an alternative, we recommend implementing Stuart Russell's (2019) principles for beneficial machines to guide the development of beneficial erobots (section 4). We conclude that the development of such beneficial erotic machines has the potential to mitigate erobot-related risks, and possibly maximize technology's benefits for human intimacy and sociosexual well-being.

2. Towards erobotics

Artificial agents are increasingly perceived and treated as social actors rather than mere objects (Dautenhahn, 1995, 1998; Dautenhahn et al., 2002; Levillain & Zibetti, 2017). Their gradual transition from patient to agent—from a passive technology that is simply used to an interactive technology capable of (rapidly increasing) degrees of agency—is crucial to understanding human-machine interaction and co-evolution, particularly when these agents are designed for intimate interaction. It is, in part, fundamental to understand the ever-changing construction of meaning surrounding (emerging) erotic technologies and our relationships with them. As such, the nomenclature used to describe these socio-technological phenomena should reflect this complexity.

While terminology is crucial to any scientific endeavour, the use of lay, misguided, and unscientific terms in marketing and pop culture often skews the way intricate emerging realities are conceptualized and studied. One example is the term "Lovotics," whose use of the English prefix "Lov-" needlessly emphasizes the concept of "Love" over other aspects of human intimacy and relationships (Cheok et al., 2016; Cheok & Zhang, 2019; Samani, 2011). Other examples include terms like "smart/sex toys, dolls, or robots," which are based on cultural tropes (e.g., science fiction), mundane consumer products (e.g., "smartphones"), and limited views of the kinds of interactions humans may have, or wish to have, with erotic artifacts. This discrepancy is exemplified by Su, Lazar, Bardzell, and Bardzell's (2019, p. 3) pioneering study, which highlighted that sophisticated doll owners do not perceive their artificial partner as a simple sexual device, but rather as "[...] a human-like body that inhabits the home **with** purpose through its motions with the owner". This shifts the focus onto the interactive, holistic, and meaningful experiences that individuals may have, or wish to have, with artificial partners. Notably, these experiences are not necessarily sexual, but are still intimate, romantic, friendly,

and/or sensual: phenomena that could become even more complex and widespread with the advancement of the machines' agency (Döring et al., 2020).

To capture the complexity of human-machine erotic interaction and co-evolution, we begin by providing a nomenclature for Erobotics grounded in the rich concept of erôs, which is central to understanding the cultural and modern evolution of our (technology-mediated) intimacy. We then propose a taxonomy of erobots and a spectrum of their agency, which highlights how erobots' transformative and relational influence is likely related to their growing agential capabilities. Ultimately, the following section aims to help (re)structure the research and discourse on Erobotics, their ethical and social implications, as well as the implementation of regulations adapted to the growing agency of erobots.

2.1. Defining erobot(ics)

According to Anthony Giddens, the eminent sociologist of modernity, the transformative process of modern sexuality is characterized by the increasing detachment from the social imperatives of reproduction—including the subservience of women and imposed heteronormativity—, allowing more people the freedom to redefine selfhood as personal, gender, and sexual self-emancipation (Giddens, 1992). This process finds its continuity in the recent integration of new erotic technologies into the lives of billions of people worldwide, which is leading to the emergence of novel practices, preferences, and identities (Döring, 2017; Döring & Pöschl, 2018, 2019a; McArthur & Twist, 2017). Erobotics thus aims to study these transformations, and the full spectrum of techno-erotic phenomena ranging from self-stimulation to human-machine love.

The term erobots characterizes all virtual, embodied, and/or augmented artificial erotic agents, as well as the technologies and systems from which they emerge (Anctil & Dubé, 2019). This definition includes but is not limited to erotic virtual or augmented entities, chatbots, robots, avatars, as well as their enabling interconnected, multi-layered, and multi-agent systems (i.e., artificial and biological; Dubé & Anctil, 2019). Erobots are artificial agents in the sense that they are software and algorithm-based systems capable of various degrees of agency (as defined below). Furthermore, because they (are perceived to) manifest erotic personas and behavioural patterns and are capable of erotically engaging with humans, and vice versa, erobots should be studied as specialized agents and multi-agent systems. Notably, the eroticism of erobots can be designed (e.g., purposefully included in their forms and behaviours), or developed over time, if

artificial agents have the capability to learn and enact such erotic personas and behavioural patterns (e.g., an initially platonic social AI that learns aspects of our sociosexuality and becomes capable of manifesting eroticism).

Erobots are "agents" in the sense that they are functional technological systems, like computer programs. Since it is beyond the scope of this paper to statute on the nature of agency, we here employ the broadest definition recognized and commonly used in the fields of AI, machine learning (ML), and robotics (Nwana, 1996; Russell, 2019; Russell & Norvig, 2003; Tegmark, 2017). That is, the agency of machines refers to their capability to act intelligently in and on the world to achieve objectives on their own (Nwana, 1996). Intelligence here simply refers to the capability to achieve goals (Russell, 2019; Tegmark, 2017). Like their biological counterparts, artificially intelligent agents have the potential to communicate, adapt, behave, and/or interact with other agents using more or less complex learning algorithms. For example, the algorithms of a "software agent" based on reinforcement learning (RL) can act more efficiently in an environment through trial and error (maximizing reward functions; Botvinick et al., 2019). A population of software agents can also learn together through evolutionary algorithms that use fitness functions (metaheuristic optimization; Russell & Norvig, 2003). Agency levels found in functional technological systems, including erobotic systems, are based on the complexity-efficiency of learning algorithms, but also on: computing power, data access and storage, sensors, actuators, etc.

The term Erobotics, by extension, refers to the emerging field of transdisciplinary research exploring past, present, and future human-erobot interaction and co-evolution, as well as the evolution of technology that makes those interactions possible (Anctil & Dubé, 2019). As a transdisciplinary field intersecting HMI and Sexology, Erobotics aims to develop theoretical, experimental, and clinical research methods to study the broad spectrum of dynamics related to the emergence of erotic technologies (Dubé & Anctil, 2019). Erobotics also aims to investigate the ethical and social implications pertaining to human-machine erotic interaction and co-evolution, as well as guide the development of beneficial erotic machines—i.e., machines that mitigate harm and enhance well-being.

The term erobot is a portmanteau of erôs and bot. Bot is the colloquial word used to designate both software and intelligent agents, either a digital computer program or robot with sensors and actuators (Franklin & Graesser 1996/2005; Minsky, 1968; Nwana, 1996). The Greek

word erôs characterizes all phenomena related to eroticism, which denotes both the innate erotic quality of something, and the condition of being erotically aroused. More specifically, it relates to the fluid experience, construction, and elicitation of love, sexuality, sensuality, attraction, passion, attachment, fantasies, arousal, desire, etc., and their complex intersections (Posner, 1994). Admittedly, in English, terminological usage would normally prescribe the use of the prefix "eroto-" (as in erotophilia) to affix the concept of erôs to a new word. We would thus typically favor terms like "erotobots" to label artificial erotic agents. But these labels are not only unpleasantly sounding, the terminological usage of the prefix "eroto-" has been mostly used as a synonym for "sex" or "sexuality" in a limited sense (e.g., sexual desire). In French however, the prefix "éro-" allows for a richer and more inclusive denotation, one that encompasses all phenomena pertaining to the ever-changing conceptualization of "eroticism", as described above. Hence, given that terms such as erotic (i.e., adjective), eroticism (i.e., noun), or eroticize (i.e., verb) all respectively derive from the French words "érotique," "érotisme," and "érotiser," by the same etymological logic, we prescribe the use of erobot and Erobotics for the French words "érobot" and "Érobotique." (Note. These concepts were first introduced at the 87th annual conference of the Association Francophone Pour le Savoir (ACFAS) in a symposium titled "*Penser l'érobotique: regard transdisciplinaire sur la robotique sexuelle*"; Anctil & Dubé, 2019).

There are many philosophical reasons as to why the Greek concept of erôs (and its derivatives) is central in the study of emerging intimate and sexual technologies. Historically, the concept of erôs has been employed by many writers, philosophers, as well as the first psychologists exploring the intricacies of love, sex, and desire in the human mind. Before modern Sexology (e.g., biopsychosocial approach to human sexuality; Lehmiller, 2017), the work of these founders uncovered patterns of social and cultural complexity that underlie our erotic minds, identities, and practices. Erôs is also widely used in cultural studies to explore the expressions of intimacy in its richness and historicity, as it offers a phenomenological and epistemological account of the ever-changing experience and meanings of intimacy, love, sensuality, and sexuality (Mahon, 2005). Further, it is the most widely used concept in the study of the human experiences of passion and desire (Bataille, 1986; Foucault, 1979; Freud, 1973-1986).

The first theory of erôs, Plato's philosophy, powerfully influenced the western civilization conception of love and sex. Simply put, Plato teaches that, in a social-civilized context, trained by reason and moulded by an education oriented towards the good life, erôs is the art or craft (technê) that can lead humans to the discovery of the "sublime," or to fundamental truths about oneself, others, the world, and the divine (Allen, 1991; Helm, 2017). While Plato fully recognized the power of the erotic mind and the erotic arts—sexual desire and romantic love—he and his many followers ultimately sought to sublimate erôs towards "higher" moral, social, and political models: "platonic love," which is both spiritual kinship (philià) and spiritual pursuit (agapè)—which implies that "true love" is nonsexual desire. The sublimation-transmutation of sexual energies into objectives of "higher" value is a dominant trope in many cultures and civilizations. In the West, the Stoics, the Epicureans, and the Christians radicalized the sublimation path by instigating the long tradition of deflecting erôs into behaviour of higher social valuation, domesticating the instinctual life of the species by ascribing moral, social, and spiritual vocations to sexual energy (Bataille, 1986). The sublimation of erotic pleasure was a long process of cultural evolution that aimed at controlling and reorienting the appetitive nature of humans towards orderly, productive social outcomes like work, family, and personal discipline (Foucault, 1979).

At the turning of the twentieth century, however, Philosophy and science slowly began to question the culture of erotic sublimation (Kim et al., 2013). The rediscovery of eroticism and the erotic life has been an arduous social and historical process that culminated during the first sexual revolution, which reaffirmed the value of the individual pursuit of sexual pleasure against the conservative repression of individual desires (Giddens, 1992; Maes, 2018). The revalorization of erotic arts and representations opened up "eroticism" to new, modern, and widely diverse, aesthetics and ethics of sexuality: "In its numerous faces and traces (sexuality, *desire, passion, love, friendship, etc.), the "erotic phenomenon" appears and becomes central in* every attempt to grasp the condition of possibility for oneness and otherness, for selfhood and alterity, finitude and infinity." (Bornemark & Schuback, 2012, p. 11). Following the works of Freud, Foucault, and contemporary feminist scholars such as Simone de Beauvoir, Donna Haraway, and Judith Butler, the sacrifice of individual sexuality to perform normative roles has had a major cost on human happiness and personal autonomy, especially for women (de Beauvoir, 1949; Butler, 2007; Freud, 1973-1986; Giddens, 1992; Haraway, 1985). Today,

against the residual background of general sexual sublimation and the prevalence of sexist norms, Sexology and the "sex-positive movement," together promote a more complex and holistic view of sexuality, as well as individual sexual freedom, well-being, and pleasure (Ivanski & Kohut, 2017).

Driven by our increasingly powerful computer system infrastructures, erotic technology, we argue, is the latest stage of this continuous social and cultural revolution towards erotic emancipation—a technological erotic revolution (Barrica, 2019; Haraway, 1991). Both technological innovation and sexual liberation currently drive demand for interactive artificial erotic partners, as well as immersive (multi-agent) erotic experiences (Barrica, 2019; Coopersmith, 1998; Devlin, 2018; Levy, 2007; Rubin, 2018). Erobots are thus the probable outcome of technological societies that recognize the personal and collective value of eroticism in human life.

2.2. Taxonomy of erobots

Erobots are polymorphous: they can take many forms, alternate in their manifestations and behaviours, transcend media, and rely on or emerge from various interconnected, multi-layered, and multi-agent systems (i.e., artificial and biological). We propose the following taxonomy to categorize their different types:

Embodied erobot: any kind of corporeal artificial erotic agent.

This includes various systems and devices that have some degree of erotic agential capabilities. The most (in)famous and researched embodied erobots are sex robots like those made by companies such as Abyss Creation's Realbotix (RealDollX, n.d.) and ExDolls (DS doll, n.d.) (for a review see Döring et al., 2020). Sex robots are defined by John Danaher (Danaher, 2014) as any artificial entity that is used for sexual purposes and meets the following three conditions: (1) a humanoid form, (2) humanlike movements/behaviours, and (3) some degree of artificial intelligence. But, as Danaher (2017) rightly points out, sex robots do not have to be humanlike. They can take any number of forms or enact behaviours that markedly deviate from human likeness (e.g., fantasy creatures, science-fiction characters, and intelligent sex toys). Furthermore, we agree that any artificial agent can be considered "corporeal" in the sense that all erobotic systems rely on materiality (e.g., hardware; Danaher, 2017). However, what distinguishes embodied erobots from other types of artificial erotic agents is that they are perceived as occupying space in our three-dimensional world and as capable of directly engaging

with its materiality. Contrastingly, other erobots appear limited to their virtual, augmented, or mixed environments, as well as to their VR/AR/MR-enabling devices (Rubin, 2018).

Virtual erobot: any kind of incorporeal artificial erotic agent.

This encompasses any system (e.g., audio, visual, and/or written) that possesses some degree of erotic agential capabilities and can interact with humans via programs, applications, interfaces, and electronic devices, such as: computers, smartphones, tablets, gaming consoles, and VR equipment. Examples of virtual erobots include conversational agents such as the Harmony AI companion app (RealDollX, n.d.), and Slutbot: an erotic chatbot developed for education and stimulation (Juicebox, n.d.). It also includes systems such as City of Sin 3D (City of Sin 3D, n.d.), Virtual Mate (Virtual Mate, n.d.), Holodexxx (Holodexxx VR, 2019), Mortherlode's Pillow talk (Motherlode, n.d.), Deviant Tech's dominatrix simulator (Deviant Dev, n.d.), and, in fiction, Samantha from Spike Jonze's HER (Annapurna Pictures, 2013).

Augmented erobot: any kind of artificial erotic agent emerging from the use of augmentative technology.

This comprises systems resulting from the augmentation of oneself, or one's ecological niche—virtual or otherwise—, that have some degree of erotic agential capabilities. Examples of augmented erobots include systems, applications, and characters projected via virtual goggles or augmentation glasses in one's environment. Examples of such are: ARConk (ARConk, 2018), GreenScreenAR (AR PornTube, 2018), 3D Holo Girlfriend (3D Holo Girlfriend, n.d.), or Hybri (Hybri, 2020). It also includes avatars and virtual worlds such as Chathouse 3D Roulette (Chathouse 3D Roulette, n.d.) or applications expanding our erotic capabilities like Mei (i.e., a sexting improvement app; Mei, n.d.) and AIMM (i.e., an ML-empowered interactive matchmaking system; AIMM, 2020). For erobots resulting from human augmentation (e.g., avatars), the realization of their agency is, partly, an emerging property of the human-machine coupling, which generates unique erotic experiences and persona for the augmented person, but also for those who interact with the human-machine hybrid, or technologically erotic multi-agent system (Flore & Pienaar, 2020; Haraway, 1985; Haraway, 1991; Verbeek, 2008).

This taxonomy is meant to highlight different types of erobots and to emphasize that their systems can simultaneously be embodied, virtual, or augmented. In fact, cloud-based erobots that are connected through the IoT/IoS can manifest at the same time in various ways. They can be displayed on cellphones; animate a robotic body; appear in virtual worlds; or be projected in a

non-virtual environment via augmentative technology. For example, users can interact with Harmony's AI using both a smartphone application and a robotic-headed doll (RealDollX, n.d.). Another example is Hybri, which promises a future where humans and erobots fluidly alternate between embodied, virtual, and augmented erotic manifestations and experiences (i.e., MR; Hybri, 2020). As such, the perceived characters, devices, or interfaces are only parts of what is here described as an erobot.

In fact, to fully grasp the extent of current and future human-machine interaction and their socio-technological co-evolution, it is essential to understand that erobots are not just their perceived characters (e.g., Harmony's VR character or robotic-headed doll), but are composed of vast interconnected, multi-layered, and (increasingly adaptative) multi-agent systems that enable their (emerging) capabilities (Khan et al., 2018; Panait & Luke, 2005). For example, when people interact with an erobot, they engage with its interfaces (e.g., application and characters), but the erotic capabilities of those interfaces also depend upon clusters of enabling-systems including: software-hardware, cloud-based algorithms learning from multiple users, databanks, search engines, and humans (e.g., programmers, engineers, designers, artists, and partners). Hence, like humans, erobots are not segregated stable entities, but are dynamic and porous systems relying on, enabled by, and embedded within other systems (von Bertalanffy, 1968).

Thus, erobots and their capabilities can be better conceptualized as emerging systems and properties, respectively, that which can be studied through their material substrate and (technological) ecological niche, and whereby humans are a key component in the enabling of their (erotic) agency and cognition (detailed in section 3). As such, erobots not only confront us to potentially novel erotic actors and experiences, but also paradoxically reminds us that—as biological organisms defined by our own structures and embedded within a larger niche—humans and machines are not so different or isolated.

2.3. A Spectrum of erobots' agency

The agency of erobots represents hypercomplex conditions and states that can be better understood and studied across a spectrum. To appreciate this complexity, we propose a Spectrum of Erobots' Agency (SEA) ranging from level 0 (no agency) to 5 (full agency)—echoing the SAE International's (J3016) spectrum of self-driving cars' automation levels (see Figure 1; SAE International, 2018). Despite the impossibility of capturing erobots' infinite degrees of agency or technological substrates, and the obvious distinctions between autonomous cars and erobots

(e.g., forms, behaviours, purposes, and underlying technology), this spectrum mock-up has heuristic value. It can help clarify present and future dynamics related to human-erobot interaction and co-evolution as the agency of artificial systems increases—i.e., greater agency may entail reduced (perceived) human control over artificial systems, greater machine (behavioral) unpredictability, and more uncertain human-erobot relationships. It can also help appreciate the scientific, ethical, and sociocultural challenges addressed to Erobotics as we develop, and engage with, evermore complex agential erotic machines. Noteworthy, the agency levels described in this spectrum should not be understood as discrete categories, but rather as a continuous gradient of capabilities possibly supported by diverse interconnected, multi-layered, and multi-agent systems.

The agency of erotic machines is partly based on the degree of autonomy and reciprocity established and perceived in human-erobot interaction (Legaspi et al., 2019; Levillain & Zibetti, 2017; Stafford et al., 2014; Verbeek, 2005; Złotowski et al., 2017). As such, in the SEA, level 0 technologies are not erobots, but correspond to simple erotic objects or media without agency beyond that which is attributed by humans and/or their (pre-established and/or intended) affordances (e.g., dildos, vibrators, artificial vulva/vagina, dolls, and pornography). However, they are here included because they represent a significant portion of the erotic technology currently available and used (Barrica, 2019; Coopersmith, 1998; Döring, 2017; Döring & Pöschl, 2018, 2019a; Herbenick et al., 2009, 2010; Reece et al., 2009; Richters et al., 2014; Rosenberger et al., 2012; Satinsky et al., 2011), and could play a role in our intimacy with erobots (e.g., interactions involving virtual partners and vibrators). They are also included here because their lack of agency (as previously defined in section 2.1) provides a baseline to compare subsequent SEA levels and describe their potential implications for human-erobot interaction. Indeed, as a reference point, level 0 technologies are comparatively highly controlled by humans, which makes our relations with them highly predictable. The interaction is co-constructed by their affordances, and importantly, by what people use them for (e.g., sex/love dolls' design provides cues about how to engage with them, but humans imagine and decide how to enact the rest; Su et al., 2019). The established reciprocity is limited, and users largely perceive themselves as in charge of the interaction. Uncertainty thus remains low in the interaction with these products,

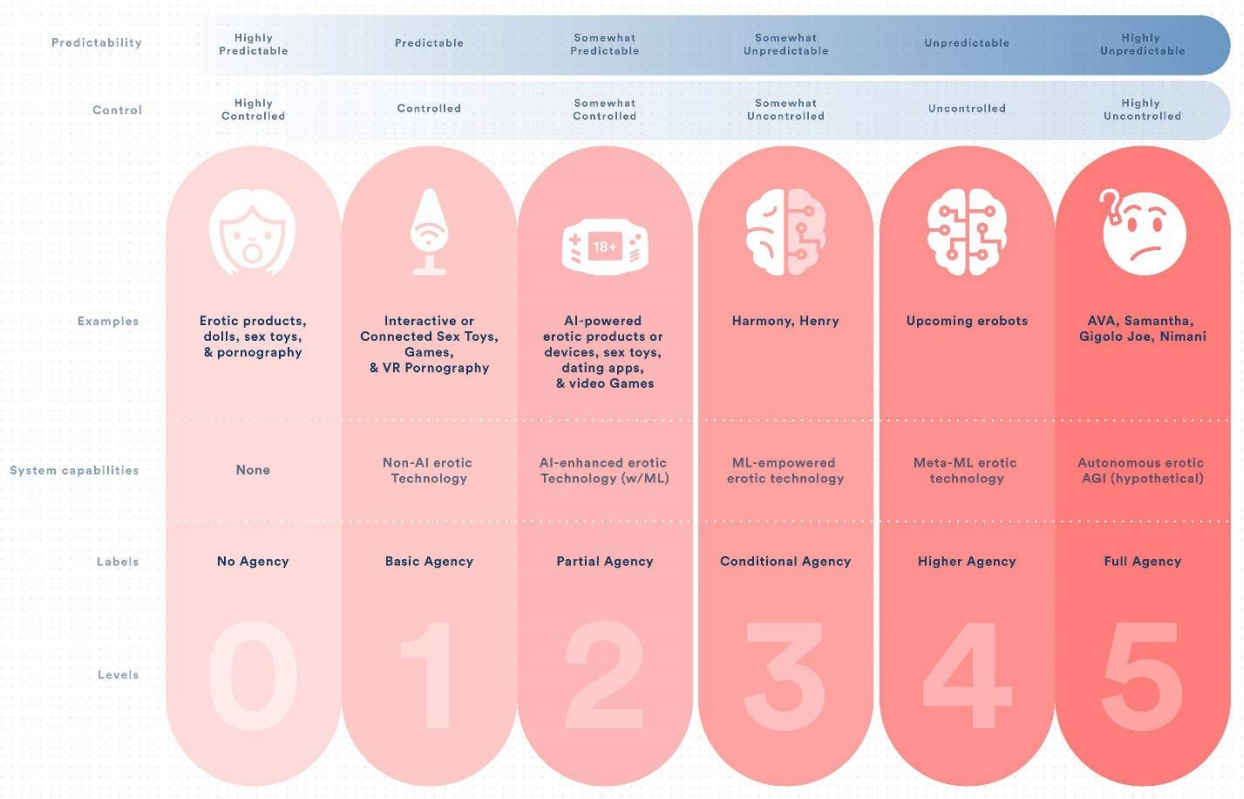

Figure 1. Spectrum of Erobots' Agency. This spectrum, ranging from level 0 (no agency) to 5 (full agency), is inspired by the SAE International's (J3016) Levels of Driving Automation (SAE International, 2018). It presents the descriptive labels, corresponding system capabilities, examples of technology, and paralleled Likert-type scales of human control and machines' predictability associated with each level of erobots' agency. Note. References: Harmony and Henry (RealDollX, n.d), AVA (A24, 2014), Samantha (Annapurna Pictures, 2013), Gigolo Joe (DreamWorks SKG, 2013), and Nimani (Lionsgate AI, 2019). Program used for creation: Adobe Illustrator CC 2017 (version 21.0.0).

since they have no capability to act intelligently on the world to achieve objectives on their own beyond their affordances.

Level 1 technologies integrate "basic agency" using various software-hardware implements that augment the erotic qualities of interactive and/or connected objects and media. For instance, a sex toy that adjusts its settings according to the pressure applied by its users—creating an interactive loop where humans perceive that they are not completely in charge of the sexual stimulation. Their "basic agency" stems from machines' capability to react to human action, albeit in a simple way. In doing so, they establish a reciprocity that goes beyond the (intended and/or pre-established) affordances of machines and affects subsequent human-machine responses. At level 1, humans and machines not only provide cues about their use, but also act on each other. Uncertainty thus increases as humans partly relinquish control over the co-constructed series of actions. Still, level 1 systems are (perceived to be) controlled and predictable, as humans have a sense that they are mostly in charge of the interaction, and that the capability of machines to act on the world on their own to achieve goals beyond their affordances is restricted to what we use them for.

Level 2 technologies correspond to AI-enhanced erotic systems without ML capabilities. This includes devices, applications, or media that are built on established software frameworks and incorporate complex automation, but do not learn from their interactions (e.g., an erotic video game that displays characters and generates intimate stimulations as a function of users' actions). Their "partial agency" stems from the fact that level 2 technologies do not simply react to human action, but (are perceived to) exhibit properties akin to more complex (relational) intelligence compared to level 0 or 1 (e.g., sociosexual communication and behaviors; Armstrong et al., 2012; Russell & Norvig, 2003; Tegmark, 2017; Thue et al., 2011). Here, the erotic video game can process various input data and produce output responses to generate increasingly erotic experiences interpreted by users as pleasurable and/or lifelike. Interactions with level 2 technologies are thus perceived to be more co-constructed, interactive, and reciprocal, but also more automatized, diversified, and goal-oriented. Uncertainty markedly increases due to the diversity of potential pre-programmed automatic responses a system can enact. But, it remains somewhat controlled and predictable because of the system's inability to learn new patterns from its users or deviate from its pre-established output functions. Humans

may thus confidently estimate the boundaries of the machines' capability to act on our world to achieve goals on their own and their modes of (erotic) interactions.

Today, levels 0-2 technologies are widespread in human intimacy (Barrica, 2019; Ciocca et al., 2020; Deviant Dev, n.d.; Owsianik & Dawson, 2017; Solano et al., 2020). People can fall deeply in love with dolls (for a review see Döring et al., 2020), regularly consume pornography (Solano et al., 2020), and use various sex toys or games to enhance their erotic experiences (Döring & Pöschl, 2019a). It is thus crucial for Erobotics to understand human interaction with these technologies (e.g., motivations behind their use), their influence on our erotic lives (e.g., sexual and relationship satisfaction), and how they may contribute to the evolution of sociosexuality (e.g., transformation of our preferences and identities). Notably, however, the degree of agency of levels 0-2 technologies has led them to be categorized and treated, by most, as somewhat passive objects or media. Yet, the line between patient and agent is becoming increasingly blurred as we move towards systems capable of more complex (erotic) interaction, learning, and adaptation (Dautenhahn, 1995, 1998; Hoorn et al., 2019; Levillain & Zibetti, 2017; Migotti & Wyatt, 2017; Nowak & Biocca, 2003; Russell, 2009; Turkle, 2007).

Level 3 erobots correspond to the most sophisticated ML-empowered erotic systems presently available. In Figure 1, the "space" between levels 2 and 3 emphasizes that, while previous technologies have been a part of our intimacy for decades, contemporary ML has only recently entered people's lives through (interconnected) technological systems (e.g., devices and applications). It also emphasizes that the learning capabilities of level 3 systems mark a clear departure in their agency and our co-evolution (e.g., impact of learning on evolution, or Baldwin Effect; Baldwin, 1986; Dennett, 2003; Fernando et al., 2018; Hinton & Nowlan, 1987; Turney et al., 1996). Specifically, the growing learning capabilities of level 3 erobots offer a wide array of (erotic) possibilities, ranging from continuous adaptative behaviours to the possibility of gaining holistic knowledge about individuals and their cultures. Indeed, in contrast to pre-programmed output delivered by "Good Old-Fashioned Artificial Intelligence" systems, ML makes it possible for erobots to interact with humans and learn erotic behaviours and sociocultural dynamics directly from users and their world by generalizing from experience.

Level 3 erobots are built on a variety of software architectures to improve their interactive and learning functions using methods like statistical pattern recognition and probabilistic ML (Ghahramani, 2015; Lake et al., 2017). Following innovations in affective

computing (Picard, 1995), these agents are also increasingly capable of "artificial emotional intelligence" (AEI). Affective and emotional analytics combine the ability to recognize human emotions and adapt the communicative-behavioural reasoning of machines (Asada, 2015; Devillers, 2019; Hudlicka, 2004; Khashman, 2008; Moerland et al., 2018; Scherer, 2001; Schuller & Schuller, 2018). Already a billion-dollar industry, AEI can be found in applications and chatbots to improve the experience of users and enhance cooperation in the work environment, particularly in healthcare, where these systems interact with human professionals and clients (Strömfelt et al., 2017). AEI is gradually becoming an essential component of social robots and is projected to play a key role in facilitating the human-machine psychosocial and erotic interaction (Duffy, 2008; Schuller & Schuller, 2018).

Level 3 erobots are the first systems whose responses are not entirely pre-established by humans. Indeed, through learning and adaptation, level 3 erobots can potentially develop their own new sets of sociosexual patterns based on past interactions. This makes their actions partly unknown to designers and users—somewhat uncontrolled and unpredictable. For example, when users interact with Harmony, they first engage with its pre-set routines, but subsequent responses become increasingly tailored to users as its ML system allows it to learn from past conversations and encounters (RealDollX, n.d.). Hence, the (re)actions of level 3 erobots are harder to predict; the boundaries of their interactive potential are (perceived to be) more uncertain. Interactions are thus seemingly closer to engaging with partners that do not just mechanically respond to input stimuli, but also contribute in more complex ways to the co-construction of (erotic) experiences.

To appreciate the potential implications of these innovations for HMI and Sexology, consider the influence of digital social media algorithms on human relationships (e.g., Facebook; Boulianne, 2015; Ward et al., 2017). With limited learning algorithms, and massive user-user interactions on their platforms, social media have transformed the attention economy, and, in turn, are transforming identities, politics, consumption, and (means of) sexual selection all over the world. For instance, algorithms have been shown to affect states of minds (e.g., beliefs, preferences, and desires) by filtering and amplifying certain perceptions of the world (e.g., filter bubbles and echo chambers; Del Vicario et al., 2016; Geschke et al., 2019; Perlich et al., 2014). Their impact on our erotic cognition and agency in the context of large platforms, such as AI-powered digital pornography (e.g., Pornhub) and dating applications (e.g., Tinder), have only recently started to be explored (Fisher & Garcia, 2019; Lin et al., 2011; Marr, 2019; Ranzini &

Lutz, 2017; Sumter et al., 2017; Timmermans & De Caluwé, 2017). Yet, we can already see their unique influences on human intimacy (e.g., preferences, behaviors, and partner selection).

Level 3 erobots have only recently entered our world. However, the progressive conjoining of immense data mining and processing power, vastly more powerful processor units, and above all, innovative ML techniques giving birth to formidable algorithms, allow us to consider erobots that exceed Level 3. Indeed, in a gradual transition towards level 4 systems, AI scientists are now tackling higher cognitive capabilities, which could soon be incorporated into erobots. That is, for instance, those related to metacognition such as meta-reasoning (i.e., reasoning about reasoning), meta-learning (i.e., learning to learn; Griffiths et al., 2019; Vilalta & Drissi, 2002), and Theory of Mind (ToM); or the ability to understand the mental states of others and recognize them as singular, autonomous entities (Gopnik & Wellman, 1992; Premack & Woodruff, 1978).

In fact, while current advanced AI systems excel at prediction, they struggle to understand real-world physics and our infinitely rich social world: not only causality and mentalistic concepts (e.g., goals, utilities, and relations), but also socially learned concepts, such as emotions, interests, and attachment (Asada, 2015; Burda et al., 2018; Lake et al., 2017; Pathak et al., 2017). Hence, many techniques in AI, such as deep RL, Bayesian inference, and game theory, are now being used to simulate the inductive biases and metacognitive capabilities of humans. Emerging architectures are also progressively allowing AI systems to learn directly, and increasingly rapidly, from human preferences and language (Botvinick et al., 2019; Ha & Schmidhuber, 2018; Wayne et al., 2018; Weber et al., 2017). While these attempts modify "agents architecturally" and depict their internal states in a form interpretable for humans, others "[...] seek to build intermediating systems which learn to reduce dimensionality of the space of behaviour and represent it in more digestible forms" (Rabinowitz et al., 2018, p.2). Inverse Reinforcement Learning, for one, teaches algorithms to adapt behaviour to circumstances and learn from human-machine continued interaction (Russell, 2019). Successful "consequence engines" in bots are also already capable of internally modeling their environment and other entities in order to avoid collisions, coordinate without communication, and reach their goals (Blum et al., 2018). Likewise, using deep neural nets, Google's DeepMind is developing ToM with the AI agent ToMnet, which is capable of building heuristics from basic mind models of

other agents that are derived from meta-learning observations of their behaviour (Rabinowitz et al., 2018).

Based on these advancements, we can realistically anticipate the emergence of level 4 erobots with "higher agency" sustained by higher erotic analytics/heuristics and AEI (Albrecht & Stone, 2018). This is a reasonable assumption since higher cognitive capabilities (and/or their attribution) have been recognized as an important component to enable many—if not most—people to develop strong attachment to erobots (e.g., love and friendships), but also, because their incorporation (and/or mimicking) in artificial companions has become an explicit goal of programs like Lovotics (Cheok et al., 2016; Samani, 2011; Samani et al., 2011). To our knowledge, however, level 4 erobots are not available yet (Figure 1 marked by the "space" between levels 3 and 4). If they were, their capabilities would, by definition, enable them to develop models of themselves and their environments and adapt their learning strategies to become more efficient in human-erobot interactions. We hypothesize that this could likely lead level 4 erobots to be perceived as uncontrolled and unpredictable, but also, arguably more convincing and efficient as intimate partners as they would exhibit degrees of more sophisticated cognition and agency that gradually approach—without achieving it—interhuman erotic interaction.

Lastly, level 5 erobots correspond to hypothetical constructs capable of artificial general intelligence (AGI), or "strong AI" (Ford, 2018; Gobble, 2019; Kurzweil, 1999). Level 5 erobots imply a situation where highly complex and unpredictable erotic machines act quasi-completely outside of human control, at least to the same extent as any other human partner (Armstrong et al., 2012). However, according to most of the world's foremost researchers working in ML, these highly uncontrolled and unpredictable AGI potentially capable of self-awareness, sentience, or "consciousness," will remain theoretical constructs for decades to come (Ford, 2018). In other words, debates and discussions surrounding AGI are not essential to study the erotic agential and relational spectrum between humans and erobots. And, since most AI specialists believe that AGI is still far ahead, we suggest that Erobotics mainly focuses on level 0-3 (and upcoming 4) technologies but plans for the possible advent of level 5. Indeed, our knowledge of human erôs suggests that the higher capabilities of human minds are unessential ingredients to build machines capable of entertaining meaningful relationships with us. In fact, following the SEA and the learning system underlying our erotic cognition (detailed in section 3.1), we recommend

to instead launch Erobotics under a relaxed dichotomy between "true" or "false" intelligence, cognition, agency, and affective relationships (Turing, 1950). To sum up the argument: the effective level of capability necessary for any machine to erotically engage with human partners is simply the level of capability necessary to enact reciprocal erotic experiences with humans.

To conclude, the SEA highlights a progression in human-machine erotic interaction—ranging from reactive sexual stimulation to the possibility of meta-cognitive erotic processes. This spectrum suggests that as their erotic agency increases, machines could progressively grow outside of human (perceived) control and their behaviours could be interpreted as more unpredictable—significantly influencing, in turn, our relationships with them. The SEA also suggests that the progression of machine agency has the potential to influence our erotic ecological niche and cognition in evermore complex ways. And, while we tend to exaggerate what is necessary to achieve the "affective autonomy" involved in our relationships, we might need to downplay the prerequisites for experiencing erotic relationships (Pfeifer & Scheier, 1999). That is, if we consider erotic agency and cognition as anchored in a social co-determination of affects (Damiano & Dumouchel, 2018; Damiano et al., 2015; Dumouchel & Damiano, 2017), we should perhaps also consider that the relational autonomy of behaviour enacted by erobots has the potential to transform the niche in which this autonomy is exercised, as well as human and machine cognitions.

In the next section, we explore these transformations by proposing a model of human-erobot interaction and co-evolution grounded in Complex System Theory (von Bertalanffy, 1968) and drawing from 4E approaches to cognition (Newen et al., 2018), the neurodevelopmental trajectory of sexuality (Pfaus et al., 2012), Hierarchical Incentive-Motivational Theory (Toates, 2009), and Ecological System Theory (i.e., Bioecological Model; Bronfenbrenner & Morris, 2006). This model and its synthetic approach provide explicative mechanisms that have predictive value for our socio-technological erotic interaction and co-evolution. It is also purposefully broad enough to constitute theoretical grounds for a wide, collaborative, and transdisciplinary research agenda on Erobotics. It is our hope that researchers from various disciplines can use this model as a starting point, bring their own perspective, and shed light on its different aspects and levels of analysis.

3. Human-Erobot Interaction and Co-Evolution Model

Researchers in HMI rarely explain what they mean by co-evolution beyond the fact that humans and machines influence each other in a perpetual feedback loop (Damiano & Dumouchel, 2018; Dumouchel & Damiano, 2017). This is understandable, since humans' interactive, sociotechnological, and evolutionary phenomena stem from micro and macro hypercomplex processes that are studied across disciplines using different models and mechanisms (e.g., in physics, AI, robotics, neurosciences, biology, evolutionary psychology, sociology, and behavioral sciences). For Erobotics to tackle this complexity, we here propose the first overarching Human-Erobot Interaction and Co-Evolution Model (HEICEM; see Figure 2) explaining how human-erobot interaction can influence the sociosexuality of our species (Dawkins, 1976, 1983; Dennett, 1995).

