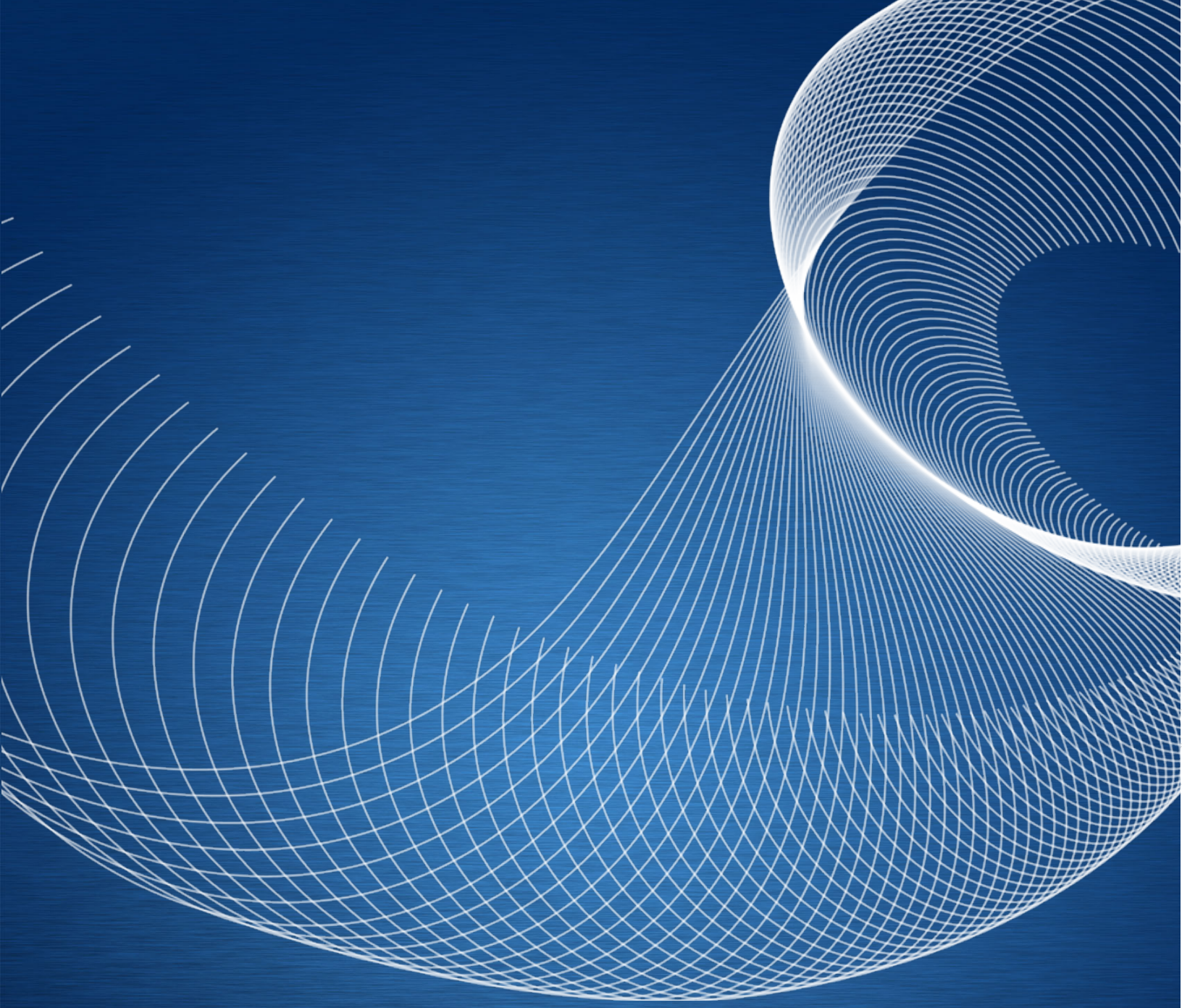

DARK UNIVERSE

EVALUATION REPORT

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Rockman Et Al

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EXECUTIVE **SUMMARY**

Rockman Et Al conducted an evaluation of *Dark Universe*, a space show created by the American Museum of Natural History (AMNH) and narrated by Neil deGrasse Tyson. The evaluation effort included a series of viewer surveys and interviews at AMNH in New York, and at the California Academy of Science (CalAcademy) in San Francisco. A total of 1239 viewers were surveyed and 71 viewers were interviewed. The study also included a comparative look at differences between shows at the CalAcademy with and without a live presentation segment and data from past space shows.

Overall, viewers' ratings were highest for visual appeal as well as the educational and entertaining aspects of *Dark Universe*. The only statistically significant difference between viewers at AMNH and viewers at the CalAcademy was for respondents' level of agreement with the statement "I would see this show again on a future visit to the museum," and we suspect this finding is a product of the fact that there is a charge for admission to the show at AMNH and no charge to see the show at the CalAcademy.

There were no statistically significant differences in viewers' ratings based on respondents' level of education. However, respondents who are not (or were not formerly) employed in a scientific field were more likely than those who were employed in scientific fields to feel that *Dark Universe* helped them understand the process of scientific discovery and how scientists know what they know—in this case, the differences between scientists and non-scientists was statistically significant.

Viewers' who rated their interest in science and astronomy more highly tended to rate the show more positively. In all but two instances, those with higher levels of interest in science and astronomy had higher levels of agreement with positive statements about the show than viewers who indicated that they had lower levels of interest in science and astronomy. Likewise, viewers who had higher levels of self-rated knowledge in science and astronomy also tended to have higher levels of agreement with several statements about the show, including how educational it was, how entertaining it was, how it inspired them to learn more about the universe, and how the show contains visualizations based on scientific data. Levels of agreement among those with higher levels of self-reported knowledge in science and astronomy for the aforementioned statements were significantly higher than those of respondents with lower levels of self-reported knowledge in science and astronomy. All viewers' responses tended to be quite positive, but these findings suggest that viewers with high levels of knowledge are even more appreciative of the show than less-knowledgeable viewers. Additionally, respondents who reported higher levels of self-reported astronomy knowledge were more likely to agree strongly with the statement "this show was appropriate for my knowledge level." None the less, viewers with less interest and knowledge still rated the show quite highly.

Viewers' ratings for interest and knowledge were also related to their agreement ratings for statements about what they planned to do in the future as a result of having seen *Dark Universe*.

Those with high levels of science and astronomy interest were more likely to agree that they would seek out additional information, encourage others to see the show, and see the show again on future visits. Likewise, those with higher levels of self-rated science and astronomy knowledge were also more likely to agree that they would do these things in the future as a result of having seen *Dark Universe.*

Viewing the show with children seemed to have an impact on respondents' feelings about the show. Viewers in groups that contained children were more likely to agree that the show made them think about things in new ways, change the way they see themselves in relation to the universe, understand the process of scientific discovery and understand how scientists know what they know. In other-words, viewers who brought children with them to see *Dark Universe* had a greater appreciation for the show's ability to foster new ways of thinking about the universe and processes of scientific discovery. However, viewers with young children (i.e., five and under) were slightly less likely than viewers with older children to rate the show as educational, entertaining, and understandable—indicating that the show is seen as being be more appropriate for and more beneficial to school-aged children.

