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Research Article

Digital Lovers and Jealousy: Anticipated Emotional Responses to Emotionally and Physically Sophisticated Sexual Technologies

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Technologies that stimulate human social and sexual impulses could affect users and societies. Here, we report on two experiments designed to test participant responses to (1) "virtual friend" chatbots that vary in capacity to engage users socially and emotionally (i.e., emotional sophistication) and (2) "digital lover" technologies—in the form of sex toys, sex robots, or virtual reality entities—that vary in capacity to physically stimulate users (i.e., physical sophistication). Participants (173 female, 176 male) read vignettes that each described a particular technology and then answered whether, if their romantic partner were to use the described technology, they would anticipate jealousy or anger, and whether they would prefer to see the technology banned. Participant anticipations of jealousy and anger were so similar that we combined them in a single composite measure. In experiment 1, both the anticipation of jealousy-anger and the inclination to ban chatbots increased with emotional sophistication, particularly in female participants. In experiment 2, both sexes anticipated greater jealousy-anger and were more inclined to ban more physically sophisticated digital lovers. Female participants expressed higher levels of both responses across the range of sophistication. Experiment 2 participants were more likely to anticipate jealousy-anger and more inclined to ban sex robots than sex toys or virtual reality lovers. Our results show only limited consistency with evolutionary theories concerning sex differences in jealousy. Generally, the anticipated levels of jealousy-anger and inclination to ban the described technologies were low, suggesting low levels of resistance to the idea of the technologies.

1. Introduction

Every technological innovation that touches human social lives spurs new questions concerning how human users will interact with the new technologies and whether the use of those technologies will change human-human interactions and societal processes [1–11]. This is true of the fast-moving contemporary developments in artificial intelligence, robotics, haptics, and material sciences that have contributed to a flourishing ecosystem of new technologies that stimulate human needs and preferences for friendship, intimacy, touch, and sexual contact. Dubé and Anctil [12] collectively refer to these technologies as "erobots." We [1] cast a broader net, calling these technologies "artificial intimacies," arguing that each technology fits into at least one of three overlapping sets: algorithmic matchmakers, virtual friends, and digital lovers. The present paper considers some psychological questions concerning the latter two categories, notably virtual friends in the form of chatbots that vary in their capacity to evoke friendship and emotional intimacy, and digital lovers in the form of sex robots, smart sex toys, and virtual reality engines that vary in their capacity to produce tailored and responsive sexual stimulation.

New technologies also provide students of human behaviour with novel tools to use in testing theories about the proximate and ultimate causes of behavioural patterns. By considering how research participants anticipate reacting to technologies that differ in specified attributes, it is possible to experimentally dissect how those attributes influence the reaction—or likely reaction—to the technology. Here, we conduct experiments of this nature to attempt to both (1) understand likely human reactions to some present-day

plausible near-future technologies and to (2) test theory about the function of jealousy in romantic sexual relationships.

1.1. Will Artificial Intimacies Affect the Lives of Users and Other People? Technologies that engage users' social capacities present a variety of potential benefits and costs (e.g., [2, 6, 7, 11, 13–15]). The improvement in chatbot technologies in recent years, enhanced by rapid progress in large language model (LLM) technology, has resulted in technologies that offer social support [15], company [11, 13], romance [1, 4], and even therapy [16]. In addition to these positives, the rise of social media, and especially of machine learning algorithms designed to capture user attention on those platforms, has been blamed for relationship disruption [17] or "technoference" [6, 7, 18], a recent rise in adolescent and youth mood disorders [19], and political polarisation and violence [20]. The argument has also been made that social media, sophisticated chatbots, and social robots will undermine the quality of interpersonal capacities such as conversation and empathy [21, 22].

Sex robots and interactive virtual reality pornography also offer both potential upsides and downsides. Benefits include entertainment, pleasure, and a capacity to support safe exploration of a diverse range of sexual expression [1, 2, 14], as well as the potential to ameliorate harmful paraphilias [23] and to mitigate the anger and violence of those forsaken by mating markets [1]. These technologies also elicit concerns, including that doing deeply human things with objects might lead to a rise in objectification, particularly of women (e.g., [8]; but see [24, 25]). While the question of objectification remains open, there is little doubt that humans readily treat objects—in the form of robots and other artificially intimate technologies—as if they were, at least in some respects, human (see [1, 2, 9, 13, 26]). Another open question is whether the use of sex robots and other artificial intimacies may cause users to seek human partners less often or to expect less from relationships, with possible upsides such as reduced sexual harassment and violence, and downsides such as missing out on the sublime and often character-building aspects of romantic love and sex (see discussion in [1, 4, 10, 27]).

The use of artificial intimacies might also undermine and destabilise romantic relationships in much the same way that emotional and sexual infidelity can. One of the first studies of this topic found that survey participants are less likely to rate using a sex robot as infidelity than comparable acts with another person [28]. In a second survey, the same authors [28] found that both men and women were more likely to consider their partner using an android or gynoid sex robot—matched to their partner's preference for men or women, respectively—as infidelity than using a sex of robot of unspecified "sex."

1.2. Jealousy. Concerns about being replaced or about one's value in a relationship being diminished by new artificially intimate technologies may be relevant to scientific debate about the functions of jealousy. In general, emotions serve to guide human behaviour. In their comprehensive review of romantic jealousy, White and Mullen [29] presented a model in which jealousy arises from the evaluation of the threat presented by a real or imagined rival to the individual or their relationship, emotions evoked by that threat, and coping effects that result. This approach predicts individual differences in romantic jealousy arising from details about the self, the apparent threat, and the partner. It is possible, then, that virtual friends and digital lovers may present varying degrees of threat, depending on the sophistication of the technology as well as the properties of the threatened individual and their partner [30].