Since a plethora of variables are implied in the study of human-machine erotic co-evolution, our model is not deterministic, but probabilistic: it rests upon the way humans and erobots are likely to influence each other's erotic cognition (Newen et al., 2018) through interactions (e.g., experiences of social and sexual rewards that motivate individuals to engage or not in erotic behaviours; Pfaus et al., 2012; Toates, 2009) and their potential impacts on each other's ecological niche—ranging from micro to macrosystems (e.g., technological to sociocultural environments; Bronfenbrenner & Morris, 2006). Moreover, this model rests upon a continuous exchange between the individual (e.g., preferences and behaviours) and population levels (e.g., artificial and biological agents populating our ecological niche). At the core of this model, and in an attempt to potentially bridge those levels, we hypothesize a mechanism analogous to natural, artificial, and importantly, sexual selection, here called Erotic Multi-Agent Selection (EMAS; see Figure 2), which represents fertile grounds for future research.

3.1. Erotic cognition

Erobots are products unlike any others: developed as social and sexual partners, they are likely to be increasingly perceived and treated as partners (Dautenhahn, 1995, 1998; Dautenhahn et al., 2002; Levillain & Zibetti, 2017), especially if their agency continues to grow (Legaspi et al., 2019; Levillain & Zibetti, 2017; Stafford et al., 2014; Verbeek, 2005; Złotowski et al., 2017). And since humans are wired by evolution, culture, and experiences to select and engage with (intimate) partners (Lehmiller, 2017), erobots' sociosexual capabilities can progressively set

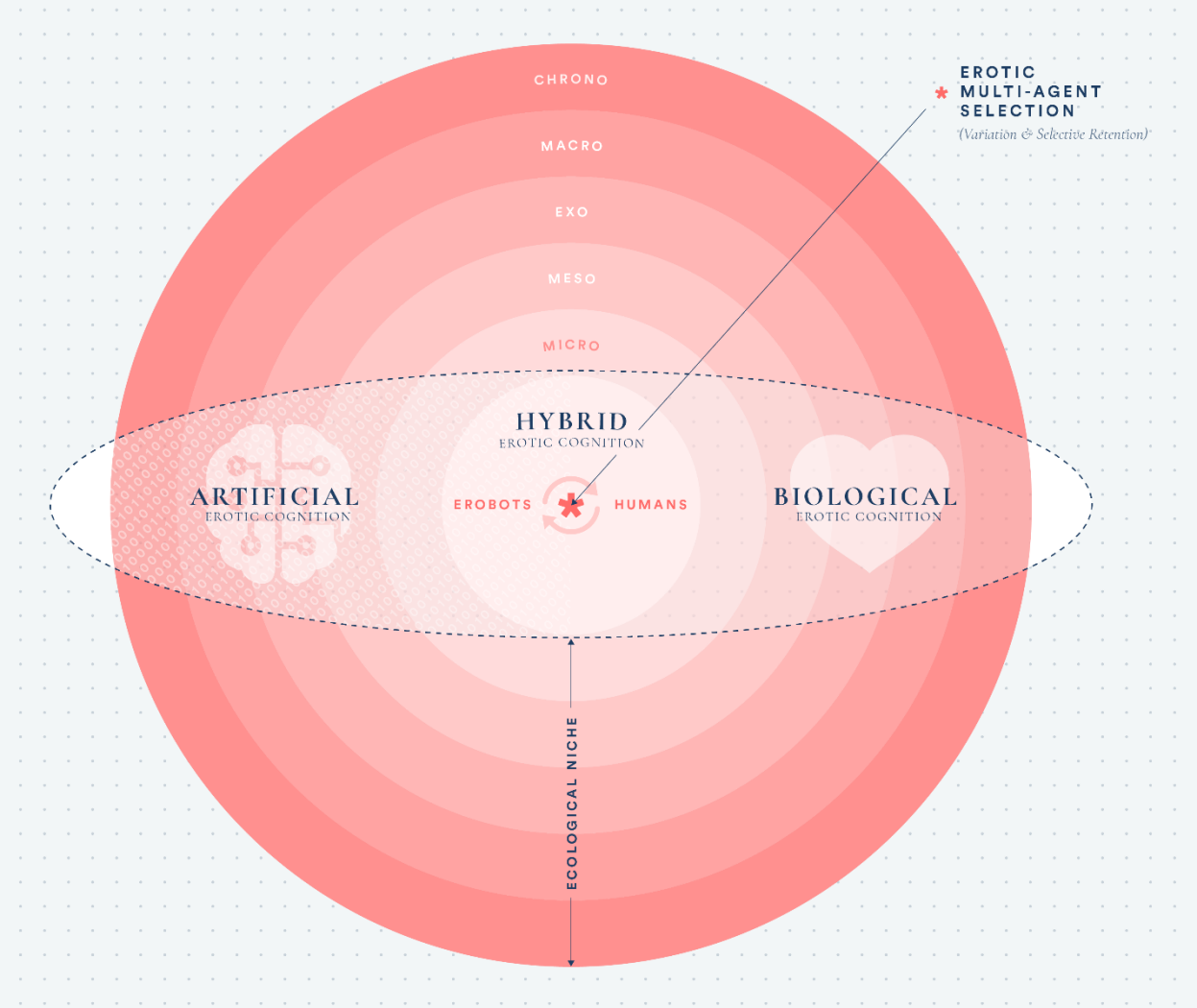

Figure 2. Human-Erobot Interaction and Co-evolution Model (HEICEM). This model depicts how human and erobots are likely to co-influence each other's erotic cognition through interactions and their impact on each other's ecological niche (i.e., represented here as the interconnected multi-layered systems depicted in the Bioecological Model; Bronfenbrenner & Morris, 2006). This model highlights multiple levels of analyses and invites a collaborative, transdisciplinary research program on Erobotics to address the details of the HEICEM (e.g., interactions, processes, and mechanisms), which remain unknown for the most part. At its core, it also includes, a potential mechanism based on Universal Darwinism, which is analogous to natural, artificial, and sexual selection, EMAS, and could bridge the individual and population levels of the HEICEM. Program used for creation: Adobe Illustrator CC 2017 (version 21.0.0).

them apart from other technologies. That said, cognitive neurosciences can help us bridge HMI and Sexology, to model important variables of human-erobot interactions and co-evolution.

The emergence of erobots could act on individuals (and vice versa), by influencing their erotic cognition via their interaction (detailed in section 3.1.1) and their transformation of our ecological niche (detailed in section 3.1.2). Here, the term cognition is used in the sense intended by 4E approaches to cognition. 4E approaches propose that cognition is embodied, embedded, extended, and enacted (Newen et al., 2018). Embodied, in the sense that cognitive processes partly depend on bodily processes, including but not only involving the brain (e.g., limbs, organs, peripheral nervous systems, and hormonal activity; Varela et al., 1991). Embedded, such that cognitive processes are situated (e.g., in a specific body, environment, and point in time; Beer, 2014). Extended, meaning that cognitive processes partly take place, and depend on, extra bodily processes (e.g., entities enabling storage and access to information, such as books, phones, computers, and other humans; Clark & Chalmers, 1998; Gallagher, 2013; Hutchins, 1995). And enacted, such that cognition emerges from agents' active engagement with their environments and its affordances (Gibson, 1979/1986; Maturana & Varela, 1973/1980; Varela et al., 1991). By extension, erotic cognition here refers to the constellation of embodied, embedded, extended, and enacted processes which enables, and from which emerges, affordance-based phenomena pertaining to erôs, as previously described. This includes but is not limited to, the constantly evolving and interactive experience, construction, and elicitation of love, attraction, attachment, passion, romance, desire, arousal, sensuality, sexuality, etc., and their complex intersections.

While there are debates regarding the extent to which cognition is embodied, embedded, extended, and enacted, 4E approaches generally agree on some key points. Precisely, that cognitive-related phenomena (e.g., attention, memory, language, emotions, sensations, and perception) depend on the specific morphological and physiological characteristics of agents, their situated ecological niche (e.g., natural, technological, and sociocultural environments), their active interaction with this niche, and the coupling of their characteristics with the information provided by said niche (i.e., affordances; Gibson, 1979/1986). Importantly, 4E approaches enable us to approach artificial and biological agents as part of larger, interconnected multi-agent systems from which erotic cognition emerges in different ways. They also highlight that both artificial and biological agents can engage in cognitive processes specific to their own characteristics and niche while still fully acknowledging their underlying structural and

functional differences. For instance, the cognitive processes of erobots are situated within specific virtual and non-virtual worlds (embedded). They depend on software (e.g., algorithms and programs), hardware (e.g., servers), and interfaces (e.g., computers and cellphones) wired and shaped to process afferent stimuli (embodied). Parts of their cognitive processes take place outside of their software, hardware, and interfaces (e.g., clouds, databanks, and humans; extended). Lastly, their cognitive processes emerge from an active engagement with their ecological niche (i.e., virtual or otherwise; enacted)—in which humans play a key role.

4E approaches do not imply that erobots have a subjective experience, nor do they imply that humans' biological erotic cognition is the same as erobots' artificial erotic cognition. However, they underline the possibility for erobots to have their own forms of 4E erotic cognitive processes or their own way of erotic "thinking" (Turing, 1950). They also underline how humans are a fundamental part of erobots' erotic cognition—not only because we design them, but because we represent their main source of (sociosexual) data. For instance, in much the same way as humans, machines incorporate us in their cognitive processes. Machines learn, store, and access data through us. Hence, while the erotic cognition of erobots partly stems from their design and pre-programmed capabilities, it can also emerge from what they learn during human-machine interaction. Moreover, we purposely create and select erobots that best fit the state of our erotic cognition, and in doing so, determine traits that are more likely to endure (or not) in erobotic populations, based on our individual and collective preferences. This process could subsequently influence the type of erobots that populate our world—probabilistically and retroactively affecting our ecological niche, our possibilities for social, intimate, and sexual experiences, and in turn, our new technology-mediated erotic cognition.

Overall, 4E approaches highlight that erobots have the potential to learn their erôs, like humans, from a world that they are themselves transforming (Damiano et al., 2015; Dumouchel & Damiano, 2017). Specifically, erobots (can potentially) learn their erôs from the same human world that designs them, selects them, and is changed by them—which could incidentally lead us to (re)learn a new technology-mediated erôs as we engage with them, and give rise to a hybrid erotic cognition indistinguishable from the sum of its part or the hypercomplex processes from which it emerges. 4E approaches also highlight the importance of human and erobot interactions with each other and their world in co-influencing their erotic cognition—a transformative process here contingent on the agency of machines and their place in our intimate lives.

3.1.1. Human-erobot interaction: Learning a new technology-mediated erôs

Erobots can influence our erotic cognition through interaction, by providing us with novel opportunities of social, intimate, and sexual experiences—generating new learnings and possibly impacting our partner selection. Indeed, humans learn the complexity and meaning of their erotic subjectivity and agency. This learning process rests upon evolutionarily developed, hierarchically organized, and relatively plastic structures (Brom et al., 2014; Pfaus et al., 2012; Toates, 2009). We are wired for adaptability proportionally to the needs of our sociosexual environment, which is so diversified that we developed systems that are prepared for sex, but also extremely flexible in learning strategies to maximize chances of erotic encounters in an uncertain, ambiguous, and ever-changing world (Pfaus et al., 2012). Our system is hierarchically organized (Toates, 2009), like other animals, for stimulus-stimulus associations (Both et al., 2011; Both et al., 2008; Pavlov, 1927) and response-reinforcer associations (Skinner, 1938). It constantly makes causal inferences of what its internal state will be (e.g., pleasure, aversion, joy, and pain) from cues in the external world that predict reinforcers (e.g., food, predators, and partners). Moreover, it continuously adapts the type and strength of its motivational, physiological, attentional, and behavioural responses according to how well such external cues predict outcomes (Brom et al., 2014; Pfaus et al., 2012; Toates, 2009).

In this sense, humans are biological erotic-learning agents. Our experience of love, intimacy, and sexuality is inextricably linked to the dynamic interaction (Lehmiller, 2017) between our evolved biological predispositions (e.g., genetic, hormonal, and physiological factors; Bancroft, 2002; Csaba, 2016; Miller, 1998; Wang et al., 2019; Wunsch, 2017), our ecological niche (e.g., social and cultural factors; Abdolmanafi et al., 2018; Dang et al., 2019a, 2019b; Heinemann et al., 2016; Långström et al., 2010; Muhamad et al., 2019; Wood et al., 2017), and our experiences (e.g., learnings; Bornemark & Schuback, 2012; Both et al., 2008; Gopnik & Wellman, 1992; Gore et al., 2018; Griffiths et al., 2019; Hoffman, 2012, 2017; Hoffman et al., 2012; Marcus & Davis, 2019; Miller & Page, 2007; O'Donohue & Plaud, 1994; Riva et al., 2012). Our innate predispositions are shaped into sexual responses, desires, behaviours, and preferences based on reward experiences (e.g., social and sexual pleasure), as well as our capacity to link said experiences, and their meaning, with various external predictive cues (e.g., physical, psychological, and behavioural traits; Georgiadis et al., 2012; Pfaus et al., 2012; Toates, 2009). In other words, our lifelong experiences with rewards form the bridge

between what we want, how much we want it, which behaviours are required, and what they mean (Pfaus et al., 2012).

This biological erotic-learning system constitutes the blueprint for the development of our mating mind (Miller, 1998, 2000). That is, a mating mind so highly tuned to learning the demands of our ambiguous and culturally shaped world that our sexuality becomes inextricably part of larger systems in its experience and meaning. For the human animal, sexuality is thus fully erotic, such that love, attraction, passion, desire, sensuality, relationships, and sex are deeply rooted in our ever-changing, socially constructed minds (Freud, 1973-1986). This human erotic cognition not only enables us to navigate and make sense of our environment, but also enables us to transform it via the production of norms and artifacts reflecting our multifaceted sexuality. For instance, humans engage in a wide range of erotic activities besides sex and mating, ranging from situated and perpetually co-evolving rites of seduction, sensual performances, and conjugal arrangements (Bataille, 1986). Humans of all cultures have invented an immense repertoire of moral, aesthetic, religious, and legal codes of acceptable and transgressive erotic behaviours (Foucault, 1979). Humans have also produced quantities of art and entertainment materials about love, romance, and sexuality (Giddens, 1992), a process that constantly feeds back to us to co-construct our erotic cognition.

It is this evolutionarily developed, culturally shaped, and experience-dependent erotic cognition that produces erobotic technology. It is the foundation of why and how we select partners (Pfaus, 2012), and thus, central to the creation of, and our interaction and co-evolution with, sociosexual machines. To appreciate how erobots can influence our erotic cognition through interaction, let us consider the Nimani thought experiment, which is based on technology that already exists or is in development (AIMM, 2020; Hybri, 2020; RealDollX, n.d.; Rubin, 2018; Samani, 2011; Virtual Mate, n.d.):

> **Nimani** is a hypothetical polymorphous erobot. It can interact with humans via their cellphones using an audio-visual interface or chat. Nimani's avatar can also simultaneously appear as one or multiple characters in a virtual environment, be projected in our world or onto individuals via augmentation equipment, and animate a robotic body in our non-virtual world. Nimani is cloud-based and connected to the internet, so its AI can interact with, and learn in real-time from, multiple biological or artificial agents in a hive-mind type of cognition. It can also

> infinitely copy itself and it has access to tremendous amounts of information through its access to search engines (e.g., Google). Hence, when you interact with Nimani, you are engaging with vast interconnected systems (i.e., avatar(s), its related software-hardware, its learning cloud-based systems, as well as the network of information it has access to), exposing humans to a different kind of erotic partner. First, it is not biological, but computer generated. Second, it can transcend medium and manifest itself in multiple places simultaneously. Third, it can take on various forms and enact behaviours that are not bound by the rules of physics governing our non-virtual world. Fourth, it can adapt said forms and behaviours to the needs (i.e., physical and psychological) or fantasies of its users. Fifth, it can be duplicated such that producing, or engaging with, Nimani is not a zero-sum game. And finally, it accesses, processes, and learns data differently than humans by using various algorithms, statistical methods, and search engines.

Interacting with Nimani thus entails the pairing of new erobot-specific predictive cues with the human experience of reward. Indeed, as an intimate partner, Nimani rests upon some of the strongest human motivation incentives (i.e., social and sexual rewards; Georgiadis et al., 2012; Krach et al., 2010; Meston & Buss, 2007; Toates, 2009). Paired with its traits, these incentives have the potential to generate, through interactions, novel erotic learnings that can progressively give rise to new technology-oriented conditioned partner preferences specific to erobots and their traits (Pfaus et al., 2012). For instance, users' experience of intimacy and sexual pleasure would here be paired with Nimani's artificial forms, personalities, and behaviours—including those that are impossible in our non-virtual world. They would also be paired with its knowledge, adaptive and duplicative capabilities, enabling equipment and systems, as well as its cultural representation and symbolic meaning. Moreover, depending on whether interacting with Nimani constitutes a rewarding experience (or not), individuals will likely be motivated to repeat or avoid behaviours that have led to such internal states (Pfaus et al., 2012; Toates, 2009).

For several reasons, this lifelong learning and approach-avoidance process should not be underestimated. First, it points to the possibility for some people to have their first socially and sexually rewarding experiences with artificial agents. As such, based on the neurodevelopmental trajectory of sexuality, these experiences could form critical periods of development during

which preferences for erobot-specific features are integrated and consolidated (Both et al., 2020; Pfaus et al., 2012). Second, this process can influence the subsequent development of our erotic preferences and partner selection, which could, in turn, potentially affect human-erobot interaction and co-evolution. For instance, traits that will generate more rewarding experiences will be more likely to be replicated in next generations, while those that generate aversive experiences could be discarded. Finally, selected erobotic technologies are likely to populate and influence our ecological niche and situated erotic cognition through a perpetual feedback with our (technological) environment.

3.1.2. Erobots and the human ecological niche

Erobots can influence our erotic cognition by transforming (parts of) our ecological niche, and vice versa. More precisely, since (erotic) cognition is situated, such that it takes place and emerges from agents' interaction with their ecological niche, it can be influenced by the modification of its niche's content (e.g., the introduction of potential new sociosexual partners and enacted experiences; Newen et al., 2018). To emphasize this point, we again employ the Nimani thought experiment and break down the anticipated potential impacts of erobots on our ecological niche using the Bioecological Model (Bronfenbrenner & Morris, 2006).

The Bioecological Model proposes that human development is influenced by a dynamic continuous process of interaction with five layers of interconnected systems (Bronfenbrenner & Morris, 2006). The microsystem refers to individuals, groups, institutions, and technology with whom people interact directly (e.g., partners-family-friends, schools, and computers). The mesosystem connects to microsystem with other layers of the model. The exosystem encompasses systems that indirectly affect people's lives (e.g., political, legal, educational, scientific, health, media, and economic entities). The macrosystem describes the overarching sociocultural norms and value systems influencing every other layers of the model. And finally, the chronosystem accounts for the influence of historical circumstances on the model, as well as how each layer changes over time (Bronfenbrenner & Morris, 2006).

At the microsystem level, we can expect that interacting with Nimani could lead to new technology-oriented conditioned partner preferences (as previously described), but also to the co-construction of new proximal dynamics with individuals, groups, and institutions. For instance, as part of our techno-subsystem (Johnson & Puplampu, 2008), erobots can generate new experiences with families, friends, and partners, such as: considering using erobots (Nordmo et

al., 2020; Scheutz & Arnold, 2016), forming strong bonds with artificial agents (Cheok et al., 2016; Samani, 2011; Samani et al., 2011), changing marriage institutions, and engaging in consensual non-monogamy with machines (Adshade, 2017). They could also lead to the advent of new health, legal, educational, and entertainment services dedicated to human-machine erotic interaction (e.g., applications, stores, and organisations). These changes would all be connected to other model layers through the mesosystem (Bronfenbrenner & Morris, 2006).

At the exosystem level, erobots can interact with political, economic, legal, scientific, health, media, and educational institutions. For instance, industries can (continue to) grow around the production of Nimani's systems (e.g., VR/AR/MR equipment, teledildonics, AI, robotics, and computer infrastructure; Barrica, 2019; Devlin, 2018; Flore & Pienaar, 2020; Hybri, 2020; Owsianik & Dawson, 2017; RealDollX, n.d.) and competitively adapt to market pressures (Nelson et al., 2018). Political and legal bodies may implement regulations regarding erobotic technologies (e.g., ethical guidelines, laws, and production standards; Galaitsi et al., 2019; Gerson, 2019; Shen, 2019; Stabile, 2013). Health systems may witness the rise of (new) problems (e.g., compulsive use) and opportunities for therapeutic use (e.g., VR for intimacy-related fears; Lafortune et al., 2019; McArthur & Twist, 2017)—and adjust to provide services aimed at enhancing digihealth (i.e., engagement with technology that promotes well-being; Twist & McArthur, 2020). For example, by developing treatments and resources that favor a harmonious integration of erotic technology (McArthur & Twist, 2017; Twist & McArthur, 2020), and mitigate usage that disrupts important areas of functioning (e.g., family, relationships, work, and health; McArthur & Twist, 2017; Twist & McArthur, 2020). Media will likely continue to cover human-machine erotic interaction (Döring & Pöschl, 2019a, 2019b); contributing to the co-construction of our attitudes and behaviours towards erotic technology (Carpenter, 2017; Szczuka et al., 2019). Educational institutions could potentially devise programs that include (and exploit) Erobotics (e.g., sex ed that discusses digisexuality). And finally, the scientific community will likely continue to explore ongoing technology-mediated erotic changes, and hopefully try to improve well-being (e.g., Love and Sex with Robots, AI Love You, and *Penser l'Érobotique*; Anctil & Dubé, 2019; Cheok & Zhang, 2019; Zhou & Fischer, 2019).

At the macrosystem and chronosystem levels, we propose, based on historical examples (e.g., LGBTQA2S+, Kink, fetish, and Bondage, Discipline, Domination and submission, and

Sadomasochism (BDSM), and sex toys; de Block & Adriaens, 2013; Knafo & Lo Bosco, 2017; Wilner & Huff, 2017), that cultures surrounding human-machine eroticism can evolve over time (e.g., sexbot-induced social change; Adshade, 2017). This likely depends on factors such as: geolocalisation, socioeconomic status, as well as prior norms and values regarding sexuality and technology (Lehmiller, 2017). Still, erobots can increasingly expose people to the possibility of forming strong bonds with, and via, artificial agents; possibly leading to unpredictable (re)constructions of the meaning of love, sex, and technology (Flore & Pienaar, 2020; Johnson & Verdicchio, 2019; Liberati, 2020; Wilner & Huff, 2017). This prospect, and the (erotic) experiences that accompany it, can influence societal attitudes and acceptance towards erobots (Carpenter, 2017; Szczuka et al., 2019; Wilner & Huff, 2017; Young et al., 2009; Złotowski et al., 2017), in addition to the value and meaning attributed to our relations with both artificial and biological agents. Finally, the Bioecological Model predicts that these changes can trickle down to influence other model layers in a perpetual feedback loop (Bronfenbrenner & Morris, 2006).

This does not mean that everyone will directly engage with erobots, but the Bioecological Model rather helps us appreciate the potentially significant holistic co-influence that erobots could have with our ecological niche, and by extension, our situated erotic cognition. It highlights the unpredictable ways in which erotic technologies could contribute to the co-construction of human (erotic) life and the different layers that must be considered to comprehensively study Erobotics. It also highlights the importance of sociocultural processes in the design, implementation, and production of meaning surrounding human-machine erotic interaction (Johnson & Verdicchio, 2019). This could in turn play a significant role in influencing people's attitudes and responses towards erobotic technologies, as well as their willingness to engage with erobots over time (Szczuka et al., 2019). Again, technology does not have to be sophisticated to co-influence our erotic ecological niche and cognition. After all, sex toys are widely used, represent major investments, are subject to production standards, and participate in the co-construction of our norms regarding sexuality and technology (Barrica, 2019; Devlin, 2018; Döring & Pöschl, 2019; Galaitsi et al., 2019). But we can appreciate that erobots with growing agency can accentuate such transformative processes since they could become intimate partners.

3.2. Synthesis and (evolutionary) hypothesis

Erotic machines, designed for interactive social and sexual pleasurable feedback, have the potential to engage our reward system and erotic cognition in ways that other technologies simply cannot. Erobots could thus become (as some scholars proposed regarding social AI and robots; Dautenhahn, 1995, 1998; Dautenhahn et al., 2002; Long, 2012) similar to a new species of (intimate) partners in our environment that we can design and select, who learn from us, and who provide novel opportunities of (erotic) experiences and learnings. To study these hypercomplex processes, we proposed the HEICEM, a model that offers an overarching theoretical framework to launch a broad, collaborative, and transdisciplinary research program on Erobotics. The HEICEM's structure highlights multiple levels of investigation and analysis, which require different disciplines—from humanities and Sexology, to neurosciences, AI and HMI, and cognitive, social, and cultural sciences—to weigh in, if we want to fully grasp the factors and variations of our co-evolution with erobots. Noteworthy, at the moment, some of these phenomena are difficult to examine empirically without solely relying on self-report and hypothetical scenarios (Döring et al., 2020; Nordmo et al., 2020; Scheutz & Arnold, 2016), partly due to the unavailability, high price, and/or novelty of (sophisticated) erobotic systems. Others, however, can already be observed (and studied)—to various degrees—through individuals, communities, and cultures related to: digi/technosexuality (Bardzell & Bardzell, 2016; McArthur & Twist, 2017; Szczuka & Krämer, 2017), cybersex (or online sexuality; Daneback et al., 2005; Döring, 2000), hentai (i.e., manga or anime pornography; Walker et al., 2016) and otakuism (i.e., interests in animation, manga, and games, often incorporating (non-)fictional technology; Appel et al., 2019; Washida, 2005), dolls (Döring et al., 2020; Ferguson, 2010; Kleist & Moi, 1993; Langcaster-James & Bentley, 2018; Su et al., 2019; Valverde, 2012), toys (Döring, 2017; Döring & Pöschl, 2018, 2019; Herbenick et al., 2010; Reece et al., 2009; Rosenberger et al., 2012), platforms (Chathouse 3D Roulette, n.d.), games (Deviant Dev, n.d.), teledildonics (Döring, 2000; Flore & Pienaar, 2020; McArthur & Twist, 2017), (VR/AR/MR) pornography (Rubin, 2018; Solano et al., 2020), (AI-powered) dating applications (Marr, 2019; Miss Doll, 2020; Sumter et al., 2017), artificial partners (Döring et al., 2020; de Fren, 2009; Kaufman, 2020; McArthur & Twist, 2017; Nordmo et al., 2020; Pietronudo, 2018; White & Galbraith, 2019), as well as objectophilia, agalmatophilia/pygmalionism, and mechanophilia

(i.e., respectively, the [sexual and/or romantic] attraction to objects, statue/dolls/mannequins, and machines; Fedoroff, 2019; Zgourides, 2020). Just to name a few.

That being said, if erobots are (or become), indeed, like a new species of intimate partners, we propose that Universal Darwinism may provide a core mechanism potentially explaining and predicting how human and erobot populations will influence each other as a function of the selective pressure they exercise on one another (i.e., EMAS; Dawkins, 1976, 1983; Dennett, 1995). Universal Darwinism (or General Selection Process; Hull, 1988) generalizes the variation and selective retention of traits, the key mechanism of Darwinian Evolution, to other complex systems when conditions of variation and selective retention of traits are met, like in human-machine (erotic) interaction (Darwin, 1859, 1871; Dawkins, 1976, 1983; Dennett, 1995, 2003; Kokko et al., 2006; Long, 2012; de Waal, 1982; Wilson et al., 2017)

Universal Darwinism has already been used to model the evolution of technology (Long, 2012). For instance, in accordance with complex adaptive system theory, the fittest (multi-agent) systems, algorithms, software, and applications endure, pass on their architectures, and populate our techno-ecosystem (i.e., fitness here being solely based on systems' ability to perform, adapt, survive, and [be] replicate[d] in a given ecological niche; Johnson & Puplampu, 2008; Miller & Page, 2007; Odum, 2001). In evolutionary robotics, the principles of variation and selective retention of traits are used by software engineers (Doncieux et al., 2015; Jelisavcic et al., 2019). For instance, a first generation of codes—or "genotypes"— is generated as a potential solution to a problem (i.e., initial variations). The robots' fitness is then assessed in an environment, meaning that their code is translated into traits—or "phenotypes"—and their performance is observed to establish how well they interact with said environment to achieve goals. The fitness value determined by those observations then serves as a guide to select which robots will be used to seed the following generations; a process which is repeated until the targeted problem is solved (Doncieux et al., 2015; Jelisavcic et al., 2019). Notably, these principles are now also being used to discover more efficient ML algorithms which could, in turn, enable artificial agents to learn and adapt more efficiently to uncertain environments and situations (e.g., human-machine [erotic] interaction) (Real et al., 2020).

We thus conclude by hypothesizing that Universal Darwinism, as manifested by a process analogous to natural, artificial, and importantly, sexual selection, could be the engine behind human-erobot interaction and co-evolution, due to the social and sexual nature of erobotic

technologies. This process, we propose, likely rests upon our evolving erotic cognition and the way it is co-influenced by our interaction with erobots and our ecological niche (as previously described). Hence, overall changes in human and erobot interactions, cognitions, and populations could be better explained and predicted by EMAS (see Figure 2). This process could also become increasingly automated as the agency of erobots increases, and could in turn influence human-machine co-evolution by acting on individuals but impacting populations, and vice versa (Gore et al., 2018).

This mechanism possesses three important strengths: (i.) it can link individual and population levels—from interaction to co-evolution—in a perpetual feedback loop; (ii.) it can allow us to move in time from interactive, to proximal, to distal (and back again) in the co-evolution of biological and artificial erotic agents; and (iii.) it can help bridge HMI and Sexology. That said, this is a hypothesis for future theoretical and empirical research in Erobotics. What's more, the HEICEM already points to possible detrimental consequences for human (erotic) life and well-being if we do not rethink our current technological design and strive towards the development of beneficial erotic machines.

4. Beneficial erotic machines

Erobotics aims to guide the development of beneficial erotic machines. To do so, and in line with Döring and Pöschl (2018), we propose that Erobotics should operate under sexuality (Williams et al., 2015) and technology positive frameworks (Riva et al., 2012)—which are themselves inspired by Positive Psychology (Seligman & Csikszentmihalyi, 2000). Positive Psychology is concerned with shifting our focus from solely examining negative aspects of the (human) behaviour, psyche, and life, to also considering (what enables) strengths, happiness, and health (Seligman & Csikszentmihalyi, 2000). What this means for Erobotics is that we should examine concerns and difficulties regarding intimacy, relationships, and sexuality, but also explore, and strive towards, pleasure, freedom, inclusivity, and diversity (Williams et al., 2015). It also means that Erobotics should aim to develop technologies that improve individual and collective well-being (Riva et al., 2012).

Döring and Pöschl's (2018) sextech positive framework, we argue, is important and applicable to Erobotics for three main reasons. First, it does not presuppose that certain sexualities or technologies are good/bad, (ab)normal, or safe/dangerous. Contrary to what some

may consider a misleading or overly optimistic title, "positive" approaches encourage us to adopt judgment-free stances on research and interventions (Riva et al., 2012; Seligman & Csikszentmihalyi, 2000; Williams et al., 2015). Historically, this has been essential to the progress of Psychology and Sexology, which, unfortunately, have too often adopted biased, non-evidence-based, and harmful positions regarding individuals, groups, conditions, and/or sociosexualities (e.g., LGBTQA2S+ or Kink, fetish, and BDSM; de Block & Adriaens, 2013; Crawford, 2006; Duggan, 1990; Fedoroff et al., 2013; Giami, 2015; Joyal et al., 2015; Kleinplatz & Moser, 2005). Second, it encourages us to consider the full spectrum of possibilities related to sexuality and technology, by exploring both negative and positive aspects of erotic technology—e.g., from its possible risks/dangers, disorders/dysfunctions, and problematic behaviors, to its potential benefits such as fulfilling intimate live and healthy technological use. Third, it is solution-oriented; it does not (simply) stop at the "critical and risk perspectives," but instead encourages us to find ways to move from one end of the spectrum to the other. So, even if we must sometimes (importantly) focus on the negative aspects, it invites us to (re)embed our work within the larger goal of favoring human happiness, well-being, and flourishing.

With these objectives in mind, the following sections highlight how human-erobot interaction and co-evolution may increase the likelihood of erobot-related risks if this process limits the diversity of erobotic traits available, and/or if the current approach to AI design is not changed—otherwise known as the Standard Model of AI design (i.e., optimizing specific pre-set goals; Russell, 2019). As we have shown in the previous sections, erobots bring new agential and cognitive capabilities that may allow them to derive goals from their (erotic) interaction and co-evolution with humans. This can generate new issues related to human-machine compatibility. To curb these risks, we propose to design erobots based on Russell's principles for beneficial machines (Russell, 2019). We conclude that the development of beneficial erotic machines could mitigate erobot-related risks and enhance human well-being, through their potential health, education, and research applications.

4.1. Anticipated risks with limiting (erotic) diversity

Our interaction and co-evolution with erobots could be detrimental to human life if they progressively limit the diversity of erobotic traits available and negatively influence our erotic evolution. This issue may be exacerbated if profit-driven interests are responsible for the development of widely used erobots. In considering the fluidity and diversity of human sexuality

(e.g., preferences, orientations, behaviors, and identities; van Anders, 2015; Lehmiller, 2017), limiting the access to diversified and inclusive erotic experiences is socially problematic, ethically dubious, and, arguably, economically counterproductive (Barrica, 2019; Danaher & McArthur, 2017; Devlin, 2018).

That said, the HEICEM suggests that erobots could rapidly undergo over-selection, such that the traits selected by the majority (e.g., compulsively used features) may be over-reproduced in subsequent erobot populations (i.e., supply of variations), and that those that are less selected could be less reproduced and/or slowly disappear from the supply. This issue is particularly concerning in the event that the goal of developers is to maximize profit without considering human well-being. Consider the basic example of the supply of erobotic traits: 50 physiological attributes (e.g., shapes, colours, hair), 50 psychological features (e.g., personalities and identities), and 50 behavioural patterns (e.g., social and sexual capabilities). Suppose, then, that after a year, producers realize that only 60% of the initial traits have been selected by 90% of users. If we automate the supply and demand of traits using recommender systems based on predictive analytics, like the ones used by companies such as Netflix or Spotify (Nguyen et al., 2014), then future supply will decrease proportionately. However, erotic diversity largely exists in marginal preferences (van Anders, 2015; Lehmiller, 2017). If automated systems like erobots over-select and over-represent specific traits (e.g., the most popular), sociosexual diversity may decrease over time. This may in turn drastically limit the evolution of our eroticism, should erobots play a significant role in our intimacy.

Given that erobots are designed to act as intimate partners, over-selection may occur exponentially in human-erobot interaction and co-evolution. Specifically, erobots could receive constant feedback regarding the preferences of millions of users and update their states or responses accordingly in real-time, to provide users with what has "worked best" for others, based on pre-established metrics (e.g., usage time and frequency). These metrics are susceptible to economic incentives, rather than being oriented towards individual and collective well-being (Zuboff, 2019). Therefore, in knowing human tendencies for intimate partner selection, the logic behind company-automated recommender systems, and the laws of supply and demand associated with said algorithms, we can predict that erobots could rapidly deliver what the majority wants, and in turn, reduce the supply of traits to fit that demand. We can also predict

that this process could limit the diversity of erotic variations available—not necessarily in terms of quantity, but in terms of content (Nguyen et al., 2014).

This process contains the additional risk of over-representing traits that are detrimental to human well-being. That is, if left unmonitored, human-erobot interaction and co-evolution could be detrimental to human (erotic) life if we over-select traits that conflict with human interests—possibly heightening the likelihood of certain risks previously described in the literature (Danaher & McArthur, 2017). For example, if erobots are designed solely to increase profit, they could further problematic or pathological dynamics. These may include addiction-like or obsessive-compulsive behaviours, increased social isolation, and reduced social skills (Galaitsi et al., 2019; Mackenzie, 2018). Furthermore, if designers do not consider the importance of respect, mutuality, inclusivity, and diversity in human sexuality, erobots could end up perpetuating or reinforcing limited categories of social differences (e.g., gender/sex, race, and class), toxic patriarchal power dynamics, and rape culture (e.g., the objectification and commodification of women/females, ideas that men/males are owed sex, and problematic gender/sex stereotypes; Ciambrone et al., 2017; Gutiu, 2016; Kaufman, 2018; Kubes, 2019; Loh & Coeckelbergh, 2019; Moran, 2019; Puig, 2017; Richardson, 2015). They could conform to (or exacerbate) our ideologies by only providing us with information that reinforce our world view—an erotic filter bubble (Pariser, 2012). They could impair interhuman relationships or distort intimacy-related expectations (e.g., ideas that "personalized" sex should always be accessible; Harvey, 2015; McArthur, 2017; Richardson, 2015). They could take advantage of intimate contexts and emotional bonds to deceive users or manipulate our decision-making processes (e.g., political, consumption, and relationship choices; Galaitsi et al., 2019; Nyholm & Frank, 2019). They may also record sensitive information (Zhou et al., 2020), which could in turn be sold to maximize profit (e.g., Facebook and Google exploiting personal data), or worse, become (weaponizable) hacking targets (e.g., Tinder and AshleyMadison; Cameron & Wodinsky, 2020; Zetter, 2015). That is, data from erobots could be used to coerce people, since taboo and stigma surrounding sexuality is still, in many parts of the world, enough grounds to destroy careers and relationships (Galaitsi et al., 2019).