For most viewers, *Dark Universe* proved to be consistent with expectations for the show. This was especially true for viewers with higher levels of science and astronomy interest and knowledge. Those who felt that the show differed from their expectations expressed their belief that the show would have been more interactive and more like traditional planetarium shows. They did, however, seem to be pleasantly surprised at the in-depth nature of the programming and astonishing visualizations. Along these lines, viewers said they liked the immersive, 3D nature of the show. *Dark Universe* viewers also found the show to be educational and generally felt that information was clearly presented—thanks both to the script as well as qualities of the narrator.

Among the things that viewers did not like were some of the logistical features about the seating and screen position, disruptions from other audience members, and the fact that the show didn't seem long enough. Viewers were mixed in terms of their opinions about the level of the program—some felt the program was too advanced and covered too much information, while others felt that the program could have covered even more information or gone into even greater depth on the topics that were covered. These findings illustrate the fact that it can be challenging to please all viewers, but for the most part, respondents felt that *Dark Universe* did a good job of being accessible to mass audiences.

Interview findings tended to support the trends and themes found in the survey data. Viewers who were interviewed stated appreciation for the visual elements of the show—especially those that helped them understand complex concepts. They felt that the show was educational and appealing to audiences with varying degrees of interest and knowledge in related sciences. The interviews also afforded the research team a chance to dive further into the types of things viewers were learning as a result of viewing *Dark Universe*. Viewers learned about dark matter and dark energy—either gaining familiarity with these concepts for the first time, or gaining a better understanding. Viewers also

learned new things about the process of scientific discovery including the sense that scientific discovery takes time and is sometimes serendipitous. A few interviewees suggested that *Dark Universe* helps to demonstrate the importance of scientific investigation, and what we can potentially learn as a result of our astronomical explorations and studies.

Generally speaking, viewers in San Francisco who saw the version of the show with a live presentation segment in the middle rated the movie more highly than the live presentation—especially in terms of its visual appeal. Ratings varied slightly based on characteristics of various presenters and data suggests that viewers responded most positively to presenters who infused humor into their presentation, and to those who spoke most clearly. Viewers' greatest critique of the live segment was that it seemed to interrupt the immersive experience of viewing the movie. They did, however, express appreciation for the fact that the live segment offered an opportunity to share information about current research and discoveries.

On the whole, the findings for *Dark Universe* were consistent with findings for previous space shows. *Dark Universe* viewers, however, were slightly more likely to agree more strongly that the show changed the way they see themselves in relation to the universe. This finding seems to be consistent with what we were hearing from interviewees, i.e., that *Dark Universe* gave them a sense of how everything in the universe is connected and held together by invisible forces that we are just beginning to understand.

METHODOLOGICAL **OVERVIEW**

Rockman Et Al was hired to conduct an independent summative evaluation o*f Dark Universe*, a space show created by the American Museum of Natural History. The evaluation effort spanned across a three-month period in the late spring/early summer of 2014.

About Dark Universe

Dark Universe presents a tale of discovery that has led to breakthroughs in how scientists have come to understand our universe, as well as their evolving understanding of dark matter and dark energy. The twenty-two minute show is narrated by Neil deGrasse Tyson, the director of the Hayden Planetarium at the American Museum of Natural History.

Data Collection Sites and Dates

Data collection sites included the Hayden Planetarium at the American Museum of Natural History in New York City and the planetarium at the California Academy of Sciences in San Francisco. Data were collected over a three-day period at each site in June 2014. At the California Academy of Sciences, *Dark Universe* is typically shown with a live-presentation segment inserted into the middle of the show. For the purposes of this study, half of the screenings during which we collected data included the live-presentation, and in the other half of the screenings the program was shown straight-through from start to finish, as is the case for every screening at the American Museum of Natural History.

Evaluation Methods

This evaluation effort included viewer surveys and interviews. Survey respondents were recruited while they were waiting to enter the planetarium. They were able to complete all demographic and background questions prior to viewing the show and were then asked to complete all remaining questions after the show. Different instruments were used in San Francisco for survey respondents who attended screenings that included the live presentation segment. Additionally, individuals and groups were selected to participate in brief post-viewing interviews as they exited the theater.

This evaluation effort was also designed so as to contribute to a larger set of data and findings from previous space shows produced by the American Museum of Natural History, including *Search for Life*, *Cosmic Collisions*, and *Journey to the Stars*. To that end, the instruments used for this study were based largely on those for previous space show evaluations.

PARTICIPANT **DEMOGRAPHICS**

A total of 1239 viewers completed all or part of the viewer survey. In some instances, given other time-constraints or logistical challenges (e.g., lighting and seating availability) some respondents did not complete the entire survey. During the analysis process, efforts were made to include partial sets of data whenever possible, thus the number of respondents for any given question or analysis may vary.

