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OTHERWORLDLY ANTHROPOLOGY

Past, Present, and Future Contributions of Ethnographers to Space Exploration

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Space exploration is a uniquely human activity. As we continue to push the limits of exploring the unknown, our knowledge of what it means to be human and our capacity for supporting human life beyond the comforts of our Earthly home continues to evolve. Scientists and engineers develop new technologies and advancements in medicine in order to support life among the stars. Likewise, social scientists aid space agencies in understanding human behavior so that astronauts and cosmonauts are selected and trained for mission success. Social science, particularly through ethnography, also aids space explorers who must learn to utilize the new technologies and medical advances in the extreme environment of space while becoming accustomed to life as a space community. It is important that researchers address these challenges so that human survival beyond Earth is not only achievable but so that life among the stars is worth living and sustaining. Ethnography is a useful tool for obtaining an insider's perspective and holistic viewpoint on the life of the space explorer. Through the application of ethnography and cultural knowledge, anthropologists are uniquely suited to address such topics and help extend the trajectory of space exploration as well as our understanding of humanity to new horizons.

"An anthropologist who studies outer space?" I wish I had a nickel for every puzzled look I receive when telling people, even fellow anthropologists, about my chosen occupation as a researcher in space systems and habitat design. The physical sciences are in familiar territory when it comes to space exploration research. The opportunities for advancements in astronomy, physics, chemistry, geology, and even the life sciences made possible by the space industry are rarely debated. Social scientists, anthropologists in particular, have been slow to acknowledge outer space as a useful domain of research and have only recently participated in applied space-related research. However, space exploration is a phenomenon offering unique views of behavior, culture, and community, though it is a research domain that often receives little attention from anthropologists. When I conducted my first

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applied study concerning crew privacy needs in long-duration spaceflight, I was the only anthropologist at the space agency even though anthropologists' fascination with this aspect of humanity began shortly after men first traveled to outer space. The following sections of this chapter provide an overview of areas in which anthropology has engaged with and continues to be involved in space exploration research and introduce a domain of anthropological research with a value that is truly out of this world, though often unexpected.

Anthropology and the Domain of Outer Space

The onset of engagement between anthropology and the domain of outer space centered on the subject of extraterrestrial life. In 1961, the National Aeronautics and Space Administration (NASA) commissioned a study to assess the impact contact with alien life would have on the public. The investigators referenced anthropological studies of societies negatively affected by the introduction of a new group possessing a different set of attitudes, values, and technologies (Dick 2006). Even though this report highlighted the benefits of applying anthropological knowledge to the task, it was not until the 1970s that anthropologists were formally involved in the discussions. In 1971, the Soviet Union invited two anthropologists to attend an international meeting on communication with extraterrestrial intelligence. NASA followed suit in 1972 by inviting anthropologist Ashley Montagu to a symposium in which Montagu made a case for the study of culture contacts. Extraterrestrial life continued to be in focus as the first substantial support of anthropology's involvement in space cultures came with the sponsorship of the popular science book *Cultures Beyond the Earth* (Maruyama and Harkins 1975) by the American Anthropological Association (AAA). The book, a result of a 1974 AAA symposium, not only covered extraterrestrial life of the alien variety, but it also classified human explorers as possible extraterrestrials.

Building on anthropological discourse on extraterrestrial life during the 1970s, anthropologist Ben Finney (Finney and Jones 1986) conducted the first fieldwork study with NASA's Search for Extraterrestrial Intelligence (SETI) project during the mid-1980s. His work with SETI in the mid-1980s was significant in that it was the first time a formal relationship between an anthropologist and a space agency was established (Dick 2006). Finney, referred to by many as the father of space anthropology (Harris 1995; Stuster 1996), was also the first to move beyond extraterrestrial speculation and look at space exploration as a topic worthy of practical anthropological inquiry. Finney continued his work in space exploration throughout the 1980s and 1990s in a consultant role for NASA, where he was the first to formulate a case study as the basis for planning future space societies (Finney 1987). The construction of space societies and extraterrestrial encounters continue to be contemporary topics of interest among social scientists and space enthusiasts (Battaglia 2006; Harris 1995; Pass 2006; Riner 1987).

