Original paper

A generational perspective over the new commercial space age

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Abstract
The prospects of growing commercial space exploration entities in a new space age have raised concerns among several scholars, who have debated its ethical, legal, and environmental implications. However, few studies in the outer space social survey field have attempted to examine public attitudes towards this subject. Additionally, such analysis has thus far not been conducted with a comparison across age groups. Past age group analysis, when applied to different disciplines of space exploration such as supporting increased NASA funding, indicated differing attitudes among those who have experienced different eras of the history of American space exploration (space race, space shuttle era, and the commercial space age). For this reason, this study combined past findings and applied them to a more futuristic perspective through a quantitative correlational research method. It was predicted that this study's three age groups' (generations one–three) perceived understanding of future commercial space exploration defined by commercial space activities (space tourism, space colonization, harvesting of raw materials in outer space, and commercial government partnerships) would be affected because of generational bias. The 268 surveyed participants indicated that the opinion aspect of an age group's perceived understanding was affected but not their self-assumed prior knowledge. Key findings were the eldest group's (generation one) tendency to align with commercial government partnerships and the youngest group's (generation three) tendency to align opposite to generation one in support of more historically futuristic concepts. The research findings could be applied to the public outreach programs of government space exploration entities such as NASA.

Keywords
Commercial space exploration, History of American space exploration, New space age, Age group analysis, Quantitative correlational research, Social survey, NASA, Space shuttle, Space tourism, Space colonization

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Introduction

In recent years human activities in outer space have been described as a new era characterized by the involvement of multiple agents (political, military, scientific, and commercial). The activities of commercial entities, or those related to the economic exploitation of outer space, have gained recent attention through billionaires Elon Musk, Jeff Bezos, and Richard Branson, and their respective space companies, SpaceX, Blue Origin, and Virgin Galactic. These and others have been facilitated by the growing space economy, which "is predicted to triple to $1.4 trillion by the end of the decade [2030]" (1). Space launch costs have also decreased with past systems such as the Space Shuttle (1981–2011) averaging $1.5 billion to launch 27,500 kg into Low Earth Orbit (LEO) while SpaceX's Falcon 9 launch system (2010–present) averages $62 million to launch 22,800 kg into LEO. Although this could be attributed to the natural progression of technology, it is also attributed to the greater efficiency of private industry compared to government space organizations such as the National Aeronautics and Space Administration (NASA) which are influenced by the support of American taxpayers (2). This is further encouraged by the policies of American lawmakers which have regulated commercial space companies to traditional government organizations such as the Department of Transportation and the Federal Aviation Administration (3). This decision has been deemed inadequate by many scholars, who have called for updated guidelines like the United Nations 1967 Outer Space Treaty or economic regulating liability caps (4, 5).

Research gaps

Among these scholars, several have raised concern over the broad ethical, environmental, and legal implications of a future commercial space age. (6-9). This past research was conducted based on commercial involvement in outer space through defined activities: tourism, colonization, the harvesting of raw materials, and government partnerships (1). However, this research has not been applied to the public through the analysis of select age demographics. Due to this gap, this study worked to form a baseline for the industries of the emerging space economy determined by groups influenced by the eras of American space exploration (space race, space shuttle era, and commercial space age). Analysis was conducted through the guiding research question; to what extent do the generational biases of age groups affect their perceived understanding of future commercial space exploration?

Literature review

Generational biases

Age has been determined to impact the later opinions of individuals, or their recollection of events, in a phenomenon known as collective remembrance. University of Michigan social researchers Howard Schuman and Willard R. Rodgers analyzed this in their study, which examined surveys distributed before and after the September 11th, 2001, terrorist attacks. These surveys asked participants to list two events from American history from 1930 to the present that they believed to be the most significant. The age groups who listed the Second World War, Kennedy assassination, Vietnam War, end of communism, or 1991

Gulf War were in young adolescence or early adulthood at the time of having experienced that event (10). This critical age in which an individual's recollection was hypothesized to be influenced the most can be further applied to the eras of American space exploration. However, it is necessary to realize the qualities that make these periods significant, to warrant the possibility for correlations among those who experienced them.

Public perspective on the space race

Dora Holland and Jack O. Burns at the University of Colorado Boulder assigned distinct themes in the American Government's justifications for the space program from President Eisenhower's to President Obama's administrations. During the space race between the United States and Soviet Union (1957–1975), the most common theme was political competition (11). This theme was displayed inconsistently in the early space race according to a retrospective study conducted by historian Kim McQuaid. The assumed "mass panic" following the Soviet Union's launch of Sputnik was deemed a political concern reflective of the Cold War tensions of the time. Publicly examined adults on the other hand, reportedly had "no evidence at all of any panic or hysteria," (12). However, this finding was not consistent with the youth of this era —which will now be known as generation one— according to an age group analysis conducted by Indiana University Political Scientist Christopher D. DeSante.

DeSante analyzed the General Social Survey distributed from 1975 to 2015 in five-year increments; more specifically, a portion of this survey that was dedicated to government space exploration. In every issue of the survey, generation one was more likely to support increased NASA funding. This was concluded to be caused by this group being especially affected by the golden age of American space exploration as young people in accordance with Schuman and Rodger's findings. This golden age coincided with NASA's peak percentage of all federal spending in the mid-1960s (Figure 1) which allowed it to host "a manned space mission every 5.4 months during the Mercury, Gemini, and Apollo programs" (13). For this reason, members of this generation were defined by witnessing the rapid beginnings of American space exploration during a political crisis, however, this definition would shift as the space race was considered "won" by the United States following the Apollo 11 lunar landing in 1969.