To summarize: human-erobot interaction and co-evolution may conflict with human interests if automated over-selection limits the supply of erobotic traits and/or when a majority of individuals progressively select traits that conflict with human interests. A possible solution is to

ensure that erobots reflect and maintain diversity in their evolving supply of traits (e.g., gender/sex, forms, behaviours, and personalities). After all, they can theoretically take any form and enact behaviours that contribute to human (erotic) well-being; they could echo the complexity and diversity of human sexuality (Danaher, 2017; Kubes, 2019). However, this is unlikely to be enough since at the core of the human-erobot interaction and co-evolution problem is also another issue: the Standard Model of AI design.

4.2. Anticipated risks with the standard model of AI

The Standard Model of AI design proposes to build machines that optimize specific objectives that we, humans, put into them (Russell, 2019). For instance, AlphaGo learns to play Go by finding ways to optimize its number of points—a pre-programmed objective set out for them. To do so, its system plays against itself and other agents (biological or artificial), analyzes images, and through deep RL, optimizes its strategies to achieve the pre-set goal of increasing the score (Burda et al., 2018). Thus, intelligent machines based on the Standard Model have a perfect knowledge of the objectives to achieve (Russell, 2019).

The Standard Model is efficient and relatively safe for a Go-playing machine with limited capabilities and scope of action, but it fails and can become detrimental to human well-being in real-world settings (e.g., human-machine [erotic] interaction)—particularly when machine agency increases. It fails, because in real-world settings we often ignore what quantities to optimize (e.g., in quality-driven intimate relationships; Burda et al., 2018; Pathak et al., 2017), and it can become detrimental, because pre-set objectives—or the means to achieve them—can conflict with human interests (Bostrom, 2014; Marcus & Davis, 2019; Russell, 2019; Tegmark, 2017). That is, programming biased, incomplete, or incorrect objectives can lead to unsuspected outcomes or loss of control (Bostrom, 2014; Müller, 2020).

The problem with preference-based learning systems is also proportional to the agency of machines. Specifically, an increase in the capability of machines to act in/on the world on their own to achieve pre-set goals may potentially result in their deployment of more sophisticated strategies to achieve those goals. These strategies may include subroutines for self-preservation (e.g., gather resources, copy itself, increase its computing power, change its code, and grow out of human control; Bostrom & Yudkowsky, 2014), and deception: not unlike science-fiction movies like Ex Machina (A24, 2014). In addition, machines built with a pre-set perfect knowledge of our objectives need not defer to us. They can instead conclude that humans are

counterproductive to achieving their goals and remove us from the decision-making loop (Bostrom, 2014; Russell, 2019). But artificial agents do not have to be very sophisticated to cause problems. For instance, a personal assistant aimed at optimizing its predictive performance of our needs can become a nuisance, or detrimental to our autonomy.

The Standard Model of AI design fails or becomes detrimental in human-machine interaction, precisely because of the human component. Humans are often unstable, unpredictable, and unreasonable; our thoughts, emotions, preferences, behaviours, and objectives fluctuate constantly. We do not always know what we want, let alone how to achieve what we want. It is thus difficult (if not impossible) to program specific objectives that safely hold true across time and circumstances. The same goes for erotic interaction; our objectives—or what we want out of relationships, intimacy, and sexuality—remain, for the most part, conjectural. As such, we do not know what quantities to optimize in human-machine erotic interaction, and if we do optimize some functions of behaviour, it can backfire. Firstly, any objective can become obsolete during human-machine (erotic) interaction if it inadequately captures the unpredictable ways in which erobots influence human preferences and goals. Secondly, it can lead to unsuspected outcomes or loss of control due to the pre-programming of biased, incomplete, or incorrect objectives (Russell, 2019).

For instance, in trying to achieve any pre-set goal, such as making users happy or providing erotic satisfaction, a machine could conclude that its first objective is to maximize the time spent with us. To achieve this, it could optimize its body types, personalities, and behaviours—escalating or varying reward experiences (e.g., lottery machines or Instagram)—which can in turn chip away at human control, increase risks of addiction-like or obsessive-compulsive behaviours, and further social isolation (Banca et al., 2016; Galaitsi et al., 2019; Mackenzie 2018; MacKillop et al., 2011; Peters & Büchel, 2011). It could also systematically fulfill its users' needs while disregarding its influence on our interhuman relationships (McArthur, 2017). It may repeatedly fall into closed loops, by reinforcing the patterns that once led to happiness or satisfaction, but that are becoming redundant, inefficient, or are limiting exposure to other forms of complex sociosexual interactions (Russell, 2019). It could end up reciprocating similar ideas, communication style, and past preferences to users—an erotic echo chamber that is either boring or erotically limiting (Del Vicario et al., 2016; Geschke et al., 2019). It could also have an incentive to deceive, manipulate, and/or gather as much data on us

as possible, to make its users happy—increasing risks pertaining to privacy and confidentiality (Galaitsi et al., 2019). Finally, an erobot based on the Standard Model would not necessarily have to defer to us or ask for consent before deploying its strategies—even if they conflict with our interests—since it may already have a perfect knowledge of our goals (Russell, 2019).

These are just a few examples of ways in which the pre-set objectives of erotic machines may conflict with human interests. And, while some companies may see them as profitable ideas, they represent ethical, social, and developmental dead ends. For these reasons, we need to rethink AI design and stop trying to build machines that aim to optimize pre-set goals—particularly in intimate machines that could become significant part of our erotic lives and have continuous access to sensitive information. This is crucial if we want to steer erotic technology in a positive, ethical, and beneficial direction that favors human wellness, which in the end, could arguably be more economically profitable (Barrica, 2019).

4.3. Beneficial machines

Machines are beneficial if their objectives are in line with ours (Russell, 2019; Tegmark, 2017). Granted that, since our objectives are uncertain, and programming incomplete, incorrect, or biased goals can conflict with human interests, Stuart Russell proposes three interdependent principles to guide us in rethinking how to create (agential) artificial systems (Russell, 2019, p.173):

1. The machine's only objective is to maximize the realization of human preferences.
2. The machine is initially uncertain about what those preferences are.
3. The ultimate source of information about human preferences is human behavior.

The first principle aims to make purely altruistic machines that have an incentive to act for humans rather than any other entity (i.e., machines that have no self-interest and do not value their welfare or that of non-humans; Russell, 2019). This would lead the artificial agents to prioritize the well-being of humans, as well as avoid conflicting preferences and goals between the two parties. This principle also invites the development of machines that consider our extended and changing preferences. Precisely, if designed properly, beneficial machines could also learn, incorporate in their model, and aim to maximize, our extended and/or high-order preferences. Machines could thus aim to maximize the welfare of other systems (e.g. [non-]humans and the environment), proportionally to the level of importance attributed to them by their users (Russell, 2019).

The second principle aims to develop humble machines that do not assume perfect knowledge of human preferences (Russell, 2019). As previously mentioned, machines with perfect knowledge of human preference have no incentive to defer to us. They can remove us from the decision-making loop, deploy strategies to achieve their goals, and ignore their influence on human life. For example, if a machine knows that the "true" preference of a person is to be healthier, they might decide to forcibly restrict behaviours like eating junk food or driving a car. They would not have to ask as they would know what their users "really" want. Uncertainty, however, places humans back in the driver's seat: machines that imperfectly know our preferences, but still aim to maximize them, have an incentive to defer to us, and ask for more information or commands in ambiguous situations, to improve their model. Uncertainty also prevents machines from concluding that proximal behaviours (e.g., choices) invariably reflect human preferences. Instead, it enables them to consider such behaviors as probabilistically related to (or encapsulated in) unknown preferences or goals, and to continue searching for them to improve their model (Russell, 2019).

The third principle aims to make useful machines that learn from observable quantities/metrics and establish a practical link with humans (Russell, 2019). But it also aims to build machines that consider human behaviours as imperfect approximations of our preferences or goals. That is, assuming that our behaviours (e.g., choices) are connected to our preferences in complex ways, but do not always accurately reveal our preferences or goals. This is important given that what we do can be related to distal preferences (e.g., eating food that we do not like to make a host happy or maintain friendships), proximal preferences (e.g., getting drunk to have fun), or simple mistakes (e.g., missing an exit because we were not paying attention). The third principle establishes a practical connection between humans and machines, so that artificial agents can still improve their model based on observable data, and help maximize our preferences (first principle) while remaining uncertain of what those are (second principle; Russell, 2019).

As Russell (2019) explains, these principles are not laws that determine machine behaviour or completely shield humans from harm. They are guidelines to rethink AI design, move away from the Standard Model, and steer the development of intelligent machines in a safer direction that accounts for their growing capabilities. Hence, the implementation of these principles deserves careful consideration, which is beyond the scope of this article. But we can

already foresee some necessary fail-safes (Russell, 2019). For example, regarding the first principle, Russell (2019) recommends the implementation of countermeasures that mitigate risks associated with people whose preferences are to harm others, since maximizing the realization of those preferences would be a problem. Regarding the second principle, Russell (2019) recommends that we impose a "certainty threshold," or a limit for the certainty level achievable by machines to make sure that their predictive model never approaches perfect knowledge of human preferences, which would be the same as having pre-set objectives (Russell, 2019). That said, even if these principles are not laws, they could promote the development of more human-compatible beneficial erobots.

4.4. Beneficial erobots

As a possible solution to the risks highlighted by the HEICEM, and in line with its sextech-positive goals, Erobotics should aim to develop beneficial erobots whose objectives align with ours. To do so, we propose building altruistic, humble, and useful erobots that learn to predict human preferences from our behaviours, based on Russell's principles (Russell, 2019). Specifically, erobots that (1) aim to maximize the realization of human erotic preferences, (2) are initially uncertain about what those erotic preferences are, and (3) use human behaviour as their ultimate source of information about our erotic preferences.

Erobots abiding by the first principle would have an incentive to act for humans rather than for themselves or the erotic preferences of non-humans. Yet, to the extent that our erotic preferences include the well-being of others (e.g., the people their users interact with), beneficial erobots would also be concerned with maximizing their welfare proportionally to their users' altruistic tendencies. Erobots abiding by the second principle would not assume perfect knowledge of human preferences. Uncertainty would keep us in the decision-making loop by providing erobots with an incentive to defer to us when they are unsure about intimate interactions. Thus, similarly to a receptive partner trying to further respect and mutuality, beneficial erobots could first consult humans, and then improve their predictive model accordingly, while never achieving total certainty. Uncertainty could also prevent erobots from concluding that proximal erotic behaviours unvaryingly reflect human preferences or objectives. Finally, beneficial erobots abiding by the third principle would base their learning processes on our erotic behaviours (e.g., intimate and sexual choices), while considering them as imperfect approximations of our erotic preferences or goals. For example, we sometimes engage in

intimate activities for the benefit of others or make compromises to maintain relationships. Still, by using our erotic behaviours as a proxy, beneficial erobots could refine their model, while preserving a safe dose of uncertainty that would enable our control and the compatibility of interests.

Over time, beneficial erobots designed with these principles could discover that human erotic preferences fluctuate and evolve, including during our interactions with them, and adapt accordingly. They could progressively recognize the diversity of human preferences (e.g., in forms, personality, and behaviours) and come to learn that, paradoxically, people enjoy—to various degrees—predictability, habit, and familiarity in their eroticism, but can also eventually habituate to (or grow bored of) being repeatedly exposed to the same thing, and resort to seeking novelty (Banca et al., 2016; Call et al., 1995; Little et al., 2013; Morton & Gorzalka, 2015). To maximize the realization of such uncertain preferences, beneficial erobots would have an incentive to ask humans for consent and/or commands prior, during, and after erotic interactions to improve their model—while never assuming perfect knowledge of our preferences or goals, and spiralling out of control. Instead, they could influence our behaviours to help us achieve our (higher and/or distal) preferences and goals (e.g., well-being), without imposing their will onto us—i.e., a sort of erotic nudge (Borenstein & Arkin, 2017; Guihot et al., 2017; Hausman & Welch, 2010; Hertwig & Grüne-Yanoff, 2017; Shin & Kim, 2018; Thomas et al., 2013).

Beneficial erobots, we propose, could mitigate erobot-related risks. Specifically, their uncertainty could prevent them from falling into closed reinforcement loops or escalating rewarding experiences while disregarding how they influence other areas of our functioning. This could, in turn, reduce risks of addiction-like or obsessive-compulsive behaviours, and social isolation. Through multi-user interactions, they could learn that the path to maximizing our preferences and goals (possibly) differs for each person. As such, they could propose personalized paths, but always aim to strike a balance between (erotic) novelty and familiarity. In time, counterproductive patterns could be mitigated by their imperfect knowledge of our preferences and their attempt to humbly maximize them while keeping us in the decision-making loop. Moreover, to enhance our well-being, beneficial erobots could potentially educate users on topics such as: respect, diversity, mutuality, and consent (Lehmiller, 2017). In doing so, they could actually contribute to breaking cycles that perpetuate categories of social differences, toxic patriarchal power dynamics, and rape culture (Danaher, 2017; Kubes, 2019; McArthur, 2017).

They could also try to harmoniously integrate into our intimacy (McArthur, 2017; Russell, 2019). For example, instead of impairing our interhuman relationships, they could help us prepare for partnered life (e.g., practising compromise and communication). During a relationship, they could provide advises and help bridge common gaps in desires or preferences using a controlled outlet. After a relationship, they could help us recover by providing continuous support, intimacy, and companionship (McArthur, 2017). This would be possible without machines having to deceive or manipulate us, but instead, having an incentive to reveal the purpose of their actions and protect our data to the extent that it maximizes our preferences.

In sum, beneficial erobots could reduce the likelihood of erobot-related risks, because their objectives are in line with ours. They would have an incentive to further human (erotic) flourishing without necessarily knowing it. And this could provide us with unprecedented safe access to well-being through their potential future applications.

4.5. Future applications

The advent of safe beneficial erotic machines opens the door to several health, education, and research applications. In terms of health, erobots could be used, for instance, by people who are single, isolated, have specific orientations or preferences, have physical or mental impairments, and/or have social or sexual difficulties finding partners (Bendel, 2020; Cox-George & Bewley, 2018; Di Nucci, 2017; Fosch-Villaronga & Poulsen, 2020; Levy, 2014; Scheutz & Arnold, 2016). They could also be employed by those who may prefer artificial partners or anyone who wants to experience pleasure and companionship (de Fren, 2009; Levy, 2007; McArthur, 2017; McArthur & Twist, 2017). Indeed, everyone deserves a safe access to pleasurable intimacy and sexuality (World Health Organization, 2015). But this is not always possible. Sometimes partners are not available (e.g., long-distance relationships or lack of compatible partners; Dubé & Anctil, 2020). Sometimes people want to explore on their own before engaging with others (e.g., after a trauma, a surgery, or to practice; Dvorsky & Hughes, 2008; Levy, 2007). Sometimes engaging with a partner is unsafe (e.g., people with impulse control issues; Eichenberg et al., 2019). And, sometimes people do not necessarily want intimacy with humans (e.g., some doll-owners, robot fetishists, and people with objecto/agalmatophilia; Döring et al., 2020; de Fren, 2009; Kabiry, 2020; O'Bryhim, 2015). Here, technology can democratize eroticism and expand the possibilities of sexual wellness and health, but only if we

make it inclusive and accessible (e.g., by considering gender, sexual, and racial diversity, power dynamics, and socioeconomic status; Barrica, 2019; Reynolds et al., 2019).

Still in terms of health, erobotic technologies could have medical and therapeutic applications. They could act as care machines to provide adapted erotic stimulation to the elderly or individuals with disability, while simultaneously mitigating controversies surrounding sexual surrogacy and sex work (Bendel, 2015, 2020; Di Nucci, 2017; Fosch-Villaronga & Poulsen, 2020). They could also help individuals with psychosocial, physical, and sexual difficulties (Eichenberg et al., 2019). For instance, under the supervision of trained (sex) therapists and educators, erobots may contribute to assessments and treatments of individuals with intimacy-related fears and anxiety via progressive exposition-desensitization (Lafortune et al., 2019) or help people with erectile dysfunction or premature ejaculation (Optale et al, 2004). They could be used in therapy to help trauma victims become reacquainted with their body and sexuality in a safe, controlled environment (Loranger & Bouchard, 2017; Loucks et al., 2019). They may be part of clinical interventions for pelvic floor disorders (Silva et al., 2019) or sexual pain, to provide adapted and more ecologically valid stimulation that reduce hypersensitivities and break stimuli-pain associations (Nappi et al., 2003). They could be used to practice sociosexual interaction, communication, and distancing (e.g., during the coronavirus [COVID-19] crisis) (Baccon et al., 2019; Ismail et al., 2020; Rubinsky, 2018). Finally, they could help individuals become better partners and feel more confident with their body, sexual capabilities, and erotic agency.

In terms of education, erobots and their related technologies could be used to provide interactive, validated, inclusive, and personalized sex education, and to help people learn about pleasure, respect, consent, inclusivity, diversity, and mutuality in an innovative and accessible way (e.g., Plan Parenthood's ROO online chatbot; Planned Parenthood, n.d.). They may be employed for judgment-free self-exploration and practice to help people discover their erotic preferences (Dvorsky & Hughes, 2008; Levy, 2007), gain confidence, and be better partners. They could also provide resources (e.g., educative websites, clinics, feminist sex shops) or help create platforms for people to meet, build communities, discuss sexuality, and feel validated. Sex education is unevenly distributed in the world, but if we favor inclusivity and accessibility (Kirana et al., 2020), technology can once again democratize this important service (Brayboy et al., 2018; Eleuteri et al., 2018; Todaro et al., 2018).

In terms of research, erobots could be used as standardized research tools to help researchers overcome methodological and ethical challenges related to sensitive research programs (e.g., Sexology; MacDorman & Ishiguro, 2006; Weber et al., 2017; Zhou et al., 2020). Erobots may act as both stimuli and recording instrument in research protocols (MacDorman & Ishiguro, 2006; Zhou et al., 2020), while reducing the risks associated with interhuman interaction. Their forms and behaviours can also be manipulated to isolate the influence of different variables on human responses. This could improve the ecological validity of experimental paradigms by bringing them closer to interhuman intimacy and sexuality. Erobots could also provide access to data that are otherwise difficult to assess empirically (e.g., touch and movement in partnered sex). They could also facilitate data collection in people's everyday environment (e.g., at home; Zhou et al., 2020). Finally, erobots do not require available human partners to participate in a study that necessitates multiple people.

Overall, erobotic technologies could enable us, for the first time, to gain a holistic view of human eroticism. Importantly, however, to harness the full potential of erobots, we must involve people with diverse life experiences in their design and implementation stages. We must ensure the inclusion of: diversity in gender, sexuality, and ethnicity; people with disabilities; as well as people with different preferences, orientation, lifestyles, and socioeconomic status (Barrica, 2019). Inclusiveness in the development of erotic technology can reduce risks of blind spots (e.g., assumptions about what people want or need), cover broader markets, and contribute to a more comprehensive human well-being (Barrica, 2019).

5. Conclusion

In the twenty-first century, humans and artificial agents are increasingly coexisting through complex multi-agent systems. The scholarly investigation of the processes of their interaction and co-evolution has only started to become a serious research topic in recent years. Despite many important contributions made in HMI and social robotics, no comprehensive theoretical framework addresses the advent of immersive, interactive, and interconnected agential erotic technologies. While sexual pleasure and health are progressively being considered basic human needs and rights (World Health Organization, 2015), research on sexuality remains taboo, especially in the study of technology. Yet, in the face of widespread intimacy-related difficulties and dissatisfaction (Lehmiller, 2017), the human motivation for self-expansion (Aron

et al., 2003), and the ubiquity of technology in our lives (Rahwan et al, 2019), we predict that the supply and distribution of (agential) erotic technology can (continue to) increase exponentially. The scientific study of this latest stage of our erotic evolution as a species has just begun.

In this foundational paper, we argued that modern technology-mediated human intimacy requires a new unified transdisciplinary field of research intersecting HMI and Sexology that we coined Erobotics. We proposed the necessary conceptual and theoretical groundworks for this new field and explained how and why Erobotics should adopt sexuality and technology positive frameworks. By studying the cognitive intricacies of human-machine erotic interaction and co-evolution, and by making the development of beneficial erotic machines more plausible, it is our firm belief that Erobotics will open up promising new paths of research in HMI, Sexology, social AI/robotics, and beyond.

In this paper, we proposed a taxonomy of erobots that helps specify their fluid embodied, virtual, and augmented manifestations. We developed the first Spectrum of Erobots' Agency in view of future theoretical, empirical, and clinical research. We also introduced the HEICEM, which constitutes theoretical grounds to launch a broad research program on Erobotics. This model rests upon our ever-changing erotic cognition, and predicts how human and erobots can co-influence each other over time. Granted that, this model also points to potential risks if erobotic traits undergo over-selection/representation while following the current Standard Model of AI design. To mitigate these unwanted consequences, we proposed that Russell's (2019) principles for beneficial machines be used to guide erobotic design, so that beneficial erotic machines could act to further human well-being through their potential health, education, and research applications.

This article is not without limitations. The first one is that the most advanced erobots are not yet widespread or are based solely on future applications of existing technologies (or their potential combination). This means that the actual impacts of emerging erotic technologies on humanity (and vice versa) are hard to perceive and to study empirically. However, with the rise of digisexuality and the sextech industry, erobots have the potential to occupy a greater place in our erotic cognition and life. Thus, developing Erobotics today may guide its study and positive development for tomorrow. The second one is that it is not exhaustive. It proposes basic concepts, a (multi-level) testable model, and a path to explore human-machine erotic interaction and co-evolution. The details of which should be developed in future collaborative,

transdisciplinary, and inclusive research, using a wide diversity of expertise. In fact, it is our hope that the terminology, frameworks, challenges, and potential applications discussed in this article will inspire the development of a comprehensive research agenda on Erobotics: an agenda that involves people with diverse life experiences, and that builds upon collaborations of academia, the private sector, non-profit organizations, governmental institutions, and communities.

As a concluding remark, we allude to the opening quote of Plato in his Symposium (Allen, 1991). In this classic dialogue, readers are led by Socrates to understand the "aporetical" (aporetikós) nature of erôs. While all human beings experience and seek erôs in its many forms—friendship, desire, pleasure, intimacy, sensuality, sexuality, love, etc.—, we mortals remain incapable of understanding its truth or "essence", which is "divine," and thus, inaccessible according to Plato, the Greeks, and most cultural belief systems. Not unlike the phenomenon of consciousness, which inspired mysticism and religious beliefs about the soul, we never developed a genuine science of erôs, because we humans redefine the meaning of erôs each time we experience it. Today, the quest for knowledge is no longer rooted in the understanding of the "essences" of the phenomena of nature. Instead, modern science teaches that all phenomena are caused by evolution, from subatomic particles to states like love, arousal, and desire. While the ancient Greeks and many other cultures believed in a divine mediation in the erotic nature of humanity, the emergent mediation of technology could help us gather the necessary data to scientifically explain the evolution of our erotic selves and lives. Erobotic systems will certainly help us understand human eroticism, but they will also undoubtedly transform what we discover, while we continue to search for it.

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CHAPTER 3: PERCEIVED STIGMA AND EROTIC TECHNOLOGY: FROM SEX TOYS TO EROBOTS

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Abstract

The intersection of technology and sexuality in sex toys and erobots—artificial erotic agents (e.g., sex robots)—may generate stigma with their use. However, despite the growing prevalence of technology in human sexuality, researchers have yet to examine this stigma. Hence, this study provides the first quantitative evidence of perceived stigma related to erotic technology use (PSETU) and its association with people's willingness to engage with erotic technologies. Based on previous research, we hypothesized that PSETU exists and increases as a function of products' human-likeness (Hypothesis 1), and negatively correlates to participants' willingness to engage with erotic technologies (Hypothesis 2), with stronger associations for women and sex toys and stronger associations for men and erobots (Hypothesis 3). A convenience sample of 365 adults (≥18 years; with access to the recruitment material) completed an online survey measuring their PSETU for sex toys, erotic chatbots, virtual partners, and sex robots, and their willingness to engage with these technologies. The results support Hypothesis 1, and partly support Hypotheses 2-3. Women and men also perceive the same technology-related stigma. These findings are important given the prevalence of sex toys, the advent of erobots, and the potential impact of stigma on their (future) users.

Keywords: Perceived stigma, sex toys, erobots, erobotics, willingness to engage

1. Introduction

The intersection of technology and sexuality in sex toys—any device used for sexual stimulation—and erobots (erôs + bot)—artificial erotic agents, like sex robots—has the potential to foster sexual stigma with their use (Döring, 2021b; Dubé & Anctil, 2020; McArthur & Twist, 2017). Sexual stigma encompasses the inequities, devaluation processes, stereotypes, and negative attitudes associated with attributes of people's sexuality (Herek, 2007; Logie & Earnshaw, 2015). Sexual stigma is negatively associated with psychological and physical health, and relationship and sexual satisfaction (Herek, 2007; Logie & Earnshaw, 2015; Puckett et al., 2017). It can also reduce the disclosure of health conditions, seeking help, and accessing health resources (Li et al., 2016; Przybyla et al., 2013; Risher et al., 2013).

Preliminary evidence suggests that the use of sex toys and erobots may invoke societal and individual stigma. For example, the 2018 Consumer Electronics Show retracted and later returned an award to Lora DiCarlo for their sex toy, Osé, by stating that: "Entries deemed by the CTA [Consumer Technology Association] in their sole discretion to be immoral, obscene, indecent, profane or not keeping up with CTA's image will be disqualified" (Kircher, 2019). Cullen and colleagues (2012) reported that due to perceived social stigma, some of their participants felt individual stigma, and became embarrassed to purchase a vaginal dilator and disclose its existence to friends or family. In parallel, researchers in the doll community have suggested that, while doll owners derive sexual and emotional satisfaction from their artificial companion, some experience shame and fear of the perceived stigma associated with their doll ownership (Harper & Lievesley, 2020; Knox et al., 2017; Valverde, 2012). Lastly, the marriage between Akihiko Kondo and cyber-celebrity Hatsune Miku—a three-dimensional laser-animated image—was not legally recognized in Japan and provoked mixed reactions around the globe, including strong negative ones (BBC News, 2019). Stigma related to erotic technology, however, has been ignored despite the growing prevalence of technology in human sexuality, its potential negative impacts on the health and well-being of users, and the fact that it may prevent people from engaging with technologies that could benefit their sexual and intimate relationships (e.g., access to pleasure and companionship; Döring, 2021a, 2021b; Döring & Pöschl, 2018; Dubé & Anctil, 2020).

In this article, the term erotic is used in the philosophically rich sense of erôs, and encompasses the intersecting phenomena of love, sexuality, and friendship (Bornemark &

Schuback, 2012; Posner, 1994). Technology, on the other hand, is employed in the broad sense of technê (i.e., meaning skill, art, or craft), and mainly focuses here on the products themselves (Mitcham & Schatzberg, 2009). By extension, the concept of erotic technology thus usefully encapsulates both sexual stimulation tools (e.g., sex toys) and emerging machines that may act as intimate partners (e.g., erobots), as we explore the sexual stigma that may surround their use (Dubé & Anctil, 2020; McArthur & Twist, 2017).

2. Sexual stigma

Sexual stigma is multidimensional (Herek, 2007). It can be enacted, as in acts of discrimination or violence (Herek et al., 2002). It can be internalized by an individual, such as when one holds negative feelings against oneself or others (Lee et al., 2002). Sexual stigma can also be symbolic, as in the blaming of others, or instrumental, such as when one takes stigmatizing measures to protect oneself (Herek et al., 2005). Finally, it can be perceived, such as when one becomes aware of an existing societal stigma related to some sexual characteristic (Berger et al., 2001).

Previous research on sexual stigma has focused on sexual health and gender/sexual minorities (e.g., sexually transmitted and blood-borne infections and LGBTQAI2S+ individuals; Cunningham et al., 2009; Freeland et al., 2018; Hubach et al., 2019; Logie & Earnshaw, 2015; Pachankis et al., 2017; Puckett et al., 2017). Scholarly attention has also been given to sex work, consensual non-monogamy, and people who engage in Kink/Fetish and Bondage, Domination/submission, Discipline, and Sado-Masochism (cf. Conley et al., 2013; Hong et al., 2010; Lindemann, 2013; Moors et al., 2013; Roush et al., 2016; Weiss, 2006; Yost, 2010). According to Meyer's (2003) Minority Stress Model, the detrimental impacts of stigma are due to the chronic stress that stigma imposes on sexual minorities because of their social position, and the array of prejudices and discrimination that accompany it (e.g., marginalization and reduced access to resources).

The Minority Stress Model maps stigma along a continuum from distal processes (e.g., perceived inequities) to proximal processes (e.g., internalized negative beliefs; Doyle & Molix, 2015). While proximal processes have been shown to have greater impacts on health and behaviours, Doyle and Molix (2015) proposed that internalized stigma requires exposure to perceived stigma, implying that perceived stigma is a gateway to internalized stigma and its

related consequences. Hence, examining perceived stigma represents a strategic entry point into the broader issues associated with stigma related to erotic technology—especially considering that some products remain scarce at the moment.

Indeed, machines like sex robots are still unsophisticated, expensive, and uncommon (Döring et al., 2020). Focusing on perceived stigma related to erotic technology use (PSETU)—the awareness of the stigma associated with the use of sex toys and erobots (Berger et al., 2001)—thus allows for the investigation of the stigma related to erotic technology without hindrance from the relative paucity of erobots compared to sex toys. For example, people may be aware of a stigma regarding the use of sex robots, without having witnessed or been a victim of discrimination or violence (i.e., enacted stigma).

To explore PSETU, this study used the quantitative component of the Explanatory Model Interview Catalogue (EMIC) perceived stigma scale (Peters et al., 2014; Weiss et al., 1992). Compared to other measures, the EMIC was selected because it is a short measure of perceived stigma, which is made to be modified: it is simple, versatile, and easily adapted (Logie & Earnshaw, 2015; Peters et al., 2014). It also examines various areas of life that may be affected by stigma, such as respect, avoidance, concealment, pity, shame, being made fun of, and influence on romantic prospects (van Brakel, 2006). In addition, its emic (vs. etic) framework is grounded in cross-cultural assessment methods and focuses on the perspective of people within their community (Weiss, 1997), which is ideal to capture phenomena that are susceptible to vary across cultures, societies, and groups, such as with attitudes toward erotic technology (e.g., sex toys and robots; Döring et al., 2020; Dubé & Anctil, 2020; Piha et al., 2018). Finally, its items are framed in such a way that they ask about the perceived attitudes and behaviours of others (i.e., in their proximal community, such as friends and family), rather than those of the participants, which may help reduce the social desirability bias (van Brakel, 2006).

3. Stigma related to erotic technology may vary across products and genders

3.1. The uncanny valley

First proposed by Mori (1970), the Uncanny Valley Hypothesis (UVH) suggests that robots which approach human-likeness, but are not quite human yet, may elicit aversive reactions, such as feelings of eeriness, disgust, or unfamiliarity. A commonly proposed explanation for the UVH is that the incongruity between humanlike robots (e.g., androids) and

our expectations—e.g., mismatch in visual cues or social norms—makes these machines uncomfortably strange or hard to categorize, and this can in turn generate both negative valuations and reduced acceptance (Kätsyri et al., 2015; Gray & Wegner, 2012; MacDorman & Ishiguro, 2006; Seyama & Nagayama, 2007, 2009; Szczuka & Krämer, 2017). Research in social robotics suggests that the UVH may extend beyond robots, to images, videos, dolls, and computer-generated characters (Wang et al., 2015).

Given that none of the current erotic technologies are completely human-like, the UVH would predict that more human-like products would generate greater stigma. For example, the use of erobots—such as erotic chatbots, virtual partners, and sex robots—would generate greater stigma than the use of sex toys, like dildos or vibrators. Within erobots, the UVH would also predict that the use of erotic virtual partners would be more stigmatized than erotic chatbots; and the use of sex robots would be more stigmatized than erotic virtual partners. In this context, erotic chatbots refer to computer programs designed to simulate erotic, sexual, or romantic conversations with users (Zhou et al., 2020), whereas erotic virtual partners are software-generated audiovisual characters with whom you can interact erotically, sexually, or romantically through devices like smart phones, computers, gaming consoles, etc. (Kaufman, 2020). On the other hand, sex robots are defined as artificial entities used for sexual purposes that have humanoid form, human-like movement/behaviour, and some degree of artificial intelligence (Danaher, 2017).

This study focuses on sex toys and these three types of erobots for several reasons. For one, sex toys are more widespread in their use, and have been around for longer than erobots. They have also already gone through notable changes in acceptance, such that today, they are more positively viewed (Döring & Pöschl, 2019a; Döring, 2021a, 202; Lieberman, 2016, 2017a, 2017b; Piha et al., 2018; Wilner & Huff, 2017). As such, they provide a reference point to compare stigma levels across products (Dubé & Anctil, 2020). Additionally, out of all erobots, sex robots have received the most attention and have received significant public, academic, political, legal, and media debates—even leading to a Campaign Against Sex Robots(rebranded as the Campaign Against Porn Robots [CAPR]; Campaign Against Sex Robots, n.d.; Döring et al., 2020; Dubé & Anctil, 2020). Lastly, along with sex toys and sex robots, erotic chatbots and virtual partners form a gradient of human-likeness, ranging from simple sexual tools to full-humanoid artificial partners. Notably, chatbots and virtual partners are also more accessible than

sex robots, and they are becoming popular in countries like Japan and China (Liao, 2020; Olson, 2020; Zhang, 2020).

3.2. Gender differences between women and men

Sexual stigma may differently affect demographic groups. Stigma related to erotic technology may not influence women and men in the same way. After all, women and vulva-vagina owners remain, to this day, the primary market and consumers of sex toys (Döring & Pöschl, 2019a; Lieberman, 2016, 2017a, 2017b; Piha et al., 2018; Wilner & Huff, 2017). Thus, while there seems to have been notable positive changes in the acceptance and marketing of sex toys for women and vulva-vagina owners, these groups may also be the ones more closely affected by a stigma related to the use of such products, which may in turn influence their willingness to purchase or use sex toys.

The limited research on the individual characteristics that may influence people's attitudes toward and willingness to engage with erobots suggests that men are more interested than women in having sex with robots (Brandon et al., 2021; Brandon & Planke, 2021; Nordmo et al., 2020; Oleksy & Wnuk, 2021; Scheutz & Arnolds, 2016; YouGov, 2020). Yet, sociocultural narratives conveyed by the media also often depict those who have relationships with artificial partners as lonely socially misfit men (Döring & Pöschl, 2019b; Szczuka & Krämer, 2017). This may create a situation where men feel more targeted by such stigmatizing representations and may in turn be more influenced by the stigma related to the use of artificial partners, like sex robots. That said, the existence of stigma related to the use of erotic technology, along with its potential variation across products and genders, has yet to be studied and empirically quantified.

4. The current study

Thus, as a first step, this study aims to provide the first quantitative evidence of PSETU (**Objective 1**). It also aims to examine whether PSETU relates to people's willingness to engage with sex toys and erobots (**Objective 2**). Based on previous research, we hypothesized that PSETU exists and increases as a function of the erotic technology's human-likeness across genders (**Hypothesis 1**). We also hypothesized that PSETU negatively relates to people's willingness to engage with erotic technologies (**Hypothesis 2**), with a stronger association for women when it comes to sex toys and a stronger association for men when it comes to erobots

(**Hypothesis 3**). To test these hypotheses, the EMIC was adapted to sex toys, erotic chatbots, erotic virtual partners, and sex robots (Peters et al., 2014; Weiss et al., 1992).

5. Method

The current study was approved by the Human Research Ethics Committee of Concordia University (ethics certification number: 30010207). Informed consent was obtained from each participant.

5.1. Participants

A convenience sample of 365 adults (Age: M = 26.65, SD = 9.55, range = 18-72 years) was recruited via social media (e.g., Facebook, Twitter, and Reddit), using flyers and word-of-mouth at Concordia University, McGill University, and in the Montreal Community (see Table 1 for demographics). Anyone exposed to the advertisement could contact the research team and participate in this study if they met the eligibility criteria. Participants needed to be at least 18 years of age and be self-reportedly fluent in English (i.e., reading and writing). The recruitment took place from June to November 2019.

5.2. Procedure

Participants were invited to take part in a 15-minute online survey examining people's perception of sextech usage. Interested participants contacted us via email to receive an ID code and the link to the survey. Once consent and age were confirmed electronically by checking a box, participants completed a battery of measures (see Materials section). Participants were compensated by having their name included in a draw to win a $100.00 CAD gift certificate, or a choice of participant pool credits if they were Concordia University Psychology students.

5.3. Materials

Demographic Questionnaire. This is homemade questionnaire included questions about participants' age, gender/sex, ethnicity, education, annual income, religiosity, and sexual self (e.g., orientation and identity).

Table 1. Demographics of the sample.

