The future is now: A mixed-methods analysis of astronauts' experience associate with space travel

Jingning Ao
University of Pittsburgh

Rudy Dunlap
Middle Tennessee State University

I-Chun (Nicky) Wu
Illinois State University

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Abstract

As SpaceX and other commercial entities enter the space industry, space travel for a broader audience will become more feasible. Since the early 1990s, tourism study has witnessed an ongoing conversation on space tourism, which mainly covers motivations of potential space tourists and their pricing expectations. This study takes a novel perspective by framing astronauts' direct experiences as inputs to build a conceptual model of space travel experience. Through a combination of traditional qualitative analysis and computation-based linguistic analysis on 19,114 Tweets (2008-2018) posted by 36 astronauts, this study aims to address an important theoretical void: When people travel to outer space, what leisure experiences attached to orbital space travel could they have? We propose "amateur astronaut" as a transiting title from astronauts to space tourists, and suggest that space travel experience brings an overview effect as our core theoretical contributions of touristic attraction.

Introduction

Space exploration never ceases to be a key theme in popular culture. As SpaceX and other commercial entities enter the space market, space travel for a broader audience will become more feasible, and it is necessary to investigate the potential of space tourism. Existing studies center on motivations of potential space tourists and their pricing expectations. However, no scholarly attention has been diverted to understand the direct experience of space travel. It can be misleading to the business development of future space tourism if the private entities build expectations of space travel on science fictions and films without abundant knowledge of the immediate space travel experience.

Stimulated by this gap, we find a quest for astronaut-like experience theoretically intriguing, particularly given the limited attention that has been paid to the relationship between professional astronauts and space tourists. Studying astronauts' experiences is important because they represent the entire population of existing space travelers, and they have generously shared real-time experiences through social media. More importantly, before travelers to space can be entirely called leisure-based tourists, there is a transition time when a blurry boundary exists between astronauts and tourists. Thinking of recent news about taking civilians to space by SpaceX and Virgin Galactic, both providers entitle their potential passengers as "dearMoon crews" and "Virgin Galactic astronauts" respectively.

Therefore, the purpose of this study is to answer the following question: When people travel to outer space, what leisure experiences associate with orbital space travel could they have? Or simply put, what's it like in space? This research question can be break down into four sub-questions: (1) What are the immediate psychological experiences of space travel? (2) What are the physical sensations of space travel? (3) How do astronauts comprehend risks and dangers? (4) Does gender matter to space travel experiences among astronauts?

Built on a social constructionism view, we conducted an inductive study using a netnography approach, with the aim of generating novel theory from qualitative data. Guided by the theory of

multiple-phase experience, we divided space travel experience into five stages as the first step of our conceptual model, including training, liftoff, in-space reentry, and reflection. Then, we purposefully sampled astronauts' real-time language about space travel. Specifically, we investigated the experiences of 36 NASA astronauts and drew on 19,114 Tweets (2008-2018) posted by these astronauts as the sources of textual data, which provided detailed information on the immediate on-site experience of space travel. We conducted two sequential analyses, the first was a traditional qualitative analysis assisted by MAXQDA to capture the details of the data, and the second was a computational-based linguistic analysis using Python and LIWC to grasp the comprehensive insights of data and to show the results in tables and figures.

The findings indicate a dominant positive emotion throughout the space travel stages, and the physical sensations are unique, diverse, and dynamic. Risks and dangers are acknowledged by astronauts, and more importantly they share ways to manage fears and make full use of risks for safety consideration for future space trips. Lastly, more similarities than differences are observed across gender groups. In conclusion, we propose "amateur astronauts" as a transiting title from astronauts to space tourists, and the overview effect as the overarching attraction associate with future space tourism.