Public perspective in the space shuttle era

Referring to Holland and Burns' study, international collaboration and American leadership would soon become justifying themes for continued space exploration during the Space Shuttle era (1981–2011) (11). Individuals who experienced their youth during this time, or members of what will now be known as generation two, are distinct from other generations. This is due to NASA's focus on reusable platforms such as the Space Shuttle as their spending capacity was lowered from the peak (Figure 1) amid the growing political skepticism over continued space exploration. Addressing these concerns, University of Michigan Political Scientist Jon D. Miller issued surveys in 1988, 2007, and 2018 asking the public whether the American space program had "paid for itself" with technological and scientific developments (Table 1).

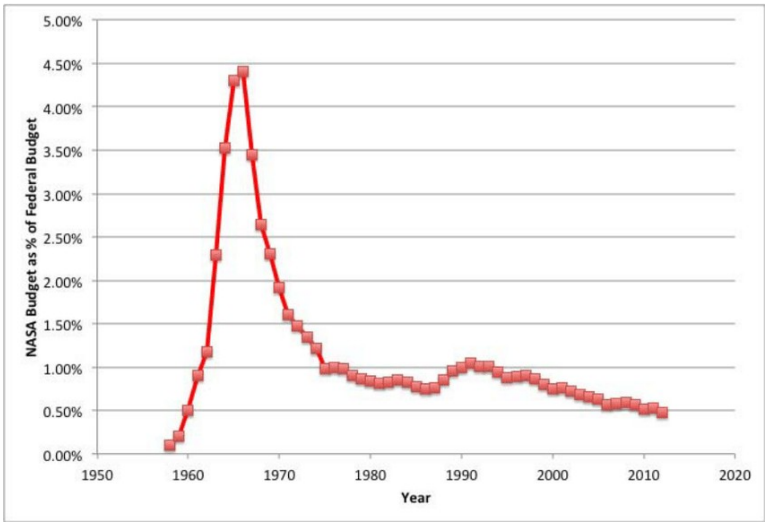

Figure 1: NASA's Percentage of the Federal Budget from 1958 to 2014 (14).

Table 1: Public agreement concerning the value of new technologies from the space program (16)

	Year		
	1988	2007	2018
Strongly Agree	6.6	13.9	19.0
Agree	49.5	45.4	50.1
Not sure/don't know	6.4	3.2	2.7
Disagree	35.2	30.7	24.2
Strongly disagree	2.3	7.0	4.0
Number of cases	2,041	1,407	2,859
Percentage of adults agreeing or disagreeing with the statement "On balance, the space program has paid for itself through the creation of new technologies and scientific discoveries."			

The results of the study suggested an increase in space science literacy among American adults, or the ability to recognize that "some of the technologies that they experience in their daily life originated in or were created by the space program," (16). This occurred despite the Space Shuttle Challenger and Columbia Disasters of 1986 and 2003, which reportedly had a minor effect on America's resolve. This is supported by a 2003 public opinion poll conducted by former NASA historian Roger D. Launius, who found that despite the tragedies, "most agree that the Space Shuttle is a magnificent machine" (17). This devotion to

such an iconic, frequently launching spacecraft is important to realize in defining this group and is characteristic of the growing standardization of American space exploration that they experienced.

Public perspective on the commercial space age

Technological literacy as outlined in Miller's study and in a general sense is characteristic of modern youth —which will now be known as generation three— who are currently experiencing the commercialization of outer space (2011–present). This is partly a result of computer education in American public schools, which has evolved exponentially since the late 1990s. By comparison, more futuristic concepts like the commercialization of space have been absent in curriculums and taught by outside organizations typically sponsored by NASA such as the National Space Biomedical Research Institute (18). For this reason, generation's three's understanding has been defined by niche content such as popular culture, which has been identified as essential for "encouraging their interest and facilitating their learning of space" by European Space Policy Institute researcher Dr. Annette Froehlich and her colleagues (19). Despite this distinction, attempts to examine generation three have provided little prolonged age group analysis as members are too young to have gathered data compared across multiple studies. Some researchers have surveyed generation three over specific aspects of commercial space exploration. For example, University of North Dakota researcher Carrie Anne Platt and her colleagues specialized their qualitative analysis to SpaceX's plan to colonize Mars (20). This examination, while vital to the field of study, did not provide a broad overview of the public's perception of future commercial space exploration and therefore did not contribute to addressing this research's gap.

Summary

Several studies have examined public support of government space exploration programs. Such studies have loosely conducted age group analysis, in which certain groups (generations one–three) have been unified by common themes. In some instances, trends were identified and maintained over many years (13). This was not examined in respect to commercial space exploration. To connect with this prior research and plug this gap, this study determined the extent to which generational biases of age groups influenced their perceived understanding of future commercial space exploration.

Methods

Study design

The goal of the study was to determine to what extent the eras of American space exploration an individual experienced would impact their understanding of a complicated concept such as future commercial space exploration. For this reason, a quantitative, correlational research study was conducted as a means of not providing causation for trends, but to determine their existence. Quantitative analysis through multiple choice surveys was the method or subject of other similar studies (12, 13, 16, 21). The likely reason for this is that correlational research is especially effective when working to "determine whether there is a relationship between two or more variables" (22). For this study, the considered independent variable was an individual's age group and it was compared

to their self-assumed prior knowledge of American space exploration and opinion over the four defined commercial space exploration activities. This, when combined with the ability of gathered observational data to be quantified, allowed for the formation of measurable trends which could be used to answer the research question.

Participants

The subjects were a broad range of individuals residing in the Southeast United States. Participants regardless of qualification were included as part of the researched population but targeted analysis took place for persons born from three age groups (generations one–three) as introduced in the literature review. These groups were first approximately defined by pre-existing generational definitions such as baby boomers (1946–1964), Generation X (1965–1980), and Generation Z (1997–2013) and then adjusted in accordance with Schuman and Rodgers' study, that defined the critical age range or period in which individuals were hypothesized to be the most affected by world events as "running from ages 12 to 29," (10). The age range was applied backwards to climax events identified for the first two eras of American space exploration; the space race and space shuttle era. These events, the Apollo 11 lunar landing (1969) and the launch of the Hubble Space Telescope (1990) were determined by the frequency of the event's recollection in another portion of Miller's study which asked respondents to recall what they believed to be the most significant achievement of the American space program (16). No climax event was defined for the commercial space age because this era is still ongoing. The year of the study's distribution, 2023, was used. Given that members were in their critical age range at the designated climax year, generations one–three were established as those born from 1940 to 1957, 1961 to 1978, and 1994 to 2011 respectively.

