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SOCIAL MEDIA USE IN SPACE: HOW NASA ASTRONAUTS' TWITTER FEEDS COMPARE TO OTHER SCIENCE COMMUNICATORS ON EARTH

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This Study looks at the activity of the Twitter feeds of three astronauts Chris Hadfield, Keran Nyberg, and Mike Hopkins. These feeds were quantitatively examined, then were compared to two professional science communicators Bill Nye and Neil deGrasse Tyson Twitter feeds to draw conclusions on the effectiveness of the astronauts' Twitter use.

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By Carl Clark

Abstract

There is a deficit in the public value placed on NASA in comparison with its true public worth. Given this lack of support, it must be understood how effective the steps that are being taken in the arena of social media at communicating its significance. The activity of the Twitter feeds of three astronauts Chris Hadfield, Karen Nyberg, and Mike Hopkins were quantitatively examined, then were compared to two professional science communicators Bill Nye's and Neil deGrasse Tyson's Twitter feeds. These subjects were selected for their communications campaigns proximity to the present. In addition the science communicators were selected for their notoriety and the astronauts for their varying degrees of effective twitter communication. The data shows that while some of the astronauts are more prolific in the use of Twitter and their audience is more engaged with their communication than their terrestrial counter parts. However, the astronauts all lack in reaching out to a large audience base that the science communicators have. The professional science communicators use entertainment and artistic culture in their communication. The astronauts who have a large follower base also use entertainment, however, it is not to the extent of the science communicators. The least popular astronauts do not utilize Twitter as frequently as their counter parts and their communications style uses no cultural or entertaining aspects.

The value of culture, art, and entertainment to draw people in must be used by the astronauts to have a farther reach on social media. This must be done in conjunction with their strict communication rules as civil servants. They also must start using the social media tools early in their career as an astronaut. The data also shows that despite the differences in the professions of the astronauts and the science communicators, astronauts can have a large reach and an engaged audience. This is only possible if the tools are used properly. The astronauts and NASA should ensure that the techniques of successful communication online are understood to maximize the chances of the astronauts having greater reach and engagement.

Introduction

In the 21st century the power of our technology to reach further than any other time in human history is increasing by the day. In the modern world we have a citizenry that does not understand the tools of the STEM fields that have produced these abilities. To this end, society has initiated programs to increase interest in the STEM fields. These programs involve large communication and education campaigns to increase awareness and interest of the general public. The variety of these communication methods varies and for the overall message to be effective, the individual strategies must be examined. This study will look at one small part of science communication in social media to better understand how professional science communicators compare to NASA astronauts' Twitter use.

Recently NASA moved on to Instagram and will likely begin to use other social media services Bertot, Jaeger, Hansen (2011). Given the power of the Internet to connect and inform, and the country's relatively low interest in space exploration Launius, R. (2003), it is important to capitalize on the tools of social media for more than inter departmental efficiency, Hrdinova, Natallie, Helbig, & Peters, (2010).

The subjects that will be examined in the study are both professional science communicators and a group of NASA astronauts. The similarities in the messages of science, learning, and the culture to which all the subjects belong are the reasoning behind their selection in this study. Karen Nyberg started at NASA as an intern and after graduation worked her way up to fly in to space two times, and on her first flight became the 50th American woman to fly in space. Chris Hadfield is a Canadian Air Force pilot, the only non-American Top Gun. He became the first Canadian space station commander in 2013, and before his retirement from NASA was the lead singer in the astronaut band Max Q. While in space, Hadfield's social media use was effective and prolific. Mike Hopkins recent stay aboard the International Space Station ended in March 2014. His experience as a University of Illinois football player and his flight's proximity to the

winter Olympics led NASA to work with him on social media. This was to link the cultural event of the Olympics to his space flight in an attempt to create interest and engagement.

These astronauts' Twitter feeds will be compared to the science communicators Bill Nye and Neil deGrasse Tyson. Bill Nye also known as Bill Nye the science guy, is a mechanical engineer, educator and CEO of the Planetary Society. Neil deGrasse Tyson is the director of the Hayden Planetarium, an educator, and researcher. These subjects were selected for the similarities of the subject they communicate about, their popularity on Twitter, their high degree of involvement in social media, and the proximity their activities have been to the present.