Future space societies represent only one area of anthropological inquiry posed by space exploration. In addition to futures studies, the domain of space exploration presents opportunities for research regarding other topics often explored by both academic and practicing anthropologists. Space-related research questions of anthropological interest are seen in projects focused on the physiological, psychological, and behavioral impacts of living and working in isolated and extreme environments. Historically, space agencies placed more importance on investigating the biological sciences, but funded projects have increasingly incorporated behavioral and communication perspectives. Although progress has been made in involving the social sciences in space research, agencies' objectives have remained fixed on improving productivity and mission success (Kanas 2005; Stuster 2010; Clancey 2003, 2012). For this reason, topics of research regarding the environmental, physical or biological, and psychosocial aspects of space travel have remained prevalent in this domain. Organizational culture, collaboration, and technology design are other subjects which anthropologists and like-minded ethnographers have engaged with in regards to space exploration. A closer examination of the five themes of research, (1) environmental, (2) physiological and psychological, (3) organizational and collaborative, (4) technological, and (5) anticipatory, provide a glimpse into the opportunities for present and future engagements between anthropology and space research. Anthropologists are uniquely suited to take part in these complex, interrelated areas of research because of their holistic training in culture and *in situ* approaches to studying human behavior.

Environmental

Space is an inhospitable environment. Few places, if any, on Earth require their inhabitants to be isolated from outside contact and remain confined to a small volume of space in order to survive the extreme environmental conditions that characterize space. Scientists and engineers tasked with designing both crewed and un-crewed spaceflight missions are rightly concerned about the extremity of space. The harsh temperatures and diminished gravity of outer space designate which materials are needed to construct satellites, robotics, and space vehicles that are functional and sustainable. The lack of a breathable atmosphere drives the need for providing an artificial, confined environment for living space explorers. The isolated, confined, and extreme (ICE) environment of outer space impacts the construction of space structures, as just noted, as well as influencing the social aspects of space exploration. Astronauts and cosmonauts are selected according to personal characteristics considered desirable and necessary for a successful mission living and working in this ICE environment – traits identified by social scientists.

Several anthropologists have embraced outer space as a source for exploring human perceptions and behaviors regarding their environment. Research in this area, including research from within academia and that applied in industry, brings into question spatial and temporal aspects of environmental adaptation and ecological evolution that result from living in the ICE environment of space (Olson 2010; Palinkas 1990). As crewed missions move beyond low Earth orbit, the impact of the unfamiliar environment that these works address becomes magnified. Combine the challenges of an ICE environment with the time required for a trip to Mars or a near-Earth asteroid, and the risks to human safety and well-being become intensified. It is unknown if feelings of isolation are magnified by the sensory awareness of being unable to see Earth. Likewise, questions remain unanswered as to the impact of being confined in a small volume for longer than a year without the ability to freely enter the surrounding environment. Indeed, the ICE environment, an acronym formalized in American space studies, is central to the challenges faced by space explorers.

Physiological and Psychological

The restrictions imposed on a spaceflight crew are arguably unique to the environment of space. As noted above, most empirical research studies have and continue to focus on the physiological and psychological impacts of space travel. Spaceflight is dangerous, and every aspect involved in traveling outside the safety of Earth's atmosphere poses a certain amount of risk to the health and well-being of humans. Weightlessness, exposure to radiation, and sensory deprivation living within an artificial habitable environment are all risks of spaceflight that affect the crew. The Human Research Program (HRP) at the NASA Johnson Space Center (JSC) investigates and works to mitigate the risks to human health and performance (NASA 2014). The HRP outlines activities aimed at identifying and addressing the undesirable effects of spaceflight on humans, and within each identified risk, they identify knowledge gaps in need of further research. The opportunities for research presented by the HRP that could benefit from anthropological insight are too numerous to list in this chapter, yet two topics deserve special mention: the development of individualized countermeasures and identifying potential interpersonal conflicts while living in space.

Even though humans have been traveling through space for over fifty years, mitigating the physiological and psychological effects of long-duration, long-distance spaceflight remains a challenge. Space agencies develop countermeasures as a means to mitigate or counteract the undesirable effects of spaceflight on humans (NASA 2011). Countermeasures include medical devices such as medication to counteract space-induced insomnia as well as formal procedures for allowing crewmembers to have free time in order to relieve work-related stress. NASA is currently investigating the potential use of countermeasures that are individualized to the needs of each crewmember. Since the permanent occupation of the International Space Station (ISS), space researchers have remarked on the inadequacy of a one-size-fits-all approach in developing countermeasures due to differences in body composition along with differing levels of compliance. Biological and applied cultural anthropologists with a focus on medicine could possibly add much to their efforts in exploring genetically and behaviorally individualized countermeasures. Lawrence Palinkas (1990, 2003, 2010) is one notable anthropologist conducting research aimed at cross-cultural medicine, but he also addresses the interpersonal dynamics among people living and working in space and how these psychosocial issues evolve over a long period of time.