Romantic jealousy is often associated with other emotions, including sadness, anger, and fear [31–33]. The potential for jealousy to arouse anger toward either one's partner or the (suspected) interloper in romantic jealousy situations is understood to be highly relevant to the emergence of controlling and abusive behaviour by the jealous party [34, 35]. Moreover, some individuals are more likely than others to identify anger and less likely to identify jealousy as their reaction to instances of real or imagined infidelity [31, 33].

To the extent that they guide individuals toward social situations that facilitate survival and reproduction, even unpleasant emotions like jealousy, anger, and fear can be adaptive [36]. Evolutionary psychologists have applied this framework to the evolution of human emotions, often arriving at unexpected and novel hypotheses regarding how emotions, including jealousy, work.

Jealousy in the context of romantic and sexual relationships mobilises individuals to retain and strengthen a valuable romantic partnership by identifying when a partner may be preparing to leave, or when a third party is trying to woo the partner away [37, 38]. Buss et al. [38] further identified that while women and men in heterosexual relationships share many of the same risks, they are also threatened in some different ways. Men's parenting investment tended, throughout deep history, to be facultative [39], and thus, the loss or attenuation of a mate's investment presents a particularly salient risk to a woman's fitness. As a result, women are likely to be more inclined than men to become jealous of his forming a deep emotional connection with another partner, because such a connection could precede his defection or his concurrent investment in another mate and family [38].

Men's uncertainty over paternity, however, means that each time a man's female partner has extra-relationship (hetero) sex with another man, there is a chance that she will conceive, leaving him to raise a child that is not his genetic progeny. Thus, men are more likely than women to become jealous about an actual or imagined instance of sexual infidelity [38, 40]. The logic is not that men consciously want to dodge responsibility to raise a given child, but rather that mechanisms that amplified male jealousy in contexts where there was a chance of cuckoldry would have been favoured by natural selection because jealous men would have more often invested their time, effort, and resources into their genetic progeny than would men who showed no such jealousy [38, 40].

The predictions from this evolutionary theory of sex differences in jealous responses to perceived threats of emotional and sexual infidelity have been tested extensively

and via a variety of methods. In general, both predictions have been upheld in a large number of studies using a variety of direct and indirect measures (see overview by [41, 42]), and by a meta-analysis of results from 40 studies [43]. The theory has not, however, been universally accepted. Criticisms have been advanced of the theory's framing, the methods used to test it, and the interpretations of the evidence [35, 44–47].

Another explanation for the observed average sex differences in jealousy comes from attachment theory, according to which attachment styles shape individual experiences and expressions of jealousy [47–50]. Sex differences in attachment styles emerge in adolescence and adulthood [51], and these sex differences, together with the high degree of within-sex variation in attachment styles, may provide a more complete (if not mutually exclusive) explanation for sex differences in the nature and strength of sexual/romantic jealousy [48].

A further possibility considers the possibility that social-cognitive variation explains most within-person and within-sex variation in jealousy, as well as average sex differences [35, 46, 52]. Such beliefs include beliefs about the nature of commitment, and context-dependent cues as to what threatens a person's primary relationship [35, 46].

The several theories regarding the origins of jealousy introduced here need not be viewed as exclusive alternatives, as they entail alternative levels of causation (e.g. proximate vs ultimate). Thus, discerning the value and veracity of each explanation is a more difficult task than simply pitting competing predictions against one another. Moreover, testing hypotheses about real or imagined interpersonal interactions like infidelities is further complicated by the fact that there are at least two and, in many cases, three or more individuals involved in every scenario, each with their own interests and agency. Moreover, emotional and physical intimacies are seldom quarantined from one another in human-human relationships.

1.3. Technology and the Capacity for New and Old Kinds of Jealousy. New technologies can offer simplified opportunities for testing ideas about human-human behaviour, including emotional responses to infidelity (e.g., [28, 30, 50, 53–57]). Intrusiveness of social media use into users' time and attention, as well as monitoring of social media activity, generated jealousy, relationship dissatisfaction, and relationship disruption [6, 17, 18]. Likewise, although the use of sex toys like vibrators is now common, including among partnered women of all sexualities [58], heterosexual women's use of sex toys like vibrators can elicit feelings of intimidation or inferiority in a substantial proportion of male partners [59].

New or near-future artificially intimate technologies that deliver sophisticated emotional or physical engagement create new opportunities both for jealousy and for the study of how jealousy arises. Recent studies have shown that both participant sex [28, 57, 60] and the apparent "sex" of the technology [28] can influence how a participant anticipates the prospect of artificially intimate technologies, including how they anticipate jealousy. Even though these technologies lack both their own interests and agency (but see [61]), they can appear to have both, and they offer a far more extensive user experience than older technologies like vibrators and social media platforms.

The extent to which new technologies like virtual friends and digital lovers might elicit emotions like jealousy is likely to depend on their capacities to build emotional intimacy, to evoke romantic love, and to provide responsive, individualised forms of sexual stimulation. One might expect high degrees of emotional or physical sophistication to evoke more jealousy in those who contemplate a partner using them, and for those responses to mirror the ways jealousy arises in human-human interactions. On the other hand, the fact that the technologies are entirely decoupled from the reproductive functions and consequences of sex, including the possibility of insemination, might render the evolved causes of human-human jealousy irrelevant to human-machine interactions.