Question

How do the Twitter analytics from the astronauts' compare to the science communicators' Twitter feeds? Do the science communicators make more prolific use of Twitter than the astronauts? Which audience is more engaged with the content the different groups of subjects are making? Engagement is measured through the audiences' interaction with the subject's tweets and how easy the subjects makes their tweets to interact with. Which Twitter feeds are more popular; the astronauts or the science communicators? If the science communicators perform better than the astronauts what does the data show can be changed so the astronauts perform better?

Background

Concentrating on ties or communication pathways that are frequently used can aid communicators to influence each other by adapting and expanding their exchange of information in order to maintain their frequently used or strong ties to one another. Weaker ties or, less frequently used, tend to fall back to established communication channels (Haythornwaite, Caroline 2002). This does not mean there is no opportunity for influence. This is

due to weak ties sometimes needing new communications' infrastructure to become influential to one or more of the involved parties. However, weak ties are susceptible to dissolving through change in the communications method or tool. The Internet and the use of social media are two examples of communications tools that have shifted from weak to strong communication methods. This is also the case with the communicators who use these tools. By their nature, strong ties are more robust to this sort of change (Haythornwaite, Caroline 2002).

Over the course of the early 90s to the early 2000s, email gradually shifted to social media, and these tools found their way into populist movements that tailored their message to fit the target audience which proliferated these organizations' message across the globe (Kahn, Kellner 2004). These tools were being used in an early version of the neo-liberalism which would later become the Occupy Wall Street movement of the early 2010s, and early usage of new media was also close to the evolution of the Arab Spring which would also take place in the early 2010s. All of these recent trends can be traced back as early as the 90s. This proves the power and pervasiveness of social media.

By the 2000s, the Internet was not only being used by populist movements, but more radical and destructive changes had also taken place. The corporatization of the World Wide Web, the new hacker culture and cyber terrorism have all sprung up in the world of the Internet. Also, the very design and culture of the Internet has changed via, web design, wikis, and the textualization of information (Kahn, Kellner 2004). There is also the tendency toward politicization, particularly in blogs (Kahn, Kellner 2004).

The Internet has become a political force in and of itself. The competition of ideas is fierce and has the potential to spill outside of the digital space. It is implied through the emphases in blogs and other forms of communication through the Internet that the world outside the digital space naturally finds its way in. Finally, the point counter-point discussion has reached a place where

new networks of people will begin to form and to oppose the old paradigms of society's structure (Kahn, Kellner 2004).

Literature Review

There are four consistent benefits of the use of social media from within an organization visibility, persistence, information editing, and open association. Visibility refers to the ability to see and have freer access to information. Persistence refers to the fact the information stays out in the cloud far longer and in its original form than other means of information storing. This information is also readily edited and repurposed. Finally, it allows for more open association across an organization or population (Leonardi, Treem 2012). The technological frontier is moving so quickly that research should not confine itself to one piece of that technology. As it stands this research only focuses its data on one social media software. However, qualitative observations made of the astronauts' and sciences communicators' content will be taken in to account when reaching conclusions. Future study should focus on the broader sociological repercussions of the great conductivity of society (Leonardi, Treem 2012).

The verging landscape of public sector social media use has been well defined and examined since 2009. The Center of Technology in Government, outlines eight areas that a government must focus on to have an effective social media policy: employee access, account management, acceptable use, employee conduct, content, security, legal issues and, citizen conduct (Hrdinova, Helbig, & Peters, 2010). The Center of Technology in Government identifies the reasons why employees might use social media in the work place and how three interests' official agency interests, professional interests, and personal interests can be fluid and overlapping (Hrdinova, Helbig, & Peters, 2010). The eight core elements of social media policy vary. For example, employee access is very different from one agency to another. A policy of access must be clearly stated and implemented. This is also based on the Center of

Technology's investigation into various agencies, activities in this area. A good policy, finding a balance between total access, and restricted access is hard to find (Hrdinova, Helbig, & Peters, 2010). These dilemmas continue into the rest of the eight core pieces of social media policy, giving insight to the problems NASA faces with their policy. This study also provides procedural recommendations on how to write effective social media policy.