Research survey

One online Google Forms survey was used to gather data for all participants (Appendix C). The survey contained four sections totaling three demographic questions, thirteen required content questions, and one optional question (Figure 2). A digital informed consent form was required to be completed for all participants prior to accessing the survey questionnaire (Appendix B). All survey content was reviewed and approved by an Institutional Review Board (IRB) and no identifiable information was required to be disclosed by participants.

Demographics segment

The demographics segment of the survey was designed to gather as little identifying information as possible. An example of one of this segment's questions was "What is your year of birth?" This question was used to determine a participant's placement into an age group. For a participant to be subject to the generational biases of American space exploration, they would have to be born in the United States, hence the question "What is your country of birth? Was also posed.

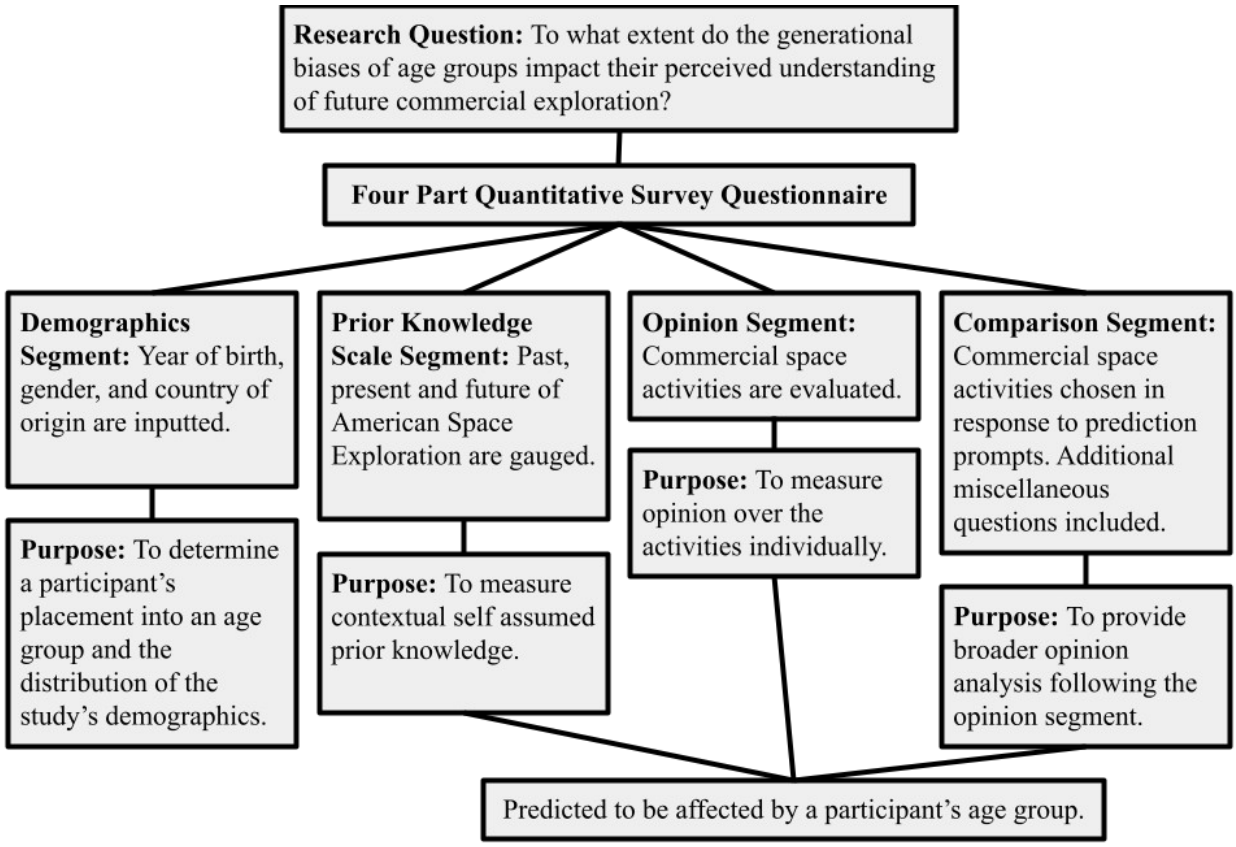

Figure 2: The 4-part Survey Instrument in Alignment with the Research Question. A flow chart depicting the purpose of each portion of the designed survey questionnaire.

Prior knowledge segment

The prior knowledge portion of the survey was partly inspired by Dubikovsky et. al. Their research gauged a group of aerospace industry professionals and students self-assumed prior knowledge using the displayed Likert scale for it to be used as an independent variable (Table 2). This scale was adapted to remove references to space education and practical experience, phrasing the answer prompts to have (one = *I have no prior knowledge*) and (five = *I am knowledgeable and could explain to others*). This was conducted to align with this study's general audience, who's self-assumed prior knowledge could be adapted from sources outside of education or the workplace. Questions for this segment consisted of "How familiar are you with the [past, present, or future] of American space exploration?" Additional relevant examples were provided such as "including but not limited to SpaceX, Virgin Galactic, and NASA's Artemis Program."