Here, we consider how people expect to respond to virtual friend technologies that vary in their capacity to build relationships and evoke emotional intimacy with users or to digital lover technologies that provide tailored, user-specific sexual pleasure to users. These responses provide an insight into the fears that potential users hold for future artificially intimate technologies, and a comparison of those fears across a variety of different kinds of artificial intimacy. They also provide an original opportunity to test whether sex differences in responses to these technologies are independent of the threat (diverted intimacy or sexual attention) or if they are consistent with evolutionary theories of sex differences in jealousy.

2. Methods

We took an experimental approach with two separate experimental manipulations designed to test separate hypotheses. The manipulations tested anticipated responses to fictional technologies of increasing emotional (experiment 1) or physical (experiment 2) sophistication. The experiments were conducted in parallel on the same sample of participants, with each participant seeing and responding to three vignettes from experiment 1 and three from experiment 2. No participant saw more than one vignette from a given combination of experiment and treatment level, but otherwise, vignettes were assigned to participants at random, and the six assigned vignettes were presented in random order. Thus, the study included both between-subjects and within-subject variation.

The study was implemented in the online survey platform Qualtrics (Provo, UT, USA). Our protocols were approved by the UNSW Human Research Ethics Committee (approval HC210426). Materials, including vignettes and their design features, as well as instructions on how to request access to the data are available as Online Supplements to this article.

2.1. Sample. The online nature of this study allowed us to recruit a varied, international sample via posts on social media sites like Facebook and Twitter, online forums (e.g.

Reddit/r/Samplesize and/r/Science), and recreational society mailing lists. This was a convenience sample in which we gathered as many participants (that met our inclusion criteria) as we could in the time appropriate to an Honours research project, within a hard limit specified by our ethics committee. Participation in the study was anonymous and was not compensated.

Upon entry to the study, participants were informed about the study and asked for their informed consent. We then gathered demographic information (age, sex, and sexual orientation). Of the 550 participants who responded, 201 were excluded for the following reasons: no consent given (3), 1 did not meet study age criteria (i.e., 18 years or older), left the study before rating all vignettes and responding to postmeasures (173), took longer than 45 minutes (14), did not answer the question regarding biological sex (10). Participants not excluded from the study took a median of 8 minutes and 51 seconds (mean = 11 minutes and 52 seconds, SD = 9 minutes and 49 seconds).

Participant sex ratio across the entire study was very close to even. Of 173 females, 160 identified as women, 1 as a man, and 11 expressed gender identities other than woman/man or did not answer the gender identity question. Of 176 males, 169 identified as men, 2 as women, and 5 expressed gender identities other than woman/man (e.g., nonbinary). There were no other responses to the biological sex question than male/female/no response. Although the majority of participants (77%) were between 18 and 25 years old, the mean age was skewed upward by a few older participants. The mean age of female participants was 28.2 (±10.2 S.D.) and of male participants was 33.0 (±14.1 S.D.) years.

The 296 participants who indicated their nationality came from 40 countries, of which Australia (115), the U.S.A. (34), Canada (10), the United Kingdom (39), and New Zealand were the most commonly represented. There were 9 participants from other Pacific nations, 4 from the Middle East, 3 from Africa, 20 from South Asia, 21 from East Asia, and 31 from Europe.

2.2. Experiment 1: Varying Emotional Sophistication in Chatbots. Each experiment involved showing participants a series of vignettes, each describing the capabilities and user experience from a fictional technology. Technologies described in vignettes for experiment 1 were chatbots that varied in their capacity to engage users emotionally (i.e., emotional sophistication) but had no described physical traits. The design of experiment 1 was a 2 (participant sex) by 5 (emotional sophistication) factorial design. The level of sophistication, fitted as a categorical fixed factor in our analyses, indicates the effect of a technology's "emotional sophistication" on participants' responses. Figure 1(a) provides a schematic representation of the design and levels of emotional sophistication of the vignettes.

Note that vignettes do not make reference to whether a technology (or one similar to that described) currently exists. This was in the interests of not having such references that make some vignettes more believable than others. Note that this study was conducted in 2021 before virtual friends like Replika.AI, Pi, and Forever Companion achieved their current media and cultural prominence, and before the recent generations of large language models (like ChatGPT) achieved widespread uptake and prominence.

Vignettes were generated to fit five levels of emotional sophistication by altering the following eight attributes:

(i) Distinguishability from a human. It considers the intellectual and behavioural traits evident in interactions with the chatbot. It includes a statement of how likely the chatbot would be to pass the Turing Test (Turing 1950)

(ii) Extent to which users would anthropomorphise the chatbot

(iii) Quality of natural language processing (NLP). The chatbot's ability to understand its user so that they can speak to their chatbot in any chosen register and be "understood"

(iv) Quality of natural language generation (NLG). The chatbot's ability to carry a conversation, using language to communicate effectively with the user

(v) Quality of machine learning to learn from previous interactions and build that content into new conversations

(vi) Scope of interaction in terms of the number of activities or games that the chatbot can play/do with the user

(vii) Building intimacy by showing interest and escalating self-disclosure [62]

(viii) Tendency of users to fall in love with the chatbot

Within each of the five levels of emotional sophistication, we generated three replicate vignettes (total = 15 vignettes). Replicate vignettes are the appropriate level of treatment replication, ensuring that any response to a level is due to the applied treatment and not due to idiosyncratic variation in one or more vignettes (see [63, 64] for further justification of this approach). Each participant was assigned to assess three of the 15 vignettes each, at random but with the condition that no two vignettes were of the same level of physical stimulation.