The government use of social media can be categorized in to three areas: access and social inclusion, privacy and archiving, and governing and governance (Bertot, Jaeger, Hansen 2011). This categorization is reflected in laws and public policy. Social media can have a far reaching effect on all of these goals. However, the regulations put in place for government can have stifling or slowing effects on the use of social media. This ensures that various agencies are in compliance with the laws to protect the free flow of information and record keeping (Bertot, Jaeger, Hansen 2011). In terms of governance, the policies are not keeping pace with the ever changing landscape of the social media sphere. These numerous issues are slowly being addressed, and as they are, the government moves forward. One of the larger problems is making sure the third party providers comply with government rules of use (Bertot, Jaeger, Hansen 2011). Despite impediments, social media is too useful for the government to overlook.

Social media's use in the private sector could translate to the government's needs to communicate with those it provides services for. Web 2.0 social media services and outlines how government uses them to connect to the citizenry and exchange information. NASA is making good use of YouTube to help make the case for supporting space exploration (Dadashzadeh 2010). Any strategic plan for the use of social media must identify the future value to the public and how each tool will be implemented to achieve the goals. The problems with governmental use of social media stem from the free form nature of social media and the bureaucratic nature of government (Dadashzadeh 2010). The cost savings and the engagement with the citizenry make web 2.0 technologies too valuable for these impediments to stop the

government from using them. This usage by the government has had benefits for all the stakeholders (Dadashzadeh 2010).

With the advance of content maker to content maker capability of web 2.0, and a company's ability to communicate with its consumer, constitutes a new hybrid form of communication (Mangold, Faulds 2009). This is relevant to a current look at NASA's social media use because of the content made by astronaut Chris Hadfield. His videos on YouTube are the sort of hybrid communications that must be understood for more effective communication online in the future. The most important part of this new kind of promotion is its integrated nature. Anyone can be a promoter. From an employee of the company to a YouTube vlogger on the street, anyone's point of view can be validated through audience traffic (Mangold, Faulds 2009).

In further examination of social media's value, a semester long experiment of 125 students in a pre-health seminar course divided them into a control and experiment group. The purpose was to measure the difference in the students' grades in conjunction with their engagement on Twitter (Junco, Heiberger, Loken, 2010). A 19 item scale was used, which was based on the National Survey of Students' Engagement. Engagement on Twitter with faculty and fellow students resulted in higher engagement in the class and higher grade point averages than the control group who did not use Twitter (Junco, Heiberger, Loken, 2010). Twitter can be used to engage in learning activities with peer groups, and that involvement in a subject produces greater retention of information and involvement in that subject (Junco, Heiberger, Loken, 2010).

A further examination of Twitter use (Zhang, Jansen, Chowdhury 2011) looked at 134,478 tweets from 96,725 users of Twitter and how their activity pertains to nine popular brands. The examination took place over a five week period. The researchers looked at the number of people interacting with the business and the engagement of customer to customer

communication. The greater amount of business engagement online the greater the consumer engagement. It also noted the importance of re-tweeting as a credible and prolific way to get information out to the consumer base. A tweet's lifetime is about one and one half hours to four hours (Zhang, Jansen, Chowdhury 2011). This study outlines the critical nature of social media, in particular Twitter, for generating interest in a brand. This understanding of analytics and how information disseminates will be useful in the analysis of the subjects' Twitter analytics.

There is a misconception the space community has regarding the supposed majority support for the Apollo era and waning of support in subsequent years, in regards to the history of public opinion of NASA (Launius, R. 2003). During the years of NASA's existence, support for the agency and its performance remains very high. However, this is in conjunction with the public's desires to see NASA receive less funding and not pursue new ambitions like human missions into deep space such as landing on Mars. This attitude is also true in the 60s. The public supported NASA's performance, but the majority of Americans didn't want to make the financial effort to land on the moon. It is also noted that there is an extreme disconnect between public knowledge and the reality of NASA's budget. The lifetime agency average of federal spending is one percent of the federal portfolio. Today, it's less than 0.5 percent, while only 10 percent of the general public knows this fact and 90 percent think it is much higher (Launius, R. 2003). There are notions the space community has about recapturing the mythological memories of overwhelming support the public once had during Apollo will help drive NASA forward once again are not true. The true driving force behind the Apollo program was the cold war rivalries between the United States and Soviet Union (Launius, R. 2003). It is important to note the view of cold war rivalries being the catalyst for the moon shot is widely accepted one in the historical community. Therefore it simply was presupposed and not investigated in (Launius, R. 2003).