Organizational and Collaborative

Space exploration affords the opportunity for a greater understanding of human society through the diversity of its explorers and the complexity of the organizations to which they belong. NASA is synonymous with space exploration and provides an excellent example of this complexity. Since the beginning of the Space Race, space exploration has been a highly politicized activity. Policy-driven mandates from Congress shaped the earliest days of the US space program and created an operational paradigm of international involvement that continues today. To this day, the US Congress and Administration remain the most prominent political influences on the planning and implementation of American spaceflight missions. NASA's strategic plans and goals are directed by American national policy, and in turn direct the design of spacecraft and the establishment of mission objectives. Throughout its history, individuals from the Legislative Branch, Congress, and the Administrative Branch of the US federal government have often played a direct role in conceptualizing the Agency's designs (Logsdon 2002). More frequently, Congress influences the design of spacecraft by appropriating funds for NASA's budget.

In addition to the direct political influence on the organization, NASA is a highly complex organization dependent on multi-sited collaboration between its various centers spread throughout the US as well as international cooperation from its partners. In this way, NASA is representative of many large, international organizations. Diane Vaughan's well-known book *The Challenger Launch Decision* (Vaughan 1996) provided the first substantial look into the organizational and work culture of NASA. Communication styles, skill sets, and problem-solving abilities differ among astronauts, scientists, and engineers due to the nature of their occupational norms and their regional culture (Clancey 2003; Kanas 2004, 2005; Stuster 2010). However, the complexity of culture, location, and performance as a virtual organization is taken further, in that NASA also works with people and technology located off-planet and in time zones that do not align with the Earth's rotation. Computer scientist and ethnographer William Clancey (2012) describes distributed teams of scientists working onsite at the Jet Propulsion Laboratory (JPL) and abroad in his book *Working on Mars* (2012). These scientists and engineers supported the Mars Exploration Rovers (MER) while living on Mars time.

As NASA historian John Logsdon reminds his readers, space exploration has long been the ultimate example of international collaboration (Logsdon 2002). Since the last days of the Apollo program, NASA has built its program around the aim of fostering international relationships, as evident in programs like Spacelab, Space-Shuttle–Mir, and the current ISS. The emphasis on international cooperation is apparent in that a greater number of NASA-sponsored studies focus on international crew relationships than on any other topic except biology. Studies including the frequently cited Shuttle–Mir and ISS research by Nick Kanas (Boyd et al. 2009; Kanas 2004, 2005) and polar and space expedition studies by Palinkas (Palinkas 1990, 2003) highlight the interactions and interpersonal conflicts among international crews. Anthropologist Jack Stuster's Astronaut Journal Flight Experiment (Stuster

2010) is notable in providing ethnographic insight on this topic and his continuing project will be essential in understanding how crew behavior evolves over time.

The people involved in carrying out future spaceflight missions, as crew or as ground support, are likely to remain multinational, interdisciplinary, and multi-sited for reasons other than political appeal. Scholars and agencies agree that space exploration is more successful when approached through international and interdisciplinary collaboration due to the increased availability of financial resources and diversity in expertise (Boyd et al. 2009; Logsdon 2002; Olson 2010; Pass 2006). Space exploration is costly not just in terms of financial resources but also in respect to the diverse, expert skills and knowledge needed to travel to the stars. The crew composition aboard the ISS continues to be a multinational, multidisciplinary mix of men and women. Therefore, it is plausible that NASA will partner with other space agencies and seek diversity in the expertise of future spaceflight crews to meet the financial, technical, and social challenges of space exploration beyond near-Earth orbit. As crews move out from Earth for longer periods of time, anthropologists are provided with a domain rich in aspects of culture, intersubjectivity, and connectedness. Few, if any, territories of research offer such a complex milieu of sociality and identity coupled with techniques and environment as that which is characteristic of space exploration. Anthropology is the reasonable choice for exploring these issues because of the discipline's familiarity with addressing complex questions regarding the human condition through synthesizing cultural, material, and biological knowledge.

