The case for space sexology

Journal:	*The Journal of Sex Research*
Manuscript ID	21-421.R2
Manuscript Type:	Original Article
Keywords:	Sexual health < HEALTH, WELLNESS, AND MEDICINE AND SEXUALITY, Reproductive health < HEALTH, WELLNESS, AND MEDICINE AND SEXUALITY, Other theoretical framework < Sexuality-related theories < THEORETICAL AND PHILOSOPHICAL ISSUES, THEORETICAL AND PHILOSOPHICAL ISSUES

Abstract

Space poses significant challenges for human intimacy and sexuality. Life in space habitats during long-term travel, exploration, or settlement may: detrimentally impact the sexual and reproductive functions of astronauts, restrict privacy and access to intimate partners, impose hygiene protocols and abstinence policies, and heighten risks of interpersonal conflicts and sexual violence. Together, this may jeopardize the health and well-being of space inhabitants, crew performance, and mission success. Yet, little attention has been given to the sexological issues of human life in space. This situation is untenable considering our upcoming space missions and expansion. It is time for space organizations to embrace a new discipline, *space sexology*: the scientific study of extraterrestrial intimacy and sexuality. To make this case, we draw attention to the lack of research on space intimacy and sexuality; discuss the risks and benefits of extraterrestrial eroticism; and propose an initial biopsychosocial framework to envision a broad, collaborative scientific agenda on space sexology. We also underline key anticipated challenges faced by this innovative field and suggest paths to solutions. We conclude that space programs and exploration require a new perspective—one that holistically addresses the intimate and sexual needs of humans—in our pursuit of a spacefaring civilization.

Keywords: Space, sexology, human and technical factors, biopsychosocial, intimacy and sexuality

The Case for Space Sexology

Introduction

What will sex look like in space? Can humans reproduce outside of our home planet? How do we build healthy and pleasurable intimate lives on spacecrafts, stations, or settlements? Given the importance of intimacy and sexuality in human life, and the long-term exploration and settlement objectives of space organizations, we urge that such questions be addressed to mitigate risks and enhance human well-being as we journey to the final frontier. We further propose that, to better address such questions, space programs must begin to seriously explore *space sexology*, here defined as: the comprehensive scientific study of extraterrestrial intimacy and sexuality.

Humanity is entering a new age of space exploration. National agencies and private companies are leading several missions to the International Space Station (ISS), the Moon, Mars, and beyond. These missions aim to conduct research, occupy strategic military and politico-economic positions, exploit resources, bolster space tourism, and settle our solar system (cf., Bainbridge, 2009; Buchanan, 2017; Christensen et al., 2019; Cohen & Spector, 2019; Grimal & Sundaram, 2018; Zubrin, 2018). For example, with its Artemis Program, the National Aeronautics and Space Administration (NASA) aims—among other objectives—to establish a permanent presence on the Moon and Mars (NASA, 2019b). Private companies such as SpaceX (2021), Virgin Galactic (n.d.), and Blue Origin (n.d.) are also reshaping the economy and technological development of space endeavours. Their investments have launched a Capitalist Space Race, which is progressively democratizing space by lowering the costs of extraterrestrial travel and tourism (Reason Foundation, 2019; Reddy, 2018; Shammas & Holen, 2019). In turn, the pooled influence of national and private organizations is making space more accessible to a wider clientele. Their recent advancements offer new opportunities for scientists, entrepreneurs, and tourists to go and live outside Earth's atmosphere for ever-longer periods of time (Reason

Foundation, 2019; Reddy, 2018). This raises several questions about how to make spacelife compatible with human needs—including our intimate and sexual needs.

Long-term space missions and settlements pose significant *human* challenges—like enabling health, psychosocial adaptation, and performance during spaceflights—which intersect *technical* challenges—like building rockets, vehicles, and viable habitats (Binsted et al., 2010; Criscuolo et al., 2020; NASA, n.d.; Patel et al., 2020; Szocik, 2019). These challenges may include radiation exposure, gravitational changes, social isolation, interpersonal conflicts, and stress (Kanas, et al., 2009; Mishra & Luderer, 2019; Steller et al., 2018; Szocik et al., 2018). They may also include restricted privacy, limited access to intimate partners, and mandatory basic sex/hygiene training. In addition, astronauts may eventually have to contend with sexual activities under microgravity or weightlessness, along with issues related to breakups, pregnancies, and sexual harassment/violence in extraterrestrial contexts (Brenner et al., 2017; Cain, 2011; Dubé & Anctil, 2020b; Jennings & Baker, 2000, 2008; Lapierre et al., 2009; Layendecker & Pandya, 2019; Noonan, 2001; Schuster & Peck, 2016; Szocik et al., 2018). Together, these challenges have the potential to detrimentally impact the health and well-being of astronauts. In turn, this can also jeopardize mission success by, for example, generating tension between crew members in confined, dangerous environments where cooperation is compulsory (Binsted et al., 2010; Layendecker & Pandya, 2019; Salas et al., 2015).