Methods

This Study will consider the analytics of Neil deGrasse Tyson's Twitter feeds after Comic Convention San Diego 2013, as this was the beginning of a major public relations campaign for the new Television series *Cosmos*. *Cosmos* is a limited run television series covering the subject of science. In addition the analytics from the premiere of the new *Cosmos* to three weeks into the series will be analyzed. This short period of time is due to the time constraints of the study. This study will also examine at the analytics of Bill Nye's Twitter feed from the time after the announcement of his debate with Ken Ham to three weeks following the event. Since the astronauts are monitored for their six month flight and the six month period before the flight, near equivalent time periods were found for the science communicators. Since Bill Nye's debate with Ken Ham was announced three weeks before the event which led to an equivalent monitoring period that is shorter in real time than any other subjects monitoring period. A brief analysis of Bill Nye's Twitter analytics over a longer time period demonstrates the shorter monitoring time period is commiserate with normal activity. Neil deGrasse Tyson was monitored for a longer time period that was close to that of the astronauts. However, the in-equivalent time period that lasted in real time ten months before the *Cosmos*'s premiere and three weeks after. This is due to the time constraints put on the study itself.

The science communicators' Twitter analytics will be compared to the Twitter feed analytics of astronauts Chris Hadfield, Karen Nyberg, and Mike Hopkins before and during the time they were in space. There are other astronauts who have been on twitter longer and are effective communicators such as Mike Massimino. The reason he and others were not selected for this study was twofold. First some are no longer an astronaut and therefor completely unbound from the communications regulations of NASA. Second their flights were in the too distant past to get an accurate comparison to the other astronauts and the science communicators. These two reasons precluded many other current and former astronauts from the study. I the case of Mike

Massimino specifically. He was also the first astronaut to use Twitter in space this makes his data overly emphasized when compared to any other possible subject as none were the first. Whoever is first to do something will invariably get more notoriety regardless of their skill at using the communications tool. The time analyzed will be the six months leading up to their respective flights and the six months during, as well as an overall time frame analysis. The website that will be used is twitonomy.com. The site Twitonomy is an analytics service web site that allows a user to look extensively at their personal Twitter accounts and into other user's analytics as well. It was selected since the analytics data of Karen Nyberg on the web site Twitonomy matches closely NASA data has. Therefore, this will be considered a credible source for the analytics information gathered in this study. The analytics will give information on how prolific, popular, and engaged each subject is with the Twitter community at large.

The coding units for the analytics are: Subject- these are the individuals who are science personalities and astronauts; Twitter Followers- these are the people who select to keep track of another individuals tweets; Tweets per day- the average number of tweets sent from the subject over a given time period; User Mentions- average number of mentions per tweet, the higher the number the more active the subject; Links- the average number of links per tweet, the higher this coding unit the more likely the subject is a source of information; Tweets Re-tweeted- proportion of the subjects tweets re-tweeted by others, the higher this figure the more the subject is considered a valuable source of information; Tweets Favorited – the proportion of the users favorite tweets from the subject. Both re-tweets and favorite tweets also measure the average number of favorites by other users. Re-tweets- percentage of re-tweets of the total analyzed tweets by the subject; Replies- the percentage of replies of the total analyzed tweets by the subject; Hashtags- the average number of hashtags per tweet, the higher this figure the more likely the subject's tweets can be found in a search.

All of these coding units have other sub coding units that pertain to the percentages of the primary coding units total real numbers. Follower/following- the ratio of followers per person followed. A high ratio combined with a large follower base is a good sign that this user is influential. Listed/1,000 followers- Average of people who added this user to a public list (per 1,000 followers). A high number combined to a large follower base means that this user's tweets are considered relevant to others. There are also the timeframes that will be analyzed for their various analytics of each subject. These points in the timelines are as follows: Both follower/following and list (per 1,000 followers) are metrics that have current information as of March 25, 2014, not data from other timeframes. The term event will be used to refer to a moment of significance for each subject. For the astronauts, it is their time in space. For the science communicators, it will be an occasion of equivalent significance for their activities.