Literature Review

Space tourism research. Existing space tourism literature have discussed four key questions of space tourism. First, what is the expected psychological experiences of space travel from the general public? Based on surveys and interviews, scholarly answers are either dangerous, thrilled, romantic, and spiritual (Laing & Crouch, 2004), or curious, learning, and creating-based (Cater, 2010). In other words, future space tourists should be high-adrenaline seekers, or novelty and sensation pursuers (Reddy et al., 2012). Second, what is the expected physical experience in space? Six expectations collected from the general public include viewing the earth and space, experiencing zero gravity, undertaking astronaut-like training, communicating with the people on earth from space, gaining abundant information to talk about this adventure, and obtaining astronaut-like recognition and souvenir (Peeters, 2010; Smith, 2000). Third, how to handle risks? Except the inherent spaceflight and technical risks (Collins et al., 1996), there are mental and physical health risks (Laing & Crouch, 2004; Marsh, 2006), privacy risk (Laing & Crouch, 2004), time-consuming risks especially in the training stage (Peeters, 2010). Lastly, do demographics matter to space travel experiences? Scholars have noticed a reverse relationship between age and willingness to take a spaceflight (Collins et al., 1996; Crouch et al., 2009). Education level seems to contribute to the decision making process as well (Peeters, 2010). As to gender, according to Collins et al. (1996), American men show more interest in space travel than American women in every age group, while it is not the case in Japan. Reddy et al. (2012) found that women are especially sensitive to safety issue, so they are less interested in space travel.

While existing space tourism literature seek to find answers of these questions from the general public using surveys and interviews, our study aims to take a different angle and draw the whole picture of space travel experience from astronauts, who have gone through the entire process. We assume, though astronauts are selected and trained to be professionals, the humanity part including excitement, fear, motivation, emotions, and physical sensations, can resonates with the rest of the earthlings. From astronauts' true stories, we may find out that those chose to go to space do not have to be adrenaline seekers — some can even be afraid of height!

A quest for astronaut-like experience. The question been asked the most to astronauts is "What was it like?" (White, 1987). People are curious about space experiences because they acknowledge that the space travel experience will be entirely different. If the envy of birds is behind the development of air travel, then it is safe to assume that space tourism is partially built on the envy of astronaut-only experiences.

This argument has been implicitly noted in several space tourism articles, including Bensoussan (2010), Cater (2010), Chang (2015), Freeland (2010), Reddy et al. (2012), Peeters (2010), and Ziliotto (2010). In particular, space tourism allows individuals experiencing what astronauts have praised for years about space travel as the most exciting experience and the planet earth as both stunning and fragile (Ziliotto, 2010), and these experiences which only a privilege group has engaged with can motivate private space explorers (Reddy et al., 2012). In other words, astronauts' descriptions of space travel have been used to support argument in space tourism studies.

However, previous studies may be overly confident about public's knowledge of space travel experience. Scholars directly reached out to people's willingness to pay for a real space trip, through survey of the public (e.g., Collins et al., 1994, 1996; Crouch et al., 2009; Depasquale et al., 2006; Le Goff & Moreau, 2013; Reddy et al., 2012), telephone questionnaire to random individuals (e.g., Collins et al., 1996), and interview of space tourism operators and travel agents (e.g., Cater, 2010; Reddy et al., 2012). Then, a concern emerges, that both the public and the scholars may not have a full picture of "What was it like?" Without the overview of space travel experience, both entrepreneurs and scholars can make assumptions based on inadequate or unrealistic information. Therefore, it is an important gap that we hope to fulfill through this study.

Blurry boundaries between astronauts and space tourists. Imagine this, one selected passenger boards SpaceX vehicle to the Moon and back, and continues his/her original life trajectory as a businessman. In this case, do you call this passenger an astronaut, a space tourist, or both? First, the moment this passenger goes beyond the orbit, this action itself earns oneself the title, astronaut (unless in the future, space agencies readjust the 50 miles altitude for awarding astronaut wings). Second, this passenger travels to space for leisure, education, art, science, and various other purposes. However, an astronaut career is never his/her aim. With this information, this is a space tourist. Therefore, the answer should be "both" that a passenger can be an astronaut and a space tourist at the same time. In fact, we do not just run a thought experiment. In reality, SpaceX has publicly promoted its dearMoon mission, sponsored by Japanese billionaire Yusaku Maezawa. Maezawa will be such a passenger that claims to be an astronaut and space tourist at the same time.