Despite that, the spokesperson for NASA's Johnson Space Center, Bill Jeffs, publicly declared: "We don't study sexuality in space, and we don't have any studies ongoing with that. If that's your specific topic, there's nothing to discuss" (Bryner, 2008). In 2021, this perspective has not changed: space organizations seem to omit the subject of intimacy and sexuality or assume that it is a nonissue (Koerth, 2017; Layendecker & Pandya, 2019; Wanjek, 2020). Specifically, to date, the challenges related to making spacelife human-compatible are mostly addressed by the fields of Bioastronautics, Astronautical Hygiene, and Space Medicine (Cain, 2011; Clément, 2011; Longnecker & Molins, 2006; Marcviacq & Bessone, 2009). However, none of them has directly, nor comprehensively, addressed the sexological realities of human life in space and the few scholars who have raised this issue have yet to provide a research program framework to study these realities (Layendecker, 2016; Noonan, 1998). This situation is untenable and counterproductive to our long-term space endeavours. Hence, here we aim to make a case for space sexology as a scientific field and research program.

To do so, we draw attention to the lack of research related to space intimacy and sexuality, along with the risks and benefits of limiting or facilitating them in extraterrestrial contexts (i.e., see section The Under-Researched Blind-Spot of Space Programs). We then propose an initial biopsychosocial framework to envision a broad, collaborative scientific agenda on space sexology, and suggests contributors to its research program (i.e., see section Towards Space Sexology). We also underline some key anticipated challenges faced by such an innovative field and potential paths to solutions (i.e., see section Potential Challenges and Paths to Solutions). Ultimately, we call for a paradigm shift on space programs and exploration: one where humans—as whole beings—are instead embraced in their complexity and prepared for the challenges of space intimacy and sexuality. We further conclude that space organizations must address the wide spectrum of human eroticism—from love and sex, to reproduction, intimate relationships, and their sexological intersections (Bornemark & Schuback, 2012)—should they choose to prioritize ethics, wellness, and human rights in their progress and future success.

The Under-Researched Blind-Spot of Space Programs

Intimacy and sexuality are central to human existence. Despite that, and despite the goals of space organizations, the scientific literature on these topics in extraterrestrial contexts remains scarce. Levin (1989), a British sexual physiologist, was the first to review the potential effects of space on the human reproductive system. Levin's (1989) work highlighted the lack of research on even the most basic aspects of our extraterrestrial sexuality, such as the impact of spaceflights on sexual functions and gametes. Around the same time, other scholars also began to explore some of the reproductive, obstetrical, gynecological, and gendered issues related to spacelife (cf., Casper & Moore, 1995; Jennings & Santy, 1990; Santy & Jennings, 1992; Sullivan, 1996).

However, it was not until 1998 that Noonan wrote the first comprehensive analytical work on long-term human intimacy and sexuality in space. In a doctoral thesis, Noonan (1998) explored the wide range of sexological challenges and constraints imposed onto astronauts by extended spaceflight, along with their potential impacts on mission success. Noonan (2001) subsequently went on to propose that space agencies should devise programs dedicated to sex research and education in collaboration with the scientific communities of sexology (e.g., the Society for the Scientific Study of Sexuality).

Four years later, Shimizu et al. (2005) argued that considering human sexuality in space exploration was essential if the goal is to build happy and peaceful spacefaring societies. Woodmandsee (2006) then reiterated the need for more comprehensive research on extraterrestrial intimacy in a seminal book titled: Sex in Space. Echoing Noonan (1998), Woodmandsee (2006, p. 95) noted that: "Everytime the media raises the topic of sex, NASA gives one of two predictable responses. First, it declares that sex is not an issue at NASA. Second, when pressed that sex will become an issue on long-term spaced missions, the agency says that sex is nothing NASA needs to focus on right now."

Finally, in a doctoral thesis, Layendecker (2016) once again emphasized the absence of human sex research conducted by NASA. He further advocated for the development of an *Astrosexological Research Institute* (Layendecker, 2016)—a proposition that the authors of this article evidently support, but that has yet to see the light of day in 2021; that is, more than 30 years after Levin (1989) first noted our lack of research on sexuality and reproduction in space. Still, the importance of such an institute remains proportional to our lack of knowledge on human eroticism in space. This ignorance was made particularly evident when Layendecker (2016, p. 105) raised the question of the possible effects of space conditions—such as the exposure to radiation and microgravity—on conception, pregnancy, and child development, but ultimately stated: "[…] the response that repeatedly surfaces when these questions are asked is: "We don't know." We simply do not know."

Overall, the work of these scholars underlines that, given enough time, love, sex, and intimate relationships will likely—and to some extent *must*—occur in space, if humanity aims at long-term travel and expansion in the cosmos. Prohibiting intimacy or imposing policies of sexual abstinence are not viable options. This brings to the forefront that space organizations and programs are well past the moment when they should have scientifically taken these realities seriously. To date, however, the limited research related to space sexology has mostly focused on the risks associated with spaceflights—and especially, those pertaining to reproductive health; but even in this area, research is sorely lacking (Layendecker & Pandya, 2019). The holistic scientific study of intimacy and sexuality in space is missing—including when it comes to their potential benefits for the health and well-being of those who travel beyond our home planet.

Anticipated Risks and Benefits Related to Intimacy and Sexuality in Space

The intimate and sexual needs of humans are unlikely to disappear as we go into space (Noonan, 1998). Rather, they will likely be influenced by the living conditions of space habitats, along with potential risks—if these needs are too constrained—and benefits—if they are enabled. As such, we propose that, as a scientific field and research program, space sexology could help mitigate the risks associated with the expression of human intimacy and sexuality in extraterrestrial contexts and enable their benefits for astronauts and future space inhabitants.