Neil deGrasse Tyson

- Announcement date of Cosmos 08/05/11
- Comic Con Cosmos promotion 07/13
- Premiere date of Cosmos 03/09/14

Bill Nye

- Announcement of Debate 01/02/2014
- Debate 02/04/2014
- Three weeks post debate 02/25/2014

Chris Hadfield

- In Space 12/19/2012-5/13/2013
- Overall 5/12/2012-5/12/2013

Karen Nyberg

- Before Space 11/10/2012-5/8/2013
- In Space 5/8/2013-11/10/2013
- Overall 11/10/2012-11/10/2013

Mike Hopkins

- Before Space 3/10/2013-9/25/2013
- In Space 9/25/2013-3/10/2014
- Overall 3/10/2013-3/10/2014

Results

All of the tables' data are broken down as follows. All of the primary coding units and their corresponding metrics are in light gray, or yellow. The sub-coding units and their corresponding metrics are in dark gray or blue. The three tables will show the five subjects compared to one another. Each of these three tables will represent one timeframe, before, after, and overall.

(Figures 2.1-2.3)

It should be noted that the External Relations Office at the Johnson Space Center starts actively working with the astronauts in regard to the astronauts' twitter feeds, social media, and press once the flight assignment is made official.

The science communicators used Twitter at least a year longer than all of the astronauts and therefore, had a great chance to build up a larger follower base. Bill Nye started using twitter on May 5, 2009 and Neil deGrasse Tyson started on January 29, 2009. In contrast, Mike Hopkins started on April 2, 2012, Karen Nyberg started March 25, 2013, and Chris Hadfield started using twitter on September 2, 2010. The science communicators have more experience in using the software and engaging with their followers. The science communicators job is to communicate, the astronauts is not. While the astronauts are the most recognizable face of NASA, their positions are to fly into space; not to solely communicate the activities of NASA and engage the public on the value of space travel. Given the right circumstances, they are a galvanizing force in the media and social media.

As the data shows Chris Hadfield gives an example of a communicator astronaut. His use of social media and usage while on board the International Space Station shows that the time astronauts spend in space can be used as an outreach to the world at large (Figure 2.3); a world and particularly a nation that has forgotten the importance of exploration and discovery (Launius, R. (2003).

In the case of astronaut Mike Hopkins, there was an attempt to duplicate what Chris Hadfield did with the "Train Like an Astronaut" weekly video postings and Twitter up dates. The data shows this was not as successful as Chris Hadfield's twitter use. Mike Hopkins was less prolific in posting to twitter, and in every coding unit, less active in using Twitter as a communications tool. (Figure 2.2)

Karen Nyberg's metrics are overall more robust than Mike Hopkins (Figure 2.3). She leads him in almost every metric except ones pertaining to re-tweets. The only two lower metrics she has are followers/following and listed/1,000 followers, and these are contingent on a large follower base. Given that her number of followers is double of Mike Hopkins on these two measuring points they are almost even. It is also important to note that Nyberg and Hopkins have the highest numbers in these two coding units. However, their relatively low follower count makes these readings less relevant.

One of the drawbacks of the software used in this study is that it does not allow for the tracking of the number of past followers the subjects have. This means it will be impossible to tell what kind of audience growth or decline each of the subjects had over the course of the various time frames, and if the event they participated in had a positive or negative effect on audience size. Also the software did not allow for the collection of Chris Hadfield's Pre-Event Data. Chris Hadfield when compared to the two science communicators, many of his metrics are close to or higher than his contemporaries.

Another data point the astronauts have higher than their science communicators counter parts is their audience is more engaged in the use of twitter. The percentage of the astronauts' audience that re-tweet shows them to be the more involved audience. The volume of re-tweets of the science communicators is mixed. Neil deGrasse Tyson is on par with the astronauts; Bill Nye has a considerably less engaged audience in comparison to the size of his follower base than any of the other subjects (Figure 2.3).