Table 2: Individual ranking of personal experience in the space industry (23)

1	I have no prior knowledge about space/ space technology
2	I understand some concepts about space/ space technology, but have not worked/ studied with any space related classes
3	I have studied some aspects about space/ space technology in a classroom environment or from personal interest
4	I regularly read space related publications, have participated on a space related class project, and/ or study space related materials
5	I have had an internship/ job with a company involved in space/ and or have worked with space materials on a university level class project

Opinion segment

A five-point Likert scale was also used in the opinion segment. This was the matrix of choice for London School of Economics and Political Science psychologists Marta Entradas and Steve Millers' study concerning the United Kingdom's role in future space exploration (21). For this study, the matrix had (one = *I am strongly against it*) and (five = *I strongly support it*), allowing the answers to follow the question prompts such as, "What are your thoughts on [space tourism, space colonization, etc.]?" more closely. Such analysis allowed for the commercial activities to be evaluated individually before being compared.

Comparison segment

The first five questions of the comparison segment were phrased "Out of the four defined commercial space activities which…" and were dedicated to what the participant was most familiar with, interested in, and what they believed to be the most ethical, profitable, and prevalent in the future. The final required question simply asked "Overall, do you consider the expansion of industry into outer space and the creation of a space economy to be worthwhile?" and was answered with a 'yes' or 'no'. The optional free response question asked the participant if they had any other comments, and was not considered in analysis.

Procedure

The study design and procedures were also approved by an IRB to ensure ethical compliance. Analysis was conducted at locations where there was a greater probability of finding the targeted age groups. For this study, these locations were high schools, colleges, and civic organizations. High schools and colleges were chosen due to their diverse student bodies and faculty likely constituting generations three and two respectively. Civic organizations were chosen given that they were not affiliated with any one major world religion or culture. Participants from this type of location were likely to be from generations one and two.

Distribution

High school administrators, college students, and club organizers were contacted with an initial email that explained the purpose of the research and that location's specific

involvement. Attached to the emails were a pdf copy of the survey questionnaire, and a survey access link and QR code. Locations that did not respond after five days were sent a follow up email. Three high schools, individual college students, and three civic organizations agreed to participate. High school administrators were required to sign an administrative informed consent form prior to participation (Appendix A). For these facilities, science teachers were instructed to voluntarily distribute the survey to students and teachers with a digital link. Personal student contacts were used at the colleges and distributed the study using various methods. For the civic organizations, the researcher attended the meetings in person with a survey access QR code to aid the meeting's likely older attendants. The club organizers were made aware of this upon approval, and allocated time for the study's distribution during a designated period.

Results and Discussion

Demographics segment

The spreadsheet containing the responses for this segment was included as a supplementary file. The survey yielded a general population size of 286 participants. Three responses were removed from consideration as the participants did not accurately disclose their year of birth. In following this study's focus in determining trends among Americans born in the United States, another 15 respondents who indicated their country of origin as outside of the United States were removed from analysis. The responses from members who qualified for placement in generations one–three were taken from the filtered population (Table 3). The groups were approximately representative of the population of the United States, as the proportion of generation one respondents (13.43%) were similar to the proportion of roughly corresponding individuals aged 65 to 84 (15.0%). Generation two (28.73%) and generation three (35.45%) respondents were similar to the proportion of roughly corresponding individuals aged 45 to 64 (25.2%) and 10 to 30 (26.3%) respectively (24).

Table 3: Demographics segment for all observed participants (n=268)

Characteristic	Total	Gen 1	Gen 2	Gen 3
Participants (n)	268	36	77	95
Proportion of total (%)	100	13.43	28.73	35.45
Year of birth (μ)	1982	1951	1970	2004
Gender (%)				
Male	55.22	77.78	62.23	49.47
Female	44.40	22.22	37.66	49.47
Other	0.37	0	0	1.05

Correlational analysis

In the content sections of the survey (prior knowledge scale, opinion segment, and comparison segment) z-tests of statistical significance were used to progress towards calculating p-values. This was adopted by other researchers, most notably in Entradas and Millers' study where "$p < 0.05$ was used as the critical value [(α)] to reject the null hypothesis or confirm the hypothesis being tested" (21). In this study, the null hypothesis was that variations in the content responses among the three age groups when compared to the population were a result of random chance. The hypothesis indicated the opposite, this being a participant's age group would influence their perceived understanding. The data analyzed was two tailed, meaning the hypothesis "specifies no direction for the difference" (higher or lower) among the means and or percentages of the age groups compared to the population (25). The formula used for the prior knowledge scale and opinion segments and the formula used for the comparison segment are depicted below (Equations 1 and 2).

Equation 1: Z-test for one population mean.

$$z = \frac{\bar{X} - \mu 0}{\sigma / \sqrt{n}}$$

Equation 2: Z-test for one population proportion.

$$z = \frac{\hat{p} - \hat{p}0}{\sqrt{\hat{p}0 - (1 - \hat{p}0)/n}}$$

Prior knowledge scale segment

The spreadsheet containing the responses for this section was included as a supplementary file. The age group means, when compared to the population means, did not produce any p-value trends. From this, it could be determined that this population's age group had little to no effect on their self-assumed prior knowledge over this topic. This expanded upon previous studies such as Schuman and Rodger's and DeSante's, which only found statistical trends among age groups in response to opinion-based questions. The graph below depicts the mean Likert scale (one–five) assumed prior knowledge mean scores for this section of the survey (Figure 3).

Overall, the population mean scores per question appeared to decrease as the questions moved chronologically to the past, present, and future (μ_0 = 3.24, 2.77, and 2.60) of American space exploration. This was surprising as the age groups were expected to assume greater knowledge over the time periods most relevant to them; but this did not occur. Space exploration's role as a "niche" which sponsors independent interest was theorized to cause the decreasing scores as living through or learning about events such as the space race transitions to current or future knowledge that requires further commitment to maintain.