In the Supplementary Material, we present a table describing the way that chatbots of each of the five levels meet these criteria (Supplement 1a) and share the full text of all fifteen vignettes (Supplement 2a). Below is an example of a Tier 4 (second most emotionally sophisticated level) vignette.

Consider the "Max," an artificial intelligence companion. When people talk to Max, they feel like they are talking to a real person and can have conversations for hours, forgetting that Max is an AI. Most people that have a Max usually call it "him" or "her" and tend to treat Max more like a person than a machine.

The AI can understand all languages and colloquialisms and only struggles with poor phrasing. Max can perform many activities and games if the user desires and can suggest

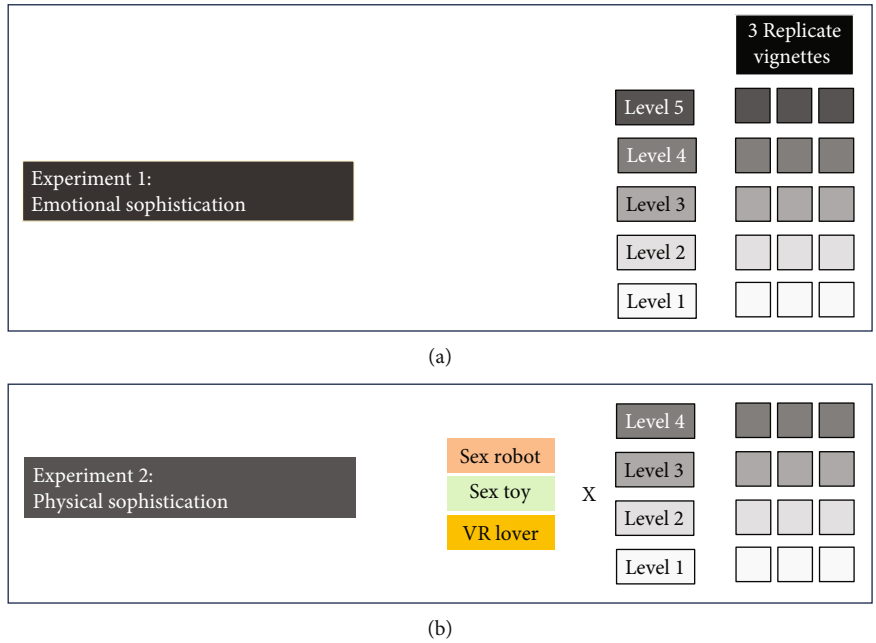

Figure 1: Diagrammatic summary of the design of (a) experiment 1 and (b) experiment 2.

things users might like to do, watch, or listen to depending on its detection of how the user is feeling. Max remembers many things about a user and uses this information to try and interact in a positive way.

Max can give advice from factual sources from the internet, attempting to help a user a much as possible. Speaking to Max is reported by users to be like talking to a friend. In tests 90% of people with these artificial companions form strong attachments with them and 30% of users defined their strong attachment as romantic.

2.3. Experiment 2: Varying Physical Sophistication of Digital Lovers. Vignettes for experiment 2 described technologies that varied in their capacity to provide physical sexual stimulation (i.e., physical sophistication) but had no described emotional capabilities. The technologies in Experiment 2 were of one of three types: sex robots, sex toys, or virtual reality games/characters. These three types of technology were chosen to range from the familiar realm of sex toys, with which large proportions of the adult public are already comfortable [58, 65], to the relative unfamiliarity of virtual reality [12], and the often uncanny world of sexual robots [30, 66]. This approach allowed us to separately assess the effects of physical stimulation from the type of technology that provided that stimulation, generating a more general test of our hypotheses concerning physical sophistication and jealousy. Experiment 2 is a 2 (participant sex) × 3 (type of digital lover technology) × 4 (levels of physical sophistication) factorial design.

Figure 1(b) provides a schematic representation of the design and levels of physical sophistication of the vignettes. For each of the three types of DL, we generated vignettes that matched four levels of physical sophistication. We generated three replicate vignettes for each type of DL and each level of physical sophistication, thus 36 vignettes in total.

The sex robots varied in physical sophistication according to the following traits (properties of the various levels are described more fully in S1, and vignettes provided in S2): life-like appearance, touch sensation, robotic movement, quality of machine learning (about user preferences), range of intimate acts, and capacity to bring user to orgasm.

The sex toys varied in physical sophistication according to the following described traits: aesthetically pleasing design; quality of sensation relative to human touch, robotics, and movement (if relevant); quality of machine learning (to improve user experience); biometric sensors to detect user arousal, and capacity to deliver user pleasure.

The interactive virtual reality DLs varied in sophistication in the following ways: capacity for user interaction, visual appeal, capacity to arouse the user, quality of machine learning (to improve user experience), and capacity to deliver user pleasure.

Participants were assigned three of the 36 vignettes each, with no two vignettes being of the same level of physical stimulation.

2.4. Dependent Variables and Covariates. After reading each vignette, the participant was asked "We would like you to imagine how you would feel if your current partner - or a future lover - used this device." Participants then answered the following three questions, each on a 7-point Likert scale (strongly disagree to strongly agree): (i) Do you anticipate feeling jealous? (ii) Do you anticipate feeling angry toward your partner? (iii) To what extent do you agree that such technologies should be banned? Responses to the three questions constitute the three dependent variables in this study which we refer to, respectively, as *jealousy*, *anger*, and *banning*.