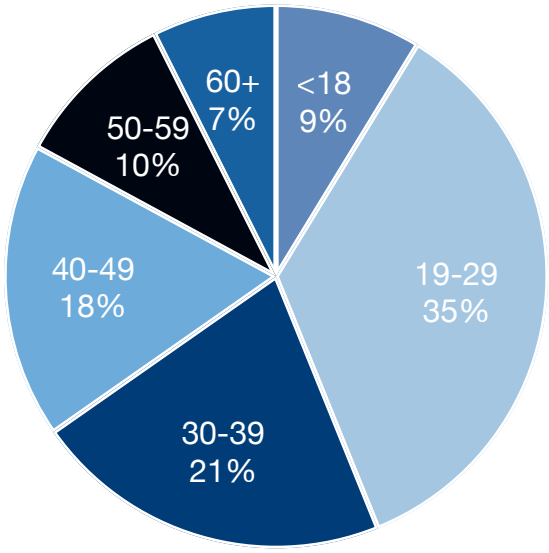
SITE-BY-SITE BREAKDOWN

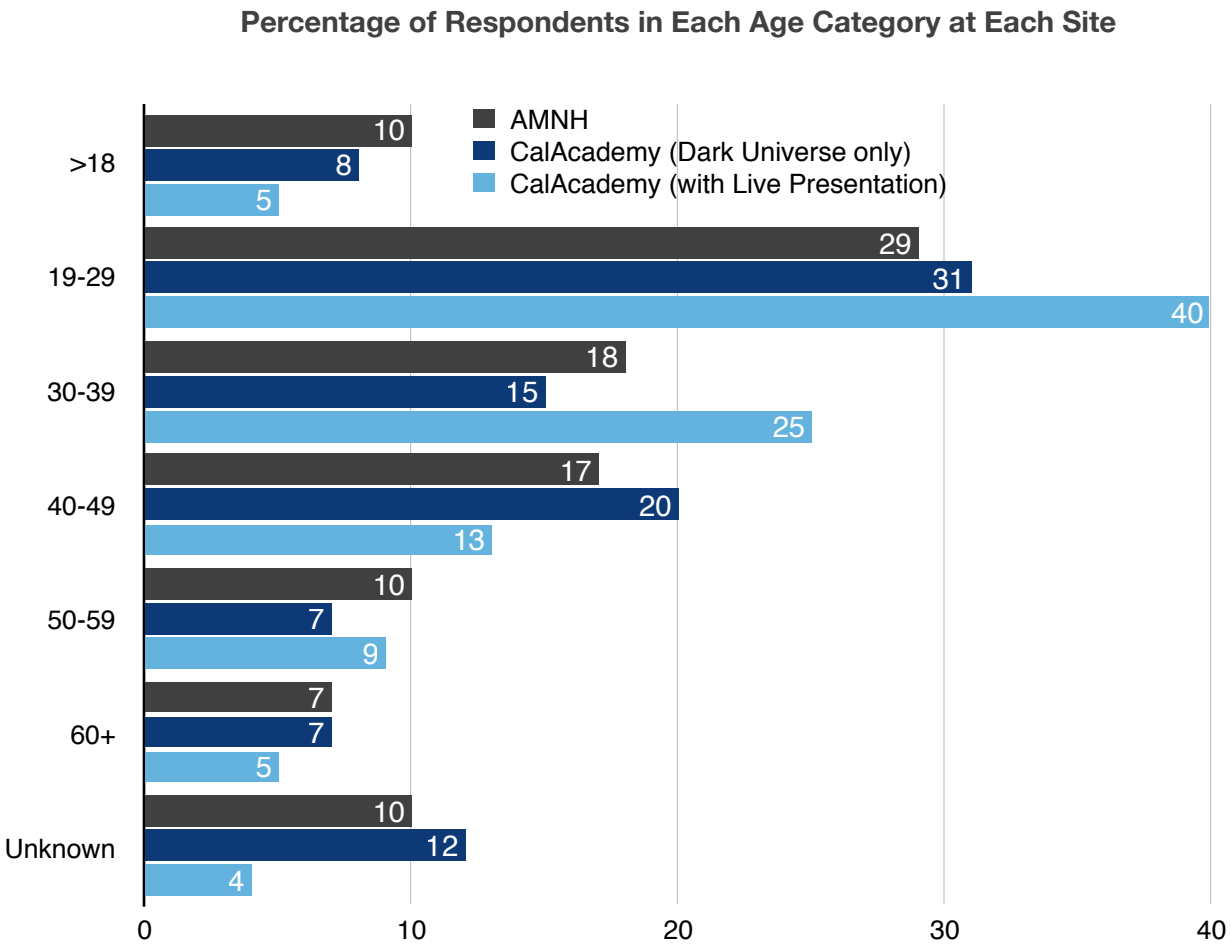
Number of Surveys Gathered by Site and Program Type

Program Type	AMNH	CalAcademy
Dark Universe Only	648	241
Dark Universe + Live Presentation Segment	Not Applicable	350

SURVEY RESPONDENT AGES

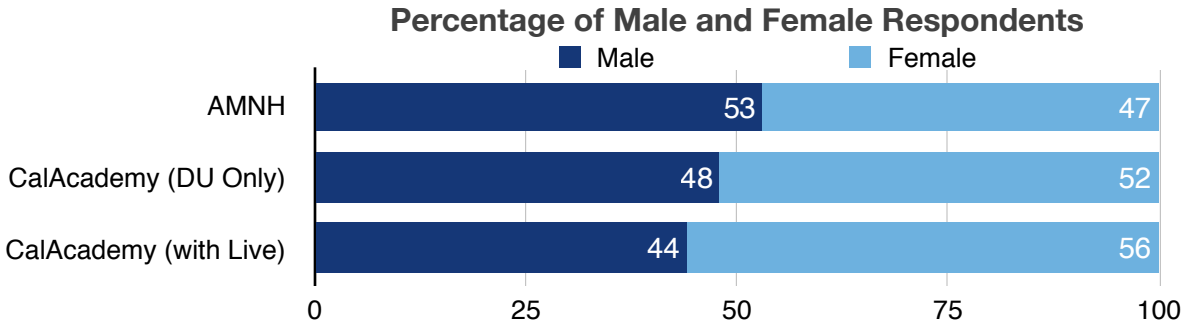
All but 102 respondents provided age data. Across both sites and in both viewing conditions in San Francisco, the largest number of respondents were between the ages of 19 and 29. The figure on the following page shows a breakdown of ages within each site and the two viewing conditions at the CalAcademy. Generally speaking, trends in respondents' ages were fairly consistent across sites and in both viewing conditions at the Cal Academy—the sole exception being slightly higher percentages of 19-39 year-old respondents surveyed during screenings of the show that included a live presentation, due in large part to that being the only viewing option at CalAcademy's NightLife event, geared toward younger adult audiences, on Thursday, June 12th.





SURVEY RESPONDENT GENDERS

The breakdown between male and female respondents was roughly equal. Overall there were 50% male and 50% female across both sites and both viewing conditions in San Francisco. There were slightly more male respondents in New York (53%) and slightly more female respondents in San Francisco (52% for screenings with only *Dark Universe,* and 56%for screenings with *Dark Universe* and the live presentation). None of these differences, however, were statistically significant.



VIEWING GROUPS

Only 6% of respondents surveyed indicated that they were viewing the show alone, i.e., not as part of a group. Of those respondents who said that they were viewing the show with one or more person, 22% said they were with a friend, 40% said they were with a spouse or significant other, 13% said they were with a parent, and 14% said they were with another adult relative.

Just under a third of respondents overall (30%) indicated that they had children in their group (either their own children or grandchildren or children other than their own). The 189 respondents who completed a supplemental family survey were grouped into one of two groups: 1) Viewing groups with young children, i.e., groups that included children ages five and under and 2) Viewing groups without young children, i..e, groups that did not include children ages five or under. Groups with young children (i.e., five and under) could also include children who were older than five. Those who completed the survey and indicated that their group only included adults were NOT included in analyses of supplemental family survey data.

MUSEUM MEMBERSHIP

Overall, only 11% of our respondents were members of the institution at which they were surveyed. More of the respondents surveyed in San Francisco were members of the CalAcademy (i.e., 15%) in comparison to only 7% of those surveyed in New York who stated they were members of the American Museum of Natural History.

EDUCATION

A quarter of survey responses reported that they were still in school, with grade levels ranging from grade-school to graduate school. Over a third (33%) indicated that they had completed a bachelors program and 35% of respondents indicated that they had received a graduate degree. There were no major differences in these trends for respondents in San Francisco or New York.