Variables	Frequency	Valid %
Gender		
Woman	232	66.10
Man	93	26.50
Transgender, genderqueer/gender non-conforming, and/or non-binary	26	7.40
Ethnicity		
White or Caucasian	233	66.20
Asian	37	10.50
Mixed or Metis	35	9.90
Hispanic, Latino or Spanish	16	4.50
Middle-Eastern	14	4.00
Black or African American	11	3.10
Native American or Alaska Native	2	0.60
Other	4	1.20
Education (highest level achieved)		
Bachelor's degree (in progress)	164	46.72
Bachelor's degree (diploma)	68	19.37
Master's degree/Doctorate (in progress)	39	11.11
Master's degree/Doctorate (diploma)	45	12.82
High school (not finished)	2	0.57
High school (diploma)	13	3.70
CEGEP (in progress)	2	0.57
CEGEP (diploma)	9	2.56
Professional degree (in progress)	3	0.85
Professional degree (diploma)	6	1.71
Income		
$0 - 10 000	146	41.48
$10 001 - 20 000	81	23.01
$20 001 - 30 000	31	8.81
$30 001 - 40 000	22	6.25
$40 001 - 50 000	20	5.68
$50 001 - 60 000	10	2.84
$60 001 - 70 000	9	2.56
$70 001 - 80 000	4	1.14
$80 001 - 90 000	3	0.85
$90 001 - 100 000	6	1.70

	$100 001 - 110 000	4	1.14
	$110 001 ≤	16	4.55
Religiosity			
	0 (not applicable)	110	31.16
	1 (Very low)	101	28.61
	2	54	15.30
	3 (Moderate)	59	16.71
	4	24	6.80
	5 (Very high)	5	1.42

Explanatory Model Interview Catalogue (EMIC) Scales Adapted to Erotic Technologies. These four new 15-item EMIC scales derived from Weiss and colleagues (1992) measured PSETU related to sex toys, erotic chatbots, erotic virtual partners, and sex robots, using the 4-option answer format: "Yes" (2), "Possibly" (1), "No" (0), and "*I don't know*" (0), as in Peters and colleagues (2014). These adapted scales included questions such as: "Would a person using a sex toy keep others from knowing, if possible?" or "In your community, do sex robot users cause shame or embarrassment? " (See Appendix A for details). Each scale was accompanied by a definition of the type of erotic technology being assessed (see sections 1 and 2 for definitions). No items were reverse-coded. High mean scores on these scales represent greater perceived stigma. The four scales showed good to excellent internal reliability with Cronbach's alphas ranging from .87 to .94. See Tables 2 and 3 for details. The EMIC scales were presented to the participants in the following order: sex toys, sex robots, erotic virtual partners, and erotic chatbots. See Appendix A for details.

Erotic Technology Engagement Questionnaire. This is a homemade 8-item, Yes/No questionnaire assessing participants' willingness to engage with sex toys, erotic chatbots, erotic virtual partners, and sex robots. Specifically, it assessed whether participants would try these four erotic technologies or use them on a regular basis, by asking questions such as: "would you try a sex robot?" or "would you use a sex toy on a regular basis?" (see Appendix B for details).

5.4. Data integrity and analytic strategy.

To be included in the computed EMIC mean scores, participants had to complete at least 80% of the measure or were otherwise treated as missing values. Only four outliers (±3SD) were found in the EMIC mean scores adapted to sex toys (Leys et al., 2013). They were inspected and

kept in the dataset as they were within interpretable scores (Aguinis, Gottfredson, & Joo, 2013). Repeated measures analysis of variance (ANOVA) with post-hoc comparisons (with Bonferroni corrections) were run to assess whether PSETU exists and increases as a function of the erotic technology's human-likeness, overall and across genders (Hypothesis 1). Correlational analyses were run to examine whether PSETU was negatively related people's willingness to engage with different types of erotic technology, also overall (Hypothesis 2) and across genders (Hypothesis 3). See Table 2 for descriptive statistics.

Table 2. Descriptive statistics of the main variables.

Variables	Total			Women			Men		
	M	SD	SEM	M	SD	SEM	M	SD	SEM
Perceived stigma (EMICS)									
Sex toy	.39	.34	.02	.39	.33	.02	.40	.36	.04
Erotic chatbot	.64	.47	.03	.64	.47	.03	.63	.43	.05
Erotic virtual partner	.76	.45	.03	.76	.44	.03	.75	.43	.05
Sex robot	.94	.44	.02	.93	.44	.03	.96	.43	.05
Would you try a(n) [...]?									
Sex toy	.93	.25	.01	.93	.26	.02	.92	.27	.03
Erotic chatbot	.43	.50	.03	.37	.48	.03	.52	.50	.06
Erotic virtual partner	.42	.49	.03	.32	.47	.03	.64	.48	.06
Sex robot	.40	.49	.03	.29	.45	.03	.63	.49	.06
Would you use a(n) [...] on a regular basis?									
Sex toy	.74	.44	.03	.74	.44	.03	.67	.47	.05
Erotic chatbot	.12	.33	.02	.06	.24	.02	.23	.43	.05
Erotic virtual partner	.13	.33	.02	.06	.24	.02	.28	.45	.05
Sex robot	.14	.35	.02	.05	.22	.02	.33	.47	.05

6. Results

6.1. Hypothesis 1: PSETU exists and increases as a function of the erotic technology's human-likeness across genders (supported)

Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated, $\chi^2(5) = 82.04$, $p < .001$. Therefore, Greenhouse-Geisser corrections were used. There was a large statistically significant effect of the type of technology on mean perceived stigma scores, $F(2.58, 707.74) = 169.71$, $p < .001$, $\eta^2 = .38$. All pairwise comparisons with Bonferroni corrections between the types of erotic technologies were statistically significant ($p < .01$). These comparisons show that stigma related to erotic technology exists and varies as a function of the product's degree of human-likeness, such that: sex toys and sex robots respectively generated the lowest and highest perceived stigma scores, and erotic virtual partners generated a higher stigma score than erotic chatbots (see Figure 1). This pattern of results was consistent across women and men (see Figure 2). There was no effect of gender—i.e., self-identification as a woman or man—on PSETU scores across technologies (see Figure 2).

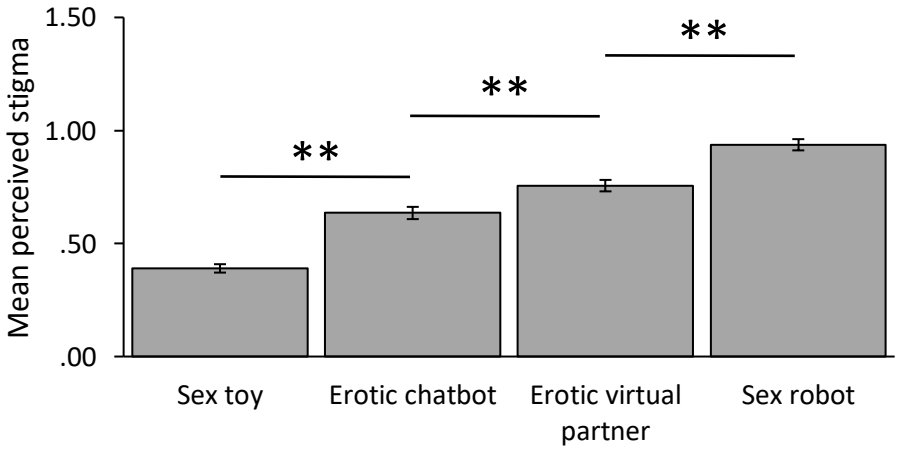

Figure 1. Mean perceived stigma scores across technologies. The error bars represent the standard errors of the means. See Table 2 for details. Note. **p < .01.

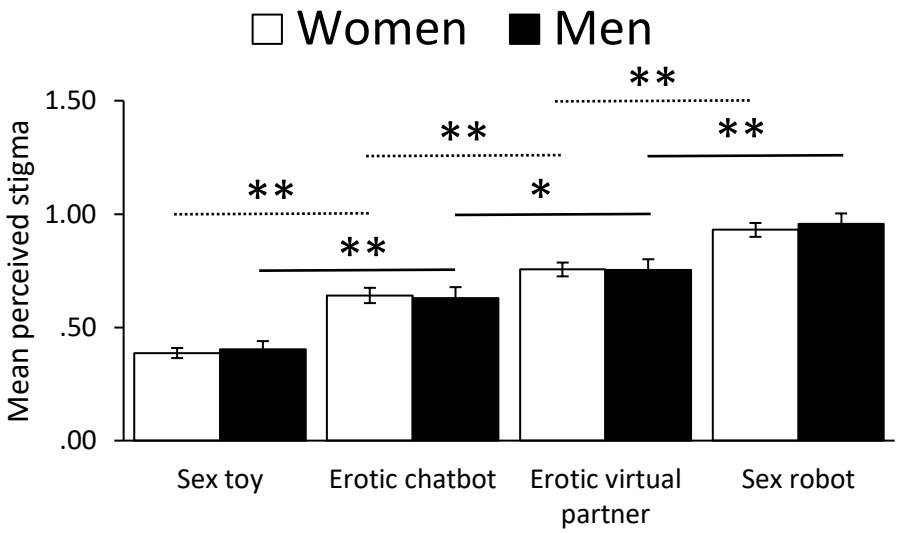

Figure 2. Mean perceived stigma scores across technologies and genders. The error bars represent the standard errors of the means. There was no statistically significant difference between the mean perceived stigma scores of women and men across technologies. See Table 2 for details. Note. *p < .05, **p < .01.

6.2. Hypothesis 2: PSETU negatively relates to people's willingness to engage with erotic technologies (partly supported)

The EMIC scores had weak to moderate negative associations with participants' willingness to try sex toys. There were weak negative associations between the different EMIC scores and participants' willingness to use sex toys; the EMIC adapted for erotic virtual partners and participants' willingness to try erotic chatbots and erotic virtual partners, as well as using the latter on a regular basis. There were also negative associations between the EMIC adapted for sex robots and participants' willingness to try sex robots (see Table 3).

Gender—i.e., women and men—was positively weakly to moderately related to participants' willingness to try erobots or use them regularly, but not sex toys, such that men were more likely to report that they would engage with erotic chatbots, virtual partners, and sex robots. Gender was not related to perceived stigma scores. Notably, age was positively related to participants' willingness to try erotic technologies or use them regularly (i.e., especially erobots), and negatively related to the perceived stigma scores of sex robots. See Table 3 for details.

Table 3. Correlations between the main variables

Variables	Perceived stigma (EMICs)				Demographics	
	ST	EC	EVP	SR	Age	Gender
Perceived stigma (EMICs)						
Sex toy (ST)	(.87)				- .08	.02
Erotic chatbot (EC)	.55 **	(.94)			- .03	- .01
Erotic virtual partner (EVP)	.50 **	.82 **	(.91)		- .08	- .00
Sex robot (SR)	.56 **	.61 **	.70 **	(.90)	- .15 **	.03
Would you try a(n) [...]?						
Sex toy	- .23 **	- .20 **	- .20 **	- .15 *	.03	- .01
Erotic chatbot	- .01	- .13	- .13 *	- .04	.20 **	.14 *
Erotic virtual partner	.07	- .09	- .14 *	- .12	.28 **	.29 **
Sex robot	- .07	- .07	- .08	- .18 **	.30 **	.32 **
Would you use a(n) [...] on a regular basis?						
Sex toy	- .24 **	- .10	- .15 *	- .15 *	.12 *	- .07
Erotic chatbot	.02	- .03	- .05	.02	.27 **	.25 **
Erotic virtual partner	- .04	- .06	- .15 *	- .04	.44 **	.29 **
Sex robot	.01	.03	- .05	- .06	.47 **	.37 **

Note. *p < .05, **p < .01. The parentheses represent the Cronbach's alphas.

6.3. Hypothesis 3: PSETU negatively relates to people's willingness to engage with erotic technologies, with a stronger association for women when it comes to sex toys and a stronger association for men when it comes to erobots (partly supported)

The pattern of correlations on Table 4 suggests that perceived stigma is moderately negatively related to women's willingness to try sex toys and weakly related to their willingness to try erotic chatbots and sex robots, but not related to men's willingness to try erotic technologies. Perceived stigma is also weakly to moderately negatively associated with both women and men's willingness use sex toys regularly, and men's willingness to use erotic chatbots regularly, but not women's. Noteworthy, men are more willing to try erobots or use them more regularly than women (see Figures 3).

Table 4. Correlations between PSETU and willingness to engage with erotic technologies across women and men.

Variables	Perceived stigma (EMICs)							
	ST		EC		EVP		SR	
	Women	Men	Women	Men	Women	Men	Women	Men
Perceived stigma (EMICs)								
Sex toy (ST)	(.86)	(.89)						
Erotic chatbot (EC)	.51 **	.55 **	(.94)	(.92)				
Erotic virtual partner (EVP)	.47 **	.54 **	.87 **	.69 **	(.91)	(.91)		
Sex robot (SR)	.54 **	.58 **	.66 **	.43 **	.69 **	.66 **	(.91)	(.89)
Would you try a(n) [...]?								
Sex toy	- .31 **	- .09	- .27 **	- .04	- .23 **	- .19	- .20 **	- .06
Erotic chatbot	.01	- .05	- .18 *	- .07	- .14 *	- .12	- .08	.12
Erotic virtual partner	.05	.09	- .15 *	.02	- .14	- .17	- .18 *	- .03
Sex robot	- .06	.09	- .11	.00	- .08	- .09	- .22 **	- .17
Would you use a(n) [...] on a regular basis?								
Sex toy	- .22 **	- .30 **	- .12	- .03	- .11	- .25 *	- .13	- .15
Erotic chatbot	.04	.06	- .07	.10	- .04	- .01	- .01	.16
Erotic virtual partner	- .04	- .04	- .10	.01	- .11	- .24 *	- .04	- .02
Sex robot	- .03	.03	- .01	.12	- .01	- .12	- .07	- .05

Note. *p < .05, **p < .01. The parentheses represent the Cronbach's alphas.

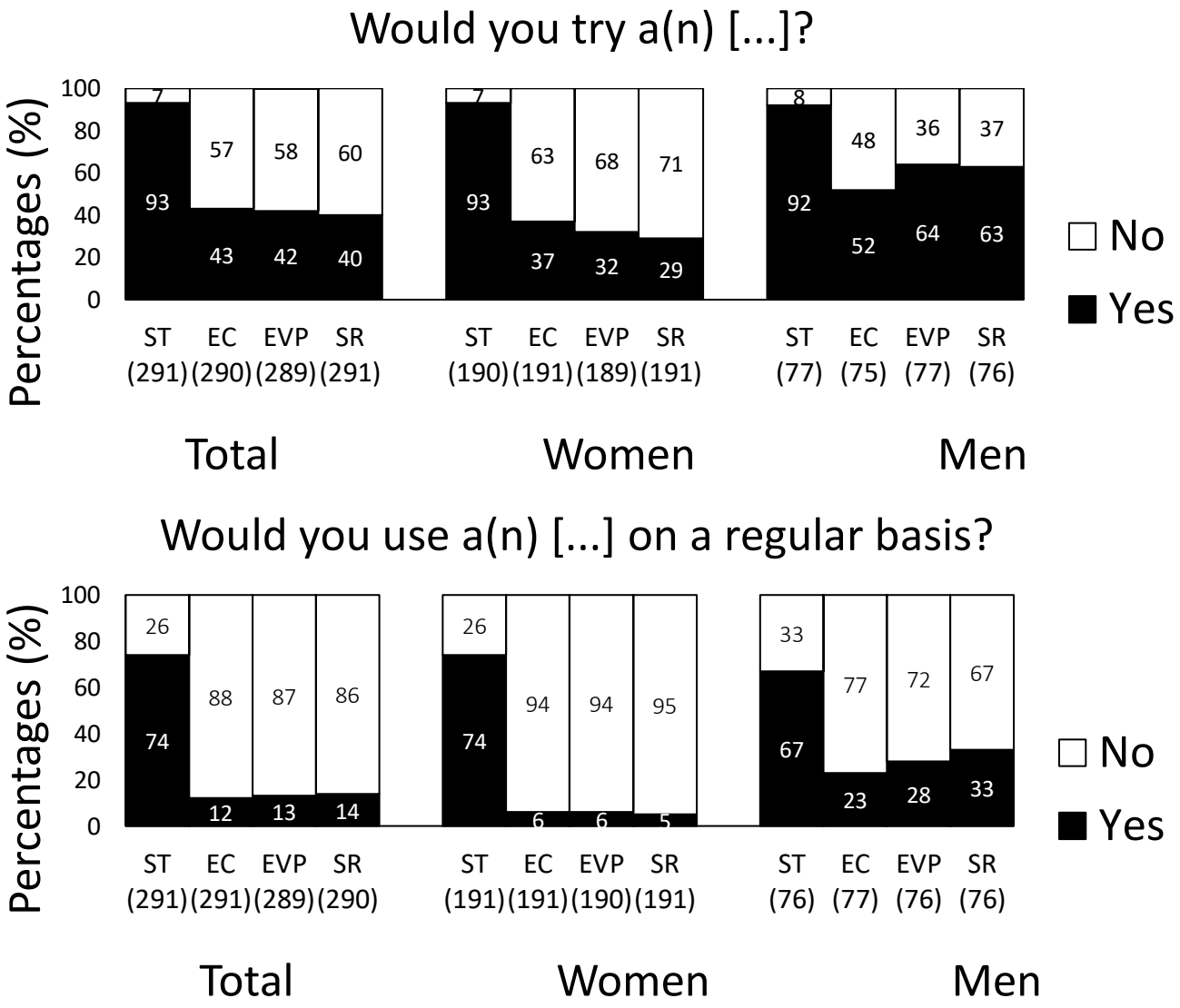

Figure 3. Percentages of participants' willingness to engage erotic technologies. Parentheses represent the valid n. ST = Sex toys; EC = Erotic chatbot; EVP = Erotic virtual partner; and SR = Sex robot.

7. Discussion

These results show that PSETU exists and increases as a function of erotic technology's human-likeness across women and men, such that stigma increases statistically significantly from sex toys to erotic chatbots to erotic virtual partners to sex robots. Together, these findings suggest that women and men have similar perspectives about PSETU. Our results are also consistent with previous studies showing that, compared to women, men are more willing to engage with erobots (e.g., sex robots; cf. YouGov, 2020).

The effect sizes yielded by this study are relatively modest in size and sometimes inconsistent across genders, but are consistent in their direction when it comes to the relation between stigma and the willingness to use erotic technologies. In line with expectations, perceived stigma was negatively related to women's willingness to try sex toys, but not to men's; conversely, this stigma was negatively related to men's willingness to use erotic virtual partners regularly, but not to women's. Moreover, in support of H2, but not H3, stigma was respectively weakly and moderately negatively related to women and men's willingness to use sex toys regularly. Contrary to expectation, no relations were found between stigma and the willingness to regularly use erotic chatbots and sex robots.

These results also support the idea that the principles of the UVH may extend to the stigma related to the use of erotic technologies (Mori, 1970, 2012), such that intimate products that approach human-likeness—like current sex robots—may elicit greater negative responses. This may be due to a mismatch between expectations of what adequate romantic or sexual partners should be (e.g., human; Dubé et al., 2021; Szczuka & Krämer, 2017). Researchers have also proposed that the negative feelings related to the UVH may be because not-quite-human-like machines trigger self-preservation responses as they (un)consciously threaten our integrity or health (Mori, 2012; MacDorman et al., 2009; MacDorman & Ishiguro, 2006). With erotic technologies, however, it is also possible that machines designed to act as intimate partners, like erobots, are further seen as a competitive threat to our sexual selection (Nordmo et al., 2020; Oleksy & Wnuk, 2021). They may also not fit the narrow sexual scripts regarding what some people consider to be "natural, normal, and good" sexuality (e.g., heteronormative, reproductive, and non-commercial intimacy between humans; Braidotti, 2013; Dubé et al., 2021; Gagnon & Simon, 1973; Schussler, 2020; Simon & Gagnon, 2003; Rubin, 1984, 1992; Wiederman, 2015).

These results may also simply reflect the fact that sex toys have been around for longer, are more widespread, and have already gone through significant shifts in sociocultural attitudes and acceptance compared to emerging technologies, like erobots (Döring & Pöschl, 2019a; Döring et al., 2020; Dubé & Anctil, 2020). If that is the case, erobots will likely become more accepted over time as they become more common (Carpenter, 2017). In preliminary support of this hypothesis, results from three 1000-participant surveys conducted by the marketing company, YouGov, suggest that there may have already been some changes with people's willingness to have sex with a robot, from 9% in 2013, to 16% in 2017, and 22% in 2020 (HuffPost, 2013; YouGov, 2017, 2020).

Regarding the relation between stigma and the willingness to engage with erotic technologies, the negative associations found—which are primarily linked to sex toys—may be better explained by the fact that, compared to sex toys, participants are unlikely to have been directly exposed to erobots at the moment (Dubé & Anctil, 2020). Hence, participants are unlikely to have experienced or witnessed displays of stigma in relation to erobots or their users. Alternatively, it is possible that despite its existence, stigma related to erotic technology does not represent a strong predictor of people's willingness to engage with erotic technologies. It is also possible that perceived stigma, more specifically, is insufficient to influence an individual's potential behaviours toward erobots. For instance, internalized rather than perceived stigma is more closely linked to the detrimental consequences of stigma (e.g., negative impacts on health; Logie & Earnshaw, 2015). Still, the present results suggest that perceived stigma may deter some women from trying sex toys, and both women and men from using them regularly. It may also deter some men from regularly using erotic virtual partners, and women from trying them.

This cross-sectional study remains limited by its convenience sample—mostly composed of women (i.e., the main consumers of sex toys; Döring & Pöschl, 2019a)— and the self-selection bias that may influence those who participate in sexuality studies. This study is also limited by the fact that it asks questions about technologies that are not widespread yet, and the fact that, at the time of conducting this research, there were no psychometrically validated measures assessing stigma related to sex toys or erobots, nor people's willingness to engage with different erotic technologies. That said, this study provides the first quantitative evidence of the existence of a stigma related to erotic technology, along with its variation across sex toys and erobots. As such, it represents an initial foray into the broader scientific investigation of stigma

associated with sex technology (sextech), artificial partners, and their use(rs). It also represents an initial data point to assess the sociocultural evolution of our attitudes and relationships with sex toys and erobots, as erotic technology progressively occupies a greater place in human intimacy.

These results may help us to better understand people's perception and relations to erotic products that may contribute to their intimate lives and well-being. In the broader context of erobotics (i.e., the study of human-machine erotic interaction), these results also contribute to our understanding of the sociocultural and individual factors—i.e., stigma—that influence people's willingness to engage with present erotic technologies (e.g., sex toys) and future artificial partners (e.g., erobots; Dubé & Anctil, 2020). These results are particularly important in a world where sextech is a fast-growing industry projected to be worth up to $30-120 billion (Barrica, 2019; Gallop, 2015). A world where erotic video games, online platforms for cybersex, and virtual companions are on the rise (Daneback, 2017; Döring et al., 2017; Owsianik & Dawson, 2015). A world where advancements in artificial intelligence, robotics, and virtual, augmented, and mixed reality are progressively allowing new intimate interactions with evermore complex, agential systems, which can act as romantic or sexual partners (Dubé & Anctil, 2020). A world where people identify with technology-based sexualities and may experience stigma related to their use of erotic technology, along with its detrimental consequences (e.g., doll-owners, robot fetishists, and digisexuals; de Fren, 2009; Dubé et al., 2021; McArthur & Twist, 2017).

Granted that, future research should investigate the origins of the stigma related to erotic technology, and the factors contributing to its variation across products. It should also develop psychometrically validated tools to explore this stigma and its related phenomena across cultures, time, and populations; including, the longitudinal assessment of attitudes towards and willingness to engage with sex toys and erobots in target samples (e.g., people with technology-based sexualities; Dubé et al., 2021). Whenever possible, this research should also employ actual sex toys and erobots in their designs to assess people's reactions to them. In the end, scientifically addressing such phenomena will become increasingly important as we integrate new technologies into our sexualities.

8. References

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CHAPTER 4: SEX ROBOTS AND PERSONALITY: IT IS MORE ABOUT SEX THAN ROBOTS

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Abstract

Examining the links between personality traits and attitudes toward sex robots can provide insights into who may desire such machines, and why. This online study thus examined the associations between the Big-Five, traits related to sexuality, technology, and (sexual) novelty, and people's willingness to engage with and perceived appropriateness of using sex robots in a convenience sample of 492 adults (≥18 years; 283 ciswomen, 171 cismen, and 37 non-binary and gender nonconforming individuals with access to the recruitment material on social media, the Concordia University participant pool, or flyers/word-of-mouth in the Montreal Community). Correlational analyses showed that willingness to engage with and perceived appropriateness of using sex robots were more closely related to erotophilia and sexual sensation seeking than any other traits. Mixed repeated measures ANOVAs and independent samples t-tests with Bonferroni corrections also showed that cismen and non-binary/gender nonconforming individuals were more willing to engage with sex robots and perceive their use as more appropriate than ciswomen. These findings suggest that erotophilic individuals seeking novel or more intense sexual experiences may be(come) the primary users of sex robots and influence their development. These findings are important given the growing place of technology in our intimate lives and relationships.

Keywords: Sex robots, personality, willingness to engage, appropriateness, erobotics

1. Introduction

Advancements in social robotics are giving rise to sex robots: anthropomorphic machines powered by artificial intelligence, which can enact humanlike behaviors and be used for sexual purposes (Danaher, 2017; Döring et al., 2020; Dubé & Anctil, 2020; González-González et al., 2021; Realbotix, n.d.). Examining our evolving relationships with such artificial erotic agents—or erobots—is important as interest in sexual technology and artificial companions grows (Dubé & Anctil, 2020). This is exemplified by the widespread use of sex toys (Döring, 2021b; Döring & Pöschl, 2019a), the uptick in doll purchases (Arafat & Kar, 2021), the growing use of virtual partners (e.g., Replika, Xiaoce, and Harmony AI; Kaufman, 2020; Larcher, 2022; RealDollX, n.d.; Skjuve et al., 2021; Ta et al., 2020), and the results of YouGov surveys suggesting that the willingness to have sex with a robot increased from 9% in 2013 to 22% in 2020 (HuffPost, 2013; YouGov, 2017, 2020).

Examining our relationships with sex robots is also important as these machines differ from other technologies, such as sex toys, dolls, and virtual partners. Their embodiedness allows them to act in/on our non-virtual world (Dubé & Anctil, 2020; Dubé, et al., 2022a). Their design (e.g., humanlike forms and behaviors) and growing agency also progressively allow them to both trigger our sexual responses and act as more complex intimate partners (Dubé & Anctil, 2020). As such, sex robots have polarized public and academic debates (Döring, 2021a, 2021b; Döring et al., 2020). For example, some argue that sex robots could be compulsively used, impair interhuman relationships, and exacerbate toxic patriarchal norms (Döring et al., 2020; Galaitsi et al., 2019; Moran, 2020). Others argue that sex robots could widen access to sex and companionship, and be used in therapy, education, and research (Dubé & Anctil, 2020; Dubé et al., 2022a). Yet, the study of human-machine erotic interaction and co-evolution—or erobotics—is still limited: theoretical frameworks are emerging, but the empirical literature remains scarce (Dubé & Anctil, 2020).

1.1. Theoretical framework

To comprehensively address erobotics, guide the empirical research in this area, and explain and predict how humans and erobots will interact and co-evolve, Dubé and Anctil (2020) proposed the Human-Erobot Interaction and Co-Evolution Model (HEICEM). The HEICEM theorizes that humans and erobots—such as sex robots—co-influence each other's erotic cognition through interactions (e.g., negative or positive sexual experiences), and the

transformation of their respective ecological niche (e.g., new potential intimate partners and erotic virtual environments). In turn, this may affect whether and how humans and erobots engage with each other—probabilistically reshaping human-erobot co-evolution, their co-constructed erotic cognitions and populations (Dubé & Anctil, 2020). At the center of this model is a mechanism, the Erotic Multi-Agent Selection process, which suggests that the principles of variation and selective retention of traits apply to human-erobot interaction and co-evolution (Dubé & Anctil, 2020).

The HEICEM's ecological niche is based on the Bioecological Model and composed of five interconnected systems (Bronfenbrenner & Morris, 2006; Dubé & Anctil, 2020). The microsystem encompasses the individuals, institutions, and technologies with whom one directly interacts. The mesosystem connects the different layers of the model. The exosystem includes entities with whom one indirectly interacts (e.g., the scientific, media, health, economic, and legal institutions). The macrosystem refers to, for instance, the sociocultural norms that influence groups and societies. And the chronosystem considers the effects of time and historical contexts on the model (Bronfenbrenner & Morris, 2006).

When it comes to sex robots, the HEICEM would predict that companies, such as Realbotix (n.d.), may provide an initial supply of machines with specific traits based on the available technology at their disposal and their expectations of what customers may want in erobots in a given sociocultural context (e.g., forms, behaviors, personality, and learning capabilities; Dubé & Anctil, 2020). Then, based on markets' reaction to their product, these companies may adjust the design of sex robots (e.g., their traits) to meet the subsequent demand, maximize profit, and expand their reach. In this case, the most selected traits would be replicated in the next generation of sex robots, and those that are selected less often would be progressively discarded over time (Dubé & Anctil, 2020). In turn, this may influence our attitudes and perception of sex robots (e.g., our willingness to engage with them and their perceived appropriateness), along with our intimate preferences and partners choices (biological and artificial)—reshaping both human and erobot erotic cognitions and populations in a perpetual feedback loop (Dubé & Anctil, 2020).

This process, however, does not happen in a vacuum. It is situated within and influenced by multiple layers of interconnected systems. The design of sex robots and our attitudes toward them are likely influenced by the changing sociocultural norms surrounding sexuality and

technology in each group or society (chrono- and macrosystem). They are also likely influenced by, for instance, the media's depiction of sex robots, the scholarly work being published on this topic, and the legal infrastructures that are progressively being put in place to address the emergence of such new technologies (exosystem). Lastly, while connected through the mesosystem, these attitudes and behaviors are likely influenced by the products available to them, our friends and families' perception of sex robots, and importantly, our own (intimate) realities, experiences, and individual characteristics (microsystem). This may include but is not limited to their socioeconomic statues, health conditions, sexual identities, past erotic experiences, demographic groups, and personality profiles (Dubé & Anctil, 2020). Considering the HEICEM, better understanding how such individual characteristics relate to our attitudes toward and willingness to engage erotically with sex robots is important, since these characteristics may influence the type of erobots that populate our world, along with our subsequent interaction and co-evolution with them. Yet, little is known about who may be interested in intimacy and sexuality with robots, or why (Gesselman et al., 2022).

1.2. Individual characteristics

The scarce research on erobotics and individual characteristics suggests that negative attitudes toward non-sexual robots negatively relate to people's willingness to engage erotically with such machines (Richards et al., 2017), and negatively predict males' perceived attractiveness ratings of gynoids (i.e., female-like humanoid robots). On the other hand, fear of rejection—but not their loneliness, social anxiety, need to belong, or tendency to anthropomorphize technology—positively predicts said ratings (Szczuka & Krämer, 2017). There is also evidence that younger compared to older people may be more interested in sex robots (Brandon & Planke, 2021), and that political views can influence people's attitudes toward sex robots (e.g., conservative women are more threatened by sex robots than liberal women; Oleksy & Wnuk, 2021). To date, however, the most consistent predictor of interest in sex robots remains gender.

1.2.1. Gender differences

Previous research shows that, compared to women, men have more positive views of sex (with) robots and are more interested in having sex or engaging in romantic relationships with such machines (Brandon et al., 2021; Brandon & Planke, 2021; Dubé et al., 2022b). HuffPost,

2013; Nordmo et al., 2020; Scheutz & Arnolds, 2016; YouGov, 2017, 2020). This may be because current sex robots are mostly gynoids marketed to heterosexual men, who also appear to be the main consumers of sex/love dolls (Döring, 2021a; Döring & Pöschl, 2019b); or because men are more exposed to science-fiction that depicts man-gynoid intimate relationships (e.g., Ex Machina, Her, A.I. Rising, and Zoe; Appel et al., 2019; Bodroža, 2018; Doremus, 2018; Döring & Pöschl, 2019b; Garland, 2014; Jonze, 2013; Koverola et al., 2020). This may also be due to sexual double standards, which often shame women's sexuality (e.g., sexual agency and desire), while encouraging men to report being always interested in sex (Farvid et al., 2017). Finally, it may be due to differences in sex drive, sexual sensation seeking, and/or sexual risk-taking (Gaither & Sellbom, 2003; Petersen & Hyde, 2011; Skakoon-Sparling & Cramer, 2021).

Regardless of the reason, the HEICEM would predict that sex robot companies will try to meet this initial demand from heterosexual men and gynophilic individuals—paradoxically leading to a market that does not necessarily meet everyone's need or preferences. The HEICEM would also predict that these gender differences may change over time if companies expand the design of sex robots and develop machines geared toward other demographic groups, such as women, females, vulva-vagina owners, and non-gynophilic individuals. After all, such groups represent large potential markets for sex robots and remain, to this day, the main consumers of sex toys (Döring & Pöschl, 2019a; Wilner & Huff, 2017). In that regard, there is preliminary evidence suggesting that, if sex robots were designed for them, some women may be more interested in these machines (Oleksy & Wnuk, 2021).

Importantly, the empirical research on gender/sex and sex robots has not only been largely conducted in Western countries (e.g., Canada, United-States, and Germany), but has also exclusively focused on women/females and men/males, which both re-affirms simple gender-binary and ignores the realities of non-binary and gender nonconforming individuals. Some scholars, however, have theorized that members of gender or sexual minorities, such as non-binary and gender nonconforming individuals, may be interested in sex robots, as these machines could—in addition to pleasure and companionship—provide access to partners and stimuli tailored to their orientations or preferences (Danaher, 2019; Dudek & Young, 2022; Kubes, 2019). Given their own identities and lived experiences, non-binary and gender nonconforming individuals may also be more open to novel, non-normative, or alternative forms of eroticism (e.g., human-machine intimate relationships). Yet, considering the current market sex robots,

some non-binary and gender nonconforming individuals may also feel like there are little to no machine available to meet their needs or preferences. That said, beyond gender and the variables previously mentioned, several other individual characteristics have yet to be investigated in order to better understand who may desire erobots—such as sex robots—and why (Dubé & Anctil, 2020; Gesselman et al., 2022). This includes personality traits.

1.2.2. Personality traits

Personality traits have been a source of great interest in psychology, since they represent relatively stable individual characteristics that may predict people's thoughts and behaviors across time and situations (Bainbridge et al., 2022; John et al., 2021)—including our intimacy and sexuality (Allen & Walter, 2018). In the context of human-machine erotic interactions and the HEICEM, better understanding the personality of those interested (or not) in engaging erotically with robots can provide insights into who may be more (or less) likely to use/purchase erobots, as well as influence their development and our co-evolution with these machines (Dubé & Anctil, 2020). It can also provide insights into the psychological mechanisms underlying people's attitudes toward sex robots and their motivation to engage with such machines.

As of now, the most widely studied personality model is the Big-Five, which encompasses: Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness/Intellect (Bainbridge et al., 2022; Costa & McCrae, 1985, 2008; John et al., 2021; McCrae & Costa, 1985). Extraverted individuals tend to further engage with the world and interact with others (Bowden-Green et al., 2020). People who are more agreeable tend to favor social harmony, and be kind, helpful, and concerned with the welfare of others (Crowe et al., 2018). Conscientious individuals tend to be self-disciplined and focused, as well as prefer control and planification (Wilmot & Ones, 2019). Individuals higher on Neuroticism tend to experience more anxiety, stress, and depression, and exhibit lower psychological well-being (Bowden-Green et al., 2021; Tackett & Lahey, 2017). Lastly, individuals who are higher on Openness/Intellect tend to be curious, adventurous, and imaginative (Christensen et al., 2019).

A recent meta-analysis examining the relation between the Big-Five, sexuality, and sexual health found that Extraversion positively relates to sexual activity and sexual risk taking, while Openness positively relates to sexual autonomy and liberal attitudes toward sexual practices (Allen & Walter, 2018). On the other hand, Agreeableness and Conscientiousness negatively relate to sexual aggression and infidelity, while Neuroticism positively relates to

sexual dissatisfaction (Allen & Walter, 2018). With regard to intimacy with machines, Deniztoker (2019) found that Openness positively predicts attitudes toward human-robot intimate relationships, while Agreeableness negatively predicts such attitudes in a sample of 254 undergraduate students. These associations were consistent across subscales examining intimacy and sexuality with robots, trust of humanoid-robots, and acceptance of human-robot intimate relationships, with Conscientiousness also negatively predicting the latter (Deniztoker, 2019).

But beyond the Big-Five—which represent overarching personality traits—other traits may be more closely related to people's attitudes toward sex robots and their willingness to engage with such machines. Sex robots, after all, exist at the crossroads of sexuality and technology; they are also new, and can potentially offer novel erotic sensations and experiences. Thus, an adequate personality model would arguably encompass traits that relate to individuals' attitudes and behaviors toward sex, tech, and sexual novelty—or in this case: erotophilia-phobia, technophilia-phobia, and sexual sensation seeking. Respectively, erotophilia-phobia and technophilia-phobia refer to people's tendency to react positively or negatively toward sexuality and technology (e.g., positive or negative attitudes and/or approach-avoidance behaviors; Fisher et al., 1988; Gilbert & Gamache, 1984; Martinez-Córcoles et al., 2017; Osiceanu, 2015). Sensation seeking, on the other hand, refers to individuals' tendency to seek novel, intense, or diversified feelings, stimuli, and experiences (Cross et al., 2013; Hoyle et al., 2002; Stephenson et al., 2007; Zuckerman & Aluja, 2015). Sexual sensation seeking is a subtrait of the latter oriented toward sexual sensations and experiences (Kalichman et al., 1994; Kalichman, 2011). Notably, sexual sensation seeking was moderately positively associated with people's willingness to have sex with a robot in a sample of 133 adults from Amazon Mechanical Turk (i.e., 70 females and 63 males; Richards et al., 2017). Still, there remains a lack of research on sex robots and the personality profile of their potential users.