Risks Related to Reproductive Health

To live in space for extended periods of time and settle new worlds, humans must master how to safely reproduce in space (Layendecker & Pandya, 2019; Szocik et al., 2018). For ethical and legal reasons, space organizations must also protect the reproductive health of the people that they take into space, and that of those who may eventually be born outside of Earth’s atmosphere (Kahn et al., 2014; Levchenko et al., 2018; Ronca, 2007; Ronca et al., 2014; Sekulić, Lukac, & Naumović, 2005). With these objectives in mind, research on space reproduction has focused on the factors that may impact human reproduction such as fertility, conception, pregnancy, and fetal or child development (Layendecker & Pandya, 2019). To date, this research has mostly relied on Earth-based and non-human animal models to simulate space conditions of interest and anticipate their potential impacts on humans (Mishra & Luderer, 2019; Proshchina et al., 2021).

Researchers have identified several space-related risks, which may converge to impair our reproductive health. For one, the exposure to ionizing radiation—such as high charge or energy particles—can alter the DNA of cells and gametes; and in turn, promote cancer formation, congenital malformations, and/or developmental anomalies (Mishra & Luderer, 2019; Proshchina et al., 2021; Ronca et al., 2014; Zhao et al., 2020). Prenatal radiation exposure in humans can further increase the spontaneous abortion rate, as well as induce growth restriction and developmental delay (Williams & Fletcher, 2010). The extreme gravitational changes involved in space travel and spacelife may also have adverse physiological effects. For instance, microgravity—such as on the Moon or Mars—and total weightlessness—such as on the ISS—can lead to deconditioning (Clément et al., 2015). Deconditioning may include reduced bone density and muscle atrophy, along with visual, neurovestibular, hormonal, and cardiovascular impairments (Mark et al., 2014; Mishra & Luderer, 2019; Platts et al., 2014; Ploutz-Snyder et al., 2014; Stavnichuk et al., 2020). Gravitational changes can also affect bodily fluids—such as blood flow and semen—which may influence vasocongestion, penile/clitoral erections, procreation, and gestation (Layendecker & Pandya, 2019). Along with that, adapting to spacelife can be stressful and disrupt nutrition intake, circadian rhythms, and microbiomes (Lapierre et al., 2009; Mishra & Luderer, 2019; Steller et al., 2018; Voorhies et al., 2019).

Related to some of these risks, non-human animal research has found that mice fertilization is possible under conditions of simulated microgravity, but typical embryo development may require a standard gravity of 1-g (Wakayama et al., 2009). More recently, Ogneva et al. (2020) found that simulated hyper- and micro-gravitational forces could negatively impact the motility and number of mice spermatozoa in mice. Studies have also demonstrated that the freeze-dried DNA of mouse spermatozoa could be safely conserved for extended periods of time aboard the ISS and used to produce viable offspring (Wakayama et al., 2021). In human experiments, a study of 13 female astronauts who gave birth post-spaceflights did not find any increase in the number or diversity of complications compared to the general population (Jennings & Baker, 2008). Bed rest studies have also found that microgravity may affect spermatogenesis, and spaceflight can reduce male testosterone levels (Ronca et al., 2014).

Notably, the limited research on the effects of space on human reproduction also suggests that there may exist gender/sex differences when it comes to astronauts' adaptation to spacelife and spaceflight. These risks may pertain to or intersect with cancer formation, pregnancy, and behavioural, muscular, and cardiovascular health (Ronca et al., 2014). Remarkably, however, little is known about the overall intimacy and sexuality of astronauts—or their reproductive health. So, even in one of the most studied areas related to space sexology, research has barely scratched the surface—and more to the point, sexology extends far beyond reproduction.

Other Anticipated Risks

Researchers have identified several other risks pertaining to intimacy and sexuality in space. For one, living in extremely remote, confined, and self-sustained artificial ecosystems can make it difficult to meet human erotic needs (NASA, 2019a; Noonan, 1998, 2001). Life in spacecrafts, stations, settlements, or even analogue environments can limit privacy, as these habitats will likely remain relatively quiet and small in the not-so-distant future (Noonan, 1998, 2001). Moreover, as it stands now, space inhabitants will also likely need to strictly follow elaborate hygiene and self-care protocols and training to ensure that extraterrestrial habitats are kept viable and pleasant (Cain, 2011). For example, astronauts must (re)learn how to eat, groom, clean, and excrete using the systems that are adapted to the ISS (Cain, 2011; Connors et al., 1994; Marcviacq & Bessone, 2009). These same principles apply to intimacy and sexuality. This means that people living in space for long periods of time will likely need to comply with certain restrictions on their solitary and partnered sexual activities, which can be at times indiscreet, and often generate noise, odours, and bodily fluids—like sweat, semen, or vaginal secretions.