Technological

In line with the complexity of the organizations involved in space exploration, the development of space technology is a complicated and painstakingly involved process. Engineers and scientists are working towards missions to the Moon, Mars, and beyond. Over the years, NASA's approach to technology design has evolved from a purely machine-centered paradigm to a practice more accepting of contemporary human-centered ideas. This shift opens the doors for design anthropologists and ethnographers with expertise in technology design and human–computer interaction to become engaged in space research. The growing opportunities in this area have the potential to increase our knowledge of how humans think about and interact with cutting-edge technologies but also provide engineers with the insight needed to design technologies that are easily adopted and function as desired.

Since the 1990s, design researchers have turned increasingly towards ethnography as a means to understand users (Cefkin 2013; Wasson 2000) and, essentially, cut the cost of development by seeking the user's perspective throughout the production cycle. Engineers' uncertainty about the future, as a result of budget cutbacks and ever-changing political mandates, continues a tradition of establishing standards "designed to the threshold of acceptability" established in the Skylab era (Compton and Benson 2011, 136). Engineers and program managers set design standards under this paradigm so as to establish what is the least amount of resources (e.g. spatial volume, industrial material, tools, etc.) necessary to sustain life and achieve mission success. Within the boundaries of what-is-affordable, NASA engineers attempt to engage in the design process to meet the demands of what-is-safe.

Anthropologists who apply ethnography to understanding and evaluating human–technology performances are extremely helpful in ensuring a successful space mission. Space travel is dangerous, and NASA has gone to great lengths over the years to create and sustain a culture of safety (Vaughan 1996). As part of these efforts, NASA continues to publish standards which engineers must follow as they endeavor to design spacecraft to effectively facilitate human space exploration. These standards are typically developed with a design reference mission, or a planned mission, in mind. However, since the end of the Space Shuttle Program in 2011, budget constraints and shifting directives from Congress have led managers to request standards be developed that could be applied to any long-duration spaceflight mission. Generalizing spacecraft design standards has proven to be a significant challenge, as definitions of long duration and habitability are often tied to the particulars of a mission (Whitmore et al. 1998, 2013). For example, perceptions of isolation during a one-year mission orbiting the Earth could be dramatically different from a one-year mission orbiting Mars. Similarly, design criteria that guide the development of a terrestrial habitat are different from those that guide the development of a vehicle used in a micro-gravity environment. Therefore, experts are continuously identifying user-centered risk factors associated with spaceflight and knowledge gaps that need to be overcome in order to achieve and sustain a successful long-duration mission. These risk factors and knowledge gaps benefit from anthropological insight focused on technology use and acceptance. Ethnographers evaluate human–technology interactions in situated conditions so that insight is obtained from a holistic viewpoint, taking into account the peripheral environment within which the interactions exist. Anthropological insight gives the analysis of such ethnographic data meaning and actionable understanding within the domain of space exploration.

Anticipatory

Predicting the known technological and social difficulties of an unplanned, future space mission presents a challenge to any discipline. For cultural anthropologists, the challenge cuts to the core of our field's emphasis on *in situ*, participant observation. Direct participant observation of the target population is arguably the most common approach to fieldwork in ethnographic, anthropological inquiry. Indeed, "being there" is the hallmark of cultural anthropologists' claim of gaining insight (Hannerz 2003). To study a space community, which does not yet exist, researchers seek fieldwork opportunities to study analogous populations from existing space-like settings. When space scientists and engineers need to test space systems and simulate space mission operations, they conduct tests at an analog site that meets the required physical aspects of the space environment they need to study. Space analogs are field sites or laboratory setups identified as having characteristics similar to the environment of space. Space analogs vary according to which aspects of

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The nature of space-related research coupled with themes of pioneering, exploration, and discovery adds to the future-oriented, science fiction undertones of adventure in space exploration. Research activities allow for the future planning of relatively near-term projects such as missions to Mars and near-Earth asteroids, but also allows for speculation about projects to be carried out past this century. The ultimate example of futures rhetoric is found in sociologist Jim Pass's (2006) work on planning space societies. The uniqueness of space as a future field site for research and its assumed importance to the future of humanity have led many social scientists to propose a shift in disciplinary paradigms. Astrobiology was created as a biology sub-discipline for the study of life in the universe, effectively shifting the paradigm of Earth-based life to universe-based life. Similar, less successful attempts have been made within the social sciences. Finney (1992, 186) proposed "astro-anthropology" as a new subfield of anthropology to study the humanization of space while Pass (2006, 2) proposes the similarly named "astrosociology." In corresponding fashion, psychologist Philip Harris (1995) proposes a paradigm shift from conceptualizing mankind or humankind into the broader term spacekind. Regardless of the terminology, these researchers agree that a futures perspective is needed in applied space research. Furthermore, the future-oriented aspect of space research provides opportunities to develop anthropological theory and ethnographic methodologies useful in other areas of futures research, such as city planning and technology development.