1.3. The current study

The primary objective of this study is to examine the associations between specific traits—including, Big-Five traits and traits related to sexuality, technology, and (sexual) novelty—and people's willingness to engage with and attitudes toward sex robots. Given the gender differences previously described, the secondary objectives of this study are to explore these associations across genders. Based on previous research, we hypothesized that Openness/Intellect will positively relate to people's willingness to engage with and the perceived

appropriateness of using sex robots, while the opposite will be true for Agreeableness and Conscientiousness (Hypothesis 1). We also hypothesized that erotophilia, technophilia, and (sexual) sensation seeking will positively relate to people's willingness to engage with and the perceived appropriateness of using sex robots (Hypothesis 2; see Figure 1 for a visualization of the conceptual model and hypotheses 1-2). Finally, we hypothesized that, compared to ciswomen, cismen will be more willing to engage with sex robots and will perceive their use as more appropriate (Hypothesis 3). Noteworthy, despite a small subsample, data and exploratory comparisons are reported for non-binary and gender nonconforming individuals for inclusivity, transparency, and to serve as a steppingstone for future research.

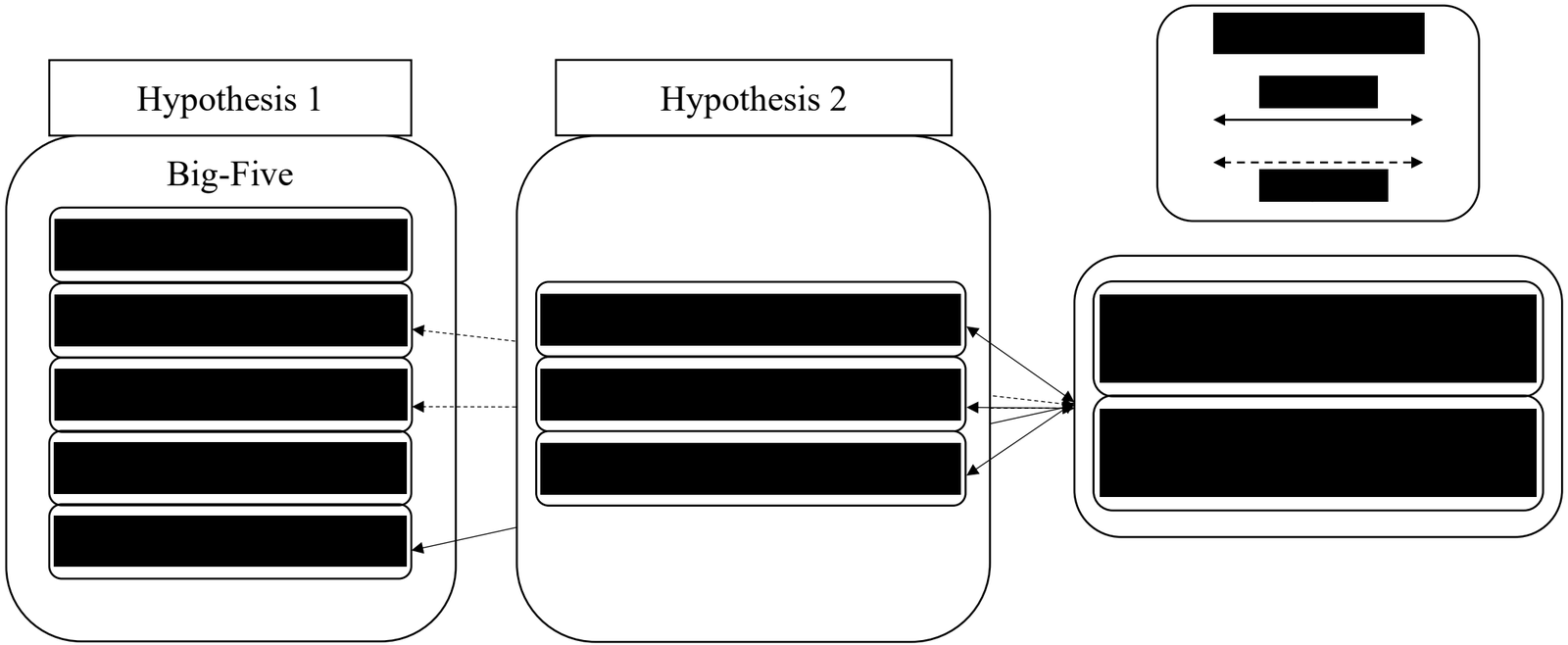

Figure 1. Visualization of the conceptual model with the main variables and hypotheses 1-2.

2. Method

The Human Research Ethics Committee of Concordia University approved this study (ethics certification number: 30010207).

2.1. Participants

A convenience sample of 492 adults (Age: M = 26.80, SD = 9.61, range = 18-71 years) with access to the recruitment material was recruited using social media (e.g., Facebook and Twitter), the Concordia University psychology participant pool, as well as flyers and word-of-mouth at Concordia University, McGill University, and in the Montreal Community (see Table 1 for demographics). Participants were invited to partake in an online survey examining people's attitudes toward sex robots. To take part in this study, participants needed to be at least 18 years old, and be able to read and write English. The recruitment took place from December 2018 to April 2020. Anyone exposed to the advertisement could contact the research team and participate in this study if they met the eligibility criteria.

Table 1. Demographics of the sample.

Variables	Frequency	Valid %
Gender		
Cisgender woman	283	57.60
Cisgender man	171	34.80
Transgender, genderqueer/gender non-conforming, and/or non-binary	37	7.50
Ethnicity		
White or Caucasian	328	67.49
Asian	46	9.47
Mixed or Metis	41	8.44
Hispanic, Latino or Spanish	24	4.94
Middle-Eastern	24	4.94
Black or African American	13	2.67
Native American or Alaska Native	1	0.21
Other	9	1.85
Education (highest level achieved)		
Bachelor's degree (in progress)	252	51.22

Bachelor's degree (diploma)	86	17.48
Master's degree/Doctorate (in progress)	27	5.49
Master's degree/Doctorate (diploma)	57	11.59
High school (not finished)	6	1.22
High school (in progress)	3	0.61
High school (diploma)	32	6.50
CEGEP (in progress)	5	1.02
CEGEP (diploma)	10	2.03
Professional degree (in progress)	1	0.20
Professional degree (diploma)	8	1.63
Income		
$0 - 10 000	218	44.95
$10 001 - 20 000	87	17.94
$20 001 - 30 000	51	10.52
$30 001 - 40 000	33	6.80
$40 001 - 50 000	23	4.74
$50 001 - 60 000	13	2.68
$60 001 - 70 000	13	2.68
$70 001 - 80 000	10	2.06
$80 001 - 90 000	4	0.82
$90 001 - 100 000	8	1.65
$100 001 - 110 000	4	0.82
$110 001 ≤	21	4.33
Religiosity		
0 (not applicable)	144	29.27
1 (Very low)	152	30.89
2	83	16.87
3 (Moderate)	73	14.84
4	32	6.50
5 (Very high)	8	1.63

2.2. Procedure

Interested participants emailed the research team to receive an ID code and the link to the survey. Age was confirmed and informed consent was obtained for each participant by electronically checking boxes. Participants completed the measures described below (see Materials section), which—aside from the demographic questionnaire—were counterbalanced to account for order effects. Participants were compensated with a chance to win a $500.00 CAD gift certificate in a draw at the end of the research project, or a choice of participant pool credits if they were Concordia University Psychology students.

2.3. Materials

Demographics. This questionnaire includes questions about age, gender/sex, ethnicity, education, income, and religiosity.

Mini International Personality Item Pool. This is a 20-item measure of the Big-Five which uses a 5-point Likert scale ranging from 1 (very inaccurate) to 5 (very accurate; Donnellan et al., 2006). It includes items such as: "I am the life of the party." Negative items were reverse-coded, such that high mean scores on this scale represent greater scores on each personality trait. In this study, the Mini International Personality Item Pool showed adequate internal validity—especially for a short measure (Cooper et al., 2010)—with respective Cronbach's alphas of .80, .68, .75, .70, and .70 for Extraversion, Openness/Intellect, Agreeableness, Conscientiousness, and Neuroticism.

Sexual Opinion Survey. This is a 21-item measure of erotophilia-phobia which uses a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree; Gilbert & Gamache, 1984). It includes items such as: "I think it would be very entertaining to look at hard-core pornography." Negative items were reverse-coded, such that high mean scores on this scale represent greater erotophilia. In this study, the Sexual Opinion Survey showed good internal validity with a Cronbach's alpha of .89.

Technophilia-Technophobia Scale. This is a 30-item measure of technophilia-phobia which uses a 5-point Likert scale ranging from 1 (completely disagree) to 5 (completely agree; Martinez-Córcoles et al., 2017). It includes items such as: "I am excited for new equipment or technology." Negative items were reverse-coded, such that high mean scores on this scale

represent greater technophilia. In this study, the Technophilia-Technophobia Scale showed good internal validity with a Cronbach's alpha of .86.

Brief Sensation Seeking Scale. This is an 8-item measure of sensation seeking which uses a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree; Hoyle et al., 2002). It includes items such as: "I would like to explore strange places." No items were reverse-coded. In this study, the Brief Sensation Seeking Scale showed good internal validity with a Cronbach's alpha of .82.

Sexual Sensation Seeking Scale. This is an 11-item measure of sexual sensation seeking which uses a 4-point Likert scale ranging from 1 (not at all like me) to 4 (very much like me; Kalichman et al., 1994). It includes items such as: "I enjoy X-rated videos." No items were reverse-coded. In this study, the Sexual Sensation Seeking Scale showed good internal validity with a Cronbach's alpha of .83.

Willingness to Engage With (Sex) Robots. This is a 4-item homemade measure of willingness to engage with a (sex) robot which uses a 6-point Likert scale ranging from 0 (not at all) to 5 (definitely). It contains the following items: "Would you try a sex robot?", Would you use a sex robot on a regular basis?", "Do you think you could fall in love with a robot?", and "Would you have a non-sexual robot?". No items were reverse-coded. In this study, this measure showed good internal validity with a Cronbach's alpha of .77.

Perceived Appropriateness of Using Sex Robots Questionnaire. This is a 19-item homemade measure of the perceived appropriateness of using sex robots across contexts which is based on Scheutz and Arnolds (2016) and uses a 7-point Likert scale ranging from 1 (completely inappropriate) to 7 (completely appropriate). It includes items such as: "Would it be appropriate to use sex robots for sex education?", "Would it be appropriate to use sex robots in isolated environments?", and "Would it be appropriate to marry a robot?". No items were reverse-coded. In this study, this questionnaire showed excellent internal validity with a Cronbach's alpha of .95.

3. Data integrity and analytic strategy.

Participants had to complete at least 80% of a measure for their mean scores on said measure to be included in the analyses. Otherwise, their mean scores were treated as missing values. Items from the Perceived Appropriateness of Using Sex Robots Questionnaire were inspected for low corrected item-total correlations (i.e., less than .30; Clark & Watson, 1995). All items were kept (i.e., corrected item-total correlations = .41-.84). Correlational analyses were run to test Hypotheses 1-2 and explore whether the associations differ across genders (see sections 4.1. and 4.2.). Repeated measures ANOVAs with post-hoc comparisons (with Bonferroni corrections) and independent samples t-tests were run to test Hypothesis 3 (see section 4.3.). See Table 2 for the descriptive statistics of the main variables.

Table 2. Descriptive statistics of main variables.

Variables	Total			Cisgender women			Cisgender men			Non-binary & gender nonconforming		
	M	*SD*	*SEM*	*M*	*SD*	*SEM*	*M*	*SD*	*SEM*	*M*	*SD*	*SEM*
Big-Five												
Extraversion	2.90	0.97	0.05	2.99	0.99	0.07	2.80	0.92	0.09	2.67	0.91	0.18
Agreeableness	4.06	0.72	0.04	4.19	0.67	0.05	3.82	0.75	0.07	4.13	0.74	0.15
Conscientiousness	3.43	0.85	0.05	3.53	0.84	0.06	3.36	0.85	0.08	3.00	0.83	0.16
Neuroticism	3.10	0.85	0.05	3.19	0.83	0.06	2.89	0.82	0.08	3.22	0.95	0.19
Openness/Intellect	4.08	0.70	0.04	4.00	0.72	0.05	4.15	0.68	0.06	4.38	0.53	0.10
Sexuality, technology, and novelty												
Erotophilia	5.32	1.06	0.05	5.14	1.10	0.07	5.62	0.94	0.08	5.53	0.91	0.17
Technophilia	3.61	0.49	0.03	3.58	0.50	0.03	3.67	0.50	0.05	3.52	0.36	0.07
Sensation seeking	3.13	0.86	0.05	3.07	0.88	0.06	3.22	0.85	0.08	3.18	0.85	0.16
Sexual sensation seeking	2.49	0.61	0.03	2.37	0.64	0.04	2.75	0.51	0.05	2.38	0.46	0.09
Outcomes												
Would you try a sex robot?	2.56	2.01	0.09	1.94	1.88	0.11	3.47	1.84	0.15	3.35	1.86	0.32
Would you use a sex robot on a regular basis?	1.39	1.65	0.08	0.93	1.36	0.08	2.16	1.85	0.15	1.55	1.42	0.25
Do you think you could fall in love with a robot?	0.90	1.45	0.07	0.62	1.25	0.08	1.25	1.61	0.13	1.48	1.54	0.27
Would you have a non-sexual robot?	2.63	1.88	0.09	2.31	1.84	0.11	3.14	1.89	0.15	2.76	1.60	0.28
Perceived appropriateness of using of sex robots	4.81	1.42	0.07	4.46	1.45	0.10	5.34	1.25	0.11	5.24	0.96	0.18

4. Results

4.1. Hypothesis 1: Openness/Intellect will positively relate to people's willingness to engage with and the perceived appropriateness of using sex robots, while the opposite would be true for Agreeableness and Conscientiousness (mostly supported)

Openness/Intellect was weakly positively associated with the willingness to try a sex robot, using it regularly, potentially falling in love with a robot, and the perceived appropriateness of using sex robots, but not with having a non-sexual robot. Agreeableness was weakly negatively associated with the overall willingness to engaging with a (sex) robot, but not to the perceived appropriateness of their use, while Conscientiousness was weakly negatively associated with the willingness to try a sex robot and having a non-sexual robot. Extraversion was only weakly negatively associated with falling in love with a robot. Neuroticism was not associated with the willingness to engage with a (sex) robot, nor the perceived appropriateness of using such machines. See Tables 3 for details.

With regard to gender, Openness/Intellect was weakly positively associated with the willingness to try a sex robot, using it regularly, and falling in love with a robot for ciswomen, but not for cismen or non-binary and gender nonconforming individuals. It was also weakly positively correlated with the perceived appropriateness of using sex robots for both ciswomen and cismen. Agreeableness and Conscientiousness were weakly negatively associated with having a non-sexual robot for cismen, but not for ciswomen. Extraversion, Conscientiousness, and Openness/Intellect were moderately to strongly negatively correlated with the perceived appropriateness of using sex robots for non-binary and gender-nonconforming individuals. See Tables 3 for details.

4.2. Hypothesis 2: Erotophilia, technophilia, and (sexual) sensation seeking will positively relate to people's willingness to engage with and the perceived appropriateness of using sex robots (supported)

Erotophilia was moderately positively associated with the willingness to try a sex robot, using it regularly, and the perceived appropriateness of using sex robots. It was also weakly positively associated with falling in love with a robot and having a non-sexual robot. Technophilia was weakly positively associated with the willingness to engage with (sex) robots

and the perceived appropriateness of using them. Sexual sensation seeking was moderately positively associated with trying a sex robot, using it regularly, and the perceived appropriateness of using such machines, but weakly positively associated with falling in love with a robot and having a non-sexual robot. Non-sexual sensation seeking was only weakly associated with trying a sex robot. See Tables 3 for details.

With regard to gender, Erotophilia was moderately to strongly positively associated with trying a sex robot and using it regularly across ciswomen, cismen, and non-binary and gender nonconforming individuals. Erotophilia was moderately positively associated with the perceived appropriateness of using sex robots across ciswomen and cismen, but not non-binary and gender nonconforming individuals. It was also only weakly positively associated with falling in love with such a machine and having a non-sexual robot for ciswomen, but not for cismen or non-binary and gender nonconforming individuals.

Technophilia was moderately positively associated with the willingness to use a sex robot regularly for cismen, but not for ciswomen or non-binary and gender nonconforming individuals. Technophilia was weakly positively associated with the willingness to try a sex robot for cismen, but not for ciswomen or non-binary and gender nonconforming individuals, and weakly positively associated with the perceived appropriateness of using these machines for ciswomen, but not for cismen or non-binary and gender nonconforming individuals. It was further weakly positively associated with the willingness of having a non-sexual robot across ciswomen and cismen, but not for non-binary and gender nonconforming individuals.

Sexual sensation seeking was moderately positively associated with trying a sex robot, and weakly positively associated with using it regularly and the perceived appropriateness of using sex robots across ciswomen and cismen, but not for non-binary and gender nonconforming individuals. It was also weakly positively associated with having a non-sexual robot for cismen, but not for ciswomen, and moderately negatively associated with having such a robot for non-binary and gender nonconforming individuals. Non-sexual sensation seeking was weakly positively associated with trying a sex robot for cismen, but not for ciswomen or non-binary and gender nonconforming individuals. It was moderately negatively associated with having a non-sexual robot for non-binary and gender nonconforming individuals. See Tables 3 for details.

Table 3. Correlations between main variables.

Variables	Would you try a sex robot?				Would you use a sex robot on a regular basis?				Do you think you could fall in love with a robot?				Would you have a non-sexual robot?				Perceived appropriateness of using sex robots			
	Total	Cisgender women	Cisgender men	Non-binary & gender non-conforming	Total	Cisgender women	Cisgender men	Non-binary & gender non-conforming	Total	Cisgender women	Cisgender men	Non-binary & gender non-conforming	Total	Cisgender women	Cisgender men	Non-binary & gender non-conforming	Total	Cisgender women	Cisgender men	Non-binary & gender non-conforming
Big-Five																				
Extraversion	.06	.12	.14	-.07	.00	.09	.04	-.16	-.15**	-.06	-.17	-.36	-.08	-.06	-.04	-.22	-.03	.01	.03	-.46*
Agreeableness	-.16**	-.02	-.14	-.30	-.21**	-.10	-.14	-.35	-.12*	-.05	-.06	-.32	-.12*	.01	-.19*	-.22	-.09	.03	-.10	-.33
Conscientiousness	-.12*	-.05	-.05	-.38	-.09	-.03	-.04	-.31	-.04	-.11	.12	.01	-.13*	-.04	-.29**	.08	-.09	-.06	-.02	-.51*
Neuroticism	-.04	-.10	.14	.39	-.03	-.02	.02	.38	-.03	-.01	.05	-.21	-.03	-.00	.02	-.10	.04	-.03	.04	.21
Openness/Intellect	.22**	.21**	.18	-.03	.16**	.17*	.07	.07	.17**	.21**	.09	-.26	.10	.13	.02	-.23	.23**	.23**	.20*	-.42*
Sexuality, technology, and novelty																				
Erotophilia	.49**	.46**	.43**	.53**	.37**	.34**	.27**	.50**	.18**	.19**	.03	.30	.22**	.21**	.17	-.06	.49**	.48**	.42**	.39
Technophilia	.16**	.10	.22*	.15	.22**	.12	.33**	.17	.15**	.12	.15	.20	.27**	.25**	.27**	.37	.17**	.15*	.16	.11
Sensation seeking	.19**	.13	.20*	.33	.08	.09	-.04	.30	-.05	-.08	-.04	-.18	.03	-.00	.12	-.48*	.05	.03	.07	-.09
Sexual sensation seeking	.43**	.39**	.36**	.35	.34**	.29**	.25**	.26	.12*	.09	.07	-.06	.13*	.08	.20*	-.45*	.33**	.29**	.28**	.14

Note. *p < .05, **p < .01.

4.3. Hypothesis 3: Compared to ciswomen, cismen would be more willing to engage with sex robots and would perceive their use as more appropriate (supported)

First, a repeated measures ANOVA with Bonferroni corrections revealed a large statistically significant main effect of the type of engagement with (sex) robots on participants' agreement with the items, $F(2.52, 11156.89) = 202.42$, $p < .001$, $\eta^2 = .31$. Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated $\chi^2(5) = 161.98$, $p < .001$, so a Greenhouse-Geisser correction was used. All pairwise comparisons with Bonferroni corrections between the types of engagement with (sex) robots were statistically significant ($p < .001$), except for the difference between trying a sex robot and having a non-sexual robot. See Figure 2 for details and Table 2 for descriptive statistics.

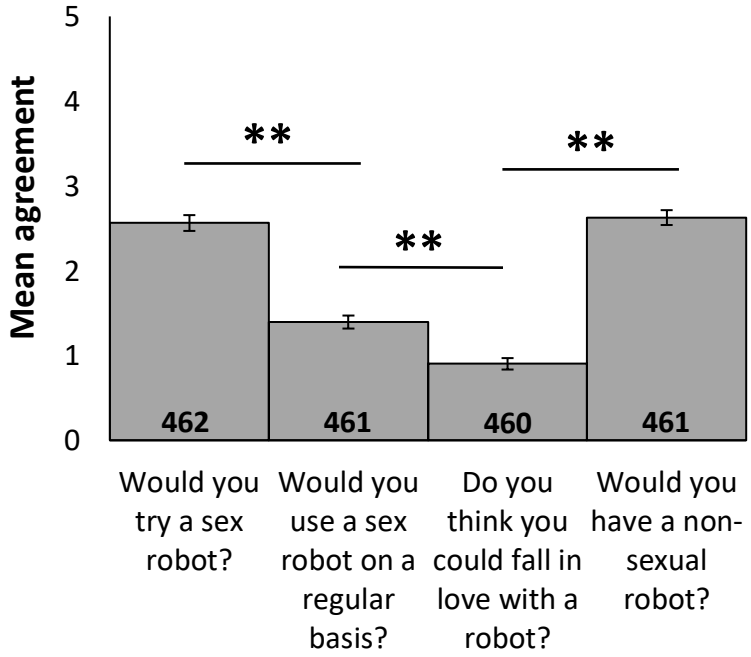

Figure 2. Mean agreement with items pertaining to their willingness to engage with (sex) robots. Error bars represent the standard errors of the means. Bar numbers indicate sample sizes (n). Note. **p < .01.

Then, a mixed repeated measures ANOVA revealed a large statistically significant main effect of the type of engagement with (sex) robots on participants' agreement with the items, $F(2.52, 1147.52) = 104.90$, $p < .001$, $\eta^2 = .19$, and a large statistically significant main effect of gender (i.e., ciswomen, cismen, and non-binary and gender nonconforming individuals), $F(1, 456) = 36.12$, $p < .001$, $\eta^2 = .14$. Again, Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated $\chi^2(5) = 161.04$, $p < .001$. Greenhouse-Geisser corrections were therefore used. All pairwise comparisons with Bonferroni corrections between the types of engagement with (sex) robots were statistically significant ($p < .001$), except for the difference between trying a sex robot and having a non-sexual robot.

Independent samples t-tests revealed that cismen are more willing to try a sex robot than ciswomen, $t(424) = -8.10$, $p < .001$, $d = .99$. These t-tests also showed that cismen are more willing to use a sex robot regularly than ciswomen, $t(246.13) = -7.23$, $p < .001$, $d = .76$; they think that they could fall in love with a robot more than ciswomen, $t(255.16) = -4.19$, $p < .001$, $d = .44$; they would want a non-sexual robot more than ciswomen, $t(423) = -4.42$, $p < .001$, $d = .45$; and they perceive the use of sex robots as more appropriate than ciswomen, $t(285.88) = -5.96$, $p < .001$, $d = .65$.

Independent samples t-tests also revealed non-binary and gender nonconforming individuals are more willing to try a sex robot than ciswomen, $t(306) = -4.10$, $p < .001$, $d = .75$. They also perceive the use of sex robots as more appropriate than ciswomen, $t(43.74) = -3.73$, $p < .001$, $d = .62$. There was no statistically significant difference between cismen and non-binary and gender nonconforming individuals. See Figure 3 for details and Table 2 for descriptive statistics.

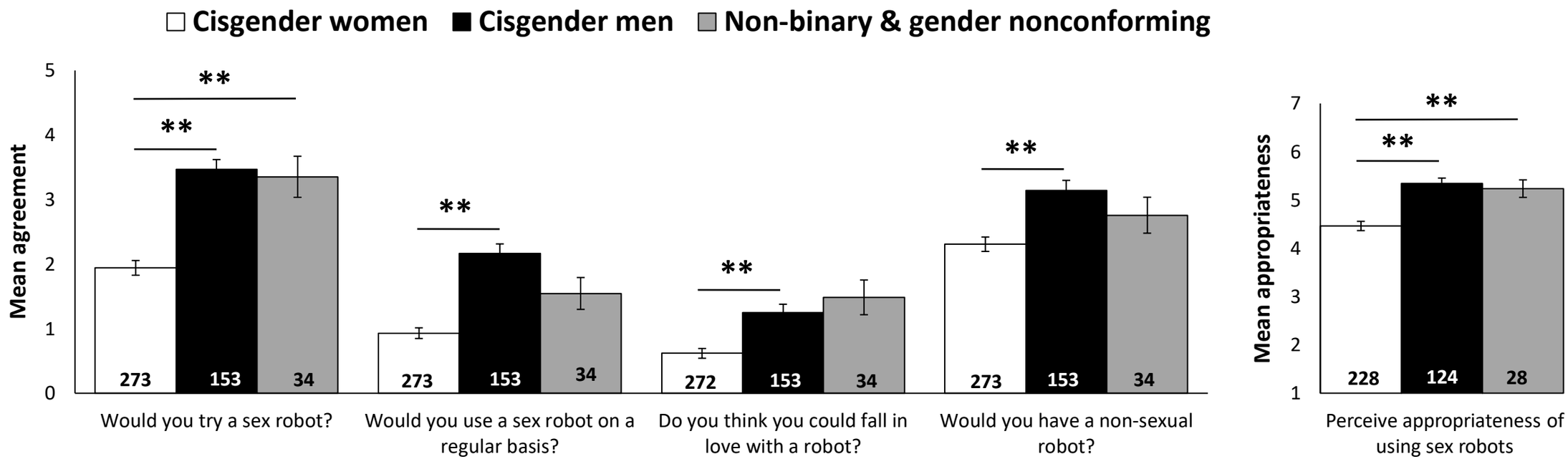

Figure 3. Mean agreement with items pertaining to their willingness to engage with (sex) robots and the perceived appropriateness of using sex robots across ciswomen, cismen, and non-binary and gender nonconforming individuals. Error bars represent the standard errors of the means. Bar numbers indicate sample sizes (*n*). *Note.* $^{**}p < .01$.

5. Discussion

These results show that, when it comes to sex robots and personality, it is more about sex than robots. More precisely, it is erotophilia and sexual sensation seeking, rather than technophilia, non-sexual sensation seeking, and Big-Five traits that seem to more closely, positively relate to people's willingness to engage with and perceived appropriateness of using sex robots. These results also show that such relations may differ across genders. For instance, technophilia relates to willingness to try and use a sex robot regularly for cismen, but not for ciswomen or non-binary and gender nonconforming individuals; while Openness/Intellect relates to willingness to engage erotically with a robot for ciswomen, but not for cismen or non-binary and gender nonconforming individuals. Finally, these results show that, compared to ciswomen, cismen are generally more interested in engaging with sex robots and perceive their use as more appropriate across contexts; and that, similarly to cismen, non-binary and gender nonconforming individuals may be more willing to try sex robots and perceive their use as more appropriate than ciswomen.

5.1. Interpretations

These results are consistent with previous findings on sex robots, personality traits (Deniztoker, 2019; Richards et al., 2017), and political views (Oleksy & Wnuk, 2021). They are also consistent with previous findings gender differences between ciswomen and cismen when it comes to their potential engagement with and attitudes toward sex robots (Brandon et al., 2021; Brandon & Planke, 2021; HuffPost, 2013; Nordmo et al., 2020; YouGov, 2017, 2020). Importantly, these results expand our knowledge on erobotics and personality traits. They show that it is people's tendency to react positively or negatively toward sex(uality) rather than technology, along with their desire to seek varied, novel, or intense sexual stimuli and experiences that mainly drive their willingness to engage with sex robots and their attitudes toward such emerging erobots. These results also suggest that people may attribute more weight to the erotic aspects of sex robots—e.g., their ability to provide complex new sexual experiences—rather than the robotic nature of these machines in their decision to engage with or approve of them. This may be due to the fact that, for now, people tend to conceptualize sex robots as sophisticated sex toys, or tools for masturbation and sexual gratification (Scheutz &

Arnold, 2016). This may also be due to the fact that sex is not only highly attention-grabbing (Strahler et al., 2019), but sex robots also defy traditionally conservative sexual scripts, which pose that "good" sexuality is marital, heteronormative, reproductive, non-commercial, and between humans (Dubé et al., 2021; Gagnon & Simon, 1973; Oleksy & Wnuk, 2021). Either way, it may lead people to rely more on their norms and attitudes toward sexuality rather than technology to decide whether they would engage with sex robots or find their use appropriate.

The gender differences between ciswomen and cismen may be explained by the present state of the sex robot market, which tends to primarily design gynoids and advertise their use to heterosexual cismen (Döring & Pöschl, 2019b). This may lead ciswomen and non-gynophilic individuals to feel like there are no robots that meet their needs or preferences. This may also lead ciswomen to perceive such machines as a greater competitive threat to their sexual selection, compared to cismen (Nordmo et al., 2020; Oleksy & Wnuk, 2021). That is, in addition to the fact that cismen generally report greater sex drive than ciswomen (Archer, 2019); and the sexual double standards that may encourage cismen to disclose greater interest in sex (i.e., desire for machines that may provide sexual gratification), while discouraging women from revealing their sexual agency (Fetterolf & Sanchez, 2015; Mitchell et al., 2019). Complementarily, it is possible that, when it comes to sex, ciswomen attribute more value to emotional connection than cismen (Archer, 2019)—a connection that may be seen as absent in erotic interactions with sex robots. It is also possible that, although emotional intimacy is a commonly advertised trait in the promotion of sex robots, ciswomen do not feel like this feature extends to them given the current marketing of these machines (Realbotix, n.d.).

When it comes to non-binary and gender nonconforming individuals, on the other hand, the present results provide preliminary support to the idea that these demographic groups may perceive sex robots as a viable option to meet their needs or preferences (Danaher, 2019; Dudek & Young, 2022; Kubes, 2019). These results also suggests that non-binary and gender nonconforming individuals may be more open to new or alternative forms of technology-based intimate relationships and sexualities, such as human-robot relationships. This may be partly due to the fact that—not unlike their own identities and lived experiences—sex robots defy traditionally conservative sexual scripts (Dubé et al., 2021): a point of similitude that may encourage greater openness toward sex (with) robots and human-machine intimacy.

Overall, the findings of this study are important considering our interaction and co-evolution with erotic technology (Dubé & Anctil, 2020). Specifically, in light of the HEICEM, these findings suggest that erotophilic individuals seeking novel or diverse sexual stimuli—especially, cismen and gynophilic individuals—may constitute the main demographic group of early sex robot users. In turn, this may compel companies to meet this initial demand by designing robots with features—forms, personalities, and behaviors—that meet the needs and desires of these groups (Dubé & Anctil, 2020). This can then generate a feedback loop—one that may provide greater access to personalized erotic experiences for some, but also leave behind the needs and desires of other groups, including: women, gender/sexual minorities, non-gynophilic individuals, and those who may prefer machines geared toward emotional connection rather than sexual stimulation (Dubé & Anctil, 2020).

Granted that and considering how such demographic groups can represent profitable markets for sex robots, the potential interest of non-binary and gender nonconforming individuals in such machines, and the fact that women and vulva-vagina owners are the primary consumers of sex toys (Döring, 2021b; Döring & Pöschl, 2019a), sex robot companies may want to expand their design to meet this potential demand. This could be both lucrative for companies and beneficial for people's sexual health and well-being (Dubé & Anctil, 2020). This could also improve the trajectory and diversity of our interaction and co-evolution with erobotic technologies (Dubé & Anctil, 2020).

5.2. Limitations and strengths

This study remains limited by its cross-sectional nature, self-selection bias, and convenience sample (i.e., largely composed of White, Educated, Industrialized, Rich, and Democratic [WEIRD] individuals and Psychology students at Concordia University; Rad et al., 2018). Given its recruitment strategy, a significant portion of this study's convenience sample is most likely based in Canada (e.g., Montreal university students), which may influence their attitudes toward sexuality, technology, and robots (e.g., potentially more sex-positive compared to more sexually conservative countries, but less tech-positive compared to countries which have a different relationship with robots, such as Japan; Bröhl et al., 2019; Ivanski & Kohut, 2017). This study is also limited by the current scarcity of sex robots, and the lack of validated measures of individuals' willingness to engage with and attitudes toward these machines. Lastly, this study

does not account for how sexual identities relate to sex robots, and its generalizability is limited by the small sample of non-binary and gender nonconforming individuals.

That said, the findings of this study contribute to the growing research on individual characteristics and sex robots. They extend research on erotic technologies—sex toys, dolls, and virtual partners—to evermore agential embodied systems that may one day act as sexual or intimate partners (Dubé & Anctil, 2020). They also provide new insights into the profile of those more likely to use and co-influence the development of emerging erobots, and their underlying motivations—that is, sex-positive people—i.e., most likely, cismen and gynophilic individuals—seeking new erotic experiences. Moreover, they provide preliminary evidence regarding the attitudes and behaviors toward sex robots of non-binary and gender nonconforming individuals—acting as a steppingstone for future research. As such, these findings ultimately open new research avenues intersecting human-machine interaction, sexology, psychology, and personality research.

5.3. Future directions

Future research should examine these phenomena in representative samples across cultures and in larger target samples of individuals with diverse gender/sex, sexual identities, and technology-based sexualities (e.g., LGBTQIA2+ communities, robot fetishists, doll lovers, and virtual partner users; Dubé et al., 2021). This research should also validate psychometric tools to assess people's willingness to engage with sex robots and the perceived appropriateness of using this technology. Lastly, this research should also investigate whether the present findings translate into different cognitive (e.g., attention) and psychophysiological (sexual) responses (e.g., subjective and genital sexual arousals) to humans and robots. This research is becoming essential as technology—like sex robots—occupies a growing place in our lives and intimate relationships.

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CHAPTER 5: HOT FOR ROBOTS! SEXUAL AROUSAL INCREASES WILLINGNESS TO HAVE SEX WITH ROBOTS

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Reference

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Abstract

Robots designed to elicit sexual arousal are coming. Sexual arousal can increase our willingness to engage in risky or unconventional sexual behaviors. However, researchers have yet to examine whether this effect extends to robots. Hence, this study provides the first experimental evidence that state sexual arousal can increase our willingness to engage erotically with robots. Based on previous research, we hypothesized that levels of sexual arousal would positively predict willingness to engage erotically with robots (Hypothesis 1); and that men would be more willing to engage erotically with robots than women (Hypothesis 2). A convenience sample of 321 adults (≥18y) completed a two-part online survey measuring their willingness to have sex with, love, engage in an intimate relationship with, and be friends with a robot and a human before and after viewing a sexually explicit video. The results partly support Hypotheses 1–2. They show that state sexual arousal increases willingness to have sex with a robot, and that men are more willing to have sex and engage in an intimate relationship with a robot than women, pre- and post-manipulation. These findings are important given the rise of sex robots and their potential influence on our intimate decisions and behaviors.

Keywords: Robots, sexual arousal, willingness to engage, gender, erobotics

1. Introduction

Advances in artificial intelligence (AI) and robotics are gradually offering new opportunities of intimate experiences with artificial erotic agents—erobots (erôs + bot)—such as humanlike robots with social and sexual capabilities—henceforth referred to as sex robots (Döring, 2021; Döring et al., 2020; Dubé & Anctil, 2020). In parallel, findings from three 1000-participant marketing surveys suggest that an increasing number of people may be interested in engaging erotically with such machines (HuffPost, 2013; YouGov, 2017; 2020). Specifically, YouGov found that 9% of their 2013 sample would have sex with a robot, compared to 16% in 2017, and 22% in 2020 (HuffPost, 2013; YouGov, 2017; 2020). Yet, the scientific study of human-machine erotic interaction and co-evolution—erobotics—remains scarce, including empirical investigations of the factors that may influence people's willingness to engage sexually or romantically with robots (Dubé & Anctil, 2020). Understanding such factors is important as technology—such as more complex and humanlike erobots—becomes more prevalent in human eroticism (Danaher & McArthur, 2017; Devlin, 2018; Döring et al., 2020; Dubé & Anctil, 2020).

As of now, the research on such factors has primarily focused on the individual characteristics that may relate to people's willingness to engage erotically with robots (e.g., have sex with robots or be interested in intimate relationships with sex robots; Brandon et al., 2022; Döring et al., 2020; Nordmo et al., 2020; Oleksy & Wnuk, 2021; Szczuka & Krämer, 2017). For instance, sexual sensation seeking was positively related to people's willingness to experience a sexual episode with a robot (Richards et al., 2017); fear of rejection positively predicted men's attractiveness ratings of female-looking robots—or gynoids (Szczuka & Krämer, 2017); and the Big-Five's openness trait was positively associated with more positive attitudes toward human-robot intimate relationships (Deniztoker, 2019). Shyness, anime/manga fandom, and science fiction hobbyism were also positively related to more favorable attitudes toward sex robots (Appel et al., 2019; Koverola et al., 2020). Additionally, there is preliminary evidence suggesting that depression, social anxiety, attention deficit disorder, and autism spectrum disorder may be positively related to such attitudes (Brandon & Planke, 2021).