It is also important to note that nearly all the metrics in volume and percentages increase during the events of the respective subjects (Figure 2.1, 2.2). The only metrics that did not match were the amount of Twitter use from the science communicators during their events; given the short time period for the time measured this is unsurprising (Figure 2.2). The small sample size of the

tweets in this time frame for these subjects is another weakness in the study. This is brought on by limitations in the software and time constraints.

Conclusion

The comparison of astronauts' Twitter feeds to that of popular science communicators' yielded contrasting results about the activity, popularity, and engagement of the subjects. The comparison of the data helps to draw recommendations for the Johnson Space Center on the best course of action regarding the future of the Astronaut Corps use of social media. NASA must make effective engagement with the American people on social media in new ways than what the agency done in the past a major goal (Zhang, Jansen, Chaowdhury2011).

There are two major differences between the astronauts and the science communicators. First, their professions are different. The astronauts' job is to first fly in space, and only as a secondary duty communicate to the general public. This means that unlike their counterparts they may not have the skills or desires to be avid communicators. However, like most NASA personnel, they do like to talk about their work. While this assertion is partially anecdotal, it is not without substantiation through the fact that the astronauts themselves started using twitter on their own Mike Massimino was the first to tweet from space on STS-125, and Chris Hadfield's successes in bringing life and culture from space to earth. His engagement metrics are also as high, and in some cases higher than the science communicators during the time frame of their respective events. Karen Nyberg's respectable twitter following and general popularity is also evidence of this.

The second difference is time. The science communicators have been on twitter longer than the three astronauts in this study by more than a year or more. This, however, is irrelevant in the final analysis. The implementation of a successful outreach campaign can bring a person to the level of the science communicators' activity, popularity, and engagement in a relatively short

period of time. Chris Hadfield is evidence of this. While his outreach was independent of the NASA structure, it was not without forethought and collaboration from NASA, artists on earth, and his son. Collaboration with other popular opinion leaders while the astronauts are in space will help disseminate their work in the population and help foster relationships in the cultural global community. Hadfield rightly linked art and science together to make a compelling case for the world's attention. Duplicating this result is and should be NASA's priority in their concerns for social media. Again people find the astronauts interesting, and the platform from which they have the opportunity to communicate a message to the world is unlike any other in the history of humankind (Zhang, Jansen, Chiwdhury 2011).

NASA is on the right track, in regards to utilizing the Astronaut Corps as their greatest asset. Their attempt at using their human communication resources to their fullest on social media is the right course of action. No matter how NASA shrunk from the forefront of popular culture, astronauts are still thought of as heroes and pioneers. In recent years space has re-entered the popular culture in many ways. This possible resurgence is another reason culture and art are important for NASA to capitalize on. There is also an evident hunger from the public for the wonders of discovery and space travel. This is evident by the success Chris Hadfield had with all of his public outreach and Twitter use.

To duplicate the science communicators and more importantly Chris Hadfield's success it is important to mimic several things. Their high engagement on twitter is likely a symptom of more than just their prolific use of the Twitter and other mass communication tools. Therefore, a holistic approach to outreach like that of Hadfield should be taken. They used art, culture, and entertainment to engage a large audience on the importance of their subject matter. People value art and culture, in the study Junco, Heiberger, Loken (2010) people were asked to engage on Twitter to see if their grades would improve if they interacted in this medium. The subjects grades improved due to the interaction, and because the subjects valued the grades. Since

people value art and culture they will also value interacting with a subject that uses it in the digital space.

Multiple mediums and art forms should be used. Incorporation of science and its value is advantageous for the later stages in the value building communication process, but is not required to bring in people. Including the value of science and space exploration is necessary to get NASA's point across to the public and elicit actions NASA wants the public to take. First audience must be drawn into a subject, to then value it. An artistic and cultural statement will likely be the best tool to attract an audience. This can be accomplished by collaborating with people outside of the NASA organization in conjunction with the on station outreach campaigns. Also it is important to recognize the unique way the science communicators have presented their message, they foster curiosity through entertainment (Dadashzadeh 2010) and (Hrdinova, Natatlie, Peters 2010). It is also understood by this study that NASA and its astronauts have constraining rules for communication, however successful astronauts like Mike Massimino have managed a far reach on social media. Creative circumvention of the rules and good interagency networking has and should allow for more effective communication in the future.