The current space industry has evolved to a stage that astronauts and space tourists are not mutually exclusive. To some degree, mass space tourism will signal a full commercialization of the space industry. We are simply not there yet. However, private space companies still try to bring a limited few to space for touristic reasons. Also, they develop research flights as a necessary step for commercial purposes. That is to say, the developmental mode of the space industry cannot directly jump from the current stage into an age of space tourism on a massive scale. As this industry evolves, a blurry boundary between astronauts and space tourists emerges. The relationship between Maezawa and SpaceX is such a case.

One may share a concern that it is a stretch to compare astronauts to space tourists. It is a valid concern. Indeed, they are different in many ways. The interesting part is, we instead explore their similarities. Specifically, space tourism represents our future. In order to get to the future, we first need to cherish the opportunity of studying the existing population of space travelers – the only

group of people on earth who have ever been to space, regardless of their trips as work or leisure. The psychological perceptions of viewing earth from space, for example, will not differ significantly as someone being an astronaut, an engineer, an artist, an educator, or a driver. The weightlessness, as another example, will impact on everybody regardless of gender, race, age, or nationality. We are all humans. We want to extract that shared humanity from astronauts' experience as a blueprint to show what to expect when we get up there. After all, it is the fundamental human nature that marks the uniqueness of a trip to space.

Therefore, this study acknowledges the natural differences between an astronaut and a future space tourist. And that is also the reason why we focus on the similarities, in terms of the motivations of self-actualization, curiosity, and exploration. It is our goal to utilize existing space knowledge to advance the development of space commercialization.

Methodology

General Approach. We conducted an inductive study using a netnographic approach with the aim of generating novel theory from qualitative data. Netnography is firstly coined between two terms, "internet" and "ethnography," by Robert Kozinets at the late 20th century (Bertilsson, 2014). Netnography is a digital form of ethnography, and it "uses computer-mediated communications as a source of data to arrive at the ethnographic understanding of a cultural or communal phenomenon" (Kozinets, 2012, p. 2).

Data. We collected 23,819 tweets from 36 NASA astronauts in Twitter as the sample of this study. Astronauts' tweets are great sources for investigations perceptions of space trips for three major reasons. First, we don't claim that astronauts' data accurately predict future space touristic experience in precision; however, we believe astronauts' experiences are necessary steps to investigate the immediate on-site reflections about space travel, which sets the foundation for future space tourism development. Second, after matching mission duration with publication time of astronauts' tweets, we found that astronauts do not wait to tweet after they finish the entire trip. In fact, astronauts tweet spontaneously throughout their mission. Hence, it is safe to argue that most tweets directly reflect what they have experienced. Lastly, astronauts do publish promotional messages, mainly publicizing NASA as a space agency and spreading educational information about the importance of STEM. In our analysis, these promotional purposes are natural motivations of space trips. Instead of concerning a biased investigation, we believe these tweets enrich the perceptions of space travel, extend the pure-leisure driven potential of space tourism, and pose higher hopes for a touristic opportunity.

After data cleaning, 19,114 Tweets were left for analysis. These tweets were manually separated into five-stages based on temporal information of all space missions achieved by each of the 36 NASA astronauts. In summary, Table 1 shows the number of tweets per stage and per gender group.

	Stage 1	**Stage 2**	**Stage 3**	**Stage 4**	**Stage 5**	**Female**	**Male**
	Training	**Liftoff**	**In-space**	**Reentry**	**Reflection**		
Number of Tweets (retweets removed)	7,105 (36.8%)	98 (0.5%)	5,023 (26.0%)	92 (0.5%)	6,978 (36.2%)	3,017 (15.8%)	16,097 (84.2%)
Type-Token-Ratio	0.12	0.42	0.13	0.42	0.13	0.16	0.09

Average Word Length	4.83	4.40	4.98	4.94	4.98	4.97	4.91
Word Count	105,728	1,556	70,597	1,252	115,954	44,763	247,617

Table 1 Descriptive of tweets (tweets update to February 8th 2018)

A Mixed-Method Analysis. The data analysis embraced two main methods. Consistent with the principles of netnography, a traditional qualitative data analysis was conducted followed by a computational-based textual data analysis. As Table 2 shows, both methods contribute to the answer-seeking process differently, and it is our hope to combine both traditional and novel textual data analyses together to bring out a full picture of space travel experience to the audience.