In parallel, not unlike previous missions, astronauts and future space inhabitants will need to adapt to long-term isolation, reduced social and sexual interactions, along with strenuous life routines and protocols (Noonan, 1998, 2001). They will also need to independently handle emergencies, as terrestrial help may be impractical, if not impossible (Szocik, 2019). Additionally, some astronauts will likely have to adapt to the reality and challenge of being away from significant others for extended periods of time. In the near future, small crews and settlements may also limit access to compatible sexual or romantic partners (Gouda-Vossos et al., 2019; Luoto, 2019; Wincenciak et al., 2015). These circumstances can foster stress, interpersonal conflicts, and mental health issues (cf., Adamczyk, 2017; Donnelly & Burgess, 2008)—particularly when considering that space inhabitants will likely live, in close quarters, with the same people that they work with, without any possibility of leaving easily.

That said, Noonan (2001) proposed that, by closely and regularly interacting, some of the people living together for extended periods of time will likely be attracted to one another. Space programs may therefore need to contend with relationships and breakups between crew members of potentially different ranks (Chory & Hoke, 2019; Noonan, 2001). Relatedly, if intimate relationships occur or people have sex in extraterrestrial contexts, space inhabitants may also have to contend with the potential impacts of these events on the morale of individuals and crew performance (Dubé & Anctil, 2020b). What's more, the remoteness of some future extraterrestrial habitats means that space inhabitants may need to address issues such as injuries, dysfunctions, and sexually transmitted or blood-borne infections; and prepare for the challenges related to space reproduction, ranging from conception, (un)intended pregnancies and abortion, to birth, miscarriage, and child rearing (Jennings & Baker, 2008; Levchenko et al., 2018; Noonan, 2001; Schuster & Peck, 2016; Sekulić et al., 2005). In that regard, it has been argued that long-term spacelife will likely require travelers and settlers to carefully plan and monitor population levels and their compositions to keep habitats and settlements sustainable (Szocik et al., 2018; Traill et al., 2007).

Researchers have also proposed that people living in space will likely need to navigate the complexity of sociocultural differences among crew members and with that, a diversity of norms and behaviours (Kanas et al., 2009; Lapierre et al., 2009; Noonan, 2001). Thus, as a function of adapting to spacelife, travelers and settlers may develop their own intimate norms and behaviours. As reported by Noonan (2001), space habitats represent a “microsociety in a miniworld” (Connors et al., 1985, p.2). As such, we propose that the mix of different cultures can ultimately lead to the emergence of specific erotic cultures adapted to such contexts, and partly based on the needs or realities of self-sustained, self-contained, and remote artificial ecosystems.

Finally, given our experience on Earth—including in the military and in scientific fieldwork—it has been anticipated that some forms of sexual harassment, violence, and assault are likely to occur in space (cf. Clancy et al., 2014; Harris et al., 2017; Nash & Nielsen, 2020). For example, in December 1999, Judith Lapierre, doctor in social medicine and health promotion, co-author of the present paper, and at the time, a young researcher in space human factors and psychosociology, joined seven male colleagues for a 110-day experiment on board a three-room Mir Space Station replica. Less than a month after she joined the experiment, Dr. Lapierre was sexually harassed—i.e., non-consensually grabbed, forced, and kissed—by a Russian crew member who oversaw the mission (Lapierre, 2007; Lapierre et al., 2009). This situation happened after she was also made the subject of a male sexist discussion, which described an experiment that would include her as the main experimental sexual object of the men of the crew, off camera (Lapierre, 2007).

These deplorable events emphasize the likelihood of sexual harassment and violence occurring in astronautics. In relation to these events, Dr. Lapierre would state: “It is time, more than ever, to meet the real challenges of space exploration, with honesty, transparency, and by recognizing that Earth’s unacceptable behaviors are also Space’s unacceptable behaviors for a spacefaring civilization” (Lapierre, 2007, p. 44). And while the present article both supports and amplifies such statements, significant changes in human factor research programs have yet to be seen and implemented. We thus want to reiterate that it would be unethical to neglect the possibility of such events occurring (again) in analogue or space contexts—that is, contexts where living and human resources are particularly scarce, and where astronauts and future space tourists or inhabitants may be vulnerable.

Importantly, we would argue that the probability of the risks described above to manifest likely increases as a function of the time that people spend in space and the distance from Earth resources. We would also argue that these risks could disproportionately and/or discriminately affect certain groups of people, such as: women, females, Black, Indigenous and People of Color (BIPOC) community members, gender or sexual minorities (e.g., LGBTQIA2S+ people and communities), individuals living with disabilities, and the intersection of some of these identities (e.g., Black transgender women; Black et al., 2014; Deerfield, 2016; Healey, 2018; Murphy et al., 2020; Sage, 2009). For example, the relative physical strength of males in combination with toxic patriarchal sociocultural norms may also subject women and non-cisgender-men to greater threat (Black et al., 2014; Carter, 2015). Moreover, in our species, female-sex bodies are responsible for bringing new human life into the world, which can increase the pressure imposed on them regarding extraterrestrial reproduction, along with pregnancy-related risks (Casper & Moore, 1995; Doyle et al., 2012; Levchenko et al., 2018). Gender and sexual minorities may also experience more difficulty finding compatible intimate partners due to the underrepresented number of individuals with shared or similar orientations/preferences, and because of the limited number of people expected to be living in space in the near future (Rahman et al., 2020). Due to prevailing oppressive mentalities, gender and sexual minorities are also expected to be at greater risks for discrimination, stigma, violence, and mental health issues (Littlejohn et al., 2019). To that, one must also add the body of research suggesting that, compared to males, some risks may disproportionately affect the cardiovascular (Platts et al., 2014), musculoskeletal (Ploutz-Snyder et al., 2014), immune (Kennedy et al., 2014), and neurosensory systems of female astronauts (Reschke et al., 2014), as well as their reproductive health (Ronca et al., 2014) and behavioural adaptation (Goel et al., 2014; for a summary, see Mark et al., 2014). As such, a perspective on justice, equity, diversity, and inclusion needs priority attention (Rathus et al., 2016).