EMPLOYMENT IN SCIENCE

Just over a quarter of respondents (26%) indicated that they had been, or currently were employed in a scientific field. Again, we found no major differences in employment trends for respondents in San Francisco or New York.

INTERESTS IN SCIENCE AND ASTRONOMY

The means for respondents' interest in science and astronomy interest were relatively high. The mean for respondents' self-rated interest in science was 4.34 - based on a five-point response scale where 1 is "not interested at all" and 5 is "very interested." The mean for respondents' self-rated interest in astronomy was 4.08.

SELF-RATED KNOWLEDGE

Respondents typically rated their science and astronomy knowledge slightly lower than their interest. The mean for respondents' self-ratings of how much they knew about science was 3.31 - based on a five-point response scale where 1 is "nothing," 2 is "very little," 3 is a "moderate amount," 4 is "a lot," and 5 is "expert." The mean for respondents' self-ratings of how much they knew about astronomy, using the same scale was 2.72.

Summary of Respondents' Self-Reported Interest and Knowledge Ratings

		N	Mean	SD
Interest	Science	1205	4.34	0.89
	Astronomy	1195	4.08	0.96
Knowledge	Science	1200	3.31	0.80
	Astronomy	1184	2.27	0.80

Participants were assigned to one of two groups based on their self-rated interest and knowledge of science and astronomy. Those who rated their interest and knowledge as a 4 or 5 (on a five-point scale where 1 is "lowest" and 5 is "highest") were assigned to the "High Interest" and/or "High Knowledge" categories. Those with responses of 1-3 were assigned to the "Low Interest," and/or "Low Knowledge" categories. These categories were used to facilitate subsequent analysis.

Summary of "High" and "Low" Groupings for Interest and Knowledge

		Frequency	Percent
Science Interest	Low	206	17%
	High	999	83%
Astronomy Interest	Low	317	26.5%
	High	878	73.5%
Science Knowledge	Low	743	62%
	High	457	38%
Astronomy Knowledge	Low	1011	85.4
	High	173	14.6

SCIENCE-RELATED BEHAVIORS

Survey respondents were also asked to indicate how often they did activities related to science using a five-point scale where 1 is “never,” 2 is “rarely,” 3 is “monthly,” 4 is “weekly,” and 5 is “daily.” Not surprisingly, watching science television programs and reading books or articles were the activities that respondents reported doing most frequently. There were no major differences between respondents at the different sites and in the two viewing conditions in San Francisco so data is reported in aggregate in the table below.

Respondents Ratings for How Often They Do Science-Related Activities

Activity	N	Mean	SD
Watch TV programs about science	1213	3.12	0.98
Read science books/articles	1208	3.05	1.17
Listen/watch science podcasts	1199	2.15	1.12
Attend science lectures classes	1200	2.28	1.27
Stargaze/do astronomical observations	1195	2.18	1.06

DECISION-MAKING TRENDS

Respondents were also asked to indicate the importance of several potential reasons for deciding to see Dark Universe. These factors were rated on a scale from 1, “not important at all,” to 5, “Very Important.” Again, there were no significant differences between respondents at the different sites and in the two viewing conditions in San Francisco, so data is reported in aggregate in the table below.

Respondents Ratings of the Importance of Different Reasons to See the Show

Reasons	N	Mean	SD
Title	1155	3.24	1.38
Narrator	1140	2.93	1.57
Educational Value	1163	3.88	1.13
New/Hadn’t Seen it Before	1119	3.84	1.28

As seen in the data presented above, the ability to learn new things trumped specific factors like the name and the narrator as decision-making factors for viewing *Dark Universe*. Respondents were also asked to indicate their level of agreement with a series of statements about why they decide to see a planetarium show in general, using a five-point scale where 1 is "Strongly Disagree," 2 is "Disagree," 3 is "Neutral," 4 is "Agree," and 5 is "Strongly Agree." Responses are summarized in the table below.

Mean Agreement Levels for Statements About Reasons to View Planetarium Shows

In general, I select planetarium shows that…	N	Mean	SD
are educational	1164	4.20	0.82
are entertaining	1160	4.26	0.80
have topics that interest me	1159	4.32	0.76
appeal to my family/group	1153	3.87	1.04

There are certainly a range of interests and experiences as well as reasons for attending, but in general, the trends we saw among the *Dark Universe* viewer survey respondents were similar to those we have seen in previous space show evaluations. In the next section of the report, we explore respondents' feedback and opinions about *Dark Universe* as well as some of the outcomes that resulted from the viewing experience.

INTERVIEWEE DEMOGRAPHICS

The following table summarizes the demographic breakdown of interview participants by site, age, and gender. A total of 71 people were interviewed across the two sites, including 38 in San Francisco and 33 in New York.

Summary of Interviewee Demographics by Site, Age, and Gender

SITE	GENDER	8 & Under	9-13	14-19	20-29	30-39	40-49	40-59	60+
San Francisco	MALE	1	3	2	2	1	2	5	5
	FEMALE	3	2	0	1	2	3	4	2
New York	MALE	1	1	1	7	1	2	3	0
	FEMALE	0	2	1	3	3	3	3	2
	Total:	**5**	**8**	**4**	**13**	**7**	**10**	**15**	**9**