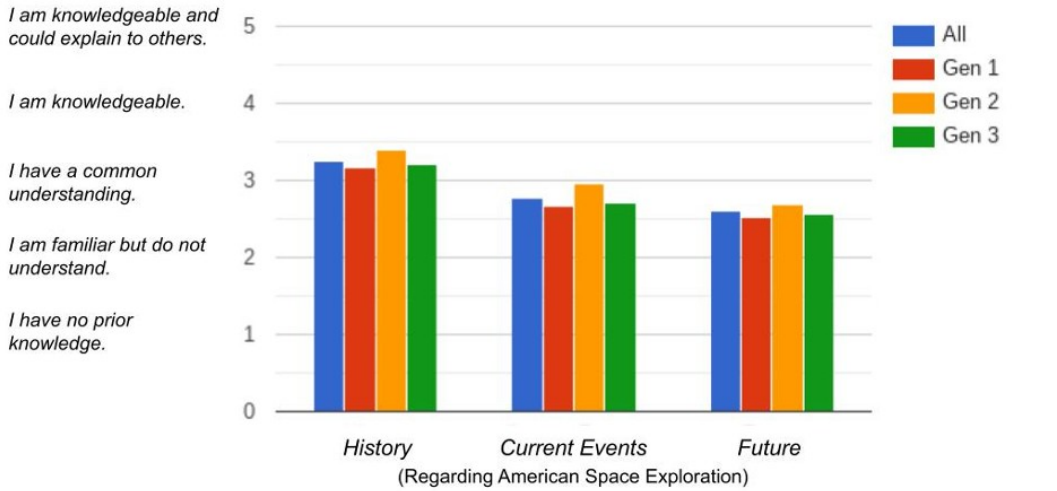

Figure 3: Prior knowledge scale segment mean Likert scale response scores.

Opinion segment

The spreadsheet containing the responses for this section was included as a supplementary file. The mean Likert scale (one–five) opinion responses are depicted in the graph below, processed like the previous section (Figure 4). There were no p-value trends in this segment except for one, this being that generation three with a mean score of $\bar{X}$=3.49 disliked commercial government partnerships more than the overall population (μ_0=3.69). This was hypothesized to be caused by this generation's distrust in the federal government's current handling of space exploration; however, the information to support this was circumstantial. The consequences of the recent decrease in NASA's percentage of the federal budget to about 0.5% in 2013 has been their partnership with commercial providers such as SpaceX and the United Launch Alliance (ULA) for more routine missions (26). Observing this decrease in NASA's capabilities may have caused generation three to view government involvement in the commercialization of space as a hindrance rather than a benefit, especially when considering their relatively low self-assumed prior knowledge scores of $\bar{X}$=2.72 for current events and $\bar{X}$=2.56 for the future. Other than this specific age group trend, respondents generally expressed indifference to limited support for all the defined commercial space activities.

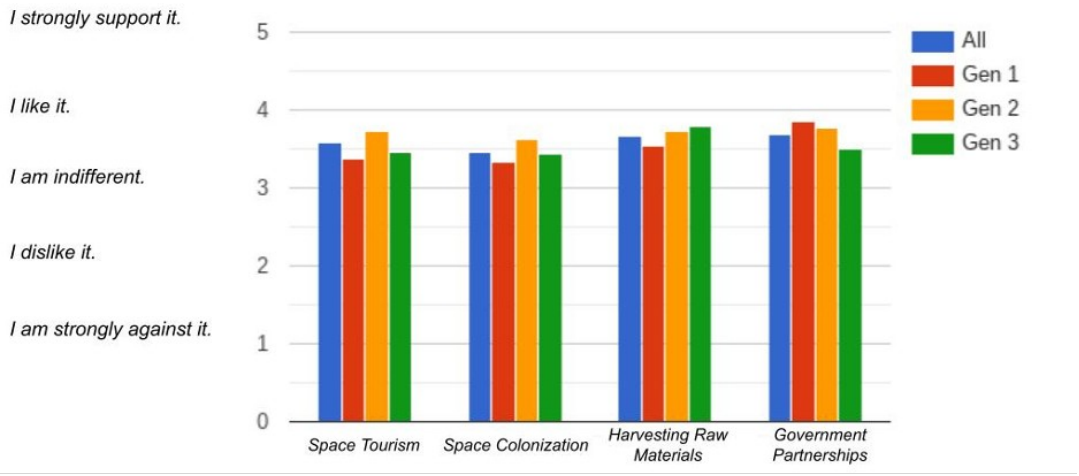

Figure 4: Opinion segment mean Likert scale response scores.

Comparison segment

The spreadsheet containing the responses for this section was included as a supplementary file. The table below depicts the most chosen commercial space exploration activity per each studied group (Table 4).

Table 4: Comparison segment most reported response proportions per group compared to the population

Question	Total	Gen 1	Gen 2	Gen 3
Most familiar with	Space Tourism 36.19	Space Tourism 41.67	Space Tourism 44.16	Space Tourism 36.84
Most interested in	Space Tourism 33.21	Space Tourism 36.11	Space Tourism 33.77	Space Colonization 34.74
Most ethically viable	Harvesting Raw Materials 30.97	Government Partnerships 36.11	Space Tourism = Government Partnerships 29.87	Harvesting Raw Materials 42.11
Most profitable	Harvesting Raw Materials 51.12	Space Tourism 36.11	Harvesting Raw Materials 51.95	Harvesting Raw Materials 63.16
Most prevalent in the future	Space Tourism 51.49	Space Tourism 52.78	Space Tourism 59.75	Space Tourism 44.21

The results were relatively uniform for familiarity and prevalence as all the groups chose space tourism most frequently. The interest and profitability questions displayed minor variations as generation three uniquely selected space colonization the most for interest while generation one uniquely selected space tourism the most for profitability. The ethics question displayed the most variations in the majority responses across all groups. Other than these differences, there were 11 p-value trends across generations one and three.

Generation one

In generation one, participants chose government partnerships significantly more for familiarity, interest, profitability, and prevalence ($\hat{p}$=38.89%, 30.56%, 27.78%, and 33.33%) compared to the population ($\hat{p}_0$=24.25%, 11.94%, 9.33%, and 19.40%). This suggests these individuals' increased tendency to align with government involvement in commercial space exploration. This can be indirectly associated with DeSante's study, which established this age group's support for increased NASA funding (13). The reasoning for this is consistent with DeSante's conclusion, which established the influence of generational bias over generation one as they experienced traditional means of government space exploration in the past and were more likely to continually support it in the future.