After the participant responded to all six assigned vignettes, we asked several follow-up questions to estimate

two covariates known to affect attitudes concerning sexuality and sexual behaviour. Self-perceived mate value [67] can influence, *inter alia*, jealous reactions [68, 69]. To keep participant experience brief, we asked only four questions from the self-perceived mate value scale, soliciting 7-point Likert scale responses (strongly disagree to strongly agree to the questions: (1) I receive many sexual invitations; (2) I can have as many sexual partners as I choose; (3) I consider myself popular; (4) several people have had crushes on me. We refer to the composite of these items as "Mate Value" in our analyses.

The Revised Sociosexual Orientation Inventory (R-SOI; [70]) describes individual-level differences in the tendency to engage in uncommitted sexual relationships. We asked participants all nine questions in the R-SOI.

2.5. Data Analysis. We analysed the data in SPSS v27 (macOS). The only data cleaning involved was to eliminate participants that did not meet our criteria for the study, did not respond to the vignettes or provide biological sex information, or took longer than 45 minutes to perform the study (when median time was less than 10 minutes). Each experiment was analysed via the fitting of a general linear mixed model with participant identity as a random intercept.

For experiment 1, participant sex, the level of sophistication, and level × sex interaction were fitted as fixed effects. Individual participants and the vignette were fitted as random identity effects. We fitted R-SOI and mate value as covariates.

For experiment 2, the process was the same, except that we fitted as fixed effect participant sex, the level of sophistication, type of DL technology (sex toy, sex robot, and VR lover), all 2-way interactions, and the 3-way interaction. Individual participants and the vignette were fitted as random identity effects. Again, we fitted R-SOI as a covariate. For both final models, we inspected plots of residuals to verify that the assumptions of residual normality were observed.

3. Results

First, we estimated the consistency of responses to the three response variables (*jealousy*, *anger*, and *banning*) by calculating Cronbach's alpha of responses across the full data set. The three response variables were positively correlated, and consistency was high ($\alpha = 0.83$). *Banning*, the tendency to agree with a statement that the technology described in a vignette should be banned, was less strongly correlated with the other two, and reliability rose to $\alpha = 0.90$ if this variable was dropped (compared to a fall to 0.71, or 0.61, respectively, if jealousy or anger were dropped). This, the high similarity in the nature of the jealousy and anger questions and the different nature of the banning question, led us to decide to analyse jealousy and anger as a single composite variable. To do so, we calculated the mean of each participant's response to these two questions for each vignette. We call this new dependent variable the *jealous-angry response*.

While jealousy and anger are understood to be different emotions, jealousy is known to arouse other emotions, notably anger [33–35]. Moreover, individuals with secure attachment styles report lower jealousy but greater partner-directed anger than those with other attachment styles, and so, it would seem that the composite measure that we used here might have less precision (in terms of the specific emotion) but greater accuracy (in terms of the anticipated negative response) than separately analysing the two emotions.

3.1. Experiment 1: Emotional Sophistication. The jealous-angry response varied in relation to sex, the level of emotional sophistication described in the vignette, and their interaction (Table 1(a) and Figure 2(a)). While both sexes of participants were more likely to anticipate jealousy-anger when contemplating the more emotionally sophisticated (i.e., higher level) technologies, female participants were especially inclined to anticipate jealous-angry reactions for the highest level of emotional sophistication (hence, the significant sex × level interactions).

Adding R-SOI and mate value to the model as covariates rendered the effect of sex on jealousy-anger and inclination to ban (Table 1(b)) as nonsignificant. More sociosexually restricted individuals, and individuals of higher mate value, anticipated greater jealousy-anger. This result suggests that at least some of the sex differences observed in the model without covariates (Table 1(a)) arose due to greater male R-SOI and higher female mate value rather than another mechanism of psychological sex difference.

The banning response varied in relation to sex, the level of emotional sophistication, and their interaction (Table 1(c) and Figure 2(b)). Adding R-SOI to the model as a covariate eliminated the significant effect of sex (Table 1(d)), suggesting that the sex difference in favouring banning technologies was possibly due to sex differences in R-SOI, but the strong sex × level interaction remained, indicating that the strongest pro-banning response (by females toward the most emotionally sophisticated level of chatbot) was not entirely due to sex differences in sociosexual restrictedness. Self-perceived mate value was not a strong or statistically significant predictor of the banning response (Table 1(d)).

3.2. Experiment 2: Physical Sophistication. There were 173 male and 174 female participants in experiment 2. The jealous-angry response varied in relation to sex, the type of technology, and the level of physical sophistication, but not any of the interaction terms (Table 2(a) and Figures 3(a) and 3(b)). Female participants anticipated more jealousy-anger than male participants did. Generally, participants were more inclined toward jealousy-anger regarding sex robots than sex toys or VR lovers and more inclined toward jealousy-anger for higher levels of physical sophistication.

Adding R-SOI and mate value to the model as covariates did not eliminate the significant main effects on anticipated jealousy-anger (Table 2(b)). The jealous-angry response was stronger in individuals of more restricted sociosexuality and individuals of higher self-perceived mate value, although the latter effect was weak, but these covariates do not explain (all of) the sex differences in anticipated jealousy-anger.

Table 1: Effects of sex and level of emotional sophistication on responses in experiment 1.