At the moment, some of the risks described above may not seem like pressing issues to space organizations. After all, aside from on the ISS, long-term crewed missions—for instance, to the Moon or Mars—have yet to happen. Astronauts are also selected based on extremely stringent criteria (Seedhouse, 2010). Their life and health are closely monitored (Doarn et al., 2016; Roda et al., 2018). Pregnancy is contraindicated for spaceflights (Jain & Wotring, 2016; Layendecker & Pandya, 2019). Female astronauts use contraceptives (Murad, 2008) and sex or intimate relationships remain seemingly prohibited on the ISS (Fisher, 2010).

Yet, there are several good reasons to begin addressing these issues now. First, as we have seen with the case of Dr. Lapierre, important problems may still arise—and in fact, have already happened in simulation contexts (Lapierre, 2007). Second, even with rigorous training, astronauts remain humans with intimate needs and desires (Dubé & Anctil, 2020b). As such, given enough time, they will likely want to find ways to fulfill those needs and desires. Third, as technology makes extraterrestrial life and travel more accessible to the public, the people who go into space in the future—from scientists to tourists—may not have to undergo the same kind of stringent training or selection process as current astronauts (cf. Wattles, 2021). Fourth, if we truly aim to travel and live in space for extended periods of time or settle new worlds, space organizations will need to rethink the way they approach extraterrestrial eroticism, along with the limits that they impose on human intimacy and sexuality (Schuster & Peck, 2016). Lastly, producing quality science and implementing systemic changes take time, so why not start immediately, rather than wait for problems to arise?

In that regard, we propose that, as a scientific field and research program, space sexology could not only help to devise solutions and mitigate the risks previously described, but also identify other risk factors that may arise and/or jeopardize the expression of human intimacy and sexuality in astronautical contexts. We further suggest that, in addition to the consideration of these risks, space sexology could explore the benefits of space sex and intimate relationships for human health and well-being, crew performance, and mission success.

Anticipated Benefits of Intimacy and Sexuality in Space

Facilitating intimacy and sexuality in space could improve the life of astronauts and future space inhabitants (Brody, 2010; Levin, 2007; Pennanen-Lire et al., 2021). Intimate and sexual activities can arguably help people adapt to space contexts and normalize spacelife. This may be achieved by, for instance: improving the health and well-being of astronauts and enabling—throughout astronomical exploration—aspects of human existence that are deemed pleasurable and beneficial.

Indeed, beyond reproduction and the continuation of our species, solitary and partnered sex—along with the psychophysiological effects of pleasure, arousal, and orgasms—have the potential to help with stress, blood pressure, and sleep (Pennanen-Lire et al., 2021). They may also help relieve pain and headaches; activate the cardiovascular and immune systems; pelvic floor muscles; and protect against prostate cancer (Pennanen-Lire et al., 2021). Sex may further improve self-esteem, body image, and overall psychological health, as well as facilitate subsequent sexual functioning, relationship satisfaction, pair-bonding, and the expression of affection (Meltzer et al., 2017; Meston & Buss, 2007; Pennanen-Lire et al., 2021).

Masturbation, in particular, may be relatively accessible in space and can complement partnered erotic interactions. Masturbation is a practical, healthy, and pleasurable expression of one's sexuality (Coleman, 2003). It is also increasingly recognized as an important and empowering component of self-care and sexual development (e.g., discovery of one's body, preferences, and agency; Bowman, 2014; Kaestle & Allen, 2011; Shapiro, 2008). And since it does not require another partner, masturbation could help astronauts autonomously access pleasure and enable some of the benefits that sex can have for their health and well-being (Brody, 2010; Kiliç Onar et al., 2020; Levin 2007; Pennanen-Lire et al., 2021).

Given the above evidence, we propose that intimacy and sexuality—like leisure—could also help endure and normalize life in space by making it more enjoyable and less lonely. The army, navy, and space agencies have known for a long time that military personnel and astronauts need regular time to relax, play, and have fun (Kelly & Kansas, 1994; Stine, 1997).

Sexual and intimate relationships not only represent valued parts of human existence, but are also pursued because they are inherently fun and pleasurable activities, which can contribute to positive affect and allow for the formation of strong interpersonal bonds (Meston & Buss, 2007; Pennanen-Lire et al., 2021). So, despite their risks, we argue that enabling sexual and intimate relationships may ultimately help astronauts unwind, acclimate to space habitats, and relieve their minds of the stress that accompanies life and work in confined environments.

More specifically, since intimacy and sexuality are typically seen as natural, positive, and essential aspects of human life (Kismödi et al., 2017), we propose that making them possible in space contexts could lead to more humane and meaningful extraterrestrial lives. Sex and intimate relationships may also, on the one hand, help reduce the likelihood of astronauts feeling like they are contributing to space missions at the expense of participating in important aspects of human existence (e.g., fulfilling sexual and romantic relationships), and on the other hand, motivate people to contribute to space endeavours which do not place scientific progression above one's own needs and desires.