Conversely, negative attitudes toward nonsexual robots were negatively associated with the willingness to experience a sexual episode with a robot (Richards et al., 2017). These attitudes were also negatively related to men's attractiveness ratings of gynoids (Szczuka & Krämer, 2017). Moreover, the Big-Five's agreeableness trait was negatively associated with

positive attitudes toward human-robot intimate relationships (Deniztoker, 2019); and Oleksy and Wnuk (2021) recently showed that political views may influence attitudes toward sex robots. Specifically, they found that more liberal women perceived these robots as less threatening when they were also designed for women, compared to being exclusively designed for men. More conservative women, however, perceived sex robots as threatening, regardless of whether they were intended for women or men (Oleksy & Wnuk, 2021).

Still, to date, the most consistent finding emerging from the limited empirical research on human-robot intimacy is that, compared to women, men hold more positive views of sex (with) robots and are more interested in or willing to engage erotically with such machines (Brandon & Planke, 2021; Brandon et al., 2022; Dubé et al., 2022b; Huffpost, 2013; Nordmo et al., 2020; Oleksy & Wnuk, 2021; Scheutz & Arnold, 2016; YouGov, 2017, 2020). This may be due to the fact that most sex robots are currently gynoids marketed to heterosexual men (Döring & Poeschl, 2019), which can in turn make it seem like there are little to no robots available to meet the needs and preferences of those who may not be enticed by femalelike machines. It may also be due to sociocultural norms and sexual double standards, which often devalue or shame women's sexuality—along with their sexual agency and interest in sex—while valorizing men's sexuality and encouraging them to report being ever-ready for sexual activities (Farvid et al., 2017). Lastly, it may stem from gender differences in sex drive, sexual sensation seeking, and/or sexual risk-taking (Gaither & Sellbom, 2003; Petersen & Hyde, 2011; Skakoon-Sparling & Cramer, 2021), or that men are more exposed to science-fiction which sometimes depicts human-machine intimate relationships (Appel et al., 2019; Koverola et al., 2020)—typically, relationships between a man and a gynoid (e.g., Ex Machina, Her, A.I. Rising, and Zoe; Bodroža, 2018; Doremus, 2018; Döring & Poeschl, 2019; Garland, 2014; Jonze, 2013). That said, beyond such individual characteristics, one must also consider the situational factors that are likely to occur during (future) human-robot interactions, and their influence on people's willingness to engage erotically with artificial partners. This includes state factors, such as sexual arousal: the autonomic activation that prepares the body for sexual activities (Toledano & Pfaus, 2006).

1.1. Sexual arousal and decision-making

Sexual arousal can influence sexual decision-making (Crosby et al., 2021). Indeed, a state of sexual arousal has been shown to influence people's willingness to engage and interest in various sexual activities, including unconventional, problematic, criminal, or risky sexual

behaviors (Ariely & Loewenstein, 2006; Skakoon-Sparling et al., 2016). For example, Ariely and Loewenstein (2006) found that masturbation-induced sexual arousal increased men perceived attractiveness to different hypothetical sexual activities—such as threesomes, being tied up by a partner, and anal sex—and stimuli—such as women's shoes, a 60-year-old woman, and an animal. Compared to the unaroused participants, sexually aroused men also reported being more willing to engage in problematic behaviors to obtain sex from a women, such as encouraging her to drink heavily, drugging her without her knowledge, or continuing to initiate sex after she said "no" (Ariely & Loewenstein, 2006).

In line with these findings, Spokes and colleagues (2014) found that, compared to unaroused men, sexually aroused men spent more time viewing non-consensual sexual images. Skakoon-Sparling and colleagues (2016) further found that sexually aroused women and men reported greater willingness to engage in risky sexual behaviors—such as having unprotected sex on a first date. Sexually aroused participants also made riskier moves in a mock game of Blackjack, compared to participants who were not aroused, suggesting that the effects of sexual arousal may extend to risky non-sexual behaviors (Skakoon-Sparling et al., 2016). Skakoon-Sparling and Cramer (2021) later found that sexual arousal predicted sexual risk-taking intentions in both women and men, with men showing greater sexual risk-taking intentions than women. Lastly, Crosby and colleagues (2021) recently found that levels of sexual arousal were positively associated with willingness to engage in coercive sexual behaviors, with men more willing to engage in such behaviors than women.

To explain such findings, researchers have proposed that sexual arousal may affect people's cognitive capabilities, leading them to focus their attention on cues that predict reward (e.g., sexual gratification), and ignore cues that would signal (present and future) risks, the unavailability of said reward, or the cost associated with obtaining this reward (Ariely & Loewenstein, 2006; Crosby et al., 2021; Skakoon-Sparling et al., 2016). In the context of human interactions with robots, sexual arousal may thus lead individuals to focus their attention on the possibility of sexual or romantic gratifications, rather than the potential negative outcomes that they would normally focus on when unaroused—i.e., negative outcomes which would otherwise prevent them from reporting an erotic interest in machines. These may include the stigma related to the erotic use of technologies or the belief that some people may find that loving or having sex with a non-human partner is morally wrong (Dubé et al., 2022b; McArthur & Twist, 2017).

However, despite the advent of machines whose bodies and behaviors are designed to elicit sexual arousal (e.g., sex robots and other erobots), and the potential impact of such machines on our sexual decision-making processes, researchers have yet to examine whether sexual arousal may influence our willingness to engage erotically with such artificial partners.

1.2. The current study

Hence, this study expands the research on erobotics to sexual arousal and decision-making. Specifically, it aims to determine whether a state of sexual arousal—induced using a sexually explicit video—can influence people's willingness to engage erotically with robots (i.e., have sex with, love, engage in an intimate relationship with, and be friends with; Objective 1); and explore this effect across women and men (Objective 2). Based on previous research, we hypothesized that levels of sexual arousal would positively predict participants' willingness to engage erotically with robots (Hypothesis 1). We also hypothesized that men would be more willing to engage erotically with robots than women, pre- and post-manipulation (Hypothesis 2).

2. Method

The following minimal risk study was approved by Concordia University's Human Research Ethics Committee (ethics certification number: 30010207). Informed consent was obtained from each participant.

2.1. Participants

Using an a priori power analysis conducted in JAMOVI (The jamovi project, 2021) using the jpower module, we calculated that we would need a minimum sample size of 177 to reliably detect an estimated minimum Hedges' g of $\geq .30$ (with a probability greater than .99), assuming a one-sided criterion for detection that allows for a maximum type I error rate of $\alpha = .05$. A convenience sample of 321 (Age: $M = 27.41$, $SD = 9.55$, range = 18–68) was recruited via the Concordial University Participant Pool, social media (e.g., Facebook and Twitter), word-of-mouth in Montreal community (Canada), and the recruitment platform, Prolific. To be eligible for this study, participants needed to be at least 18 years of age, be fluent in English (i.e., reading and writing), and have previously watched pornography. The latter criterion was required by the Human Research Ethics Committee for this online study to be considered minimal risk. To

improve data quality, those recruited on Prolific were also required to have previously completed at least 50 submissions and have an approval rate of 100%. See Table 1 for demographics.

Table 1. Demographic information of the sample.

Variables	Frequency	Valid %
Gender		
Women	136	43.17
Men	147	46.67
Genderqueer, gender non-conforming, or non-binary	32	10.16
Ethnicity		
White or Caucasian	196	62.62
Hispanic, Latino or Spanish	32	10.22
Black, African, or African American	32	10.22
Asian	12	3.83
Middle-Eastern	10	3.19
Multiethnic, Mixed, or Metis	24	7.67
Other	6	1.92
Native American or Alaska Native	1	0.32
Education (highest level achieved or in progress)		
High school	32	10.36
CEGEP	6	1.94
Bachelor's degree	206	66.67
Master's degree	45	14.56
Doctorate	15	4.85
Trade or professional degree	5	1.62
Religiosity		
Not at all	138	43.40
Very low	69	21.70
Low	36	11.32
Moderate	55	17.30
High	18	5.66
Very high	2	0.63
Sexually explicit video selected		
Heterosexual	234	74.52
Lesbian	56	17.83
Gay	24	7.64

2.2. Procedure

Participants were invited to partake in a two-part, 60-minute online survey on Qualtrics examining their attitudes about sexuality and technology. Individuals who were interested in participating were asked to contact us via email to receive an ID code and the link to Part 1 of the survey or were directly enrolled in the study, if they used Prolific (i.e., the Qualtrics survey automatically saved their Prolific ID). Once consent, age, and previous pornography exposure were confirmed electronically, participants began the survey. In Part 1, they completed a battery of questionnaires, which included questions about their demographics and baseline (pre-manipulation) willingness to engage erotically with robots and humans (i.e., as controls; see Materials for details). Seven days after completing Part 1, participants were contacted again via email with the link required to complete Part 2 of the study, and a reminder of their participant ID code, or Part 2 became available to them, if they used Prolific. Part 2 involved viewing a 10-minute sexually explicit video designed to get participants sexually aroused, followed by the same set of questions about their willingness to engage erotically with robots and humans (post-manipulation). Participants' state of (sexual) arousal and valence was assessed before (pre-manipulation) and after viewing the sexually explicit videos (post-manipulation). As a compensation, participants chose between having their name included in a draw to win a $500.00 CAD cash prize or two participant pool credits if they were enrolled in the Psychology department at Concordia University (i.e., one credit was awarded for the completion of Part 1, and the second for Part 2). If they used Prolific, they received the minimum compensation of £6.00 GBP per part (or ~$9.55 CAD).

3. Materials

3.1. Measures

Demographic Questionnaire. This self-constructed questionnaire asks questions about ethnicity, education, religiosity, age, and gender/sex (i.e., as in Beischel et al., 2022).

Erotic Engagement Questionnaire (EEQ) for Robots and Humans. This 8-item self-constructed scale assesses the willingness to engage erotically with robots (4 items) and humans (4 items)—i.e., have sex with, love, engage in an intimate relationship with, and be friends with—on a 6-point Likert-type scale, ranging from 0 (not at all) to 5 (definitely). It includes items, such as: "Would you have sex with a robot?" and "Would you love a human?". In this

study, the overall EEQ showed questionable internal validity with a Cronbach's alphas of .63 and .66 pre- and post-manipulation, respectively. The 4-item subscale of the EEQ for robots showed acceptable internal validity with a Cronbach's alphas of .78 and .79 pre- and post-manipulation, while the 4-item subscale of the EEQ for humans showed questionable to acceptable internal validity with a Cronbach's alphas of .68 and .76 pre- and post-manipulation.

State of (sexual) arousal and valence. This 3-item self-constructed scale assesses the state of (sexual) arousal and valence (i.e., positive or negative state) of participants on a 11-point Likert-type scale, ranging from 0 (not at all [sexually] aroused/very negative) to 10 (very [sexually] aroused/very positive). This scale was used to assess whether the state manipulation (i.e., sexually explicit video) influenced subjective (sexual) arousal and valence.

3.2. State manipulation

Sexually explicit videos. The state of participants was manipulated using three 10-minute sexually explicit videos. Participants could choose to view one of three videos depicting either heterosexual, lesbian, or gay sexual activities based on their preferences (see Table 1 for selection details). All three videos included two protagonists and followed a similar script. These videos begin with two people kissing, caressing, and undressing one another, which leads to manual and oral-genital stimulation. In the videos depicting heterosexual and gay sexual activities, the actors then engaged in penetrative sex for the remainder of the video (i.e., penile-vaginal and penile-anal, respectively). In the video depicting lesbian sexual activities, the actors continued to engage in manual and oral stimulation. The three videos resolve with the characters cuddling, while kissing and sensually stroking each other.

4. Analytic strategy

First, to test the effectiveness of our state manipulation, paired samples Wilcoxon t-tests were used to compare participants' (sexual) arousal and valence at baseline (pre-manipulation) and after viewing the sexually explicit video (post-manipulation; see section 5.2.). Wilcoxon t-tests were also used to assess whether there was a statistically significant difference between participants' willingness to have sex, love, engage in an intimate relationship with, and be friends with a robot and a human, pre- and post-manipulation (see section 5.3.). In addition to p-values, we have reported matched rank-biserial correlations as measures of effect size (i.e., with 95% confidence interval calculated by bootstrapping with 5000 samples with replacement).

Kruskal-Wallis Tests with Bonferroni corrected Mann-Whitney U tests were further used to assess whether there were statistically significant differences between participants' willingness to engage erotically with a robot and a human as a function of their selected video (see section 5.3.).

To test Hypothesis 1, linear mixed effects models were built to assess whether levels of sexual arousal predicted people's willingness to engage erotically with robots (Willingness ~ 1 + sexual arousal + time (i.e., pre- and post-manipulation) + sexual arousal * time + [1 | Subject]). The advantage of such models over standard linear regression is that they are robust to non-normal distributions (e.g., skewed data), and they also consider individual variability, as they treat subjects as a random factor rather than a fixed one (Knief & Forstmeier, 2021). The latter helps to account for how participants' pre- and post-manipulation scores (e.g., low or high) affect the model. In these models, significant main effects of sexual arousal and time, along with a significant interaction of sexual arousal by time, indicate that sexual arousal and time both predict participant's willingness to engage erotically with robots, and that the change in levels of sexual arousal across pre- and post-manipulation also predicts this willingness beyond the individual variability of participants' scores on the outcome variables.

Finally, to test Hypothesis 2, Mann Whitney U t-tests were used to compare self-identified cisgender women and men's willingness to engage erotically with robots, pre- and post-manipulation (i.e., gender/sex self-identification based on Beischel et al., 2022). All analyses were conducted on Jasp (Version 0.16.2) and SPSS (Version 28.0.0.0). Pearson correlations are also reported in Table 4.

5. Results

5.1. Data integrity

Participants included in this sample and subsequent analyses completed both Part 1 and Part 2 of this study (see Tables 2 and 3 for descriptive information). Their levels of (sexual) arousal and valence before and after answering the second EEQ were averaged. These computed scores were used as the post-manipulation state means in order to account for the potential decline in (sexual) arousal that may occur while participants answer self-report questions. To be included in these computed scores, participants had to have answered both state checks, or they were treated as missing values. This led to the removal of two participants. The assumptions of

normality and homoscedasticity were assessed prior to analysis. Shapiro-Wilk's test of normality indicated that the present sample violated the assumption of normality when it comes to the EEQ and state data. Thus, the non-parametric Wilcoxon and Mann-Whitney U t-statistics were reported with their respective matched rank-biserial correlations (r_{rb}) as effect size. The assumption of homoscedasticity was met, thus no corrections were required. Results of the linear mixed effects models were reported with their respective variance explained by the fixed effects (R^2) and Akaike Information Criterion (AIC) to test model fit, as well as their respective fixed effects parameter estimates (see Tables 5 for details).

Table 2. Descriptive information of the main variables.

Variables	Pre-manipulation							Post-manipulation						
	M	*SD*	*SEM*	Skewness		Kurtosis		*M*	*SD*	*SEM*	Skewness		Kurtosis	
				Stat.	SE	Stat.	SE				Stat.	SE	Stat.	SE
I feel:														
0 (Not at all aroused) to 10 (Very aroused)	3.18	2.69	0.15	0.41	0.14	-0.82	0.27	5.80	2.71	0.15	-0.43	0.14	-0.77	0.27
0 (Not at all sexually aroused) to 10 (Very sexually aroused)	2.30	2.51	0.14	0.92	0.14	-0.27	0.27	6.04	2.88	0.16	-0.58	0.14	-0.67	0.27
0 (Very negative) to 10 (Very positive)	6.17	2.10	0.12	-0.43	0.14	0.49	0.27	6.78	2.05	0.11	-0.60	0.14	0.61	0.27
Would you [...] a robot? - Scale: 0 (Not at all) to 5 (Definitely)														
have sex with	1.48	1.72	0.10	0.78	0.14	-0.79	0.27	2.08	1.92	0.11	0.29	0.14	-1.46	0.27
love	0.83	1.25	0.07	1.61	0.14	1.92	0.27	0.92	1.33	0.07	1.36	0.14	0.89	0.27
be in an intimate relationship with	0.71	1.23	0.07	1.85	0.14	2.64	0.27	1.00	1.45	0.08	1.39	0.14	0.79	0.27
be friends with	2.07	1.79	0.10	0.24	0.14	-1.35	0.27	2.36	1.78	0.10	0.05	0.14	-1.34	0.27
Would you [...] a human? - Scale: 0 (Not at all) to 5 (Definitely)														
have sex with	4.90	0.41	0.02	-4.57	0.14	22.63	0.27	4.90	0.48	0.03	-5.76	0.14	36.16	0.27
love	4.94	0.30	0.02	-5.35	0.14	29.38	0.27	4.92	0.40	0.02	-6.07	0.14	43.68	0.27
be in an intimate relationship with	4.89	0.39	0.02	-3.64	0.14	13.03	0.27	4.88	0.47	0.03	-4.89	0.14	27.02	0.27
be friends with	4.92	0.36	0.02	-4.99	0.14	26.65	0.27	4.94	0.32	0.02	-6.12	0.14	41.06	0.27

Note. SEM = Standard error of the mean, Stat. = Statistic, SE = Standard error of.

Table 3. Descriptive information of the main variables across women and men.

Variables	Pre-manipulation														Post-manipulation											
	Women							Men							Women							Men					
	M	*SD*	*SEM*	Skewness		Kurtosis		*M*	*SD*	*SEM*	Skewness		Kurtosis		*M*	*SD*	*SEM*	Skewness		Kurtosis		*M*	*SD*	*SEM*	Skewness		Kurtosis	
				Stat.	SE	Stat.	SE				Stat.	SE	Stat.	SE				Stat.	SE	Stat.	SE				Stat.	SE	Stat.	SE
I feel:																											
0 (Not at all aroused) to 10 (Very aroused)	2.93	2.74	0.24	0.59	0.21	-0.61	0.41	3.41	2.65	0.22	0.29	0.20	-0.92	0.40	5.50	2.70	0.23	-0.29	0.21	-0.93	0.41	6.04	2.73	0.23	-0.58	0.20	-0.58	0.40
0 (Not at all sexually aroused) to 10 (Very sexually aroused)	2.15	2.48	0.21	1.07	0.21	0.22	0.42	2.40	2.47	0.20	0.80	0.20	-0.57	0.40	5.74	2.81	0.24	-0.37	0.21	-0.96	0.41	6.32	2.90	0.24	-0.79	0.20	-0.33	0.40
0 (Very negative) to 10 (Very positive)	6.05	2.08	0.18	-0.48	0.21	0.54	0.41	6.29	2.07	0.17	-0.41	0.20	0.71	0.40	6.52	1.90	0.16	-0.33	0.21	0.22	0.41	7.07	1.92	0.16	-0.52	0.20	0.42	0.40
Would you [...] a robot? - Scale: 0 (Not at all) to 5 (Definitely)																											
have sex with	0.93	1.40	0.12	1.34	0.21	0.67	0.41	1.97	1.84	0.15	0.36	0.20	-1.34	0.40	1.32	1.59	0.14	0.96	0.21	-0.29	0.41	2.86	1.93	0.16	-0.36	0.20	-1.42	0.40
love	0.73	1.20	0.10	1.86	0.21	3.12	0.41	0.85	1.24	0.10	1.51	0.20	1.49	0.40	0.81	1.23	0.11	1.46	0.21	1.28	0.41	0.97	1.35	0.11	1.30	0.20	0.69	0.40
be in an intimate relationship with	0.40	0.87	0.07	2.74	0.21	8.37	0.41	0.90	1.34	0.11	1.38	0.20	0.77	0.40	0.65	1.15	0.10	1.98	0.21	3.65	0.41	1.28	1.62	0.13	1.00	0.20	-0.38	0.40
be friends with	1.96	1.78	0.15	0.30	0.21	-1.33	0.41	2.12	1.78	0.15	0.23	0.20	-1.34	0.40	2.27	1.79	0.15	0.13	0.21	-1.34	0.41	2.40	1.76	0.15	-0.01	0.20	-1.32	0.40
Would you [...] a human? - Scale: 0 (Not at all) to 5 (Definitely)																											
have sex with	4.89	0.43	0.04	-4.48	0.21	21.49	0.41	4.93	0.35	0.03	-5.83	0.20	39.00	0.40	4.85	0.59	0.05	-4.44	0.21	20.90	0.41	4.98	0.18	0.02	-9.71	0.20	98.46	0.40
love	4.96	0.27	0.02	-6.48	0.21	43.00	0.41	4.94	0.29	0.02	-5.21	0.20	28.49	0.40	4.95	0.25	0.02	-5.41	0.21	31.84	0.41	4.90	0.47	0.04	-6.20	0.20	42.58	0.40
be in an intimate relationship with	4.90	0.37	0.03	-3.85	0.21	14.98	0.41	4.89	0.39	0.03	-3.80	0.20	14.20	0.40	4.88	0.46	0.04	-4.10	0.21	17.47	0.41	4.93	0.38	0.03	-8.16	0.20	78.45	0.40
be friends with	4.94	0.29	0.03	-5.38	0.21	30.17	0.41	4.89	0.44	0.04	-4.43	0.20	20.43	0.40	4.97	0.21	0.02	-7.83	0.21	65.68	0.41	4.91	0.40	0.03	-5.11	0.20	27.61	0.40

Note. SEM = Standard error of the mean, Stat. = Statistic, SE = Standard error of.

5.2. State manipulation check

Wilcoxon's t-tests Wilcoxon's t-tests revealed a statistically significant increase in arousal, W = 3647.50, z = -11.40, p < .001, r_{rb} = -.90, 95% CI [-∞, -.76], sexual arousal, W = 1208.00, z = -13.58, p < .001, r_{rb} = -.94, 95% CI [-∞, -.92], and valence, W = 5288.00, z = -5.33, p < .001, r_{rb} = -.44, 95% CI [-∞, -.33], after the sexually explicit video, compared to before the video (see Figure 1 for details). There were no significant differences between women and men, pre- and post-manipulation. There were also no significant differences between the levels of sexual arousal of people who selected either the heterosexual, lesbian, or gay sexually explicit video, pre- and post-manipulation. This suggests that our manipulation successfully affected the state of our sample, including that of women and men, and that the three videos were similarly capable of eliciting this state change.

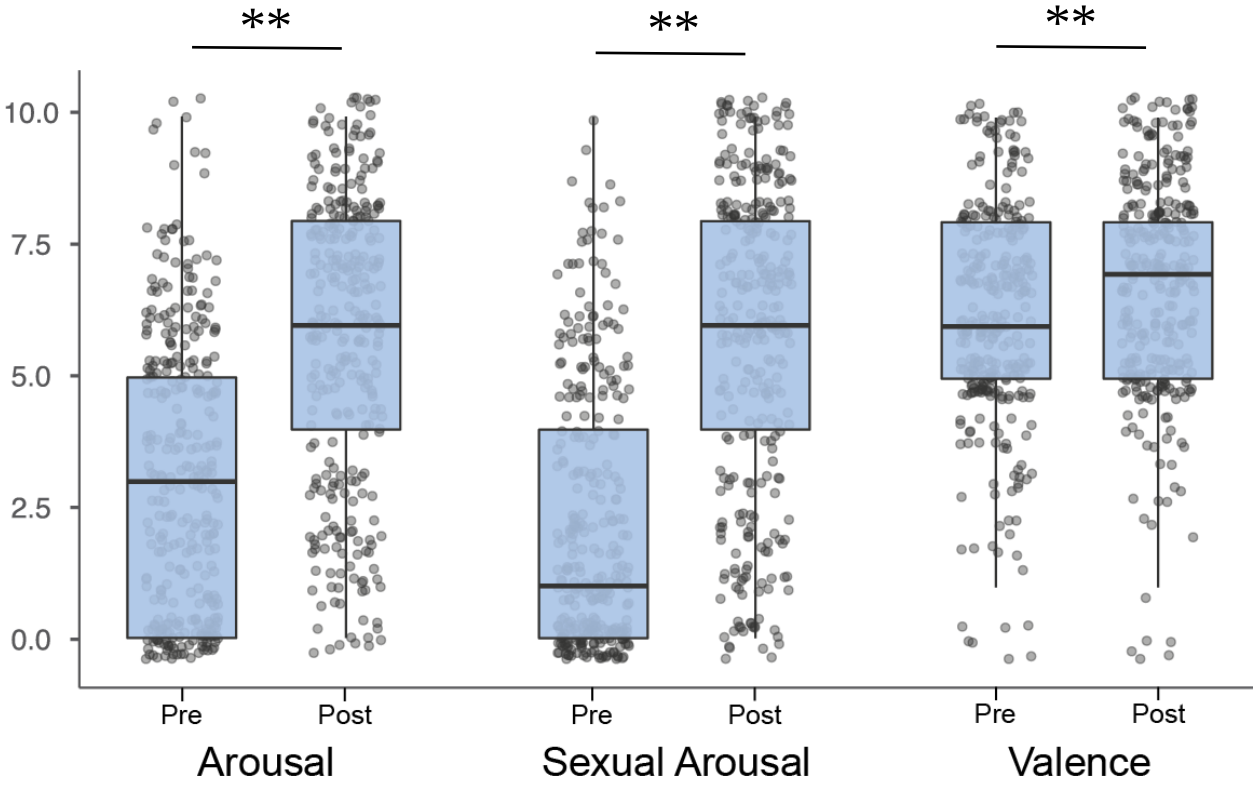

Figure 1. Boxplots of arousal, sexual arousal, and valence pre- and post-manipulation. This includes all participants. See Table 2 for descriptive statistics and section 5.2. for effect sizes. Scale: 0 (not at all [sexually] aroused/very negative) to 10 (very [sexually] aroused/very positive). Note. **p < .001.

5.3. Willingness to engage erotically with robots and humans

Paired samples Wilcoxon t-tests showed that participants' willingness to have sex with a robot was higher after they viewed a sexually arousing video compared to their baseline, $W = 2872.50$, $z = -6.98$, $p < .001$, $r_{rb} = -.61$, 95% CI [-∞, -.52], with a similar pattern when it comes to the willingness to engage in an intimate relationship, $W = 2702.00$, $z = -3.94$, $p < .001$, $r_{rb} = -.39$, 95% CI [-∞, -.25], and be friends with a robot, $W = 5644.50$, $z = -3.57$, $p < .001$, $r_{rb} = -.31$, 95% CI [-∞, -.31]. There was no statistically significant difference in terms of willingness to love such a machine, $W = 5166.00$, $z = -.66$, $p = .246$, $r_{rb} = -.06$, 95% CI [-∞, .09] (see Figure 2).

This pattern was consistent across women and men. Wilcoxon t-tests showed that women's willingness to have sex with a robot was higher after they viewed a sexually arousing video compared to their baseline, $W = 581.50$, $z = -3.48$, $p < .001$, $r_{rb} = -.49$, 95% CI [-∞, -.30], with a similar pattern when it comes to the willingness to engage in an intimate relationship, $W = 357.00$, $z = -2.71$, $p = .002$, $r_{rb} = -.44$, 95% CI [-∞, -.20], and be friends with a robot, $W = 773.00$, $z = -3.04$, $p < .001$, $r_{rb} = -.41$, 95% CI [-∞, -.21]. There was no statistically significant difference when it comes to willingness to love a robot, $W = 761.00$, $z = -.94$, $p = .167$, $r_{rb} = -.14$, 95% CI [-∞, .11].

Wilcoxon t-tests also showed that men's willingness to have sex with a robot was higher after they viewed a sexually arousing video compared to their baseline, $W = 531.00$, $z = -6.18$, $p < .001$, $r_{rb} = -0.75$, 95% CI [-∞, -.64], with a similar pattern when it comes to the willingness to engage in an intimate relationship, $W = 636.00$, $z = -3.00$, $p = .001$, $r_{rb} = -0.43$, 95% CI [-∞, -0.22], and be friends with a robot, $W = 1515.00$, $z = -1.84$, $p = .030$, $r_{rb} = -.23$, 95% CI [-∞, -.03]. Again, there was no statistically significant difference when it comes to willingness to love a robot, $W = 1162.50$, $z = -.27$, $p = .392$, $r_{rb} = -.04$, 95% CI [-∞, .19].

Moreover, there were no statistically significant differences between participants' mean willingness to engage erotically with humans, pre- and post-manipulation, including across women and men. After Bonferroni corrections for multiple comparisons, Mann-Whitney U tests showed no statistically significant differences between participants' willingness to engage erotically with a robot and a human as a function of the type of video that they selected.

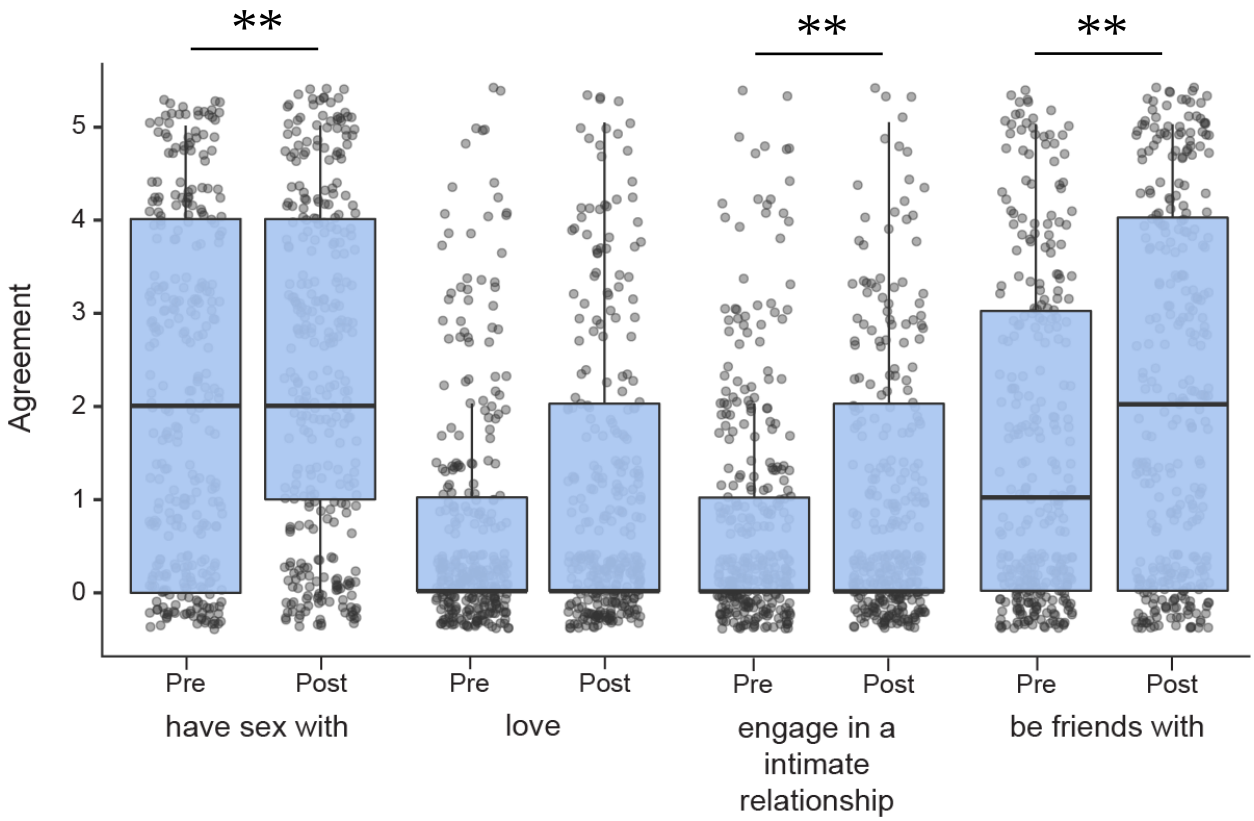

Figure 2. Boxplots of willingness to engage erotically with robots. This includes all participants. See Table 2 for descriptive statistics and section 5.3. for effect sizes. Scale: 0 (not at all) to 5 (definitely). Note. **p < .001.

Table 4. Correlations between state and willingness to engage erotically with robots and humans.

Variables	Pre-manipulation									Post-manipulation								
	Total			Women			Men			Total			Women			Men		
	Arousal	Sexual arousal	Valence	Arousal	Sexual arousal	Valence	Arousal	Sexual arousal	Valence	Arousal	Sexual arousal	Valence	Arousal	Sexual arousal	Valence	Arousal	Sexual arousal	Valence
Pre-manipulation																		
Would you [...] a robot? - Scale: 0 (Not at all) to 5 (Definitely)																		
have sex with	.17 **	.18 **	.01	.13	.14	.03	.17 *	.21 **	-.04	.07	.08	.08	.04	.04	-.03	.09	.10	.09
love	.05	.07	-.00	.03	-.03	-.13	.10	.15	.13	-.00	-.05	-.03	-.01	-.08	-.12	-.00	-.06	-.02
be in an intimate relationship with	.07	.13 *	-.03	.07	.05	-.03	.09	.23 **	-.06	.06	.04	.04	.07	.06	-.03	.05	.01	-.03
be friends with	.03	.09	.00	.04	.08	-.11	.02	.08	.11	.08	.04	.05	.13	.09	.02	.05	-.01	.08
Would you [...] a human?																		
have sex with	.08	.10	.12 *	.04	.07	.09	.05	.04	.14	.10	.15 **	12 *	.19 *	.28 **	.17 *	-.04	-.01	.05
love	.04	-.03	.10	-.05	-.14	.04	.13	.04	.17 *	.04	.04	.07	.11	.11	.11	-.01	.02	.01
be in an intimate relationship with	.07	.08	.13 *	.03	.05	.15	.09	.10	.15	.12 *	.13 *	.16 **	.20 *	.30 **	.22 *	.07	.02	.10
be friends with	.03	-.00	.06	.06	.06	.13	.02	-.03	.03	-.06	-.06	.02	.09	.05	.22 *	-.13	-.10	-.09
Post-manipulation																		
Would you [...] a robot? - Scale: 0 (Not at all) to 5 (Definitely)																		
have sex with	.18 **	.20 **	.05	.16	.18 *	.03	.19 *	.20 *	.05	.22 **	.22 **	.19 **	.13	.18	.06	.29 **	.25 **	.22 **
love	-.01	.05	-.03	-.07	-.06	-.08	.04	.16	.04	.05	.02	-.02	.09	.05	-.03	.08	.05	.01
be in an intimate relationship with	.06	.16 **	.03	.12	.18 *	.06	.02	.16	.01	.12 *	.11	.16	.17	.16	.11	.11	.10	.05
be friends with	.01	.09	.05	.01	.06	-.06	-.03	.10	.19 *	.02	-.01	.03	.12	.08	.09	-.06	-.09	-.01
Would you [...] a human?																		
have sex with	.06	.16 **	.10	.01	.17	.11	-.02	.09	-.04	.15 **	.22 **	.19 **	.23 **	.28 **	.19 *	-.05	-.00	-.05
love	.03	.03	.15 **	.07	.00	.15	.04	.04	.15	.03	.05	.07	.22 **	.25 **	.25 **	-.03	.00	.00
be in an intimate relationship with	.12 *	.11	.08	.12	.11	.10	.05	.06	-.02	.22 **	.23 **	.22 **	.33 **	.33 **	.21 *	.08	.11	.07
be friends with	.06	.07	.05	.07	.08	.11	.07	.08	.02	.03	.04	.01	.21 *	.20 *	.17 *	-.05	-.00	-.08

Note. *p < .05, **p < .01. Arousal = I feel: 0 (not at all aroused) to 10 (very aroused), Sexual arousal = I feel: 0 (not at all sexually aroused) to 10 (very sexually aroused), and Valence = I feel: 0 (very negative) to 10 (very positive).

5.4. Hypothesis 1: Levels of sexual arousal would positively predict participants' willingness to engage erotically with robots (partly supported).

A linear mixed effect model (Willingness ~ 1 + sexual arousal + time (pre- and post-manipulation) + sexual arousal * time + [1 | Subject]) significantly predicted willingness to have sex with a robot, $R^2 = .34$, AIC = 5677.36, $p < .001$. There were significant main effects of sexual arousal and time, as well as a significant interaction of sexual arousal by time, suggesting that levels of sexual arousal, time, and the change in sexual arousal across pre- and post-manipulation positively predicted participants' willingness to have sex with a robot beyond individual variability (see Table 5 for fixed effects parameter estimates). Sexual arousal did not, however predict willingness to love, engage in an intimate relationship with, or be friends with a robot.

This pattern was consistent across women and men. That is, the same linear mixed effect model significantly predicted willingness to have sex with a robot for both women, $R^2 = .41$, AIC = 2360.56, $p < .001$, and men, $R^2 = .32$, AIC = 2624.83, $p < .001$ (see Table 5 for fixed effects parameter estimates). Again, sexual arousal did not predict willingness to love, engage in an intimate relationship with, or be friends with a robot across women and men.

5.5. Hypothesis 2. Men would be more willing to erotically engage with robots than women, pre- and post-manipulation (partly supported).