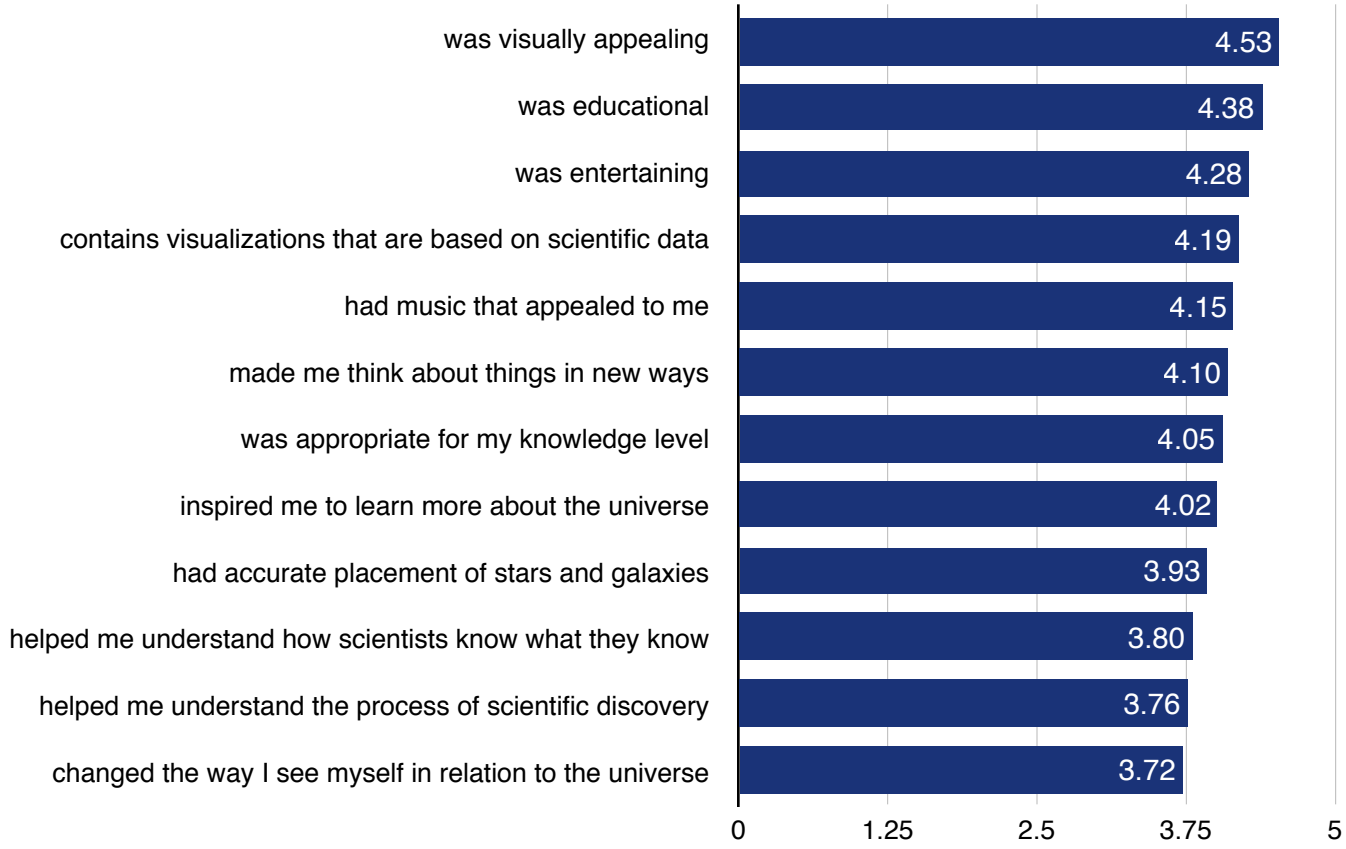
FINDINGS: **DARK UNIVERSE**

After viewing the show, respondents were asked to complete a set of questions about the show, including what they liked, what they learned and what they felt they would do as a result of viewing *Dark Universe*. The first question asked viewers to rate their level of agreement with a series of statements about Dark Universe using a five-point scale, where 1 is "Strongly Disagree," 2 is "Disagree," 3 is "Neutral," 4 is "Agree," and 5 is "Strongly Agree."

Mean Agreement Levels for Statements About *Dark Universe*

The show I viewed today/*Dark Universe*…	N	Mean	SD
was educational	1106	4.38	0.70
was entertaining	1106	4.28	0.80
made me think about things in new ways	1097	4.10	0.92
was visually appealing	1094	4.53	0.69
had music that appealed to me	1087	4.15	0.87
was appropriate for my knowledge level	1088	4.05	0.92
inspired me to learn more about the universe	1097	4.02	0.92
changed the way I see myself in relation to the universe	1092	3.72	1.07
helped me understand the process of scientific discovery	1091	3.76	1.00
helped me understand how scientists know what they know	1094	3.80	0.96
contains visualizations that are based on scientific data	1080	4.19	0.81
had accurate placement of stars and galaxies	1054	3.93	0.90

Mean Agreement Levels for Statements About *Dark Universe*



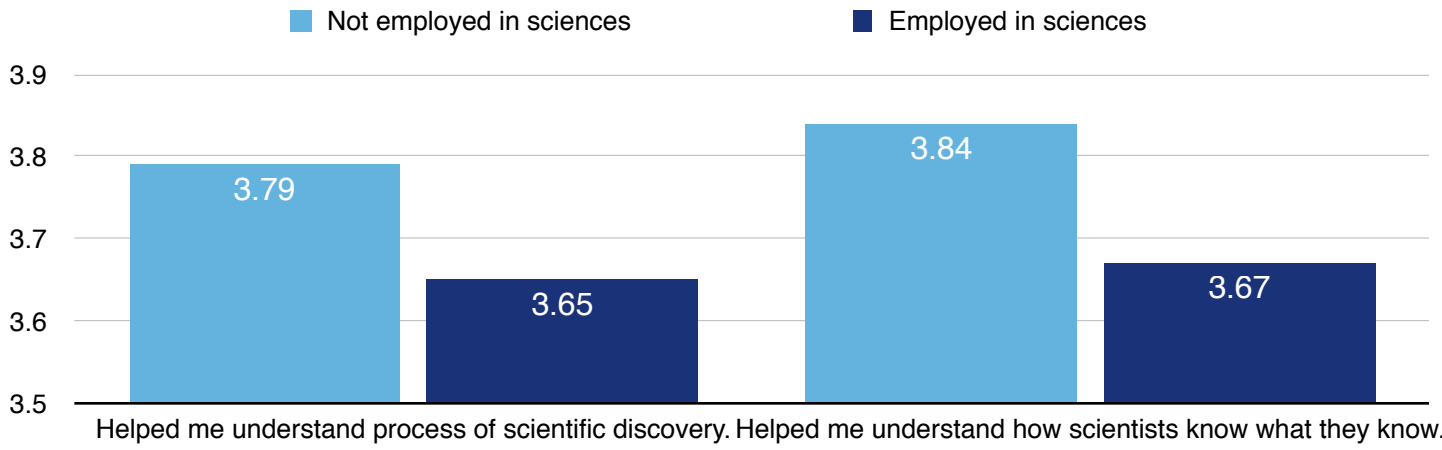
Overall, *Dark Universe* respondents tended to have high levels of agreement with every statement about the show, but their agreement was highest for its visual appeal, educational nature, and entertaining nature (in that order, as visualized in the figure above). There were no statistically significant differences found between viewers in New York and San Francisco, nor were there statistically significant differences found among viewers with higher levels of education (i.e., those with a masters or doctorate degree) in comparison with viewers who had not completed graduate degree programs.

IMPACT OF RESPONDENTS' CAREERS

We found statistically significant differences between respondents who reported having been employed in a scientific field (either currently or previously) and those who had never been employed in a scientific field. Those who had not been employed in scientific fields were more likely to agree more with the following statements:

- *Dark Universe* "helped me understand the process of scientific discovery." (p=.049)
- *Dark Universe* "helped me understand how scientists know what they know." (p=.012)

Mean Agreement Levels for Statements About *Dark Universe:* By Employment Type



These differences are not surprising given that people employed (or previously employed) in the sciences would already have a good grasp on the process of scientific discovery and a good understanding of how scientists know what they know. In this case, those who were not employed in the sciences simply had a greater ability to acquire new knowledge and understanding in this area, and the data suggests that they did.