Method	Traditional qualitative analysis	A computational analysis
Data size	3,468 tweets (popularity-driven)	19,114 tweets (generability-driven)
Tool	Manual coding assisted by MAXQDA	Python, LIWC
Sub-question to answer	(1) What are the immediate psychological experiences of space travel?	
	(2) What are the physical sensations of space travel?	
	(3) How do astronauts comprehend risks and dangers?	(4) Does gender matter to space travel experiences among astronauts?

Table 2 Methods and their contribution to research questions

Results

Table 3 shows the results of the three-order qualitative coding process for each stage of space travel. Table 4 and Table 5 summarize the results from the quantitative analysis.

Stages	**First-order categories**	**Second-order themes**	**Aggregate theoretical dimension**
Training	A. Variety of training programs	1. Importance of training	I. Competence-building as an attraction
	B. Leisure activities in training	2. Fun and new training experiences	II. Curiosity as an attraction
	C. Global training sites		
Liftoff	A. Pre-launch excitement	3. Positive launch experience	III. Emotional arousal as an attraction
	B. Post-launch gratitude		
	C. Never-get-old launches		
In-space	A. Mixed feelings being in space	4. Dynamic impressions	
	B. Views about planet earth	5. Visual activities	IV. Sightseeing as an attraction
	C. Views about outer space		
	D. Space observations of spacecraft launch and docking		
	E. Observations of spacecraft reentry		
	F. Leisure activities in microgravity	6. Challenge taken-for-granted sensations	V. Novelty as an attraction
	G. Spacewalk	7. Phenomenal in-space experience	VI. Uniqueness as an attraction

	H. Work and research	8. Cutting-edge work experience	VII. Sense of achievement as an attraction
	I. Greetings from space	9. Communicate to people on earth	VIII. Human interaction as an attraction
Reentry	A. Pre-reentry reflection	10. Practice of emotional closure	IX. Sense of ritual as an attraction
	B. Landing as an astronaut	11. Recognition	
	C. Gravitational pull	12. wild reentry experience	X. Extreme ride as an attraction
Reflection	A. Body adjustment to gravity	13. Sense of change	XI. New reality of life as an attraction
	B. "First-time" earthbound activities after coming back from space		
	C. Visit sites seen from space		
	D. Mixed feeling	14. Happy struggle	
	E. Miss space life and favorite memories		
	F. Home as gravity of heart		
	G. Precious planet earth	15. Awareness and appreciation	
	H. Motivate others	16. Act of influence	XII. Professional dedication as an attraction
	I. Express new perspectives		
	J. Support rocket launch and landing	17. Work	
	K. Being a subject to science		

Table 3 Key attractions from the most popular astronauts' tweets

	Training	**Liftoff**	**In-space**	**Reentry**	**Reflection**	**Female**	**Male**
Polarity (Python)	0.30	0.25	0.28	0.29	0.34	0.31	0.31
Subjectivity (Python)	0.52	0.49	0.51	0.47	0.55	0.52	0.53
Positive emotion (LIWC)	5.02	5.26	3.32	4.70	5.18	4.41	4.69
Negative emotion (LIWC)	0.59	0.32	0.42	0.24	0.69	0.51	0.60
Representative top adjectives (Python)	great good new ready awesome	ready great much good Russian	good great new beautiful happy	great good happy awesome amazing	great happy good new beautiful	great good new happy last	great good new happy beautiful