The time that a communicator or astronaut is on twitter is a factor and the astronauts should start using social media as soon as they are selected as astronauts. NASA should start helping the astronauts with their overall cultural and artistically driven outreach as soon as feasibly possible.

Development of communication skills and planning for their on station outreach campaigns ideally should start early. The sooner the astronauts can begin to capitalize on their position, the better. If possible, from the time they are selected as astronauts, they should start utilizing social media and the holistic outreach approach. In the External Relations Office, the groundwork can be laid early for the astronauts' outreach during their mission. These plans should incorporate

informing the public, artistic creativity, cultural expression, collaboration with outside opinion leaders, and education about science. The plans need to be flexible to capitalize on each astronaut's unique talents and interests. Whatever the astronauts' interests and abilities are it will be advantageous to use the community of the subject they are interested in. For example, Chris Hadfield collaborated with musicians and video editors on earth to make his Space Oddity cover song and video. This will give the astronauts' outreach a pre-built network of distributors. For the "Train Like an Astronaut" it could have been advantages for Mike Hopkins to make use of some of Nike's applications designed for tracking work outs and feeding them to the internet. Being able to collaborate with other organizations and individuals would be useful as they can bring NASA and its value to audiences who might not have otherwise been exposed to its message.

These networks and distributors will be interested to see their content proliferated. This flexibility will also allow NASA to take advantage of unforeseen opportunities. Training the astronauts to be better communicators may be necessary, as they may not know how to present themselves in a way that will draw people in. They may also not know how they can use their artistry and cultural knowledge to communicate. These are all talents that will need to be cultivated over time, and if possible included in the astronaut selection process.

These conclusions and recommendations were drawn from looking at not only the data from the study but what the subjects did and how they communicated their message to the general public. It should be noted that this study is not recommending that the Astronaut Corps become a public relations group. Their focus is and should remain safe and societally valuable space flight. It is recommending that greater steps be taken to ensure their potential communicative abilities and scale is actualized.

A Major weakness of this study is its sample size for one of the subjects and the limitations of the software used, this constitute flaws in the data set in regards to drawing concrete conclusions. The rest of the data does seem to stand on its own in its ability to be used for interpretation and analysis. Also this study is not generalizable to a larger population. For these reasons it is necessary to revisit this question with more time and more capable software. It will also be advantageous to look at this kind of data periodically. This repeated investigation gives NASA a better idea of the level of engagement, and how prolific their most recognizable public figures are (Leonardi, Treem 2012) and (Dadashzadeh 2010). Further analysis on other astronauts is necessary since Chris Hadfield is not an American astronaut he followed different rules for communication. His information is still useful as a means to prove strong creative communication is possible even if so rule must be changed or creatively circumvented.

(F-2.1)Pre-Event Metrics

Coding Unites	Neil deGrasse Tyson	Bill Nye	Chris Hadfeild	Karen Nyberg	Mike Hopkins
Followers/following	36919	33557	17672	2041	5283
Listed/1,000 followers	15	9.15	7.58	16.08	15.45
Analysed tweets	301	42	N/A	198	151
Analysed from	7/21/2013	1/2/2014	N/A	11/10/2012	3/10/2013
Analysed to	3/9/2014	3/4/2014	N/A	5/8/2013	9/25/2013
Tweets per day	1.3	0.68	N/A	1.1	0.76
Re-tweets	0	6	N/A	12	3
% of tweets being re-tweets	0	14.29	N/A	6.06	1.99
User mentions	161	19	N/A	135	81
Mentions per tweet	0.53	0.45	N/A	0.68	0.54
Replies	18	4	N/A	88	61
% of tweets being replies	5.98	9.52	N/A	44.44	40.4
Links	65	10	N/A	26	4
Links per tweet	0.22	0.24	N/A	0.13	0.03
Hashtags	24	6	N/A	70	8
Hashtags per tweet	0.08	0.14	N/A	0.35	0.05
Tweets retweeted	301	36	N/A	125	108
% of tweets being re-tweeted	100	85.71	N/A	63.13	71.52
Total number of re-tweets	527594	16843	N/A	1740	2175
Re-tweets per re-tweeted tweet	1752.8	467.86	N/A	13.92	20.14
Re-tweets/100 followers	29.16	1.25	N/A	1.74	3.74
Tweets favorited	301	36	N/A	133	121
% of tweets being favorited	100	85.71	N/A	67.17	80.13
Total number of favorites	436120	22262	N/A	2028	2408
Favorites per favorited tweet	1448.9	618.39	N/A	15.25	19.9
Favorites/100 followers	24.11	1.66	N/A	2.03	4.14
	Lead up	Pre Debate	Before space	Before space	Before space