Nonetheless, to curb the risks and enable the benefits of intimacy and sexuality in space, we need to first understand them. This means studying human eroticism in analogue missions and, whenever possible, in the extraterrestrial contexts. In turn, the knowledge gained through this scientific investigation may help us to better prepare and educate humans for the realities of astronautical intimacy, as well as promote safe space environments—e.g., free of sexual harassment, unintended pregnancies, or issues related to the excessive limitation of human sexuality—and the respectful expression of astronauts' needs and desires—e.g., enabling healthy love, sex, and intimate relationships. It may also help us to develop space programs, habitats, and vehicles that meet such needs and desires. To make this happen, we invite space organizations to adopt an ethical approach: one that arguably starts with the development of space sexology.

Towards Space Sexology

The realities associated with human intimacy and sexuality in space could be better addressed through a unified and integrated transdisciplinary scientific field and research program on space sexology. This could help avoid inefficient, compartmentalized, or incomplete means of exploring extraterrestrial eroticism. It could also help ensure the development and implementation of a coherent, convergent collaborative scientific agenda and training program dedicated to such topics.

With this in mind, we propose that, to develop a comprehensive space sexology field and research program, it may be heuristically and epistemologically helpful to use a Biopsychosocial Model (Lehmiller, 2017). The Biopsychosocial Model posits that human phenomena—including our intimacy and sexuality—rest upon the interaction between biological (e.g., genetics, physiology, lifespan development, and neurochemistry), psychological (e.g., cognition, personality, and attitudes), and social/cultural factors (e.g., norms, education, socio-economic variables, and interpersonal relationships; Lehmiller, 2017). Since its inception, this model has proved useful across disciplines—like medicine and sexology—to envision complex, ever-changing human realities (Lehmiller, 2017).

As such, we suggest that, within the broader scope of the overlapping space research on human and technical factors, this model and its interrelated factors can help space organizations more accurately anticipate, prioritize, study, and generate solutions to the challenges of human intimacy and sexuality in space, along with enabling their potential benefits. For instance, researchers in space sexology may use the Biopsychosocial Model to approach human eroticism systematically and holistically—along with its diverse research dimensions—in analogue and space contexts. This model can also help researchers to appreciate the complexity of extraterrestrial human intimacy and sexuality; envision the development of adapted training programs, systems, and protocols that facilitate space eroticism; and ultimately, contribute to the health and well-being of astronauts and future space inhabitants (see Figure 1).

[Insert Figure 1]

Although it is beyond the scope of this paper to describe all the potential research dimensions that may be derived from this framework, the Biopsychosocial Model of Space Sexology enables researchers to foresee that the issue of reproduction in space, for example, does not only pertain to biological and physiological risks, but also encompasses a wide range of psychosocial and cultural challenges. It also increases researchers' awareness of the challenges related to extraterrestrial human intimacy and sexuality, and the fact that these challenges are not just a matter of having sex under microgravity or total weightlessness, but also include the complex and ever-changing relational and emotional dynamics of spatial microsocieties.

The details and priorities of a comprehensive space sexology field and research program will likely need to be developed through the collaboration of an international and intersectorial advisory committee or task force. In that regard, space organizations may consider integrating space sexology into their Human Research Programs, given that such programs already focus on identifying and developing research approaches to help understand and mitigate the risks associated with human work and life in space (NASA, n.d.). Yet, the full expression of human intimacy and sexuality in space may also require the development of new technological systems. Hence, to reflect this requirement, the biopsychosocial model of space sexology is here positioned at the intersection of research on human and technical factors.

Moreover, to build such a comprehensive field and program on space sexology, space organizations may require the input of various sources beyond that of the Science, Technology, Engineering, and Mathematics (STEM) and human factor researchers currently involved in space programs (Canadian Space Agency, 2018). As Noonan (2001) suggested, these sources may include sexologists and relationship experts (e.g., sex researchers, therapists, and coaches). But they also extend to nurses, obstetricians, gynecologists, reproductive endocrinologists, and fertility specialists. We propose that space sexology may further require the input of people from various demographics (e.g., age, ethnicity, cultures), capabilities (e.g., people living with disabilities), and sexual configurations (e.g., gender/sex, identities, orientations, preferences, and relationships structures; van Anders, 2015). After all, all these individuals could eventually live (or be born) in space or, at a minimum, contribute to space endeavours. Given this, diversified and inclusive inputs may increase the likelihood of mission success by reducing the probability of ignoring the needs of certain groups or individuals, as has been done (Boehmer, 2002; Douglas et al., 2017).

In fact, space programs have historically been overwhelmingly dominated or almost exclusively composed of men—with the exception of clerical workers, and other important contributors, such as the famous Hidden Figures (e.g., Katherine Johnson, Mary Jackson, and Dorothy Vaughan; Shetterly, 2016). Throughout 60 years of human spaceflight, less than 15% of space travelers have been women, and none of these women were granted the opportunity to travel beyond Earth's orbit (Corlett et al., 2020; NASA, 2021a). Due primarily to sexist and discriminatory norms and attitudes, the inclusion and advancement of women in space programs have been an arduous battle (Healey, 2018; Deerfield, 2016; Sage, 2009; Weitekamp, 2004). NASA's first human spaceflight program, Project Mercury in 1958, set the precedent for this exclusion when President D. Eisenhower deemed that astronaut candidates should be selected from a pool of military fighter jet test pilots—a profession that women were barred from pursuing toward the end of the Second World War up until 1993 when this restriction was lifted (Ackmann, 2004; Merryman, 2001).