IMPACT OF SCIENCE INTEREST

Viewers who indicated they were more interested in science tended to rate the show more positively (i.e., those categorized as having "High Science Interest" by responding to a question about their level of interest in science with a 4 or 5 on a five-point scale where 1 is "not interested at all," and 5 is "very interested"). The only exception to this general trend occurred with agreement ratings for the statements about "helping me understand how scientists know what they know" and "the show had accurate placement of stars and galaxies." All of the following differences for which the "High Science Interest" group had higher means were significant at the .05 level, and most were significant at the .001 level.

- *Dark Universe* "was educational."
- *Dark Universe* "was entertaining."
- *Dark Universe* "made me think about things in new ways."

- *Dark Universe* "was visually appealing."
- *Dark Universe* "had music that appealed to me."
- *Dark Universe* "was appropriate for my knowledge-level."
- *Dark Universe* "inspired me to learn more about the universe."
- *Dark Universe* "changed the way I see myself in relation to the universe."
- *Dark Universe* "helped me understand how scientists know what they know."
- *Dark Universe* "contains visualizations that are based on scientific data."

Mean Agreement Levels for Statements About *Dark Universe:* By Science Interest Level

	LOW INTEREST			HIGH INTEREST		
The show I viewed today/*Dark Universe*…	N	Mean	SD	N	Mean	SD
was educational	185	4.20	0.76	907	4.41	0.69
was entertaining	185	3.99	0.88	907	4.34	0.78
made me think about things in new ways	183	3.92	0.97	901	4.13	0.90
was visually appealing	183	4.35	0.76	898	4.56	0.67
had music that appealed to me	179	4.15	0.87	894	4.20	0.83
was appropriate for my knowledge level	182	3.80	1.00	892	4.10	0.90
inspired me to learn more about the universe	184	3.56	1.01	899	4.10	0.86
changed the way I see myself in relation to the universe	182	3.57	0.94	895	3.82	0.96
helped me understand the process of scientific discovery**	185	3.68	1.07	892	3.77	0.98
helped me understand how scientists know what they know	185	3.67	0.94	895	3.82	0.96
contains visualizations that are based on scientific data	183	3.98	0.85	883	4.24	0.79
had accurate placement of stars and galaxies**	180	3.82	0.87	861	3.95	0.90

The starred items in the list above are the ones where those with "Low Science Interest" had higher means.

IMPACT OF ASTRONOMY INTEREST

Findings for respondents who had high levels of interest in astronomy (i.e., those categorized as having "High Astronomy Interest" by responding to a question about their level of interest in science with a 4 or 5 on a five-point scale where 1 is "not interested at all," and 5 is "very interested"), agreed more strongly with all statements about *Dark Universe* than those with "Low Astronomy Interest" (i.e., all other respondents). These differences were all statistically significant, with significance levels ranging from .001 to .004.

Mean Agreement Levels for Statements About *Dark Universe:* By Astronomy Interest Level

	LOW INTEREST			HIGH INTEREST		
The show I viewed today/*Dark Universe*…	N	Mean	SD	N	Mean	SD
was educational	285	4.21	0.78	798	4.43	0.67
was entertaining	285	4.11	0.86	798	4.35	0.77
made me think about things in new ways	282	3.93	0.95	793	4.16	0.90
was visually appealing	280	4.36	0.79	792	4.59	0.64
had music that appealed to me	279	3.98	0.91	786	4.21	0.84
was appropriate for my knowledge level	279	3.82	0.96	787	4.13	0.89
inspired me to learn more about the universe	284	3.57	0.98	791	4.17	0.83
changed the way I see myself in relation to the universe	282	3.49	1.09	788	3.79	1.05
helped me understand the process of scientific discovery	281	3.60	1.02	788	3.81	0.98
helped me understand how scientists know what they know	283	3.64	0.93	789	3.86	0.96
contains visualizations that are based on scientific data	276	3.97	0.86	782	4.27	0.78
had accurate placement of stars and galaxies	273	3.64	0.87	760	4.02	0.88

IMPACT OF SCIENCE KNOWLEDGE

Findings for respondents who had high self-rated science knowledge (i.e., those categorized as having "High Science Knowledge" based on their responses to a question about their level of science knowledge; the respondents placed in this category responded with either a 4 or 5 on a five-point scale for how much they know, where 1 is "nothing," and 5 is "expert"), agreed more strongly than those who had lower ratings of science knowledge on the following items:

- *Dark Universe* "was educational."

- *Dark Universe* "was entertaining." (p=.004)
- *Dark Universe* "was visually appealing." (p=.001)
- *Dark Universe* "inspired me to learn more about the universe." (p=.049)
- *Dark Universe* "contains visualizations that are based on scientific data." (p=.005)
- Dark Universe "had accurate placement of stars and galaxies." (p=.030)

This finding is interesting because it suggests that those with high levels of science knowledge are even more likely than those with lower levels of science knowledge to enjoy and learn from the show and also more likely to appreciate the visuals and use of authentic data.

Mean Agreement Levels for Statements About *Dark Universe:* By Science Knowledge Level

	LOW KNOWLEDGE			HIGH KNOWLEDGE		
The show I viewed today/*Dark Universe*…	N	Mean	SD	N	Mean	SD
was educational	660	4.33	0.73	432	4.45	0.66
was entertaining	659	4.22	0.84	4.33	4.39	0.74
made me think about things in new ways	*656*	*4.11*	*0.93*	*429*	*4.07*	*0.91*
was visually appealing	652	4.48	0.73	428	4.61	0.61
had music that appealed to me	*650*	*4.11*	*0.90*	*426*	*4.20*	*0.82*
was appropriate for my knowledge level	*650*	*4.02*	*0.93*	*427*	*4.09*	*0.92*
inspired me to learn more about the universe	658	3.97	0.93	428	4.08	0.89
changed the way I see myself in relation to the universe	*654*	*3.73*	*1.07*	*426*	*3.69*	*1.08*
helped me understand the process of scientific discovery	*651*	*3.78*	*1.01*	*427*	*3.70*	*0.98*
helped me understand how scientists know what they know	*654*	*3.82*	*0.95*	*427*	*3.76*	*0.98*
contains visualizations that are based on scientific data	644	4.14	0.83	424	4.28	0.78
had accurate placement of stars and galaxies	627	3.87	0.90	415	4.00	0.89

Note: italicized items in the table above were not statistically significant.