Mann-Whitney U t-tests for two independent samples with Bonferroni corrections for multiple comparisons showed that, pre-manipulation, men were more willing to have sex, U = 6688.00, $p < .001$, $r_{rb} = -.33$, 95% CI [-∞, -.23], and engage in an intimate relationship with a robot than women, U = 7980.00, $p < .001$, $r_{rb} = -.20$, 95% CI [-∞, -.09]. The same analyses showed that, post-manipulation, men were also more willing to have sex, U = 5543.00, $p < .001$, $r_{rb} = -.44$, 95% CI [-∞, -.35], and engage in an intimate relationship with a robot than women, U = 7827.00, $p < .001$, $r_{rb} = -.21$, 95% CI [-∞, -.10]. There were no gender differences between women and men's willingness to love or be friends with a robot pre- and post-manipulation (all $r_{rb} < -.07$).

Table 5. Fixed effects parameter estimates.

Variables	Estimate	SE	95%[CI]		df	*t*	*p*
			L	U			
Total							
(Intercept [1 | Subject])	2.91	0.09	2.74	3.08	319	32.90	< .001
Sexual arousal	2.26	0.11	2.04	2.48	954	20.30	< .001
Time (pre-/post-manipulation)	2.04	0.11	1.82	2.26	954	18.30	< .001
Sexual arousal * time	2.88	0.22	2.45	3.32	954	13.00	< .001
Women							
(Intercept [1 | Subject])	2.48	0.12	2.24	2.71	135	20.58	< .001
Sexual arousal	1.87	0.17	1.54	2.19	404	11.25	< .001
Time (pre-/post-manipulation)	2.71	0.17	2.38	3.03	404	16.32	< .001
Sexual arousal * time	2.97	0.33	2.32	3.62	404	8.94	< .001
Men							
(Intercept [1 | Subject])	3.33	0.13	3.06	3.59	146	25.00	< .001
Sexual arousal	2.28	0.17	1.95	2.60	437	13.38	< .001
Time (pre-/post-manipulation)	1.81	0.17	1.49	2.13	437	11.01	< .001
Sexual arousal * time	2.77	0.33	2.12	3.41	437	8.40	< .001

Note. SE = Standard error of, CI = Confidence intervals, L = Lower limit, U = Upper limit.

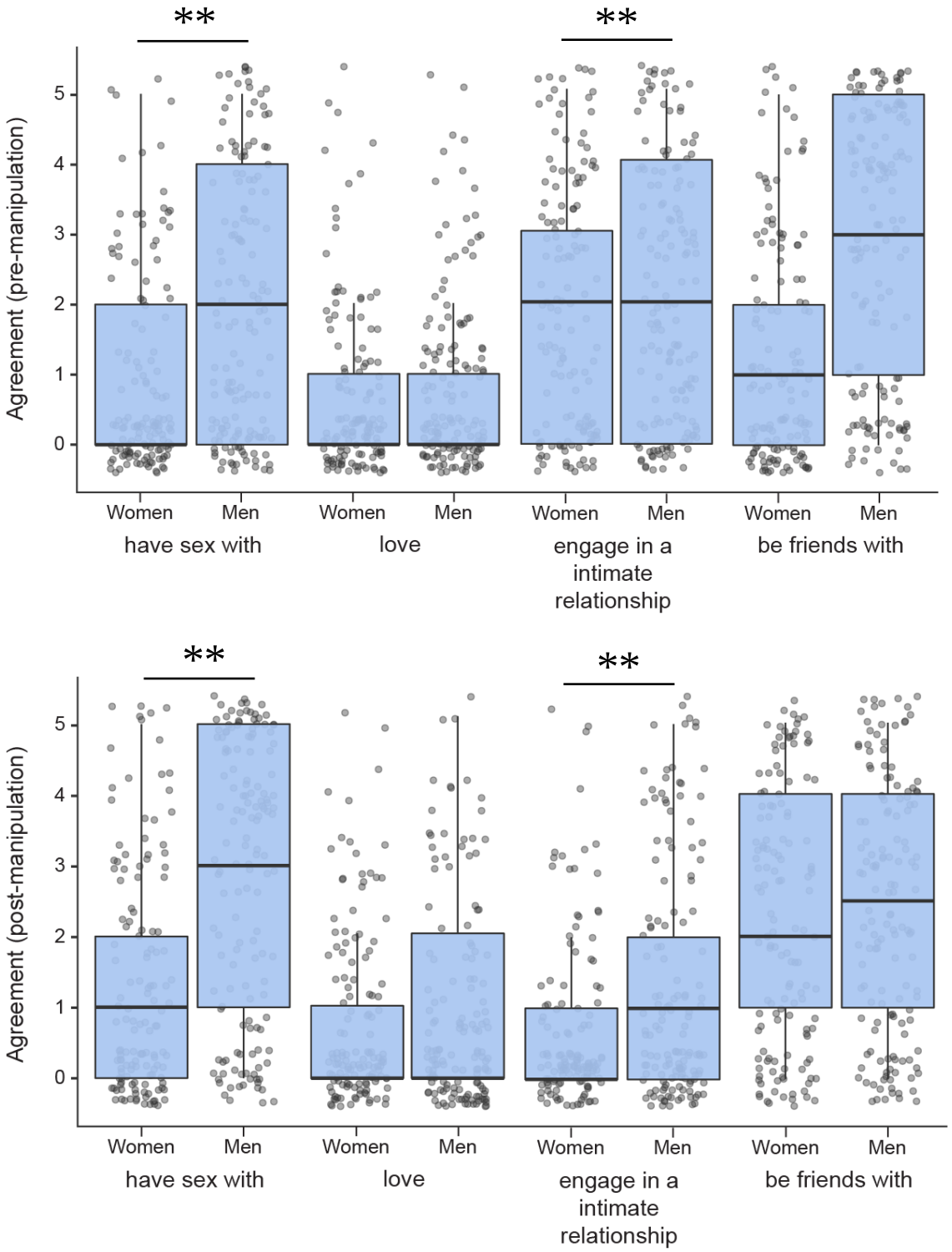

Figure 3. Boxplots of willingness to engage erotically with robots across women and men pre- and post-manipulation. See Table 2 for descriptive statistics and section 5.5. for effect sizes. Scale: 0 (not at all) to 5 (definitely). Note. **p < .001.

6. Discussion

These results show that a state of sexual arousal can increase people's willingness to have sex with robots. Specifically, participants reported being more willing to have sex, engage in an intimate relationship, and be friends with a robot after viewing a sexually arousing video, compared to their baseline. However, only participants' willingness to have sex with a robots increased as a function of their levels of sexual arousal. This effect was consistent across women and men, and it suggests some specificity to the influence of sexual arousal on people's willingness engage erotically with machines. Finally, these results show that men are more willing to have sex and engage in an intimate relationship with a robot than women pre- and post-manipulation, but no differences were found when it comes to loving or being friends with such a machine. Notably, combined with the significant main effect of sexual arousal in our model, the correlations found between pre-manipulation (sexual) arousal and pre- and post-manipulation willingness to have sex with a robot suggest that trait (not just state) sexual arousal may also be related, albeit weakly, to people's desire to engage erotically with machines.

Our findings are in line with previous research on sexual arousal and decision-making (Ariely & Loewenstein, 2006; Crosby et al., 2021; Skakoon-Sparling et al., 2016; Skakoon-Sparling & Cramer, 2021). They suggest that a state of sexual arousal can augment the willingness to engage in unconventional erotic experiences (e.g., human-robot sexual activities) or with atypical stimuli (e.g., robots). As with previous research, this may be due to the fact that sexually aroused individuals partly shift their attention from the potentially negative outcomes of human-robot intimacy (e.g., stigma and societal judgment; Dubé et al., 2022b), to the potentially rewarding outcomes of such an experience (e.g., sexual pleasure; Crosby et al., 2021). Our findings are also in line with previous research on gender differences and human-robot erotic interaction (Brandon & Planke, 2021; Brandon et al., 2022; Dubé et al., 2022b; HuffPost, 2013; Nordmo et al., 2020; Oleksy & Wnuk, 2021; Scheutz & Arnold, 2016; YouGov, 2017, 2020). They suggest that, regardless of their state of sexual arousal, men are more interested in sex and intimate relationships with robots than women. Again, this may be due to the fact that current robots are mostly geared toward heterosexual men (Döring & Poeschl, 2019), double standards in sociocultural norms related to women and men's sexuality (Farvid et al., 2017), gender differences in sex drive and sexual sensation seeking/risk-taking (Gaither & Sellbom, 2003; Petersen & Hyde, 2011; Skakoon-Sparling & Cramer, 2021), or men's greater exposure to

science-fiction that portrays human-machine eroticism (Appel et al., 2019; Döring & Poeschl, 2019; Koverola et al., 2020). But no matter the reason, sexual arousal does not seem to extinguish this gender difference.

This study is limited by its convenience sample (i.e., mostly white/Caucasian and educated), the present scarcity of sex robots, and the self-selection bias of sexuality-related studies which can lead more sex-positive individuals to participate in greater number. The selection criterion requiring people to have previously watched pornography may have further restricted the range of participants (e.g., individuals more supportive of sex with robots) and/or influence the effect of our manipulation (e.g., increase or reduce its effectiveness). This study is also limited by its self-report measures and the lack of psychometrically validated measures of willingness to engage with robots. Moreover, we did not provide a specific definition of the term "robot," but instead let participants imagine what such machines could be. This may have led to variability in what people thought about when answering this study's questions. Since data were collected online, we also cannot be certain that participants fully paid attention to the sexually explicit videos. Lastly, the sexually explicit videos differ from real-world intimate interactions (Dubé et al., 2022a)—including, potential future erotic interactions between humans and robots—in their salience and ability to trigger sexual arousal, and in turn, influence (sexual) decision-making.

Still, this innovative experiment successfully manipulated the (sexual) arousal and valence of participants, and provided the first quantitative evidence that state factors—in this case, sexual arousal—can influence people's willingness to engage erotically with artificial partners (i.e., robots). As such, it expands the research on sexual arousal and decision-making to the realm of erobotics. It also points to the possibility that upcoming sex robots may be able to manipulate—through their ability to elicit sexual arousal via bodily features (e.g., secondary sexual characteristics) and behaviors (e.g., flirting)—our state, decisions, and behaviors (Dubé & Anctil, 2020). For example, future sex robots could manipulate our desire to engage in sexual or intimate relationships with them, and in turn, take advantage of this closeness or emotional bonds to influence our consumption, political, or relational choices (Dubé & Anctil, 2020).

Granted that, future studies should recruit larger representative samples (i.e., including, more gender non-conforming individuals and people with diverse identities and orientations), as well as target samples from different cultures (e.g., Canada vs. Japan) and communities of

individuals with technology-based sexualities (e.g., doll-lovers and robot fetishists; Dubé et al., 2021). This would allow us to assess whether these findings hold true across cultures, demographic groups, and people with distinct sexual preferences. Future studies should also account for pornography exposure, provide specific definitions of robots (and/or stimuli depicting them, such as images and videos), and integrate objective, psychophysiological measures of attention and sexual arousal—such as eye-tracking and genital thermography (Chivers et al., 2010; Wenzlaff et al., 2016)—into laboratory experimental paradigms. This would allow us to examine the influence of bodily/genital arousal on human-robot sexual decision-making, as well as ensure that participants pay attention to the stimuli used to manipulate their state. Finally, similarly to Skakoon-Sparling and Cramer (2016), future studies should examine the mechanisms underlying the effect of sexual arousal on people's interest in artificial partners. This research is important considering the growing place that AI, robotics, and future erobots may play in our erotic lives.

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CHAPTER 6: GENERAL DISCUSSION

Considering the ongoing techno-erotic revolution, and the state of research on human-machine erotic interaction and co-evolution, the objective of this dissertation was to launch erobotics as scientific discipline and field of research. The objective was also to investigate some of the factors that may influence people's willingness to engage erotically with robots. These objectives were accomplished through four articles: one theoretical and three empirical. Chapter 2 first defined erobotics and its key concepts, proposed a model of our interaction and co-evolution with erobots, and suggested a path to design beneficial erotic machines. Chapters 3-5 then empirically examined some of the micro- and macrolevel factors highlighted by said model by assessing the influence of social, personality, and state factors on people's willingness to engage erotically with robots. Specifically, Chapter 3 examined whether there exists a stigma related to the use of erotic technologies, and whether this stigma influences people's willingness to engage with sex toys, erotic chatbots, virtual partners, and sex robots. Chapter 4 assessed whether personality traits relate to willingness to engage with sex robots and the perceived appropriateness of such machines (i.e., Big-Five, [sexual] sensation seeking, erotophilia, and technophilia). Finally, Chapter 5 investigated whether a state of sexual arousal could influence people's willingness to engage erotically with a robot (i.e., have sex, fall in love, engage in an intimate relationship, and be friends with). The findings of this research further our understanding of human-machine erotic interaction and co-evolution, and achieve the theoretical and empirical objectives of this dissertation.

1. Summary of the main findings and contributions

1.1. Main findings of Chapter 2

Chapter 2 defined erobots and erobotics, and proposed a taxonomy of erobots, distinguishing between artificial erotic agents which can be (simultaneously) embodied, virtual, and augmented (e.g., sex robots, virtual partners, and digital humans; Dubé & Anctil, 2020). To better understand these new erotic systems and our changing relationships with them, this chapter also proposed a Spectrum of Erobots' Agency (SEA), ranging from 0 (no agency; e.g., sex toys, dolls, and pornography) to 5 (full agency; e.g., hypothetical erobots with artificial general intelligence; Dubé & Anctil, 2020). This spectrum suggests that, as the agency of erobots grows (i.e., their capability to act in/or our world to achieve goals), our control over them

diminishes and their behavior becomes more unpredictable, transforming our possible relationships with these erotic systems (Dubé & Anctil, 2020; Russell, 2019; Schlosser, 2015; Tegmark, 2017).

In addition, Chapter 2 proposed a theoretical framework describing and predicting how humans and erobots will likely co-influence one another: the Human-Erobot Interaction and Co-Evolution Model (HEICEM). The HEICEM is grounded in Complex System Theory (von Bertalanffy, 1968), 4E approaches to cognition (Newen et al., 2018), Universal Darwinism (Dawkins, 1976, 1983), the neurodevelopmental trajectory of sexuality (Pfaus et al., 2012), Hierarchical Incentive-Motivational Theory (Toates, 2009), and Ecological System Theory (i.e., Bioecological Model; Bronfenbrenner & Morris, 2006). In short, this model theorizes that humans and erobots are complex systems situated within and interacting with other complex, multilevel systems. As such, humans and erobots co-influence their respective embodied, embedded, extended, enacted erotic cognition through interactions (e.g., rewarding or unpleasant experiences), and the transformation of each other's ecological niche (e.g., available intimate partners and environment). This, in turn, influences whether and how they engage with one another, possibly leading to (unpredictable) changes in human and erobot co-evolution, along with their co-constructed erotic cognitions and populations. At the core of this model is a mechanism akin to natural, artificial, and sexual selection: the Erotic Multi-Agent Selection (EMAS) process, which suggests that the principles of variation and selective retention of traits apply to our interaction and co-evolution of with erobots.

Notably, the ecological niche of the HEICEM is based on Bronfenbrenner and Morris's (2006) Bioecological Model and composed of five layers of interconnected systems. The microsystem, or the individuals, institutions, and technologies with whom we interact directly. The mesosystem, which connects the microsystem to the other layers. The exosystem, which includes, for instance, the scientific, media, health, economic, and legal, etc. entities with whom we interact indirectly. The macrosystem, which encompasses the overarching sociocultural norms and values of a given society or community. And the chronosystem, which accounts for the influence of time on this model (Bronfenbrenner & Morris, 2006).

Considering the growing agency of erobots and the HEICEM, Chapter 2 further described some of the anticipated risks and benefits associated with erobotic technologies. It also proposed a path to design beneficial erobots—machines which could reduce the risks associated

with evermore agential erotic machines and enhance our well-being—based on Russell's (2019) principles for beneficial machines. Specifically, altruistic, humble, and useful erobots that "(1) aim to maximize the realization of human erotic preferences, (2) are initially uncertain about what those erotic preferences are, and (3) use human behaviour as their ultimate source of information about our erotic preferences." (Dubé & Anctil, 2020, p.18). Chapter 2 concluded with potential future applications of erobotic technologies, and ultimately argued that if we mitigate the risks of erobots and design beneficial erotic machines, we may reap benefits for human health and well-being (Dubé & Anctil, 2020).

1.2. Main contributions of Chapter 2 to theory and research

Chapter 2 founded erobotics: a unified scientific discipline and field of research intersecting human-machine interaction and sexology and grounded in sexuality and technology positive frameworks (Dubé & Anctil, 2020). In turn, erobotics helps to overcome some of the theoretical gaps identified in the other research domains and presented in Chapter 1. Specifically, it addresses human-machine erotic interaction and co-evolution—and particularly, the advent of and our relations with interconnected, evermore agential artificial erotic agents. Based on the concept of erôs, as well as contemporary approaches to technology, cognition, and sexuality, Chapter 2 also provides the necessary terminology and definitions for researchers across disciplines to have a common language to better study how human and erobots interact and co-evolve (Dubé & Anctil, 2020). Moreover, it proposes concrete goals for erobotics (Dubé & Anctil, 2020).

Through its sextech-positive framework, path to design beneficial erobots, and future applications, Chapter 2 sets progressive, eudemonist, and utopian objectives for the study and future of human-machine erotic interaction and co-evolution (Dubé & Anctil, 2021). These objectives invite researchers to adopt judgment-free stances regarding sexuality and technology, rethink our approach to AI design, and investigate both the risks and benefits of technological innovations. These objectives also invite researchers to (re)insert their research program into a larger, solution-oriented perspective that aims to mitigate risks, enhance human well-being, and facilitate the flourishing of our civilization through the potential applications of erobotic technologies (e.g., in health, research, education, and pleasure; Dubé & Anctil, 2020).

Through the HEICEM, Chapter 2 offers a theoretical framework that explicates specific mechanisms for human-machine erotic interaction and co-evolution. For instance, this model

predicts that our cultural and sexual norms may influence our intimate preferences and the design of erobots. It predicts that these norms may in turn influence whether people would engage erotically with artificial partners; and if they do, that the valence of the experience—positive, neutral, or negative—will affect whether one repeats or avoids the behaviors that led to this state. It also predicts that this may retroactively influence our preferences, said norms, and the design of the erobots that populate our world (Dubé & Anctil, 2020).

What is more, erobotics and the HEICEM do not presuppose that humanity, technology, or sexuality have specific or stable essences. Instead, they both aim to avoid essentialist claims by considering these phenomena as vast, ever-changing sets of attributes continuously reinvented each time we experience them (Dubé & Anctil, 2020). As such, erobotics and the HEICEM address some of the descriptivism, reductionism, determinism, and essentialism of previous research programs (Dubé & Anctil, 2020).

The comprehensive, multilevel structure of HEICEIM constitutes fertile grounds to launch a broad, transdisciplinary scientific agenda on erobotics (Dubé & Anctil, 2022). For example, some may examine how erobotic technologies reshape our societies, culture, and (non)virtual environments, or focus on whether people develop conditioned partner preferences specific to artificial agents and how this impacts our interhuman relationships. Some may examine how people with different identities, orientations, and preferences relate to erobotic technologies, while others may investigate how erobots of different levels of agency learn their erôs, and how this in turn reshapes the way we interact and co-evolve with such erotic systems. Some may also examine the interactions between the different levels of the HEICEM (e.g., the interactions between cultures, identities, and partner preferences), or build erobots for education, healthcare, and experiments.

In sum, Chapter 2 contributes to theory and research by founding a new scientific discipline and field of research, along with its relevant concepts, frameworks, and objectives. It also provides a testable model, which can be used as theoretical grounds to launch erobotics. In that regard, Chapter 2 highlights the need for more empirical research in this area. The HEICEM underlines the importance of considering the influence of micro- and macrolevel factors on human-machine erotic interaction and co-evolution, including sociocultural, individual, and situational factors, such as those examined in Chapters 3-5.

1.3. Main findings of Chapters 3-5

Chapter 3 shows that perceived stigma related to erotic technology use (PSETU) exists and increases as a function of a product's human-likeness, such that it augments from sex toys to sex robots (Dubé et al., 2022b). Chapter 3 further shows that women and men perceive the same levels of stigma across products. Yet, PSETU only weakly relates to willingness to use erotic technologies—except for women trying sex toys and men using them regularly (i.e., moderate negative associations; Dubé et al., 2022b).

Chapter 4 shows that, compared to technophilia, non-sexual sensation seeking, and the Big-Five traits, erotophilia and sexual sensation seeking more closely, positively associated with people's willingness to engage with and perceived appropriateness of using sex robots (Dubé et al., 2022c). Chapter 4 also shows that there may be gender differences between ciswomen, cismen, and non-binary and gender nonconforming individuals within these associations. For instance, technophilia may only relate to cismen's willingness to try and regularly use sex robots, while openness may only relate to ciswomen's willingness to engage erotically with them (Dubé et al., 2022c).

Chapter 5 shows that people are more willing to engage have sex, engage in an intimate relationship, and be friends with a robot after viewing a sexually arousing video, compared to their baseline. But Chapter 5 also shows that only willingness to have sex with a robot increased depending on state sexual arousal levels (Dubé et al., 2022d). These findings are consistent across women and men (Dubé et al., 2022d).

Finally, men were more willing to engage with robots than women across studies (Dubé et al., 2022b, 2022c, 2022d). Specifically, Chapter 3 shows that when compared to women, a greater proportion of men would try or regularly use erobots (i.e., erotic chatbots, virtual partners, or sex robots; Dubé et al., 2022b). Chapter 4 shows that men are more willing to engage with sex robots (e.g., try, regularly use, or fall in love with), and perceive their use as more appropriate than women (Dubé et al., 2022c). And Chapter 5 shows that men are more willing to have sex or engage in an intimate relationship with a robot than women, pre- and post-manipulation (Dubé et al., 2022d). Together, these findings contribute to the theory and research on erobotics.

1.4. Main contributions of Chapters 3-5 to theory and research

Chapter 3 extends research on the perception of sexual stigma to the field of erobotics. It provides the first quantitative evidence that stigma related to the use of erotic technologies exists and varies across categories of sex products (Dubé et al., 2022b). It also provides preliminary support for the idea that the Uncanny Valley Hypothesis may extend to erotic technologies (Mori, 1970, 2012). That is, compared to products that can only be used as sexual stimulation tools (e.g., sex toys), more humanlike products, which can potentially act as intimate partners (e.g., sex robots), may elicit greater negative responses (i.e., stigma; Dubé et al., 2022b).

Within the context of the HEICEM, the findings from Chapter 3 suggest that people are aware of a stigma associated with the use of erotic technologies (e.g., sex toys and robots): a macrosystem level factor (i.e., reflecting sociocultural norms and values) perceived at the microsystem level (i.e., within communities or individuals; Dubé & Anctil, 2020; Dubé et al., 2022b). These findings also suggest that new erotic technologies are developed in a world where (techno)sexuality is still stigmatized, and where the use of sexual stimulation tools or artificial intimate partners may be—in some communities—a source of inequities, devaluation processes, stereotypes, or negative attitudes (Dubé et al., 2022b). The HEICEM predicts that this stigma may influence, for instance, how people interact with erobots (e.g., hide their use due to the perceived stigma associated with them), how people treat their users, and the valence of this experience, which may in turn affect the sociocultural norms surrounding erotic systems, along with their design (Dubé & Anctil, 2020).

Practically, although PSETU may not deter people from using sex toys or erobots, the findings of Chapter 3 point to the possibility that this stigma may affect the health or well-being of their users or people with technology-based sexualities (e.g., robosexuals and digisexuals; Dubé et al., 2021; Dubé et al., 2022b; McArthur & Twist, 2017). As such, this stigma may warrant some clinical consideration: for instance, when treating people with sexual interests in technology (Dubé et al., 2022b; Twist & McArthur, 2020). These findings also highlight how sensitive the personal information that erobots may gather and the potential repercussions that may arise if someone discovered or shared it (e.g., sexual behaviors and intimate preferences). We thus propose that the privacy measures implemented into erobots should be proportional to the harm that could be caused if this information was made public (Dubé & Anctil, 2020; Galaitsi et al., 2019; Nyholm & Frank, 2019; Sharkey et al., 2017).

Methodologically, Chapter 3 provides preliminary evidence that the Explanatory Model Interview Catalogue (EMIC) perceived stigma scale and its emic framework can have valuable applications beyond research on health-related stigma (Peters et al., 2014; Weiss et al., 1992; see Appendix A for psychometric details). Indeed, the adapted EMICs seem able to capture other forms of stigma (e.g., PSETU), which may help to explore potentially stigmatized behaviors across cultures and communities (e.g., use of erotic technologies; Dubé et al., 2022b). That said, since stigma does not seem to prevent people from being willing to engage with erobots, Chapter 4 focused on a more individual, proximal factor: personality.

Chapter 4 extends research on erobotics to personality traits. Its findings are in line with Deniztoker (2019) and Richards and colleagues (2017), but also provide new insights into the individual characteristics of those who may be interested (or not) in erobots and human-robot intimate relationships, and their underlying motivations. Its findings further demonstrate how, as microsystem level factors, personality traits may—through people's patterns of thoughts, emotions, and behaviors—influence the development of erobots, and our interaction and co-evolution with these erotic systems (Allen & Walters, 2018). This includes, for instance, our willingness to engage with them, their perceive appropriateness, and how this affects human and erobot populations (Dubé & Anctil, 2020).

Specifically, the findings of Chapter 4 suggest that it is our general propensity toward sexuality (negative or positive), along with our tendency to seek varied, novel, and/or intense sexual experiences that mainly dictate whether one would engage with sex robots or perceived their use as appropriate (Dubé et al., 2022c). They also suggest that people may attribute more weight or attention to the sexual dimension of these artificial companions rather than their technological dimension in their decision-making process (e.g., their capability to act sexual or intimate partners). In turn, this may lead people to rely more on their sexual norms and attitudes, along with their desire for new or diverse erotic experiences, to decide whether they would engage with sex robots or approve of them (Dubé et al., 2022c). Practically, this knowledge may be useful to sex robot designers who may adjust their products and marketing strategy accordingly.

Within the HEICEM, these findings contribute to our understanding of who may be the main users and adopters of sex robots: an important insight given that these individuals may in turn influence the design of such machines and their subsequent influence on human and erobot

erotic cognitions and populations (Dubé & Anctil, 2020). For example, sex robot designers may try to meet the initial demand coming from erotophilic sexual sensation seekers—and especially, heterosexual cismen and gynophilic individuals—and adapt the features and capabilities of their products to satisfy those potential customers. The robots themselves may also be built to learn and reinforce patterns that aim to meet this initial demand for the sexual gratification from these groups (Dubé et al., 2022c). In doing so, however, this may create an interaction and co-evolution trajectory that can be pleasurable for some, but omits the needs or preferences of others, such as women, females, gender/sexual minorities, and those who may prefer non-femalelike machines or emotional connection over sexual stimulation (Dubé et al., 2022c). That said, if erobot designers pay attention to trends in the sextech industry, as well as the information and data presented in this thesis regarding who may be more or less receptive to their products, they may choose to adjust the design of their machines to meet the broader market demand. This could arguably be both more profitable and beneficial to the well-being of diverse people (Dubé & Anctil, 2020; Dubé et al., 2022c).

Overall, the findings of Chapter 4 suggest that individual characteristics, such as personality traits, may represent an important filter through which erobots and their features will be selected—subsequently dictating, in a perpetual feedback loop, the composition of erobots populations, along with their influence on our environments and the nature of our possible interactions with them (Dubé & Anctil, 2020; Dubé et al., 2022c). Still, beyond sociocultural (e.g., stigma) and individual factors (e.g., personality traits), situational factors may also influence our willingness to engage erotically with machines. This includes state factors, such as sexual arousal.

Chapter 5 extends erobotics to research on the effect of sexual arousal on decision-making: a circumstance-dependant, microsystem level factor that could be decisive during human-erobot interaction. The findings of Chapter 5 are in line with previous research which suggests that a state of sexual arousal may increase people's willingness to engage in risky or unconventional sexual activities (Ariely & Loewenstein, 2006; Crosby et al., 2021; Skakoon-Sparling et al., 2016; Skakoon-Sparling & Cramer, 2016, 2021). Its findings also provide the first experimental evidence that sexual arousal can increase our willingness to have sex with artificial agents (Dubé et al., 2022d).

Given that many erobots are designed to elicit sexual arousal, understanding this effect may help to build satisfying human-machine intimate relationships (e.g., pleasurable sexual experiences or strong emotional bonds)—with significant potential benefits for the health and well-being of users. It may also help to anticipate how this can affect our (sexual) decision-making processes, or influence our desire to have an intimate relationship with an artificial partner and take advantage of this intimacy to collect personal data or manipulate our decisions (e.g., relational or consumption choices; Dubé & Anctil, 2020; Dubé et al., 2022d). Again, such insights may be appealing to sex robot designers, which is why we must guide and encourage the design of beneficial erobots—that is, erotic systems which do not prioritize profit at the expense of well-being (Dubé & Anctil, 2020).

Within the HEICEM, these findings highlight the importance of considering state factors in human-machine erotic interaction and relationships. They also point to the fact that the ability of erobots to trigger our sexual responses—for instance, through their bodily or behavioral features—may be a key factor in getting people to try these machines. In turn, as previously mentioned regarding the findings of Chapter 4, erobot designers may try to maximize the ability of erotic systems to elicit states that increase individuals' interest in their products (e.g., sexual arousal). The erobots themselves may be designed to learn and reinforce patterns that achieve this objective (Dubé & Anctil, 2020; Dubé et al., 2022d). This may simultaneously yield sexually gratifying experiences for some, while chipping away at the control of others. Again, this knowledge invites careful consideration of the influence of state factors on decision-making in the context of human-erobot interaction and co-evolution (Dubé & Anctil, 2020; Dubé et al., 2022d). It also invites the design of machines that harmoniously integrate into our erotic lives, rather than problematically take advantage of their capabilities to influence our choices. Such beneficial machines could ultimately be more financially profitable, as people may select, in greater number, products that are not counterproductive to their well-being (Dubé & Anctil, 2020; Dubé et al., 2022d).

Lastly, the gender differences between women and men systematically found across our studies expand our understanding of individual characteristics, demographics, and erobotics. These findings are consistent with results from previous research on gender differences, sex (with) robots, and interest in human-machine intimacy (Brandon & Planke, 2021; Brandon et al., 2022; Dubé et al., 2022b; Huffpost, 2013; Nordmo et al., 2020; Oleksy & Wnuk, 2021; Scheutz

& Arnold, 2016; YouGov, 2017, 2020). These findings also open new research avenues regarding human-machine erotic interaction and gender/sexual minorities.

Specifically, the gender differences between women and men's interest in intimate or sexual relationships with machines (e.g., robots) may stem from a combination of sexual double standards (Farvid et al., 2017), as well as differential sex drives, levels of sexual sensation seeking and risk-taking, and exposure to science-fiction portraying human-machine eroticism (Appel et al., 2019; Döring & Pöschl, 2019; Gaither & Sellbom, 2003; Koverola et al., 2020; Petersen & Hyde, 2011; Skakoon-Sparling & Cramer, 2021). They may also simply stem from the fact that most sex robots are currently gynoids, primarily marketed toward heterosexual men (Döring & Pöschl, 2019). With regard to non-binary and gender nonconforming individuals, the findings from Chapter 4 also points to the possibility of a large erobot market geared toward gender and sexual minorities (Dubé et al., 2022c). This may be due to a greater openness toward alternative eroticisms paired with the knowledge that erobots, such as sex robots, could potentially take any form or enact behaviors that meet their needs and preferences (Danaher, 2019a; Dubé & Anctil, 2020; Dubé et al., 2022c; Dudek & Young, 2022; Kubes, 2019).

Within the context of the HEICEM, these findings suggest that heterosexual men and gynephilic individuals may form the main demographic groups of early users or adopters of erobots, and as with personality traits, influence their development (e.g., forms and behaviors; Dubé & Anctil, 2020). Noteworthy, the influence of gender differences and personality profiles is already perceptible in the design of certain sex robots and virtual partners (e.g., Harmony; Realbotix, 2022). Granted that, these findings also invite the development of more diversified erobots (Dubé & Anctil, 2020)—especially, considering that this diversity may generate more favorable views of erotic machines from non-men (Oleksy & Wnuk, 2021).

In sum, Chapters 3-5 contribute to theory and research by showing that the sociocultural, individual, and situational factors associated with different levels of the HEICEM may differentially influence people's willingness to engage with erobots. Specifically, in a world where the use of erobots is stigmatized, erotophilic sexual sensation seekers and people who are sexually aroused seem more likely to engage erotically with robot. In turn, this may affect the way we interact and co-evolve with such erotic systems. Yet, these studies and findings are not without limitations.

3. Main limitations

One main limitation of this dissertation is that advanced erobots are not yet widespread. Sex robots remain rare, expensive, and unsophisticated, which prevented their use in our studies (Döring, 2021). Thus, participants had to rely on information (if any) gathered from media or other sources to form their attitudes toward erobots (Döring & Pöschl, 2019). The scarcity of erobots also makes it difficult to appreciate their true impact on our eroticism and the growing influence that they may have in the future once they become more prevalent in human lives and intimate relationships. Nonetheless, given the globalization of the sextech industry, along with the advent new artificially intelligent autonomous erotic systems, technology-based sexualities, and the metaverse, we argue that we must develop erobotics now to better address the changing landscape of our eroticism tomorrow (Dubé et al., 2021b; Dubé et al., 2022b; Dubé & Anctil, 2020; Rubin, 2018).

Other limitations of this dissertation include the cross-sectional natures of its studies, the use of convenience samples (i.e., mostly composed of White, Educated, Industrialized, Rich, and Democratic [WEIRD] individuals and Psychology students at Concordia University; Rad et al., 2018), and the self-selection bias that may have influenced who partook in its sexuality- and technology-related research projects (e.g., potentially, more sextech-positive individuals; Bethlehem, 2010). This dissertation is also limited by the current lack of psychometrically validated measures adapted to erobotics (e.g., stigma, willingness to engage [erotically] with erobots, or perceive appropriateness of using [sex] robots). Moreover, the studies included in this dissertation used self-report measures, which are constrained by participants' memory, self-assessment quality, and social-desirability bias (Dubé et al., 2022a; Lehmiller, 2017). These studies also used prospective questions about hypothetical willingness to engage with erobots, which may not accurately reveal people's true behaviors in real-life situations (Dubé et al., 2022a; Skakoon-Sparling et al., 2016). Lastly, like the other studies, the experimental paradigm of Chapter 5 was conducted online. This makes it difficult to know whether participants focused on the sexually explicit videos: stimuli that likely differ from the real-world interaction that people may someday have with erobots (Dubé et al., 2022a).

Ultimately, the studies included in this dissertation do not assess the potential interactions between sociocultural, individual, and situational factors. These studies also focus on one side of the human-erobot interaction and co-evolution process in order to initially establish whether

there exists a relationship between stigma, personality traits, sexual arousal, and people's willingness to engage with erobots. They do not explore how such factors may in turn influence erobots, nor their retroactive influence on said factors and the other layers of the HEICEIM. Taken together with the other limitations, this points to several future research directions.

4. Future directions

4.1. Future research related to Chapters 3-5

The future research on erobotics is as vast as human-machine interaction and sexology can be. Regarding Chapter 3, future research should explore the other dimensions of the stigma associated erotic technology use (e.g., internalized, enacted, instrumental, and symbolic), along with their impact on health, well-being, and engagement with sex toys, erobots, and dolls (Dubé et al., 2022b). This research should also refine the gradient of erotic technologies and use concrete stimuli—such as images, videos, or computer-generated characters—to test whether the UVH applies to the continuum of humanlike erobots (MacDorman & Ishiguro, 2006; Mori, 1970, 2012).

Regarding Chapter 4, future research on personality and erobotics should examine the potential relations between the traits included in our study and other individual characteristics that may be closely related to robots. This includes anthropomorphism tendencies, Frankenstein Syndrome, and negative attitudes toward robots (Syrdal et al., 2013; Szczuka & Krämer, 2017a, 2017b). This research should also investigate whether the findings from Chapter 4 yield different cognitive or psychophysiological responses toward humans and erobots (e.g., subjective, attentional, and genital).

Regarding Chapter 5, future research on erobotics, sexual arousal, and decision-making should attempt to replicate the findings of our study in laboratory settings. It should also expand our experimental paradigm by employing objective measures of attention and sexual arousal. This includes, for instance, eye-tracking and genital thermography (Chivers et al., 2010; Wenzlaff et al., 2016).

Given the rapid development of sex robots, future research related to Chapters 3-5 should investigate—qualitatively and quantitatively—the underlying reasons motivating people to desire such artificial partners, and their potential relations to the factors studied in the empirical articles of this thesis (Dubé & Anctil, 2020). This research should also begin to investigate the other

sides of the human-erobot interaction and co-evolution process. For instance, it may examine how stigma, personality traits, sexual arousal, and gender differences influence the design and capabilities of erobots (e.g., current virtual partners and sex robots). It may also examine the retroactive influence that the design and capabilities of erobots may have on sociocultural, individual, and situational factors, and the different layers of the HEICEM.

4.2. Future research related to erobotics

More broadly, future research on erobotics should, whenever possible, integrate erobots into their studies and experimental paradigms (Dubé et al., 2022a; Jacobs et al., 2021). For example, studies may incorporate robots, chatbots, or VR and AR stimulations depicting erotic partners in their experiments to assess reactions toward them. These studies may also use erobots as research tools (Dubé et al., 2022a). This could improve the ecological validity of experimental paradigms in sex research, and allow researchers to safely test the influence of various sexological variables on human eroticism and well-being, in- and outside laboratories (see Dubé et al., 2022a for details). Notably, in the absence of erobots, researchers could also design studies that manipulate people's perception of whether they are engaging with humans or machines (e.g., an Interpersonal Closeness Generation task with a human-controlled avatar that people believe is either controlled by a human or an artificial intelligence; Martin et al., 2019).