Still, in 1959, Dr. Donald Flickinger and Dr. William R. Lovelace II conducted pioneering research on women's adaptation to spaceflight (Ryan et al., 2009). They proposed—somewhat radically for that time—that women would be better suited than men for space travel due to their lower mass, volume, and oxygen requirements (Landis, 2000; Ryan et al., 2009). At the time, they launched the Women in Space Program to examine the suitability of women as pilots for space (Weitekamp, 2018). In this program, Dr. Lovelace subjected 19 women to the same 87 physical and psychological tests as men, and not only found that 13/19 women candidates, compared to 18/32 men candidates, passed the test; but also, that women surpassed men on several tests, including those assessing their capability to withstand prolonged isolation (Ryan et al., 2009). Notwithstanding this, the program was terminated, and the data were never published (Ryan et al., 2009; Weitekamp, 2004). Around the same time, Betson and Secrest (1964) published a comment in the American Journal of Obstetrics & Gynecology expressing concerns about the place of female astronauts in space programs, with a particular focus on menstruation, and its physiological and "temperamental" effects. Both situations highlight, once again, how biased and uninformed assumptions may discriminately skew "scientific" opinions, along with people's perceptions of them (Healey, 2018; Sage, 2009).

Since then, women have rightfully taken on a greater role in space programs. But we encourage space programs to continuously strive toward greater diversity, equity, and inclusiveness (Rathus et al., 2016). This process starts with women holding active and equitable roles in space organizations and exploration, but should also extend to a better consideration of gender/sexual minorities and their realities. More broadly, to facilitate the advent of space sexology, we suggest that the people involved in space programs collaboratively invest the necessary resources to holistically explore space intimacy and sexuality. We argue that crossing this scientific frontier is the only way to avoid repeating past mistakes and foster a positive future for all of humankind among the stars.

Potential Challenges and Paths to Solutions

We anticipate that the development of space sexology will face several challenges. The first one is politico-economic and refers to the fact that the decisions of space agencies and companies often intersect with the sociocultural norms of those financing their endeavours (e.g., taxpayers and shareholders; Layendecker & Pandya, 2019; Whitesides, 2008). As such, space sexology may be limited by the traditionally conservative sexual views of the population, since space organizations may choose to evade anything related to sex—as they seem to have done historically—to avoid controversies and losing their funding (Layendecker & Pandya, 2019; Noonan, 1998; Whitesides, 2008; Woodmansee, 2006).

To begin addressing this challenge, it may be useful to remind national and private space organizations that access to intimacy and sexuality is increasingly recognized as a fundamental human right—a right that progressively encompasses pleasure and the recognition of sex/gender-based issues (Kismödi et al., 2017). It may also be useful to remind space organizations of the risks of limiting intimacy and sexuality in space, along with the benefits of enabling them (i.e., see section The Under-Researched Blind-Spot of Space Programs for details). Lastly, it may be useful to remind these organizations that, since mistakes have already happened in the past and some scholars have been calling for research on related topics for more than 30 years, they will not be able to feign ignorance (cf., Brenner et al., 2017; Lapierre et al., 2009; Layendecker & Pandya, 2019; Levin, 1989; Noonan, 2001; Ryan et al., 2009). In fact, space agencies and companies may be held legally and/or publicly accountable for the health and well-being of the people whom they carry into space, especially if issues arise (cf., Bensoussan, 2010). So as an alternative, we advise space organizations to address the intimate and sexual needs of astronauts and future space inhabitants. To do so, space organizations may want to align themselves with a progressive, sex-positive agenda—one that promotes sexual rights, empowerment, and freedom—to help the public and their investors understand the importance of intimacy and sexuality in space (Ivanski & Kohut, 2017; Kismödi et al., 2017), since promoting the respect of individual rights to health and safety may better resonate with a larger audience.

The second challenge is technical and refers to the fact that the technological systems and protocols enabling human intimacy and sexuality will need to be compatible with the artificial ecosystems of space habitats (Cain, 2011; Connors et al., 1994; Marcviacq & Bessone, 2009; Noonan, 1998, 2001). Beyond being pleasurable, this means that—like eating, grooming, cleaning, and excreting—the systems and protocols related to space eroticism will likely need to be designed in a way that is both safe and hygienic. It also means that astronauts will likely need to learn and practice how to use these systems as well as adhere to their relevant protocols.