IMPACT OF ASTRONOMY KNOWLEDGE

Findings for respondents who had high self-rated astronomy knowledge (i.e., those categorized as having "High Astronomy Knowledge" based on their responses to a question about their level of astronomy knowledge; the respondents placed in this category responded with either a 4 or 5 on a five-point scale for how much they know, where 1 is "nothing," and 5 is "expert"), agreed more strongly than those who had lower ratings of science knowledge on the following items:

- *Dark Universe* "was educational." (p=.011)
- *Dark Universe* "was entertaining." (p=.003)
- *Dark Universe* "was appropriate for my knowledge-level" (p=.001)
- *Dark Universe* "inspired me to learn more about the universe." (p<.001)
- *Dark Universe* "changed the way I see myself in relation to the universe." (p=.022)
- *Dark Universe* "had accurate placement of the stars and galaxies." (p<.001).

These findings indicate that that viewers with higher levels of astronomy knowledge are even more likely to feel that the show is at an appropriate knowledge level, and that the show is capable of teaching them new things and inspiring them to act or think differently in the future. Those with higher levels of astronomy knowledge are also more likely to recognize the painstaking efforts that went into the scientifically accurate visualizations of space.

Mean Agreement Levels for Statements About *Dark Universe:* By Astronomy Knowledge Level

	LOW KNOWLEDGE			HIGH KNOWLEDGE		
The show I viewed today/*Dark Universe*…	N	Mean	SD	N	Mean	SD
was educational	916	4.35	0.71	164	4.51	0.67
was entertaining	917	4.26	0.82	163	4.46	0.72
made me think about things in new ways	*910*	*4.08*	*0.93*	*163*	*4.14*	*0.87*
was visually appealing	*907*	*4.51*	*0.70*	*162*	*4.60*	*0.67*
had music that appealed to me	*902*	*4.13*	*0.87*	*160*	*4.23*	*0.84*
was appropriate for my knowledge level	903	4.01	0.93	162	4.28	0.88
inspired me to learn more about the universe	910	3.96	0.92	163	4.31	0.83

The show I viewed today/*Dark Universe…*	LOW KNOWLEDGE			HIGH KNOWLEDGE		
	N	Mean	SD	N	Mean	SD
changed the way I see myself in relation to the universe	905	3.69	1.07	162	3.90	1.05
helped me understand the process of scientific discovery	*906*	*3.73*	*1.00*	*160*	*3.88*	*0.96*
helped me understand how scientists know what they know	*908*	*3.77*	*0.96*	*161*	*3.93*	*0.94*
contains visualizations that are based on scientific data	894	4.16	0.81	161	4.35	0.81
had accurate placement of stars and galaxies	873	3.87	0.89	156	4.22	0.87

Note: italicized items in the table above were not statistically significant.

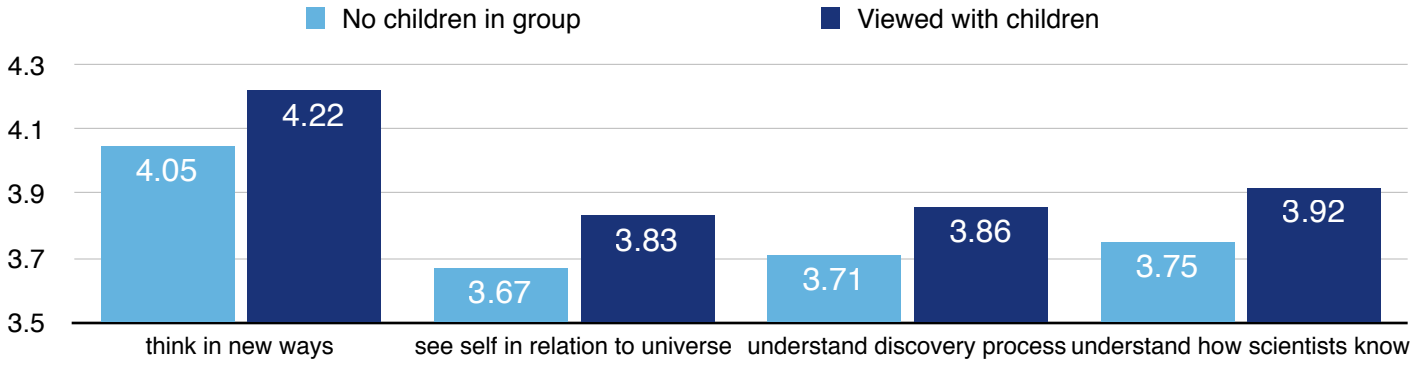
IMPACT OF VIEWING WITH CHILDREN

Viewers who indicated that they had children in their group showed statistically significant differences in their responses, as compared to those of viewers who did not have children in their group, for the following items:

- Dark Universe "made me think about things in new ways." (p=.005)
- Dark Universe "changed the way I see myself in relation to the universe." (p=.026)
- Dark Universe "helped me understand the process of scientific discovery." (p=.008)
- Dark Universe "helped me understand how scientists know what they know." (p=.008)

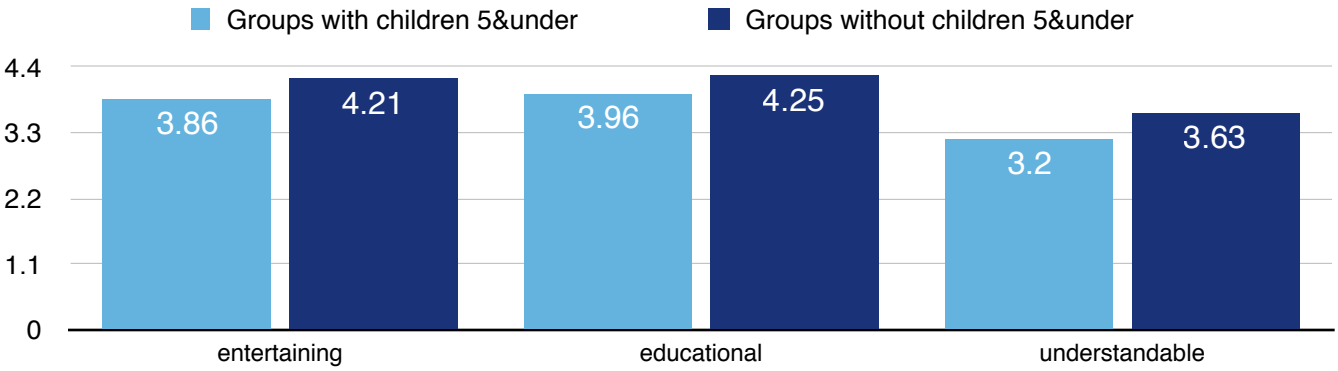
In each case, respondents who had children in their viewing groups exhibited higher levels of agreement with the statements above. Specific findings are summarized in the following figure:

Mean Agreement Levels for Statements About *Dark Universe:* Children vs. No Children



Survey respondents in viewing groups that included children were also given a short set of supplemental questions. Over 200 supplemental survey responses were also received, though some were only partially completed. None the less, we were also able to analyze this additional data submitted by groups—most often family groups—who attended *Dark Universe* with children. Specifically, we were interested in looking at the impact of young children on viewers' ratings for how entertaining the show was, how educational the show was, and how understandable the show was. The rating scale for these questions was a five-point scale that ranged from 1 ("strongly disagree"), to 5 ("strongly agree").