Space in Space: A Case Study of Space Anthropology

The themes, or areas of inquiry, of space research often overlap. The best way to illustrate the interrelatedness of topics in space research and the richness of the ethnographic data is with an example of a study conducted for NASA regarding habitat design. In 2013, I conducted ethnographic research to explore perceptions of privacy and privacy needs among astronauts living and working in space as part of a long-distance, long-duration mission.[1] The study addressed the complexities involved in determining the privacy needs of a future spaceflight crew and offered practical insight regarding design considerations for providing privacy through an ethnographic study of space analog crews and designers. I triangulated evidence from in-depth interviews, photo and video narratives, archival research, guided walk-throughs of habitats, and direct participant observation to gain an understanding of privacy issues experienced by a space crew. As a case study, the research represents the often overlapping themes of space research outlined above as well as illustrating the benefits of applying anthropology within the domain of space exploration.

NASA, other national space agencies, and the commercial space partners of these agencies are working to develop vehicles and habitats capable of sending humans beyond low Earth orbit. The development of habitable environments suitable to long-duration spaceflight, informally defined as a mission lasting longer than one year, has become an agency priority for NASA. In recent years, the focus of their mission objectives has turned from missions in near-Earth orbit, such as the ISS to missions to asteroids, Mars, and beyond. The researchers in the Habitability and Human Factors organization and the Behavioral Health and Performance organization represent two groups at the NASA Johnson Space Center tasked with exploring the challenges anticipated for a long-duration space mission. One area of their investigations focuses on determining the minimum habitable volume requirements for habitats supporting the day-to-day life and work of a long-term crew. The need for privacy has been identified as particularly challenging to account for in defining the minimal habitable volume for optimal, long-duration crew performance. I joined these organizations as a research apprentice in 2013 to address this challenge.

The Problem of Privacy

From lessons learned during spaceflight missions lasting less than six months, the NASA Human Research Program (HRP) recognized habitat volume and layout as a contributing factor to human health and performance in space (NASA 2011; Simon et al. 2011). An incompatible vehicle or habitat design poses a risk that can affect crew safety and mission success (Whitmore et al. 2013). Future vehicle and habitat design strategies will need to address adequacies in the livable, or habitable, volume and acceptable architectural layouts in order to mitigate design-related stressors during a long-duration mission. Design-related stressors include sleep deprivation from high ambient noise levels and interpersonal conflict arising from issues of confinement and the inefficient designs of working and living spaces (NASA 2011; Whitmore et al. 2013). The effects of these design-related stressors are generally understood with regards to short-term missions, but it remains unknown how these stressors evolve over long periods of time.

Habitability design standards are established as a means of guidance for engineers responsible for creating the concepts, prototypes, and operational space systems supporting human life. These standards must meet the needs of crewmembers with regards to their physical and mental health and well-being in order to assure mission safety and success (NASA 2011). In 2011, NASA identified issues of privacy as a top-priority design-related stressor concerning habitability designs for long-duration, space exploration missions (Simon et al. 2011). The allocation of space, or habitable volume, becomes an increasingly complex issue in outer space due to the costs associated with maintaining an artificial, confined environment bounded by limitations of mass while located in an extreme environment. Given the challenges of sustaining life in such a limited environment, NASA deemed it necessary to determine the acceptable minimal amount of habitable volume for activities requiring at least some level of privacy so as to support optimal crew performance.

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In addition to the environmental challenges associated with spaceflight, the number of crewmembers, objectives, and duration of a space mission drive the amount of habitable volume required. Evidence from American spaceflight shows that the larger the crew and the more cramped the volume, the more likely behavior and performance will be impaired, and feelings of being confined or cramped are noted to intensify over time (Perner and Langdoc 1994). Frequently cited work from the 1960s by Thomas Fraser (1966, 1968) suggested that a volume of 4.24 m^3 per person would be adequate for flights as long as thirty days. However, standards for the acceptable net habitable volume (NHV) of a spacecraft had yet to be determined for missions lasting longer than one year at the time this research was conducted. NHV, also referred to as functional volume, is defined as the total volume that is not occupied by other elements occupying space within a given environment and which is therefore accessible by crewmembers for performing tasks (NASA 2011).