To address this challenge—and considering the technological nature of space habitats—researchers in space sexology may want to explore the possibility of employing sex(ual) technology to help meet the intimate needs of astronauts (Dubé & Anctil, 2020b). For instance, a combination of adapted erotic stimuli, sex toys, haptic equipment, and/or artificial erotic agents could be used to facilitate safe and hygienic access to sex and intimate relationships between astronauts both *in*- and *out*side of their crew (Dubé & Anctil, 2020a; Dubé & Anctil, 2020b). These same erotic technologies could also be used to help connect intimate partners at a distance; mitigate some of the hardships associated with involuntary abstinence; and act as a complement to their daily medical exams by monitoring the health and well-being of people living in space (Dubé & Anctil, 2020a; Dubé & Anctil, 2020b; Roda et al., 2018). After all, military personnel and people on scientific missions are allowed to bring stimulation material (e.g., pornography and/or sex toys), particularly during long-term missions (Smith, 2019; Vincent, 2020), so why not astronauts and other space travelers? Notably, however, given the nature of human intimacy and sexuality, as well as the constraints of space habitats, erotic products may need to be easily cleaned, relatively discreet (e.g., small, practical, and silent), produce little to no waste, and be light enough to be carried into space.

The last challenge is human and encompasses the fact that the success of space sexology may rest upon the contribution and cooperation of space organizations and people going into space. That means that everyone involved in space endeavours will need to contribute to and comply with the guidelines, training, and protocols surrounding intimacy and sexuality in space. This may require shifts in the sexual norms and views of some administrators or astronauts, but ultimately, the solution must include them, along with their experiences and perspectives.

To begin addressing this challenge, space organizations may need to dedicate a part of their resources to designing selection and training programs that recognize the complexity of human intimacy and sexuality—along with the diversity of astronauts' backgrounds—and seek to foster sex-positive ethics within their institutions and personnel. This will require an ethics that allows astronauts and future space inhabitants to grasp the importance of safely and shamelessly expressing their intimate or sexual selves in space and respecting that of others around them do the same. Hopefully, such a program would help to steer the erotic culture of the future space habitats in a beneficial direction (Ivanski & Kohut, 2017; Kismödi et al., 2017), one that mitigates the risks and enhances well-being.

Conclusion

As a spacefaring civilization, the next chapter of our expansion requires a new perspective: one that fully acknowledges the intimate and sexual needs of humans, and directly addresses the constraints imposed by space onto human eroticism. In 2021, we cannot delay our actions any longer, since space organizations are moving forward with sending people into space for ever-longer periods of time; and producing conclusive, quality research takes both time and resources. Space organizations need a paradigm shift regarding the way they approach space exploration and human research programs. Otherwise, we risk impairing the health and well-being of astronauts and future space inhabitants, jeopardizing mission success, and end up becoming unhappy or unfulfilled space citizens.

To make this case, we have underlined the lack of knowledge on space intimacy and sexuality, along with the potential risks and benefits of respectively limiting or facilitating them. We further called for the development of a scientific field and research program dedicated to space sexology, the content of which will likely need to be developed further through the wide-scale collaboration of international and intersectorial stakeholders—including but not limited to: astronauts, human factor researchers, sex and relationship experts, and citizens of various backgrounds and experiential knowledge. Moving forward, the phenomena pertaining to sex and intimate relationships in space may be explored in analogue missions, on the ISS, and eventually on the moon to help future astronauts and space inhabitants prepare and adapt their intimacy and sexuality to long-term spacelife (NASA, 2019a).

In conclusion, as per other types of research, the knowledge gained through space sexology may very well benefit human intimacy and sexuality on Earth. We also posit that, as a species, we may want to give ourselves the means to build a space journey that reflects the best in humanity. Because in the end, as Vanna Bonta elegantly expressed (as cited in Woodmansee, 2006, p. 129): “Sex in space is not about going somewhere else to have sex; it’s ultimately about expanding beyond our immediate neighborhood, into a Universe to which we belong.”

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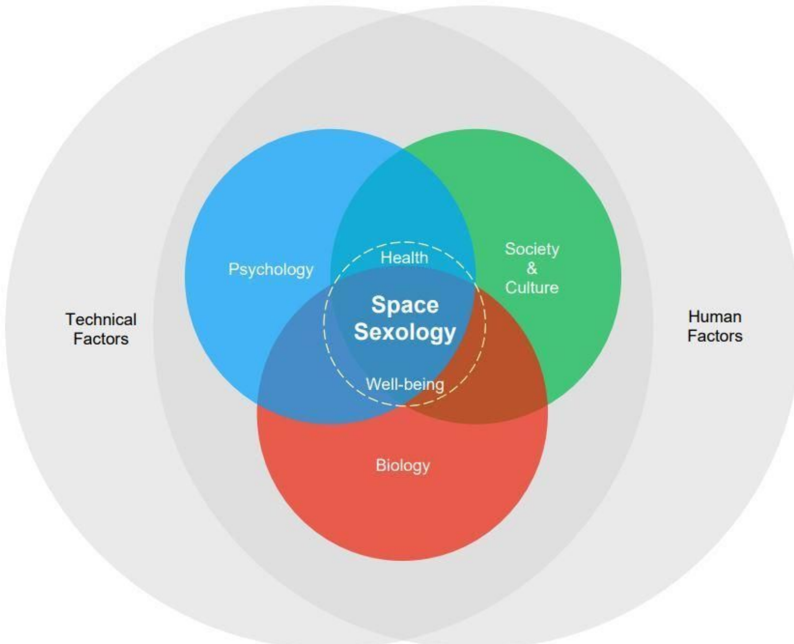

Figure 1. The biopsychosocial model of space sexology within its overlapping scientific research on human and technical factors.