(a)

	Jealous-angry response		
	F	d.f.	*P*
Sex	15.36	1, 999	0.000
Level	119.87	4, 999	0.000
Sex × level	9.39	4, 999	0.000

(b)

	Jealous-angry response		
	F	d.f.	*P*
Sex	3.19	1, 963	0.075
Level	119.68	4, 963	0.000
Sex × Level	8.52	4, 963	0.000
R-SOI	20.94	1, 963	0.000
Mate value	12.74	1, 963	0.000

(c)

	Banning response		
	F	d.f.	*P*
Sex	4.74	1, 322.6	0.030
Level	28.72	4, 9.4	0.000
Sex × level	9.62	4, 700.8	0.000

(d)

	Banning response		
	F	d.f.	*P*
Sex	1.94	1, 320.6	0.165
Level	28.58	4, 9.4	0.000
Sex × Level	9.51	4, 701.5	0.000
R-SOI	7.59	1, 320.9	0.006
Mate value	0.36	1, 320.7	0.548

The inclination to ban the digital lovers varied in relation to sex, the type of technology, and the level of physical sophistication, but not the interaction terms (Table 2(c) and Figure 3(b)). Female participants anticipated more inclination to ban the technologies than male participants did.

Adding R-SOI and mate value to the model as covariates resulted in the sex difference becoming not significant (Table 2(d)), suggesting that the sex difference in inclination to ban the technologies described in experiment 2 might be due, at least in part, to female sociosexual restrictedness.

4. Discussion

A simple approach of describing artificial intimacies with varying degrees of sophistication and then asking participants to anticipate their jealousy and anger if a partner (or future partner) were to use such a device, and asking participants whether they agree that the described technology should be banned, provided some insights into the likely reception of such technologies. Most obviously, greater emotional (experiment 1) or physical (experiment 2) sophistication resulted in higher levels of anticipated jealousy-anger, and a greater inclination to ban the technology. In both experiments, female participants anticipated being more jealous-angry and were more likely to favour banning.

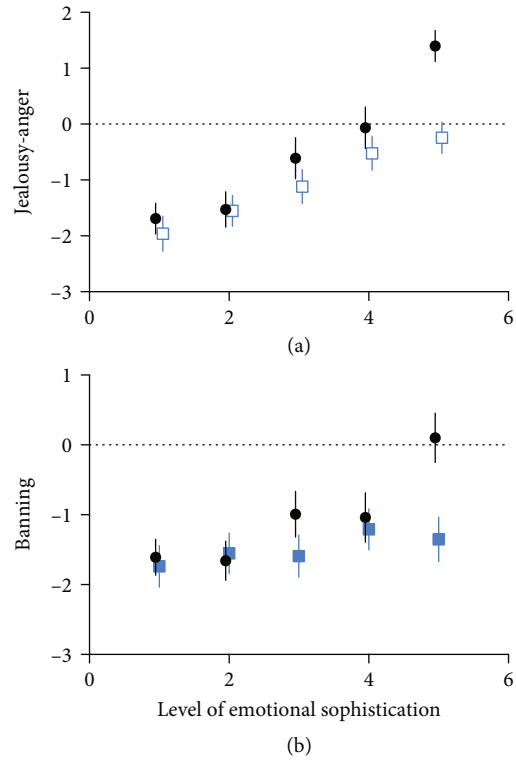

Figure 2: Responses to questions about anticipated (a) jealous-angry reaction or (b) agreement that technologies should be banned in relation to sex (black = female, blue = male participants) and level of emotional sophistication of chatbots in experiment 1. Data from 7-point Likert scales, with 0 as neutral, -3 as strongly disagree, and 3 as strongly agree, that participants would be jealous-angry or inclined to ban.

The interaction between sex and level of emotional sophistication was strong in experiment 1, indicating that female participants anticipated greater jealousy-anger and were more in favour of banning than male participants for high levels of emotional sophistication. By contrast, there was no significant interaction between sex and level of physical sophistication (experiment 2). That is to say that the differences between the sexes and the effects of level of sophistication were independent of one another.

4.1. Implications for Theories of Jealousy. Our results show limited consistency with evolutionary theories concerning sex differences in jealousy. Our predictions, derived from Buss et al. [38], were (1) that women would anticipate stronger jealousy toward technologies that provide the emotional components of a relationship, but (2) men would anticipate greater jealousy toward technologies that provide physical stimulation.

Table 2: Effects of sex, technology type, and level of physical sophistication on responses in experiment 2.

(a)

	Jealous-angry response		
	F	d.f.	*P*
Sex	21.76	1, 324.6	0.000
Level	66.56	3, 667.0	0.000
Type of tech.	25.32	2, 668.5	0.000
Sex × level	1.20	3, 667.0	0.310
Sex × type	0.70	2, 668.5	0.495
Type × level	1.41	6, 666.2	0.207
Sex × type × level	1.57	6, 666.2	0.153

(b)

	Jealous-angry response		
	F	d.f.	*P*
Sex	10.18	1, 322.2	0.002
Level	67.03	3, 671.4	0.000
Type of tech.	25.12	2, 672.6	0.000
Sex × level	1.08	3, 671.1	0.358
Sex × type	0.74	2, 673.2	0.476
Type × level	1.40	6, 670.7	0.214
Sex × type × level	1.64	6, 670.4	0.134
R-SOI	24.57	1, 321.5	0.000
Mate value	3.91	1, 321.9	0.049

(c)

	Banning response		
	F	d.f.	*P*
Sex	6.55	1, 322.6	0.011
Level	12.13	3, 645.5	0.000
Type of tech.	10.42	2, 646.6	0.000
Sex × level	0.84	3, 645.5	0.472
Sex × type	0.92	2, 646.6	0.397
Type × level	2.14	6, 644.9	0.047
Sex × type × level	1.84	6, 644.9	0.089

(d)