The other observed trends for this group were its lower tendency to select space colonization as what they were most familiar with and interested in ($\hat{p}$=2.78% and 8.33%) compared to the population ($\hat{p}_0$=19.78% and 27.24%) and harvesting raw materials as what they believed to be most profitable ($\hat{p}$=30.56%) compared to the population ($\hat{p}_0$=51.11%). The lowered selection rate of harvesting raw materials (the population's most chosen option) for the profitability question was likely caused by the higher selection rate of government partnerships. Space colonization by comparison has historically been portrayed as science fiction or something in the distant future even though SpaceX claims that colonization could begin on Mars as soon as 2030 (27). It is likely that the historic portrayal is still held by generation one due to their lower self-reported prior knowledge responses for the future ($\bar{X}$=2.51). For this reason, it was hypothesized that this generation does not see any relevance in a futuristic concept such as space colonization because of their old age, thus explaining their lower selection rates.

Generation three

In generation three, many of the observed p-value trends demonstrated opposite extremes to those in generation one. The one exception to this was this group's tendency to identify harvesting raw materials as what they thought most ethically viable more ($\hat{p}$=42.11%) compared to the population ($\hat{p}_0$=30.97%). These extremes were in the tendency of this age group to select space colonization as what they were most familiar with more and government partnerships as what they were most familiar with less ($\hat{p}$=32.63% and 12.63%) and harvesting raw materials as what they thought to be most profitable more ($\hat{p}$=63.16%). The higher selection rate of space colonization is interesting, as young individuals in Platt's study "were highly skeptical about both the feasibility and desirability of the SpaceX plan to colonize Mars" (20). However, Platt's qualitative analysis likely revealed greater insight than this study's multiple-choice

surveys. Nonetheless, this pattern, although not directly supported by prior research, indicated an evolution of beliefs over time, which in reference to this study, concerns traditional commercial activities in outer space.

Final question

The last question of the comparison section did not yield any p-value trends but did indicate that most participants believe that the creation of a space economy is worthwhile. Although not statistically significant, the magnitude of support for the commercialization of space generally increased for generations one, two, and three ($\hat{p}$=72.22%, 75.32%, and 80.00%). This suggests the foundation for potential variations, which may become more measurable with the passage of time as this study's surveyed content adopts a more modern perspective.

Conclusion

Fulfillment of gaps in the research

This study's design and results worked to address several gaps in the pre-existing research. General space exploration public opinion studies have not considered age group analysis in the commercialization of space. Age group analysis within this field has either been limited to the precise examination of one group (typically generation one) or another topic: support for government funded space exploration programs (13, 21). The study's design was unique in that it organized groups by the three eras of American space exploration and asked questions about complex commercial space activities to a general audience. This and the overall futuristic perspective contributed to findings that worked to combine past research and apply it to a new broad area of understanding.

Overall findings

This new understanding partly refuted the hypothesis that a participant's perceived understanding of the survey content would be affected by their age group as their self-assumed prior knowledge did not vary. This was not the case for their opinion, because there were several p-value trends among generations one and three mostly within the comparison segment. Generation one selected commercial government partnerships to a greater extent for all questions except for those regarding ethics. Often opposite to generation one, generation three identified with more futuristic concepts (space colonization and the harvesting of raw materials in outer space). Generation two's responses aligned the most with the population for all three content segments of the survey. These patterns indicate that variations in this population's consideration of commercial space exploration, if present, gravitated from one extreme in generation one, to a population baseline in generation two, and finally to an opposite extreme in generation three. Such variations were also consistent with previously established themes in past literature, these being government facilitation, normalcy, and uncertainty for generations one–three respectively. However, these variations, while affiliated with a participant's past generational biases in this study, could have also been a byproduct of the Dunning-Kruger (DK) Curve. This proposition, which indicates the tendency of individuals with low knowledge of certain concepts to overestimate their understanding and individuals with high knowledge to underestimate their understanding was not

intended to be a formal part of the study (28). Despite this, the DK Curve's influence can be implied due to the futuristic emphasis of the survey content as it has been with other subject areas (29). When considering the self-assumed prior knowledge portion of the survey, participants commonly believed to have a level of familiarity to common understanding over the future of American Space Exploration, which particularly applied to the remaining survey content. This middle-leaning evaluation arguably aligned with the first stage of the DK curve, as this section could have been the first-time study participants were asked to consider future space exploration, and they would have therefore selected the least controversial or the middle-leaning option. As the survey progressed, participants theoretically progressed along the DK curve. The simplified, limited exposure they had to the subject matter with the commercial space activities, in accordance with the curve, could have caused them to believe that the topic itself was simple. Following this line of thought, the participant age groups with the most fundamental differences (generations one and three) selected the commercial space activity that applied to them as previously mentioned. With this reasoning, the general population's understanding will likely evolve past the DK Curve's "peak mount of stupidity" as the topic will "mature" and not simply be the subject of hypothetical conjecture. Nonetheless, whether this study's findings are affiliated with purely the DK Curve, generational biases, or a combination of both phenomena, they reveal a relationship that can be applied to real-world stakeholders.