(F-2.2)During Event Metrics

Coding Unites	Neil deGrasse Tyson	Bill Nye	Chris Hadfeild	Karen Nyberg	Mike Hopkins
Followers/following	36921	33557	17672	2041	5283
Listed/1,000 followers	15	9.15	7.58	16.08	15.45
Analysed tweets	25	10	1933	493	111
Analysed from	3/9/2014	2/4/2014	12/19/2012	5/8/2013	9/25/2013
Analysed to	3/21/2014	2/25/2014	5/13/2013	11/10/2013	3/10/2014
Tweets per day	1.92	0.45	13.24	2.64	0.66
Re-tweets	0	1	146	8	0
% of tweets being re-tweets	0	10	7.55	1.62	0
User mentions	8	6	549	198	11
Mentions per tweet	0.32	0.6	0.28	0.4	0.1
Replies	2	0	423	131	4
% of tweets being replies	8	0	21.88	26.57	3.6
Links	3	3	167	47	0
Links per tweet	0.12	0.3	0.09	0.1	0
Hashtags	3	1	20	68	0
Hashtags per tweet	0.12	0.1	0.01	0.14	0
Tweets retweeted	25	9	1771	441	111
% of tweets being re-tweeted	100	90	91.62	89.45	100
Total number of re-tweets	63550	4195	822790	85330	34099
Re-tweets per re-tweeted tweet	2542	466.11	464.59	193.49	307.2
Re-tweets/100 followers	3.51	0.31	76.32	85.32	58.67
Tweets favorited	25	9	1778	466	111
% of tweets being favorited	100	90	91.98	94.52	100
Total number of favorites	76355	6624	623436	85087	40898
Favorites per favorited tweet	3054.2	736	350.64	182.59	368.45
Favorites/100 followers	4.22	0.49	57.83	85.08	70.37
	On Air	Post Debate	In Space	In Space	In Space

(F-2.3)Over All Metrics

Coding Unites	Neil deGrasse Tyson	Bill Nye	Chris Hadfeild	Karen Nyberg	Mike Hopkins
Followers/following	36920	33557	17676	2041	5283
Listed/1,000 followers	15	9.15	7.58	16.08	15.45
Analysed tweets	320	32	1918	689	260
Analysed from	7/21/2013	1/2/2014	5/12/2012	11/10/2012	3/10/2013
Analysed to	3/21/2014	2/25/2014	5/12/2013	11/10/2013	3/10/2014
Tweets per day	1.31	0.58	5.24	1.88	0.71
Re-tweets	0	3	142	20	3
% of tweets being re-tweets	0	9.38	7.4	2.9	1.15
User mentions	166	17	548	333	91
Mentions per tweet	0.52	0.53	0.29	0.48	0.35
Replies	20	4	423	219	64
% of tweets being replies	6.25	12.5	22.05	31.79	24.62
Links	68	9	166	73	4
Links per tweet	0.21	0.28	0.09	0.11	0.02
Hashtags	27	4	20	137	8
Hashtags per tweet	0.08	0.13	0.01	0.2	0.03
Tweets retweeted	320	29	1760	564	217
% of tweets being re-tweeted	100	90.63	91.76	81.86	83.46
Total number of re-tweets	560598	7477	801391	86963	36065
Re-tweets per re-tweeted tweet	1751.87	257.83	455.34	154.19	166.2
Re-tweets/100 followers	30.99	0.56	74.32	86.95	62.06
Tweets favorited	320	29	1767	597	230
% of tweets being favorited	100	90.63	92.13	86.65	88.46
Total number of favorites	489952	11013	604536	87017	43137
Favorites per favorited tweet	1531.1	379.76	342.13	145.76	187.55
Favorites/100 followers	27.08	0.82	56.06	87	74.23
	Over All	Over All	Over All	Over All	Over All

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