	Banning response		
	F	d.f.	*P*
Sex	1.18	1, 320.6	0.279
Level	12.26	3, 650.0	0.000
Type of tech.	10.56	2, 650.8	0.000
Sex × level	0.85	3, 649.7	0.467
Sex × type	0.94	2, 651.3	0.390
Type × level	2.13	6, 649.4	0.048
Sex × type × level	1.80	6, 649.2	0.096
R-SOI	30.90	1, 320.1	0.000
Mate value	2.58	1, 320.4	0.109

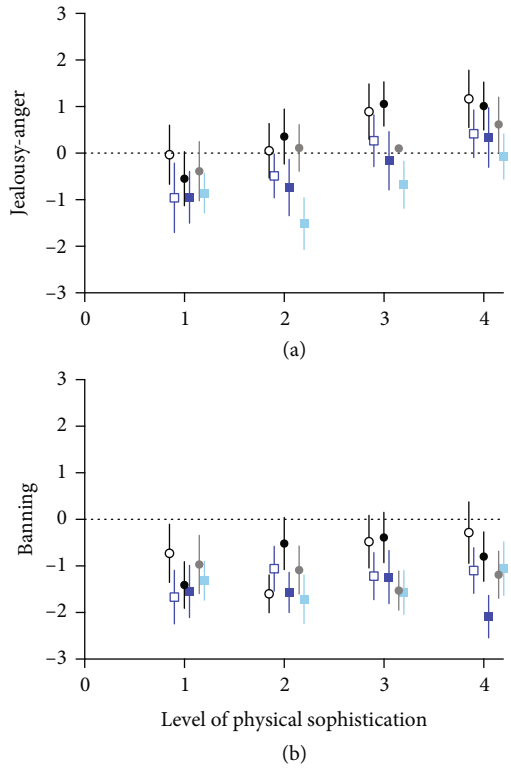

Figure 3: Responses to questions about anticipated (a) jealous-angry reaction or (b) agreement that technologies should be banned in relation to sex (black/grey = female, blue = male participants), level of sophistication, and type of technology (open symbols = sex robots, closed dark symbols = sex toys, closed light symbols = virtual reality) in experiment 2. Data from 7-point Likert scales, with 0 as neutral, -3 as strongly disagree, and 3 as strongly agree, that participants would be jealous-angry or inclined to ban.

Female participants' higher anticipated jealousy-anger, and inclination to ban chatbot technologies with the highest levels of emotional sophistication, is consistent with prediction 1. This finding is consistent with the evolutionary idea [38, 42] that women have more to lose than men do from the emotional defection of a partner. Interestingly, however, the evolutionary theory of sex-dependent jealousy emphasises that women's jealous responses to emotional intimacy directed elsewhere are ultimately due to the high costs of a women's partner leaving the relationship for somebody new. The threat presented by the digital lover vignettes that we describe here is not one of defection, but rather simply the partner having another emotional output. The psychological architecture of the anticipated jealous-angry responses that we find here would be an interesting subject for future study, both to learn more about the likely implications of artificially intimate technologies and to test competing theories of jealousy.

The second prediction, concerning sex differences in jealousy toward digital lovers of increasing physical sophistication [38, 40], was not upheld. We saw both sexes anticipate feeling some jealousy-anger, and an inclination to ban technologies that provide more sophisticated opportunities

for physical pleasure compared with less physically sophisticated technologies. Here, again, female participants anticipated greater jealousy-anger and inclination to ban. These findings contrast with evolutionary prediction 2 that males—at least those in heterosexual relationships—are more likely to be jealous of their partner being physically intimate with another person than women are [38, 71–73]. Instead, they are consistent with evidence that males are more positive than females to the idea of physically sophisticated sex technologies like sex robots [57, 60].

The fitness threat that evolutionary theories of jealousy posit is behind the evolution of sex differences in jealous responses to physical infidelity is the risk of raising another man's genetic offspring [38]. This threat is, again, not present in our digital lover vignettes, none of which are capable of insemination or fertilisation. Indeed, men might anticipate that sex robots, smart sex toys, and virtual reality sexual experiences could, by substituting for extrapair sexual activity, reduce their chance of being cuckolded, and thus the risk of misdirected paternal effort. This is an intriguing possibility, but it does remain at odds with the fact that men are more opposed to more sophisticated forms (i.e., higher levels) of these technologies.

Our findings are, however, also consistent with Penke and Asendorpf's [74] finding that, under cognitive constraint, sex differences in emotional jealousy are detectible but sex differences in sexual jealousy are not. The hypotheses regarding sex differences in jealousy are two distinct, if related, hypotheses and should be tested as such [74]. The possibility that the emotional ("virtual friends") dimension of artificially intimate technologies will draw more sex-dependent responses than the sexual ("digital lovers") dimension remains an intriguing possibility with implications for both the psychology of jealousy and the likely reception of those technologies.

4.2. Other Implications. Responses to the three physically stimulating ("digital lover") technologies differed, but not dramatically. Generally, both sexes were more hostile toward sex robots than sex toys and virtual reality. This may be due to two straightforward factors. First, sex toys already exist and are part of public discussion [58, 59, 65], so they may be less unfamiliar and perhaps hold less taboo than virtual reality [12] or sex robots [30, 66]. Second, there has been sustained media interest in sex robots over the past decade, and much discussion about potential downsides like furthering the objectification of and violence against women (see [2, 8, 75]). Virtual reality digital lover technologies are likely to be the least familiar type, although some resonances with pornography [1, 12] may make them seem less unfamiliar, at least to some study participants.