Implications

Commercial space entities, although not as intensively bound by the same constraints as NASA, now have some sort of notion about how a general population perceives their future business plans. This notion was that the commercialization of outer space was worthwhile, but it is somewhat concerning as it seems to ignore the issues of an unregulated commercial presence in outer space as outlined in past literature. As per the structure of this study's multiple-choice survey, these issues could have been voiced by the population but left unacknowledged in the literature as they did not particularly apply to any of the survey questions. They could have also been ignored due to the responses being a product of the DK Curve, rather than of genuine generational effects. Assuming this reasoning is true, the public is essentially a "blank slate" regardless of age and will hence have their opinion manufactured by the invested stakeholders. Among these, the ones with the greatest public outreach capabilities will likely have the greatest impact. NASA, although influential due to its past achievements, is at a disadvantage financially as its budget is capped at a small proportion of all federal spending. While NASA currently contracts many commercial space entities such as the ULA and SpaceX, there will likely come a time when these entities will separate further. This separation, which has already taken place through space tourism conducted by companies such as Virgin Galactic will likely continue and result in greater opportunities for commercial space entities. These entities, which already share the largest margin of the greater aerospace economy will have superior resources despite NASA's current public outreach devices: publicity events, scientific

research, and educational programs (30). With this, the public will likely be swayed by traditional marketing practices which may portray commercial space activities as sustainable and beneficial. Unless the public is further educated over this topic, they may progress out of their hypothesized placement along the uncertainty portion of the DK curve with a biased outlook on future, purely commercial space exploration.

Limitations

The study's findings were slightly compromised by issues during data collection. Colleges were intended to be surveyed sites along with high schools to analyze members of generations three and two, but the three colleges contacted indicated that surveys could not be distributed by school administrators. For this reason, individual college student contacts were used, resulting in a lack of responses. Future researchers should consider an approach to analyze this demographic, as their responses could greatly influence the rest of generation three. The study was mostly distributed to generation one's older participants in person to assist with any technological issues. Despite this, many participants still experienced difficulties when filling out the online survey on their cell phones. These data collection shortfalls were worsened by the inability of quantitative data to provide definite trends, such that the explanations used in the analysis of data can only be deemed as speculation. This applies especially to generational biases and the DK Curve, both of which were invoked in response to loosely related findings.

Areas of future study

Nonetheless, the actual validity of these findings and this study's broad emphasis on the future commercialization of outer space can catalyze new areas of research. Prolonged age group analysis requires the periodic redistribution of research to determine if trends are maintained over time. This analysis could specify the surveyed topics, as it would be interesting to see how this study's age groups or others' views have evolved as the widespread commercialization of outer space comes closer to reality. The questions of the survey used in this study could also be updated and expanded upon to include qualitative analysis, which could go further in determining not just if variances exist, but why. Such analysis could specifically be designed around the DK curve to indicate the population's general standing. The population itself could also be specified to include involved stakeholders such as NASA employees. These individuals have historically been the subject of more technical analysis due to their expertise; which means that they would likely fall towards the curve's later stages, in which they are modest regarding their understanding of the topic but are actually quite knowledgeable (14). All of these measures, if applied separately or together, would provide an exploration of unconsidered variables, which would build upon this study's findings and more importantly, address new gaps in research regarding the inevitable commercialization of outer space.

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Abbreviations

SpaceX- The Space Exploration Technologies Corporation
LEO- Low Earth Orbit
NASA- National Aeronautics and Space Administration
Generation One or Gen One- Participants born from 1940 to 1957 that were one of the age groups compared to the population during data analysis
Generation Two or Gen Two- Participants born from 1961 to 1978 that were one of the age groups compared to the population during data analysis
Generation Three or Gen Three- Participants born from 1994 to 2011 that were one of the age groups compared to the population during data analysis
ULA- United Launch Alliance
DK Curve- Dunning Kruger Curve/ Effect which indicates the lapses in actual understanding compared to confidence in understanding over potentially foreign concepts

Symbols

n- Population Size
μ- Average
p- P-value
α- Critical Value (0.05)
z- Z-score
$\bar{X}$- Sample Mean
μ_0- Population Mean
σ- Population Standard Deviation
$\hat{p}$- Sample Proportion
$\hat{p}_0$- Population Proportion

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Appendix A

Blank Copy of High School Administrator Consent Form

Note. Crossed out is the researcher's personally identifiable information. This was done to maintain anonymity. This form was used at several educational insitutions.

Administrative Consent Form
(Name of School, City, State)

Title of the Study: "A Generational Perspective Over the New Commercial Space Age"

Researcher Names and Contact Information: [redacted]

Purpose and Background: The purpose of this research is to determine a correlation among three age groups, generation one born 1940-1957, generation two born 1961-1978, and generation three born 1994-2011 and their knowledge and opinions over outer space. This study will specifically cover the future of space flight and activities of commercial entities such as SpaceX in outer space. These activities will be defined broadly as space tourism, space colonization, raw material extraction, and government partnerships. Information from this research study will be helpful to any group involved in the space economy to direct their activities to align with the thoughts of the general public generated from this study.

Procedure: While participating in this study, your students and teachers will be asked to complete an online survey distributed via Google Forms divided into multiple sections. The first portion of the survey will ask participants to input basic demographic information such as year of birth, gender, and country of origin. The second portion of the survey will ask participants to present their thoughts on the four defined commercial space activities displayed before in multiple choice questions. The final portion of the survey will have a series of multiple choice questions and one optional free response question asking participants to summarize their overall thoughts over the defined activities choosing from them as answer options or describing them broadly.

Use of Findings: Findings from this study will be used in a student thesis that presents the findings of the research, as well as an oral defense presentation to the instructor of Advanced Placement Capstone Research, as well as a board that is created in response to the content of the study. Findings of the research have the potential to be published in a scholarly journal.

Consent: I hereby give my consent for my (students and teachers) to participate in this research study. I acknowledge that the researcher has provided me with:

A. An explanation of the study's purpose and procedure.
B. Answers to any questions I have asked about the study procedure.

I understand that:

A. My students and teachers participation in this study will take approximately 5 minutes
B. The probability and amount of harm/discomfort anticipated as a result of my students and teachers participating in this study are not greater than those ordinarily encountered in daily life.
C. Research sessions will not be held when important (academic material, deadlines, etc.) is being covered.