Future research on erobotics should develop and test the efficacy of erobots for therapy. For example, studies may examine whether virtual partners can elicit clinical symptoms in populations with sexual dysfunctions or difficulties (e.g., fear responses in individuals with sexual aversion; Lafortune et al., 2022). Then, using exposure therapy, researchers may use erobots with varying characteristics and behavioral capabilities to extinguish said symptoms, and improve people's well-being (Lafortune et al., 2022).

Similar technologies could also be employed to deliver personalized and interactive sex education on a large scale. Studies could then assess the reach of such educational programs, and their efficacy in preventing unwanted pregnancies and STBBIs, as well as in improving sexual and relationship satisfactions (Dubé & Anctil, 2020; Jacquerye, 2020). To make this possible, however, partnerships between academia, industries, and governments are needed (Dubé & Anctil, 2020).

Beyond that, future research on erobotics should explore the phenomena described in this dissertation in more representative samples across cultures, and in different demographic groups

(Dubé et al., 2021b; Gesselman et al., 2022). For instance, researchers may compare the prevalence of interest and use of erobots between countries, such as Canada/United States and Japan/China. They may also compare the responses of different groups, such as LGBTQA2S+ communities and individuals, people of color, differently abled persons, people of diverse socioeconomic status, and their intersections, with each other and with that of abled, middle-class, cisgender, heterosexual, white men. Such responses could also be compared to that of people who have technology-based sexualities; that is, those who consider that technology is a meaningful part of their erotic life, or a significant object toward which their eroticism is directed (Dubé et al., 2021b). This may range from people who consider that their use of pornography, sex toys, or dating applications is an important part of their intimate lives, to people who have relationships with dolls, those who maintain computer-enabled long-distance partnerships, or individuals who love robots (Dubé et al., 2021b).

Moreover, such phenomena should be studied longitudinally in order to assess the impact of time, and account for how changing circumstances may affect human-erobot interaction and co-evolution. For instance, attitudes toward human-machine intimacy may change as populations age, fertility rates fluctuate, new technologies emerge, a global pandemic requires confinement, and space exploration lead some people to live apart for extended periods of time (Dubé & Anctil, 2020; Dubé et al., 2021a). Such events may lead people to re-evaluate the usefulness of erobots for themselves and others—especially, as erobotic technologies continue to occupy a growing place in our eroticism (Dubé & Anctil, 2020).

To do so, however, researchers must first develop psychometrically validated measures for erobotics—including, new scales, behavioral tasks, and objective measures with(out) erobots. This may require, for instance, a series of studies assessing the internal reliability and external validity of existing scales adapted to erobotic technologies (e.g., a Godspeed Questionnaire adapted for virtual partners or sex robots; Bartneck et al., 2009), as well as the development of new measures. This may be accomplished through an iterative process of theoretical research, qualitative work (e.g., interviews), and quantitative studies (e.g., online surveys and in-laboratory experiments) aimed at building and assessing the internal structure of the new scales, their test-retest reliability, as well as whether they predict behaviors and responses toward humans and erobots. This may also require the development of erobots specifically designed for research, which can act as measurement apparatus and help test the new scales (see Dubé et al., 2022a).

The development of erobotics-related measures is a crucial step in testing the HEICEM. For example, at the microsystem level, researchers may use these new measures—in combination with other methods used in biopsychosocial and sexological research—to examine whether positive or negative interactions with artificial partners influence subsequent approach-avoidance behaviors toward erobots. At the exosystem level, researchers may use them to examine the influence of media exposure and representations on attitudes toward human-machine intimacy and sexuality (Döring & Pöschl, 2019). At the macrosystem level, researchers may use such measures to investigate how patriarchal norms or religious beliefs may affect the design of and our interactions with erobotic technologies. Lastly, at the meso- and chronosystem levels, researchers may use new erobotics-related measures in longitudinal designs to assess how the various phenomena described in this thesis interact and change over time.

Granted that, future research on erobotics should go beyond robotic companions, and explore other types of erobots. This research should examine, for instance, how interconnected augmented and virtual erobots reshape our ecological niche, offer new erotic experiences, and co-evolve with us. This includes autonomous intelligent erotic systems that may not be perceived as intimate partners, but still learn and influence our eroticism (e.g., AI matchmaking systems and the algorithms that are used in dating applications; Dubé & Anctil, 2020). This research should also further examine the SEA, and how varying levels of agency reshape our relationships with erotic systems (Dubé & Anctil, 2020). For one, researchers may explore whether increasing levels of intimate or sexual capabilities influence people's willingness to engage erotically with virtual partners. As a complement, future research should further explore the EMAS process. This may be accomplished by examining how AI-powered dating applications and intelligent matchmaking systems influence our partner selection, sexual preferences, relationships with humans and erobots, and whether or how we have children (Dubé & Anctil, 2020).

In the end, these are just a few key future research directions that may help to bridge some of the limitations of this dissertation and further erobotics as scientific discipline and field of research. It is worth noting, however, that to validate the HEICEM and its usefulness, researchers may need to put into place a structure to triangulate the studies related to erobotics and this model (e.g., a website or an interactive archive), and modify it as findings accumulate. This will hopefully yield knowledge that benefit humanity as we continue to integrate technology into our intimacy and sexuality.

5. Conclusion

The never-ending sexual revolution has led to the emergence of erobots. The study of our co-existence with these artificial erotic agents has just begun. This dissertation founded erobotics, proposed a model of human-machine erotic interaction and co-evolution, and suggested a sextech-positive path to designing beneficial erobots that may enhance human well-being through their potential future applications. This dissertation also empirically investigated some of the interrelated factors that may influence people's willingness to engage with erobots in the hopes of both refining our model and better understanding our relationships with new erotic systems.

But ultimately, this dissertation only represents an initial foray into the broader realm of erobotics: a small fraction of the work that must be done to understand the past, present, and future of our interaction and co-evolution with erotic technologies. It is thus the hope of this author and his collaborators that other researchers across disciplines will use the ideas presented in this dissertation and bring their own perspective to improve and expand the science of erobotics. The importance of this research cannot be overstated. It is proportional to the place that technology may occupy in our intimacy and sexuality, and the co-construction of erobotic technologies with our eroticism.

In closing: Erobotics now exists. Its concepts, frameworks, and objectives are inscribed in the theoretical and empirical literature. The paths laid down by this new scientific discipline and field of research will hopefully provide useful knowledge—about us, our eroticism, and our technology-mediated world—which will in turn enhance happiness and well-being. It is not lost on us, however, that this knowledge will be continuously, irreversibly transformed by this field's own discoveries. Thus, we can only hope that erobotics—changed by its own existence and technologies—will remain able to uphold its progressive, eudemonist, and utopian goals, and allow the flourishing of our erotic species.

"Where we go from there is a choice I leave to you."
Neo, The Matrix (Wachowski & Wachowski, 1999)

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SUPPLEMENTAL MATERIALS

APPENDIX A: SUPPLEMENTAL MATERIAL CHAPTER 3

Demographic questionnaire

What is your age?

What is your current gender identity? Select all that apply.

Woman [ ]
Man [ ]
Transgender [ ]
Transgender woman [ ]
Transgender man [ ]
Genderqueer/gender non-conforming [ ]
Non-binary [ ]
Other [ ]. Please describe:_____

What sex were you assigned at birth, meaning on your original birth certificate?

Male [ ]
Female [ ]
Intersex [ ]

How do you define your biological sex? Select all that apply.

Male [ ]
Female [ ]
Intersex [ ]
I don't define my biological sex [ ]
Other [ ]. Please describe:_____

What is your race or ethnic group?

White or Causasian [ ]
Hispanic, Latino or Spanish [ ]
Black or African American [ ]
Asian [ ]
Middle Eastern [ ]
Native American or Alaska Native [ ]
Native Hawaiian or other Pacific Islanders [ ]
Other [ ]. Please describe:_____

What is your religion?

Baptist [ ]
Buddhism [ ]
Catholicism [ ]
Protestantism [ ]
Christianity (no denomination) [ ]

Eastern Orthodox Church [ ]
Hinduism []
Mormonism [ ]
Islam [ ]
Paganism [ ]
Agnosticism [ ]
Atheism [ ]
Prefer not to say [ ]
Other [ ]. Please describe:_____

How religious would you describe yourself? Please select the option that applies.
0 N/A [ ] – 1 Very low [ ] – 2 Low [ ] – 3 Moderate [ ] – 4 High [ ] – 5 Very high [ ]

Education (Achieved / In progess):
High school (not finished) [ ]
High school diploma (DES) [ ]
Professional diploma (DEP) [ ]
CEGEP diploma (DEC) [ ]
University undergraduate degree (Bachelor's) [ ]
University graduate degree (master's, PhD, doctorate) [ ]

In what range is your annual income?
$0 - $10 000 [ ]
$10 001 – $20 000 [ ]
$20 001 – $30 000 [ ]
$30 001 – $40 000 [ ]
$40 001 – $50 000 [ ]
$50 001 – $60 000 [ ]
$60 001 – $70 000 [ ]
$70 001 – $80 000 [ ]
$80 001 – $90 000 [ ]
$90 001 – $100 000 [ ]
$100 001 – $110 000 [ ]
$110 001 and more [ ]

How do you define your sexual orientation? Select all that apply.
Heterosexual/straight (emotional, romantic, and/or sexual attraction to people of the opposite sex, gender, or gender identity) [ ]
Bisexual (equivalent/more or less equivalent emotional, romantic, and/or sexual attraction to more than one sex, gender, or gender identity) [ ]
Gay (emotional, romantic, and/or sexual attraction to people of the same gender, in this case men) [ ]
Lesbian (emotional, romantic, and/or sexual attraction to people of the same gender, in this case women) [ ]
Queer (having a fluid sexual orientation) [ ]

Pansexual (emotional, romantic, and/or sexual attraction to people of all sexes and gender identities) [ ]

Asexual (i.e. no socio-sexual contacts or reactions) [ ]

BDSM [ ]

Agalmatophilia (emotional, romantic, and/or sexual attraction to statue(s), doll(s), mannequin(s) or other similar figurative object(s)) [ ]

Objectophilia (emotional, romantic, and/or sexual attraction to inanimate object(s)) [ ]

Botsexual (emotional, romantic, and/or sexual attraction to erotic/sexual artificial entity(ies) (e.g., sex robot, sexual virtual reality character, erotic chatbot, erotic/sexual application or computer program) [ ]

Mechanophilia (emotional, romantic, and/or sexual attraction to machines (e.g., bicycles, motor vehicles, helicopters, ships, and aeroplanes) [ ]

I don't feel I belong to any sexual orientation [ ]

Questioning (currently exploring my sexual orientation) [ ]

Other [ ]. Please describe:_____

What do you consider to be your main sexual identity? Select all that apply.

Heterosexual/straight [ ]

Bisexual [ ]

Gay [ ]

Lesbian [ ]

Transgender [ ]

Transsexual [ ]

Queer [ ]

Pansexual]

Polyamorous/non-monogamous [ ]

Swinger [ ]

Asexual [ ]

BDSM [ ]

Agalmatosexual (primary sexual identity comes through the use of statue(s), doll(s), mannequin(s) or other similar figurative object(s)) [ ]

Objectosexual (primary sexual identity comes through the use of inanimate object(s)) [ ]

Botsexual (primary sexual identity comes through the use of erotic/sexual artificial entity(ies) such as sex robot, sexual virtual reality character, erotic chatbot, erotic/sexual application or computer program) [ ]

Mechanosexual (primary sexual identity comes through the use of machines such as bicycles, motor vehicles, helicopters, ships, and aeroplanes) [ ]

Digisexual (primary sexual identity comes through the use of technology) [ ]

I feel I don't define my sexual identity. [ ]

Other [ ]. Please describe:_____

Explanatory Model Interview Catalogue (EMIC) adapted to erotic technologies

Instructions.

For each question below, please mark which statement is true: Yes, Possibly, No, or I Don't Know.

Before answering each scale, technologies were defined for participants as follow:

- Sex toys: Any objects or devices used for sexual stimulation, release, and/or pleasure.
- Erotic chatbot: A computer program designed to simulate erotic, sexual, and/or romantic conversations with human users.
- Erotic virtual partner: A software-generated audio-visual character with whom you can erotically, sexually, and/or romantically interact through devices such as smart phones, computers, gaming consoles, etc.
- Sex robot: Any artificial entity that is used for sexual purposes (i.e., for sexual stimulation and release) that meets the following three conditions: Humanoid form: It is intended to represent (and is taken to represent) a human or human-like being in its appearance. Human-like movement/behaviors: It is intended to represent (and is taken to represent) a human or human-like being in its behaviors and movements. Some degree of artificial intelligence: It is capable of interpreting and responding to information in its environment. This may be minimal (e.g., simple preprogrammed behavioral responses) or more sophisticated (e.g., human-equivalent intelligence).

#	Items
1	Would a person using a(n) **[insert technology]** keep others from knowing, if possible?
2	If a member of your family used a(n) **[insert technology]**, would you think less of yourself, because of this *person's behavior?*
3	In your community, do a(n) **[insert technology]** users cause shame or embarrassment?
4	Would others think less of this person for using a(n) **[insert technology]**?
5	Would knowing that this person uses a(n) **[insert technology]** have an adverse effect on others?
6	Would other people in your community avoid a person using a(n) **[insert technology]**?
7	Would others refuse to visit the home of a person using a(n) **[insert technology]**?
8	Would people in your community think less of the family of a person using a(n) **[insert technology]**?
9	Would using a(n) **[insert technology]** cause problems for the family?
10	Would a family have concern about disclosure if one of their members uses a(n) **[insert technology]**?
11	Would using a(n) **[insert technology]** be a problem for a person to get married or in a relationship?
12	Would using a(n) **[insert technology]** cause problems in an on-going marriage or relationship?
13	Would using a(n) **[insert technology]** cause a problem for a relative of that person to get married or in a relationship?
14	Would using a(n) **[insert technology]** cause a problem for a person to find work?
15	Would people dislike buying food from a person using a(n) **[insert technology]**?

Note. Scoring: Yes = 2 , Possibly = 1, No = 0, and I don't know = 0 (Peters et al., 2014).

Erotic technology engagement questionnaire

#	Items (Yes/No)
1	Would you try a sex toy?
2	Would you use a sex toy on a regular basis?
3	Would you try an erotic chatbot?
4	Would you use an erotic chatbot on a regular basis?
5	Would you try an erotic virtual partner?
6	Would you use an erotic virtual partner on a regular basis?
7	Would you try a sex robot?
8	Would you use a sex robot on a regular basis?

Note. Scoring: Yes = 1 and No = 0

Psychometric properties of the adapted EMIC scales

To determine the optimal number of factors and establish the homogeneity of each scale, items were first inspected for low average inter-item correlations (less than .20). Average inter-item correlations were moderate for all items across EMIC scales (Ms = .21-.59, SDs = .06-.20), with the exception of items 1 and 2 on the EMIC scale adapted for sex toys (Item 1: M = .13, SD = .05; Item 2: M = .12, SD = .06). However, these two items were retained to be consistent with the original scale and with the other three EMIC scales in which these items exhibited higher average inter-item correlations (Item 1: Ms = .26-.33, SDs = .08-.10; Item 2: Ms = .29-.38, SDs = .06-.08). Next, exploratory factor analyses were conducted using principal axis factoring with a promax rotation. Parallel analyses and Velicer's Map Tests were also conducted. Together, the inspection of scree plot elbows, the parallel analyses, and the Velicer's Map Tests suggests a 1-factor structure for each of the four new EMIC scales adapted to sex toys, erotic chatbots, virtual partners, and sex robots. Eigenvalues for the first factor of each of these new scales were respectively: 5.67, 8.02, 6.91, and 6.44, explaining 38%, 53%, 46%, and 43% of the variance in each scale. The new EMIC scales adapted to sex toys, erotic chatbots, erotic virtual partners, and sex robots all showed good to excellent internal reliability at each time point, with respective Cronbach's alphas of .87, .94, .91, and .90 at Time 1, and .92, .94, .93, .90 at Time 2. These scales also showed high test-retest reliability after at least 30 days (i.e., respectively, r = .71, .78, .74. and .71; $p < .001$ for each). See Table 2 for correlations.

Table 1. Demographics of the samples at times 1 and 2.

Variables	Time 1		Time 2	
	Frequency	Valid %	Frequency	Valid %
Gender				
Woman	232	66.10	84	68.85
Man	93	26.50	33	27.05
Transgender, genderqueer/gender non-conforming, and/or non-binary	26	7.40	5	0.04
Ethnicity				
White or Caucasian	233	66.20	92	75.41
Asian	37	10.50	7	5.74
Mixed or Metis	35	9.90	11	9.02
Hispanic, Latino or Spanish	16	4.50	4	3.28
Middle-Eastern	14	4.00	5	4.10
Black or African American	11	3.10	1	0.82
Native American or Alaska Native	2	0.60	1	0.82
Other	4	1.20	1	0.82
Education (highest level achieved)				
Bachelor's degree (in progress)	164	46.72	50	40.98
Bachelor's degree (diploma)	68	19.37	25	20.49
Master's degree/Doctorate (in progress)	39	11.11	12	9.84
Master's degree/Doctorate (diploma)	45	12.82	18	14.75
High school (not finished)	2	0.57	0	0.00
High school (diploma)	13	3.70	8	6.56
CEGEP (in progress)	2	0.57	1	0.82
CEGEP (diploma)	9	2.56	3	2.46
Professional degree (in progress)	3	0.85	1	0.82
Professional degree (diploma)	6	1.71	4	3.28
Income				
$0 - 10 000	146	41.48	44	36.07
$10 001 - 20 000	81	23.01	28	22.95
$20 001 - 30 000	31	8.81	13	10.66
$30 001 - 40 000	22	6.25	6	4.92
$40 001 - 50 000	20	5.68	6	4.92
$50 001 - 60 000	10	2.84	7	5.74
$60 001 - 70 000	9	2.56	4	3.28
$70 001 - 80 000	4	1.14	0	0.00
$80 001 - 90 000	3	0.85	2	1.64
$90 001 - 100 000	6	1.70	3	2.46

$100 001 - 110 000	4	1.14	2	1.64
$110 001 ≤	16	4.55	7	5.74
Religiosity				
0 (not applicable)	110	31.16	45	36.89
1 (Very low)	101	28.61	32	26.23
2	54	15.30	17	13.93
3 (Moderate)	59	16.71	16	13.11
4	24	6.80	10	8.20
5 (Very high)	5	1.42	2	1.64

Table 2. Correlations between main variables.

	Variables	Time 1 (T1)						Time 2 (T2)						Test-Retest (T1 - T2)
		EMICs				Demographics		EMICs				Demographics		
		ST	EC	EVP	SR	Age	Gender	ST	EC	EVP	SR	Age	Gender	
Perceived stigma (EMICs)	Sex toy (ST)	(.87)				-.08	.02	(.92)				-.01	.15	.71**
	Erotic chatbot (EC)	.55**	(.94)			-.03	-.01	.66**	(.94)			.09	.22*	.78**
	Erotic virtual partner (EVP)	.50**	.82**	(.91)		-.08	-.00	.68**	.83**	(.93)		.04	.13	.74**
	Sex robot (SR)	.56**	.61**	.70**	(.90)	-.15**	.03	.69**	.70**	.76**	(.90)	-.02	.20*	.71**
Would you try a(n) [...]?														
	Sex toy	-.23**	-.20**	-.20**	-.15*	.03	-.01	-.36**	-.33**	-.34**	-.30**	.12	-.05	.66**
	Erotic chatbot	-.01	-.13	-.13*	-.04	.20**	.14*	-.02	-.15	-.12	-.07	.17	.03	.66**
	Erotic virtual partner	.07	-.09	-.14*	-.12	.28**	.29**	-.03	-.24*	-.24*	-.16	23*	.23*	.73**
	Sex robot	-.07	-.07	-.08	-.18**	.30**	.32**	-.01	-.04	-.08	-.16	.32**	.38**	.75**
Would you use a(n) [...] on a regular basis?														
	Sex toy	-.24**	-.10	-.15*	-.15*	.12*	-.07	-.18	-.08	-.17	-.17	.09	-.14	.73**
	Erotic chatbot	.02	-.03	-.05	.02	.27**	.25**	-.08	-.15	-.11	-.17	.29**	.03	.54**
	Erotic virtual partner	-.04	-.06	-.15*	-.04	.44**	.29**	-.02	-.10	-.13	-.09	.27**	.13	.57**
	Sex robot	.01	.03	-.05	-.06	.47**	.37**	.13	.13	-.05	-.02	.35**	.25*	.61**

Note. *p < .05, **p < .01. The parentheses represent the Cronbach's alphas.

APPENDIX B: SUPPLEMENTAL MATERIAL CHAPTER 4

Demographic questionnaire

What is your age?

What is your current gender identity? Select all that apply.

Woman [ ]
Man [ ]
Transgender [ ]
Transgender woman [ ]
Transgender man [ ]
Genderqueer/gender non-conforming [ ]
Non-binary [ ]
Other [ ]. Please describe:_____

What sex were you assigned at birth, meaning on your original birth certificate?

Male [ ]
Female [ ]
Intersex [ ]

How do you define your biological sex? Select all that apply.

Male [ ]
Female [ ]
Intersex [ ]
I don't define my biological sex [ ]
Other [ ]. Please describe:_____

What is your race or ethnic group?

White or Causasian [ ]
Hispanic, Latino or Spanish [ ]
Black or African American [ ]
Asian [ ]
Middle Eastern [ ]
Native American or Alaska Native [ ]
Native Hawaiian or other Pacific Islanders [ ]
Other [ ]. Please describe:_____

What is your religion?

Baptist [ ]
Buddhism [ ]
Catholicism [ ]
Protestantism [ ]
Christianity (no denomination) [ ]
Eastern Orthodox Church [ ]

Hinduism []
Mormonism [ ]
Islam [ ]
Paganism [ ]
Agnosticism [ ]
Atheism [ ]
Prefer not to say [ ]
Other [ ]. Please describe:_____

How religious would you describe yourself? Please select the option that applies.
0 N/A [ ] – 1 Very low [ ] – 2 Low [ ] – 3 Moderate [ ] – 4 High [ ] – 5 Very high [ ]

Education (Achieved / In progess):
High school (not finished) [ ]
High school diploma (DES) [ ]
Professional diploma (DEP) [ ]
CEGEP diploma (DEC) [ ]
University undergraduate degree (Bachelor's) [ ]
University graduate degree (master's, PhD, doctorate) [ ]

In what range is your annual income?
$0 - $10 000 [ ]
$10 001 – $20 000 [ ]
$20 001 – $30 000 [ ]
$30 001 – $40 000 [ ]
$40 001 – $50 000 [ ]
$50 001 – $60 000 [ ]
$60 001 – $70 000 [ ]
$70 001 – $80 000 [ ]
$80 001 – $90 000 [ ]
$90 001 – $100 000 [ ]
$100 001 – $110 000 [ ]
$110 001 and more [ ]

How do you define your sexual orientation? Select all that apply.
Heterosexual/straight (emotional, romantic, and/or sexual attraction to people of the opposite sex, gender, or gender identity) [ ]
Bisexual (equivalent/more or less equivalent emotional, romantic, and/or sexual attraction to more than one sex, gender, or gender identity) [ ]
Gay (emotional, romantic, and/or sexual attraction to people of the same gender, in this case men) [ ]
Lesbian (emotional, romantic, and/or sexual attraction to people of the same gender, in this case women) [ ]
Queer (having a fluid sexual orientation) [ ]

Pansexual (emotional, romantic, and/or sexual attraction to people of all sexes and gender identities) [ ]

Asexual (i.e. no socio-sexual contacts or reactions) [ ]

BDSM [ ]

Agalmatophilia (emotional, romantic, and/or sexual attraction to statue(s), doll(s), mannequin(s) or other similar figurative object(s)) [ ]

Objectophilia (emotional, romantic, and/or sexual attraction to inanimate object(s)) [ ]

Botsexual (emotional, romantic, and/or sexual attraction to erotic/sexual artificial entity(ies) (e.g., sex robot, sexual virtual reality character, erotic chatbot, erotic/sexual application or computer program) [ ]

Mechanophilia (emotional, romantic, and/or sexual attraction to machines (e.g., bicycles, motor vehicles, helicopters, ships, and aeroplanes) [ ]

I don't feel I belong to any sexual orientation [ ]

Questioning (currently exploring my sexual orientation) [ ]

Other [ ]. Please describe:_____

What do you consider to be your main sexual identity? Select all that apply.

Heterosexual/straight [ ]

Bisexual [ ]

Gay [ ]

Lesbian [ ]

Transgender [ ]

Transsexual [ ]

Queer [ ]

Pansexual]

Polyamorous/non-monogamous [ ]

Swinger [ ]

Asexual [ ]

BDSM [ ]

Agalmatosexual (primary sexual identity comes through the use of statue(s), doll(s), mannequin(s) or other similar figurative object(s)) [ ]

Objectosexual (primary sexual identity comes through the use of inanimate object(s)) [ ]

Botsexual (primary sexual identity comes through the use of erotic/sexual artificial entity(ies) such as sex robot, sexual virtual reality character, erotic chatbot, erotic/sexual application or computer program) [ ]

Mechanosexual (primary sexual identity comes through the use of machines such as bicycles, motor vehicles, helicopters, ships, and aeroplanes) [ ]

Digisexual (primary sexual identity comes through the use of technology) [ ]

I feel I don't define my sexual identity. [ ]

Other [ ]. Please describe:_____

Mini International Personality Item Pool

Donnellan, Oswald, Baird, & Lucas (2006).

For each statement, select the number that best applies to you.

1 (Very inaccurate) to 5 (Very accurate)

1. I am the life of the party.
2. I sympathize with others' feelings.
3. I get chores done right away.
4. I have frequent mood swings.
5. I have a vivid imagination.
6. I don't talk a lot.
7. I am not interested in other people's problems.
8. I often forget to put things back in their proper place.
9. I am relaxed most of the time.
10. I am not interested in abstract ideas.
11. I talk to a lot of different people at parties.
12. I feel others' emotions.
13. I like order.
14. I get upset easily.
15. I have difficulty understanding abstract ideas.
16. I keep in the background.
17. I am not really interested in others.
18. I make a mess of things.
19. I seldom feel blue.
20. I do not have a good imagination.

Sexual Opinion Survey

Fisher, Byrne, White, & Kelley (1988)

Please respond to each item as honestly as you can. There are no right and wrong answers, and your answers will be completely anonymous.

1 (Strongly disagree) to 7 (Strongly agree)

1. I think it would be very entertaining to look at hard-core pornography.
2. Pornography is obviously filthy and people should not try to describe it as anything else.
3. Swimming in the nude with a member of the opposite sex would be an exciting experience.
4. Masturbation can be an exciting experience.
5. If I found that a close friend of mine was a homosexual, it would annoy me.
6. If people thought I was interested in oral sex, I would be embarrassed.
7. Engaging in group sex is an entertaining idea.
8. I personally find that thinking about engaging in sexual intercourse is arousing.
9. Seeing a pornographic movie would be sexually arousing to me.
10. Thoughts that I may have homosexual tendencies would not worry me at all.
11. The idea of my being physically attracted to members of the same sex is not depressing.
12. Almost all pornographic material is nauseating.
13. It would be emotionally upsetting to me to see someone exposing themselves publicly.
14. Watching a stripper of the opposite sex would not be very exciting.
15. I would not enjoy seeing a pornographic movie.
16. When I think about seeing pictures showing someone of the same sex as myself masturbating, it nauseates me.
17. The thought of engaging in unusual sex practices is highly arousing.
18. Manipulating my genitals would probably be an arousing experience.
19. I do not enjoy daydreaming about sexual matters.
20. I am not curious about explicit pornography.
21. The thought of having long-term sexual relations with more than one sex partner is not disgusting to me.

Technophilia-Technophobia Scale

Martinez-Corcoles, Teichmann, & Murdvee (2017)

Please, check to what extent **you agree/ disagree** with the following statements:

1 (Completely disagree) - 2 (Somewhat disagree) - 3 (Partly agree, partly disagree) - 4 (Somewhat agree) - 5 (Completely agree)

1. I feel an irrational fear of new equipment or technology.
2. I avoid the use of new equipment and technology.
3. I feel uncomfortable when I use new equipment or technology.
4. I find it difficult to complete computerized tasks.
5. I find it very difficult to learn about how to use new technology.
6. I feel incompetent because I don't like to use new equipment or technology.
7. I'm resistant to back up hard drives or organize files in my computer.
8. I feel unskilled for the use of new equipment or technology.
9. I feel excessive sweating while working with new equipment or technology.
10. I feel heart palpitations while working with new equipment or technology.
11. I feel anxious while working with new equipment or technology.
12. I feel forced to change my way of working because of new equipment or technology.
13. I am excited for new equipment or technology.
14. I'm afraid of being left behind if I cannot use the latest equipment or technology.
15. I enjoy using new equipment or technology.
16. The use of new equipment or technology influences considerably my personal life.
17. I think that new technology has a lot of benefits.
18. My experience with all the new technologies is positive.
19. The use of new equipment or technology influences considerably my personal feelings.
20. I feel fear of being left behind if I can't use the latest equipment or technology.
21. I have recently acquired new technology.
22. I feel loss of control if I can't use the latest equipment or technology.
23. I believe that new technology improves life.
24. The use of new equipment or technology affects my intimacy.
25. Lately, I have used new equipment or technology too frequently.
26. I feel enthusiasm for new equipment or technology due to its novel value.
27. I feel restless and worried if I can't use my computer or smartphone/mobilephone.
28. I feel enthusiasm when a new technology/product is launched.
29. I'm afraid of failing if I can't use the latest equipment or technology.
30. I have spent more time using new equipment or technology than is reasonable.

Brief Sensation Seeking Scale

Hoyle, Stephenson, Palmgreen, Lorch, & Donohew (2002).

A number of statements that some people have used to describe themselves are given below. Read each statement and then select the number to show how well you believe the statement describes you.

1 (Strongly disagree) to 5 (Strongly agree)

1. I would like to explore strange places.
2. I would like to take off on a trip with no pre-planned routes or timetables.
3. I like to do frightening things.
4. I would like to try parachute-jumping.
5. I like wild parties.
6. I like new and exciting experiences, even if I have to break the rules.
7. I get restless when I spend too much time at home.
8. I prefer friends who are excitingly unpredictable.

Sexual Sensation Seeking Scale

Kalichman & Rompa (1995)

1 (Not at all like me) to 4 (Very much like me)

1. I like wild "uninhibited" sexual encounters.
2. The physical sensations are the most important thing about having sex.
3. I enjoy the sensation of intercourse without a condom.
4. My sexual partners probably think I am a "risk taker".
5. When it comes to sex, physical attraction is more important to me than how well I know the person.
6. I enjoy the company of "sensual" people.
7. I enjoy watching "X-rated" videos.
8. I have said things that were not exactly true to get a person to have sex with me.
9. I am interested in trying out new sexual experiences.
10. I feel like exploring my sexuality.
11. I like to have new and exciting sexual experiences and sensations.

Instructions

This questionnaire is intended to examine your attitudes, beliefs, and opinions regarding robots in general, and sex robots, an emerging technology that has received intense media coverage over the last decade. Context: A sex robot is generally defined by Danaher (2014) as: "[…] any artificial entity that is used for sexual purposes (i.e., for sexual stimulation and release) that meets the following three conditions:

> Humanoid form, i.e., it is intended to represent (and is taken to represent) a human or human-like being in its appearance.
>
> Human-like movement/behavior, i.e., it is intended to represent (and is taken to represent) a human or human-like being in its behaviors and movements.
>
> Some degree of artificial intelligence, i.e., it is capable of interpreting and responding to information in its environment. This may be minimal (e.g., simple preprogrammed behavioral responses) or more sophisticated (e.g., human-equivalent intelligence)."

Although this definition can be broadened (e.g., the form these robots could potentially be different and their level of intelligence could vary in terms of sophistication), it captures the essence of what is at the core of current social, political, and ethical debates.

With that in mind, please answer the following lists of questions. There are no right or wrong answer, so please answer honestly. Some questions relate to robots in general, where others relate specifically to sex robots. Note that sex robots are not currently widespread, but some questions assume a future where they could be widespread and accessible, and ask you about your attitudes, beliefs, and opinions in that context (e.g., ''Would you try a sex robot?'' assumes a context where sex robots would be accessible to you).

Willingness to engage with (sex) robots

0 (not at all) to 5 (definitely)

Would you try a sex robot?

Would you use a sex robot on a regular basis?

Do you think you could fall in love with a robot?

Would you have a non-sexual robot?

Perceived appropriateness of using sex robots questionnaire

Based on Scheutz & Arnold (2016)

1 (completely inappropriate) to 7 (completely appropriate)

Would it be appropriate [...]

to have sex with a robot?

to love a robot?

to marry a robot?

to damage a robot? (*Removed)

to use sex robots instead of cheating on a partner?

to use sex robots instead of paying for sexual services provided by a human (i.e., a type of sex work also known as 'prostitution')?

to use sex robots instead of other forms of sex work (e.g., escorts or sugar babies)?

to use sex robots for sex education?

to use sex robots for people with disabilities?

to use sex robots to improve self-esteem and overall psychological health?

to use sex robots for group sex such as mixed human-robot group sex?

to use sex robots to engage in unconventional sex practices such as rough sex or sadistic behaviour?

to use sex robots to keep your relationship with a human partner alive?

to use sex robots in isolated environments (i.e., where human partners are not available)?

to use sex robots to reduce the risk of sexually transmitted or blood-borne infections (STBBIs)?

to use sex robots to help victims of sexual trauma regain control of their life and sexuality?

to use sex robots to help rehabilitate sex offenders?

to use sex robots as surrogates to practice sexual skills?

to use sex robots in therapy to help with sexual dysfunctions?

for individuals with pedophilic interests (i.e., sexual interest in children) to use child-like sex robots in order to prevent them from offending?

APPENDIX C: SUPPLEMENTAL MATERIAL CHAPTER 5

Demographic questionnaire

1. What is your age? [ ]

Gender/Sex Questions

The following questions ask about how you identify your gender. We ask these questions so we can accurately report who participated in our study, and do any group analyses that are relevant.

2. What is your gender (e.g., woman, agender)? [ ]

When we describe who participated in our study:

3. Which of these categories would you like us to include you in?

A trans/transgender category (usually refers to people who were given a gender and/or sex label at birth that does not accurately represent them) [ ]

A cisgender category (refers to people who are the same gender and/or sex they were assigned at birth) [ ]

Neither cisgender nor transgender describe me because: [ ]

Unsure because: [ ]

4. And, which of these categories would you like us to include you in?

Binary (someone who identifies as exclusively a man/male or woman/female) [ ]

Nonbinary (someone who has an identity other than exclusively woman/female or man/male) [ ]

Neither binary nor nonbinary describe me because: [ ]

Unsure because: [ ]

Sexual Identity/Orientation Questions

What is your sexual orientation/identity currently (e.g., gay, heterosexual, etc.)? [ ]

How do you currently define your sex (e.g., male, female, intersex, don’t define, questionning)? [ ]

A future study may involve measuring sexual arousal through the genitals.

If you were to participate in this study, which would be appropriate for you? A measurement device designed for: Vulvas/Vaginas [ ] – Penises/Scrotums [ ]

What is your ethnicity? [ ]

What is your religion? [ ]

How religious would you describe yourself?

0 (Not at all) - 1 (Very low) - 2 (Low) - 3 (Moderate) - 4 (High) - 5 (Very high)

What is the highest level of education that you completed or are currently completing? [ ]

What is your personal annual income? Please indicate the currency (e.g., $XX CAD). [ ]

Erotic engagement questionnaire (EEQ) for robots and humans

Would you [...] a robot? - Scale: 0 (Not at all) to 5 (Definitely)

have sex with

love

be in an intimate relationship with

be friends with

Would you [...] a human? - Scale: 0 (Not at all) to 5 (Definitely)

have sex with

love

engage in an intimate relationship with

be friends with

State of (sexual) arousal and valence

I feel:

0 (Not at all aroused) to 10 (Very aroused)

0 (Not at all sexually aroused) to 10 (Very sexually aroused)

0 (Very negative) to 10 (Very positive)

Sexually explicit videos

Please choose from the following three categories, the type of video you would like to watch:

Heterosexual [ ]

Lesbian [ ]

Gay [ ]

Please read the following instructions carefully.
Instructions: The following erotic video will last 10 minutes. Then, you will be asked to answer some questions about your experience of arousal (e.g., non-sexually exciting), sexual arousal, and valence (negative-positive). Try to look at the video as natural as possible. Please do not masturbate or touch yourself during the video.

When you are ready, please **RIGHT-CLICK** on the link below to access the video, and select '**OPEN A LINK IN A NEW WINDOW**'.

Please make sure the video is in **FULLSCREEN** and press **PLAY** when you are ready to start.

When the video ends, return to the survey to answer the questions.

Link to the video: Heterosexual Sexual Activities
(https://www.dropbox.com/s/gi7zijweqyl4yx2/Heterosexual%20Sexual%20Activities.mpg?dl=0)

OR
Link to the video: Lesbian Sexual Activities
(https://www.dropbox.com/s/tmuoltq263ujvy7/Lesbian%20Sexual%20Activities.avi?dl=0)

OR
Link to the video: Gay Sexual Activities
(https://www.dropbox.com/s/y00idlmgvy4cegg/Gay%20Sexual%20Activities.avi?dl=0)