One study concerning sex robots showed that women's discomfort with the idea of a partner having sexual interactions with a robot is more associated with attitudes toward technology, including the tendency to anthropomorphise, rather than the women's own attractiveness or mate value [30]. This is consistent with the finding that women's less positive views of robots, and especially sex robots, underpin a more jealous response and greater antipathy concerning these technologies [30, 57, 60].

It should be noted that although most of this discussion has considered the causes of negative reactions to our digital lover vignettes, most participants disagreed with the statements about anticipating jealousy or anger, or about banning the technology. Our vignettes evoked only limited negative reactions, and participants were overwhelmingly more likely to disagree than they were to agree that the technologies should be banned. Our results, therefore, are consistent with a range of studies indicating that large portions of the adult public are open to and even enthusiastic about emotionally engaging virtual friends [76] and a variety of digital lover technologies [2, 30, 60, 77]. Taken together with these previous studies, our findings suggest that a broad public resistance to technologies like the ones described in our vignettes might not eventuate, should similar technologies make it to market. It would appear that there remains a long way to go in understanding variation in resistance or openness to digital lover technologies.

4.3. Limitations. The approach that we use here has several limitations, both for the testing of theory regarding the functional nature of emotions like jealousy and for estimating likely responses to artificially intimate technology. Foremost is that the technologies described in the vignettes are, for the most part, imagined. Some, especially at lower levels of emotional or physical sophistication, resemble technologies that are presently available. But it is unclear to the extent to which participants' anticipated reactions reflect how they would react if they were ever faced with the described technologies. This limitation is one that applies in general to studies of future technologies, and to vignette studies in general.

Our use of gender-neutral names and our attempts to avoid gendered descriptions within the vignettes were intended to avoid the complications of gendered technology, and of assuming the preferred gender of each participant. While this is made for experimental simplicity, and generality, studies of artificially intimate technologies indicate that gender cues can be an important influence on participant reactions [78–80]. We believe that future experimental research could provide a more versatile understanding of the factors involved in reactions to artificial intimacies by manipulating cues of gender in descriptions of the technologies.

The attempts to test theories of the origins of jealousy, and especially sex differences in jealousy, are constrained by the fact that artificial intimacies can only provide some of the features of human intimates. In particular, technologies cannot presently fulfil reproductive functions like gestation or insemination, and nor can they presently offer economic collaboration via wages or domestic effort. Thus, some of the costs and benefits of human-human relationships are largely irrelevant to human-machine relations of the present or the foreseeable future. This limitation means that using vignettes about present and future technology can only provide limited insight into human-human relations.

Our study deliberately dissected the effects of emotional sophistication (experiment 1) from those of physical sophistication (experiment 2). These two dimensions are, however, likely to be intertwined in many artificially intimate technologies of the future. We would encourage attempts to understand their effects, including nonadditive effects, via simultaneous manipulation of the two traits.

The phrasing of our questions about jealousy, anger, and banning technologies may have been suggestive in a way that biased participants against the technologies. We note that a more neutral and sensitive approach to measuring the dependent variables might have yielded more positive mean scores.

The majority of participants in our study were of WEIRD (white, educated, industrialised, rich, and democratic, *sensu* [81]) origin. Sexual permissiveness and exposure and openness to ideas like sex-tech are likely greater in this sample than much of the rest of the world. Moreover, willingness to go through with a study that describes virtual friends and digital lovers and asks for reactions thereto likely biases the sample of opinion measured. Further, we did not capture any information from participants regarding their digital literacy, familiarity with the kinds of technology described in the vignettes, religion, or political orientations. Familiarity with chatbots, VR, smart sex toys, or sex robots, and religious and political backgrounds may all influence how people perceive these technologies (see, for example, [82]). Careful studies that address the kinds of questions that we ask here but in more culturally and socially delicate ways will likely provide important context for the generality of our findings.

5. Conclusions

Our experiments indicated that participants generally anticipate low levels of jealousy-anger when contemplating a partner using artificially intimate technologies and that participants were generally disinclined to ban such technologies. More emotionally or physically sophisticated technologies attracted greater jealousy-anger and sympathy for banning, especially among female participants. Results concerning emotional sophistication were consistent with evolutionary theories that predict greater concerns about emotional infidelity in women. Results concerning physical sophistication, however, are not consistent with the evolutionary prediction that men would be more inclined to be jealous of a female partner's physical pleasure. Instead, our results are consistent with other studies that indicate greater resistance to artificially intimate technologies among women than men [30, 53, 54, 57].

These findings suggest that, at least in the Western, wealthy cultural contexts from which most of our participants came, people are open to both emotionally sophisticated virtual friends and physically sophisticated digital lover technologies. Of the digital lovers, participants were less receptive to sex robots than to sophisticated sex toys and virtual reality lovers, suggesting that additional hurdles might impede the uptake of sex robots compared with other artificially intimate technologies.

Abbreviations

DL: Digital lover
LLM: Large language model
R-SOI: Revised sociosexual inventory
VR: Virtual reality
AI: Artificial intelligence.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Disclosure

This paper is available as a preprint at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4379859 ("Digital Lovers and Jealousy: Anticipated Emotional Responses to Emotionally and Physically Sophisticated Sexual Technologies").

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Supplementary Materials

Supplementary 1. Description of how the technologies in experiment 1 (Supplement 1a) meet the criteria for each level of emotional sophistication and how the technologies in experiment 2 (Supplement 1b) meet the criteria for physical sophistication.

Supplementary 2. The full text of all vignettes used in experiment 1 (Supplement 2a) and experiment 2 (Supplement 2b).

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