Addressing the Problem

The need for an improved understanding of the relationship between habitat volume, social stressors, and privacy served as the foundation of the study. The goal of the applied project was to obtain a more thorough understanding of how privacy concerns related to habitat and vehicle design issues as well as to social issues affect crew performance and quality of life for long-duration spaceflight. Rather than determining a numerical value for the optimal, minimal habitable volume as called for by the NASA HRP, the research objectives of this project were to advance the knowledge of the space research community concerning the elements that constitute privacy that influence spatial volume and habitat design considerations.

The examination of "space in space" required an integrated investigation of the design of the astronauts' living environments, their work processes and relationships within NASA, as well as an understanding of the values and viewpoints of the NASA organization. An understanding of both privacy as a human condition and the effect of the space environment on the human condition was needed to design and carry out a successful study that would effectively address the research question. Moreover, knowledge of NASA as an organization would be key in producing actionable results to meet the needs of both the Habitability and Human Factors group and the Behavioral Health and Performance group.

At the beginning of the study, I was familiar with NASA as a highly complex, highly technological organization because I had worked within the agency for several years in the Mission Operations Directorate.[2] However, I was only somewhat familiar with the NASA HRP based on a brief, independent study I conducted in 2011 (Aiken 2012) during which I went through the HRP to gain access to potential participants. In order to reacquaint myself with the activities and culture of the NASA space agency, I spent five months conducting an in-depth review of literature and embedded myself in the everyday activities of the researchers onsite at JSC prior to conducting the fieldwork. During this period of discovery, I learned that the inability of experts to agree on a definition was central to the complexity of addressing privacy. The engineers I worked with at JSC and other American space researchers generally follow NASA's definition of privacy as documented in the Human Integration Design Handbook (NASA 2011), "an acceptable level of control over the extent of sharing oneself (physically, behaviorally, or intellectually) with others" (NASA 2011, 997), yet my colleagues struggled to accept this definition as universal and, more importantly, actionable in all aspects of designing for life in space. The need for me to address particular definitions of privacy in my study was guided in part by their reluctance to design for the individualistic nature of perceptions of privacy and also as a direct result of my training in anthropology and fondness for user-centered design research. Therefore, I made the decision early on in the project's design to allow my participants to define privacy, instead of examining perceptions of it based on a pre-determined definition. I chose this approach so that the voice of the unique study population, or the community of practice that characterizes space exploration, could best be heard.

The methods used in the study were selected so that the results would contextualize participants' behavior and their perceptions of privacy, and included interviews, photo and video narratives, the review of archival material in the form of mission debriefs, habitat walk-throughs, and direct participant observation. In-depth, semi-structured interviews were conducted one-on-one by myself with fifty participants and served as the primary method for this study. To supplement the interviews, I used photo and video narratives to examine observed behaviors and contextualize behaviors within the ICE environment. In each interview, I presented the participant with previously published photos and archival video footage, if available, to trigger past memories of a particular experience. When possible, the participants were asked to map out behaviors chronologically using a printout of the habitat floor plan. While onsite at JSC, I was allowed to attend and indirectly participate in the post-flight mission debriefs for the NASA astronauts who had recently returned from the ISS. I was also allowed to view transcripts from previous ISS post-flight mission debriefs and debrief data reports, which are archived by a team within the Habitability and Human Factors branch. As a method, guided walk-throughs of habitat mockups allowed for the collection of photographs and video that would otherwise have been unobtainable. High-fidelity mockups are currently used to prototype and test design strategies as well as train spaceflight crewmembers.