D. The potential benefits of this study include educational exposure to future commercial space developments and events covering the American space exploration narrative.
E. My students and teachers will not be compensated for participating in this study.
F. My decision to allow my students and teachers to participate is voluntary, and I may withdraw my consent and discontinue my students and teachers participation in the study at any time. My refusal to allow my students and teachers to participate will not result in any penalty or disadvantage for me or my students and teachers.
G. In addition to my written consent, my students and teachers will digitally input their agreement to participate in the research. My students and teachers will be able to discontinue their participation at any time, without penalty, and this will be explained to them before they agree with an online informed consent form.
H. My students and teachers' responses in this study will be kept confidential, to the extent permitted by law. The data will be stored in a secure location on a password protected flash drive, will be available to the researcher and advanced placement instructor [redacted] and research reports will only present findings on a group basis, without any personally identifying information of me or my students and teachers.

(School Name)
(Printed): _____
Administrator, (Name)
(Printed): _____
Signature: _____ Date: _____

Appendix B

Blank Copy of Participant Online Informed Consent Form

Note. Crossed out is the researcher's personally identifiable information. This was done to maintain anonymity.

Consent Form

[redacted] **AP Capstone**

Title of the Study: " A Generational Perspective Over the New Commercial Space Age"

Researcher Names and Contact Information: [redacted]

Purpose and Background: The general purpose of this research is to determine trends among three age cohorts over their prior knowledge and opinion of the future commercial uses of outer space. Participants in this study will be asked to complete a survey examining demographic information in reference to Likert scale, free response, and multiple choice questions. Data from this study will be used in a student thesis that presents the findings of the research, as well as an oral defense presentation to the instructor of Advanced Placement Capstone Research, as well as a board that is created in response to the content of the study. Findings of the research have the potential to be published in a scholarly journal.

I understand that:

A. My participation in this study will take approximately five minutes. I agree to complete the study in one sitting.
B. The probability and magnitude of harm/discomfort anticipated as a result of participating in this study are not greater than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests.
C. The potential benefits of this study include educational exposure to future commercial space developments and events covering the American space exploration narrative.
D. I will not be compensated for participating in this study.
E. My participation is voluntary, and I may discontinue participation in the study at any time by closing the survey. My refusal to participate will not result in any penalty.
G. My responses will be kept confidential, to the extent permitted by law. The data will be stored in a secure location in the researcher's private home on a password protected computer, will be available to the AP Research Instructor, and research reports will only present findings on a group basis, without any personally identifying information.
    - Click the checkbox to the left to indicate that you have read and understand your rights, and that you consent to participate in this online research study.

Appendix C

Survey Questionnaire

Note. Responses indicated as other in the opinion segment were labeled "null" and not figured in the calculation of mean Likert scale responses. The final free response question was optional and the results were not considered in analysis.

Space Exploration Form

Demographics Segment

1. What is your year of birth?
   Free Response: (Input year of birth)
2. What is your gender?
   A. Male
   B. Female
   C. Other
3. What is your country of origin?
   A. United States
   B. Outside United States

Prior Knowledge Scale Segment

(Questions will be answered using the following five-point Likert Scale)

1 = *I have no prior knowledge*
2 = *I am familiar but do not understand*
3 = *I have a common understanding*
4 = *I am knowledgeable*
5 = *I am knowledgeable and could explain to others*

1. How familiar are you with the history of American space exploration? Including but not limited to the Space Race, Space Shuttle, or the International Space Station.
   1, 2, 3, 4, 5
2. How familiar are you with current events regarding American space exploration? Including but not limited to SpaceX, Virgin Galactic, or NASA's Artemis Program.
   1, 2, 3, 4, 5
3. How familiar are you with future events regarding American space exploration? Including but not limited to space colonization, space tourism, or asteroid mining.
   1, 2, 3, 4, 5

Opinion Segment

(Questions will be answered using the following five point Likert Scale)

1 = *I am strongly against it*
2 = *I dislike it*
3 = *I am indifferent*
4 = *I like it*
5 = *I strongly support it*
Null = Other (Fill in the blank)

1. **Space Tourism**
   What are your thoughts on people going to space as a tourist destination?
   Including but not limited to suborbital launches, space cruises, and space hotels in orbit or on other planets.
   1, 2, 3, 4, 5, Other
2. **Space Colonization**
   What are your thoughts on people permanently living in space on commercial run settlements?
   Including but not limited to Space X's plant to colonize Mars, reservations of individuals with companies to live in space, or the construction and habitation of moon bases.
   1, 2, 3, 4, 5, Other
3. **Harvesting Raw Materials**
   What are your thoughts on the extraction of raw materials from outer space?
   Including but not limited to asteroid mining to get precious metals such as gold, harvesting water on Mars, or extracting hydrogen for rocket fuel.
   1, 2, 3, 4, 5, Other
4. **Government Partnerships**
   What are your thoughts on the commercial facilitation of government space programs?
   Including but not limited to commercial launch systems facilitating government projects in the research, defense, or exploration of space both manned or unmanned.
   1, 2, 3, 4, 5, Other

Comparison Section
(Multiple Choice Answer Options)

A. Space Tourism
B. Space Colonization
C. Harvesting Raw Materials
D. Government Partnerships

1. Of the four defined areas of commercial space activities, which were you the most familiar with prior to taking this survey?
   A, B, C, D, E. I was not familiar with any of these activities
2. Of the four defined areas of commercial space activities, which are you the most interested in?
   A, B, C, D
3. Of the four defined areas of commercial space activities, which do you believe to be the most ethically viable?
   A, B, C, D
4. Of the four defined areas of commercial space activities, which do you believe to be the most profitable?
   A, B, C, D
5. Of the four defined areas of commercial space activities, which do you predict to be the most prevalent in the near future?
   A, B, C, D

(Final required content question)

6. Overall, do you consider the expansion of industry into outer space and the creation of a space economy to be worthwhile?
    A. Yes
    B. No

(Optional free response question)

Do you have any additional thoughts?