Table 4 Results related to psychological experience of space travel

	Stage 1	**Stage 2**	**Stage 3**	**Stage 4**	**Stage 5**	**Gender**	
	Training	**Liftoff**	**In-space**	**Reentry**	**Reflection**	**Male**	**Female**
Representative top words	great thanks space training today	launch rocket crew hours ready	space_station yearinspace day good earth	earth space home back thanks	space great nasa earth thanks	space great space_station yearinspace thanks	space nasa great training space_station

						good	
Representative top bigrams	star city looking forward can't wait good luck getting ready	press conference can't wait getting suited well wishes huge thanks	good night good morning looks like yearinspace earthart robotic arm	last sunrise i'm coming yearinspace countdown ground teams looking forward	looking forward mission control years ago happy birthday stay tuned	looking forward star city good morning mission control can't wait	looking forward can't wait star city good luck mission control
Representative top trigrams and collocations	star city Russia; left star city	last press conference godspeed space station	space_station yearinspace goodmorning space_station yearinspace halloween	yearinspace countdown throwback i'm coming home	i'm looking forward entrepreneurs looking forward	space_station yearinspace earthart space_station yearinspace goodmorning	yrs ago today yrs ago spacewalk
Representative top nouns	today space training crew team	launch rocket time tomorrow earth	space night morning earth view	home earth time today sunrise	space earth thank time crew	space earth time crew night	space_station, training time team spacewalk
Representative top verbs	be see go get looking	launch getting watching suited sitting	be looking see get took	be see did coming retweeting	be see looking get sharing	be see looking go get	be see training, looking go

Table 5 Results of authentic space experience per stage and per gender group (Method Two)

Psychological experience of space travel. We find the evidence of space travel as a trip full of dynamic psychological experiences with a dominant positive emotion. The top adjectives in Table 4 are very similar across stages, which sets a positive perception for the entire trip. Moreover, the positive and dynamic nature of space travel experience is significant for the development of private space travel, because how astronauts have reacted to a particular event may be highly relevant to future space tourists in terms of what this event may play a role in their perceptions.

Physical experience of space travel. Our data show that every single stage has its unique attractions, and examining them together demonstrates a general picture of what a space trip truly looks like. In detail, at a training stage, astronauts visit various training sites and conduct activities in caves and under water. At the liftoff stage, their physical sensations link to the rocket launch and experience constant change of gravity. When in space, weightlessness is the condition for all daily movements, which provides a unique perspective to taken-for-granted human activities. Reentry brings the gravitation back and contains the acceleration sensations. While after landing, normal physical experiences become different after weightlessness; astronauts claim to appreciate the daily routines on earth. In particular, the in-space stage should be the key to marketing and commercialization for the development of space tourism, considering that the change of environment from earth gravitation to microgravity can bring a whole set of physical sensational changes for passengers.

Risks and dangers. We find surprisingly that astronauts mention this topic the most during the last stage, after counting the frequency of terms "risk" and "danger" across all five stages. Specifically, astronauts are explicit about past failures of space programs, they carry on the work to truly honor those who lost lives in this journey, and they still firmly believe in space exploration as "risky, rewarding and necessary." Meanwhile, with professional dedication, astronauts are a group of people that put missions ahead of their own lives, as one astronaut quotes from an Apollo astronaut in a tweet, "*'We are in a risky business and we hope that if anything happens to us, it will not delay the program.' Gus Grissom #Apollo1*." We acknowledge that the level of dedication

could be a major difference between an astronaut and a space tourist. Most importantly, astronauts share the insight about the difference between fear and danger (sufficient training is the key), and educate the public about how they manage themselves about fear and facilitate work with the real dangers. Risks and dangers are inherent with space travel and what more importantly is how people get prepared and manage fear.

Gender Similarities. Examining space travel experience from a gender perspective, we have found much more similarities than differences, which can be advantageous because it indicates a relatively stable set of attractions that can potentially be developed as a journey of space tourism. For example, in terms of what do men and women describe about their space experiences, there are a lot of overlapped nouns, adjectives, verbs, and collocations (see Table 4 and Table 5). That is to say, in terms of describing emotions and physical experiences, we do not find any sharp distinction. One aspect does stand out, compare to their male fellows, female astronauts do emphasize more about training. It may be due to the effort of proving an equal qualification across two gender astronaut groups. According to a tweet posted by one female astronaut, training made women as competent as men in terms of space travel. Her expression of displaying competency makes sense, considering the relatively small number of women in a career choice like astronaut.