As noted previously, direct participant observation is perhaps the most challenging aspect of ethnographic research involving astronauts. Like many topics of interest in this domain, the future-oriented nature of the research question called for a uniquely defined population, which is uncommon in traditional ethnographic studies. Ethnographers typically study an existing population or community. Schensul et al. (1999, 7) define ethnographic research as that which is conducted "locally" within the particular community of study. However, the community of study for this research does not yet exist. Earth has yet to send humans beyond low Earth orbit (LEO) for a mission lasting longer than six months. Astronauts and cosmonauts have lived aboard space stations for long durations, but these space stations have

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remained in orbit around the Earth. The Apollo Program sent men to the Moon, beyond LEO, yet the longest mission time averaged only twelve days. To study a space community that does not yet exist, I elected to use crewmembers from existing space analogs. In addition to providing the parameters for the study's population, I utilized a space analog as a site for direct participant observation. In August 2013, I was selected as a member of the inaugural Human Exploration Research Analog (HERA) crew, HERA-1. The mission took place in September onsite at JSC with the goal of evaluating the newly reconfigured habitat used in previous Desert Research and Technology Studies (Desert RATS). The four crewmembers, including myself, another female and two males, spent three days and two nights in HERA, located inside a building onsite. Even though the mission was short and severely limited as a high-fidelity space simulation, I was able to observe how crewmembers interacted with each other and with their analog environment first-hand.

Research Outcomes

The study resulted in twenty-five key findings regarding perceptions and behaviors relating to privacy in a space habitat environment. The user-centered definition of privacy I sought for this study offered the opportunity to conceptualize privacy in terms of both practical, technical applications and social affordances in the situated voice of a space crew. Participants used the term "ability" most often when defining privacy. The term ability implies the capacity to do something that achieves a specified goal or that enables a specific function, and is therefore task-oriented. Related to the idea of privacy and successfully completing tasks is the suitability or the effect of the design of the physical environment for affording individuals living and working within it the needed level of privacy. Participants often referred to privacy within the context of a physical space or setting that either provides or impedes the desired level of privacy. The aspect of the participants' definition most surprising to my NASA colleagues and myself was the reported social or "shared" element of privacy. As evident in participant narratives, privacy is a social affordance as well as a group need. However, in relation to the social aspects of privacy, participants emphasized the need to control or have a "choice" about how they share and receive information.

The findings, grounded in a shared definition of privacy, offered insights and recommendations that were of practical use in the design of space vehicles and habitats. The individual as well as the social aspects of perceived needs illustrated the attributes of privacy that affect performance and the well-being of humans in an ICE environment. The study also contributed to the growing body of knowledge within anthropology on subjectivity, personhood and what it means to be human. The domain of space exploration, as evident in my work, offers unique insight into our understanding of how humans conceptualize self, space, and time, and their corresponding, permeable boundaries, and how the built and "natural" environments influence the formation of ideas. Through my applied work with space crews, I am also addressing theoretical notions of distributed cognition and sensemaking within anthropology and design research. My past and continuing work with NASA illustrates the inherent nature of anthropology as a discipline that is able to address both practical, applied problems while also contributing to theory development.

Conclusion

Space exploration is a domain of anthropological inquiry rich in opportunity. The uniqueness of space presents an ethnographic field site like none on Earth for understanding spatial, temporal, and material perceptions of self and community. The themes of research described in this chapter speak to the prospects for research that is beneficial for both the discipline of anthropology and the interdisciplinary space research community. The subject of space in space, as explained in the case study, proved to be a challenging and rewarding endeavor in which ethnographic methods were stretched to address a practical problem in an unreachable, future field site while staying true to anthropological principles. More importantly, what began as a study aimed at meeting the needs of the NASA stakeholders proved to be mutually beneficial to all disciplines of researchers involved in the task of habitat design. The study provides an illustration of the benefits of applying anthropology to a practical space exploration problem, and also demonstrates the benefits of space research to the discipline of anthropology. The anthropology *of* space exploration and anthropology *for* space exploration both provide new resources for obtaining knowledge that contributes to our understanding of what it means to be human.

Future space travel seems certain, at least for now. Although this chapter has focused on American, government-supported activities, other national space agencies continually incorporate the social sciences in their research and training endeavors. Commercial space corporations present another exciting avenue for engaging in space-related research. Often referred to as NewSpace (Valentine et al. 2009), entrepreneurial space companies maintain growth in their efforts to privatize space exploration. As long as nations and industry partners continue to develop our exploration capabilities, practicing anthropologists will have otherworldly opportunities to further our understanding of humanity and help push boundaries further beyond the confines of Earth.

Notes

1 This work was funded by the National Space Biomedical Research Institute via NASA Cooperative Agreement NCC 9-58.
2 The Mission Operations Directorate leads overall crewed spaceflight mission activities including mission planning, astronaut training, and flight support through the Mission Control Center at the NASA Johnson Space Center.

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