Discussion

Compare to other touristic destinations, our results indicate that space may represent the most ideal location considering adventure, beauty, and novelty. Most earthbound trips involve elements of anticipation, transportation, and recollection. However, no other tourism contains such a multi-phasic experience with unique attractions throughout all five stages. With supporting evidence that astronauts being "part-time" space tourists, and in the future, the latter earn astronaut title when traveling above 50 miles, we propose that the blurry boundary between astronauts and space tourists can be term "amateur astronauts". In particular, all attractions of space travel can lead to at least one realization, that is called an overview effect.

Transiting from astronauts to space tourists: amateur astronauts. Based on our assumption about the attraction of space tourism as a quest for astronaut-like experience, the most likely space tourists in recent years will become both astronauts and tourists. This transiting status can then be termed as "amateur astronauts". In particular, before the age of space tourism fully revives, a blurry boundary between astronauts and space tourists will maintain. For passengers boarding SpaceX or Virgin Galactic vehicles without a pursuit of astronaut career, the title, amateur astronauts, is appropriate. Because it does not only capture the nature of the trip as a quest for astronaut-only experiences, but also reflects the adventure, leisure, or even scientific purposes.

An amateur astronaut is different than a professional astronaut in many ways. Amateur astronaut is not a title for a career profession, and tourists have to fund the trips on their own. Amateur astronauts may not hold the same level of competencies and spend much less time in space compare to professional astronauts. Both amateur and professional astronauts also share several similarities. The astronaut title is rewarded by their corresponding organization. Both go through the five-stage experiences; in particular, what the in-space attractions professional astronauts have had may be the same for amateurs. In summary, we propose a definition for amateur astronaut:

> *Amateur astronaut is a hobbyist title that symbolizes the private participants taking spacecraft to the orbit and beyond for pleasure and/or recreation.*

Space travel experience: An overview effect. "People living in space settlements will always have an overview! They will be able to see how everything is related, that what appears to be 'the world' to people on Earth is merely a small planet in space, and what appears to be 'the present' is merely a limited viewpoint to one looking from a higher level. People who live in space will take for granted philosophical insights that have taken those on Earth thousands of years to formulate. They will start at a place we have labored to attain over several millennia" (White, 1987, p. 4). The overview effect is introduced by White (1987) to explain a realization that physical location defines people's worldview. It answers "so-what" question about space tourism and "what's next" question for space exploration.

We have seen evidence from astronauts' tweets about this transformation of the worldview. The time for travel long distances, for example, can be largely shortened, as one astronaut describes from space, "Mountains of Alaska to Florida Peninsula. Only a 20- minute trip up here." The view of earth, is "[m]ore than the 'view'; [it is a] 'global perspective'...Earth as a fragile oasis in a vast empty sea," according to another astronaut. The best evidence of realization based on the physical place in the universe is this one, "My favorite part of spacewalking is the panoramic view of our fragile blue planet suspended in the endless sea of space." In our findings, attractions including novelty, uniqueness, and new reality of life directly link to this overview effect.

The overview effect explains the core attraction of an astronaut-like experience — to gain a novel philosophical point of view after being in a different physical environment. This novel view may not necessarily be positive, as evident at the in-space stage having the lowest value of the positive emotion (see Table 4). Instead, the overview effect involves a majestic panorama, a calm realization, a complete freedom, an appreciation of earth and being, and an urge of a peaceful pursuit of space frontier (White, 1987).

Conclusion

As astronaut E.J. Garn says, "Those of us who have been privileged to travel into space feel an overwhelming compulsion to describe what we've seen," we hope this study captures a fraction of their experiences and more importantly, interpretate what it means. In conclusion, this study answers a simple question, "what's it like in space?" We frame space travel experience as a dynamic interaction between subjective perceptions and physical positions based on social constructionism. Through the lens of astronauts' on-site and immediate language, we have built a conceptual model of space travel experiences with key attractions that are potentially helpful for space tourism development. We will end with a quote from an Apollo astronaut:

> "*If somebody'd said before the flight, 'Are you going to get carried away looking at the Earth from the Moon?' I would have [said], 'No, no way.' But yet when I first looked back at the Earth, standing on the Moon, I cried.*" – Alan Shepard

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