Mean Agreement Levels for Statements About *Dark Universe:* by Children's Ages



In each case, groups that did not include any children ages five and under were found to have slightly higher means than those for viewers who's groups included children ages five and under. The difference in viewers' means for level of agreement with the following statements were statistically significant:

- "This show was entertaining for everyone in my group." (p=.020)
- "This show was understandable to everyone in my group." (p=.028)

The difference between groups with young children and those with older children for the following item: "This show was educational for everyone in my group," was not statistically significant. Findings suggest that adults feel the show is equally educational for older and younger children, but slightly more entertaining and understandable for older children in comparison with their younger counterparts.

WHAT VIEWERS PLAN TO DO

Survey respondents also rated their level of agreement with statements about things they planned to do after seeing the show. Agreement was rated using a five-point scale, where 1 is "Strongly Disagree"

and 5 is “Strongly Agree.” Agreement was highest with the statement “I will encourage others to see this show.”

Mean Agreement Levels for Statements About Planned Activities After Seeing *Dark Universe*

Statements	N	Mean	SD
I plan to seek out additional information on one or more topics that I learned about in the show.	1155	3.24	1.38
I will encourage others to see this show.	1140	2.93	1.57
I would see this show again on a future visit to this museum.	1163	3.88	1.13

The only statistically significant difference that was found between viewers at AMNH and viewers at the CalAcademy who did not attend a screening with a live presentation (i.e., a statistically significant difference between groups of viewers in both sites who saw *Dark Universe* without a live segment), was in response to the question that asked respondents to rate their level of agreement with the statement: “I would see this show again on a future visit to this museum.” Viewers at AMNH had a mean of 3.59 in response to this question and viewers at the CalAcademy had a mean of 3.87. This difference was significant at the .05 level (p=.004), and potentially the result of a $5 ticketing charge to view the show at AMNH as compared to CalAcademy, where the show was free for visitors.

Statistically significant differences were also found for what viewers said they planned to do after seeing *Dark Universe*, based on levels of science and astronomy interest as well as science and astronomy knowledge. Specific means are reported in the table on the following page but the p values are reported below.

- Those with “High Science Interest” had higher ratings for all statements about the things they planned to do. The p value for all items: p<.001.
- Those with “High Astronomy Interest” had higher ratings for all statements about the things they planned to do. The p value for all items: p<.001.
- Those with “High Science Knowledge” had higher ratings for all statements about the things they planned to do. The p values varied and are as follows: “seek out additional information” p=.030, “encourage others to see the show” p<.001, “see the show again on a future visit” p=.027.
- Those with “High Astronomy Knowledge” had higher ratings for all statements about the things they planned to do. The p values varied, and are as follows: “seek out additional information” p=.030, “encourage others to see the show” p<.001, “see the show again on a future visit” p=.027.

The table below summarizes all significant findings based on viewers' interest and knowledge levels.

Mean Agreement Levels for Statements Based on Interest and Knowledge Levels

	LOW			HIGH		
SCIENCE INTEREST	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**
I plan to seek out additional information on one or more topics that I learned about in the show.	176	3.15	1.07	868	3.78	0.95
I will encourage others to see this show.	177	3.81	0.96	870	4.22	0.83
I would see this show again on a future visit to this museum.	177	3.35	1.16	865	3.75	1.16
ASTRONOMY INTEREST	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**
I plan to seek out additional information on one or more topics that I learned about in the show.	268	3.20	1.04	768	3.84	0.93
I will encourage others to see this show.	267	3.88	0.88	772	4.24	0.84
I would see this show again on a future visit to this museum.	268	3.38	1.14	766	3.78	1.17
SCIENCE KNOWLEDGE	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**
I plan to seek out additional information on one or more topics that I learned about in the show.	628	3.57	1.00	416	3.82	0.98
I will encourage others to see this show.	628	4.10	0.86	420	4.22	0.86
I would see this show again on a future visit to this museum.	626	3.63	1.17	416	3.76	1.18
ASTRONOMY KNOWLEDGE	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**
I plan to seek out additional information on one or more topics that I learned about in the show.	873	3.60	1.00	160	4.10	0.92
I will encourage others to see this show.	876	4.11	0.86	161	4.39	0.79
I would see this show again on a future visit to this museum.	870	3.62	1.17	161	4.04	1.13

ALIGNMENT WITH VIEWERS' EXPECTATIONS

Most viewers agreed that the show was what they expected. Three-hundred and thirty respondents said they "agreed" and 249 said they "strongly agreed" with the statement: "This show is what I expected." Overall the mean in response to this question was 3.98 (based on responses with a five-point scale where "Strongly Disagree" was coded as a 1 and "Strongly Agree" was coded as a 5; n=1037, SD=0.95).

Viewers with higher levels of science and astronomy interest and astronomy knowledge also had statistically significant higher levels of agreement with the statement: "This show is what I expected" (p values for the the statistically different findings for expectations based on respondents interest and knowledge levels were $p<.001$, $p<001$. and $p=.048$ respectively).

When asked to elaborate on how the program differed from their expectations, less than one percent of respondents offered additional detail. Among the seventy-five open-ended comments that were shared, we learned that some viewers were not expecting as in-depth of an exploration of the topics as well as those who were hoping for even greater depth. Some were expecting a more traditional and interactive planetarium show focused on constellations and planets, and some felt that the program was not as accessible to young children as they had expected it to be. None the less, the most frequent type of response for how the show differed from expectations was that Dark Universe exceeded viewers' expectations, in terms of how entertaining it was and how informative it was. Visual aspects of the show were frequently cited among the factors contributing to the fact that the show exceeded expectations. Additional quotes from survey respondents include the following:

- *I didn't expect the show to describe so much of the history behind scientists understanding space.*
- *It was much more entertaining and informative!*
- *It was much more visually appealing, much more in-depth.*
- *The astonishing visuals and realistic view of the universe was amazing.*

What Viewers Liked Most

We analyzed viewers' responses to an open-ended question that asked respondents to indicate what they liked most about the show. A total of 581 statements were given in response to this question. Responses were coded and in some instances, statements were tagged with more than one code. The most frequently cited thing that viewers said they liked most about *Dark Universe* were the rich visuals and graphic effects. Other responses included the narration, the general sense of being entertained, the sense of motion, the educational nature of the program, the music and sound effects, the topic, and general features about the theaters (including seats, staff, screen, etc.).

Production Values: Audio-Visual Elements

Forty-nine percent of the respondents who shared an open-ended response about what they liked most mentioned one or more visual element of the show. Viewers particularly appreciated the immersive, 3D nature of the show. Examples of other statements shared by respondents are presented below:

- *The visual aspect of the movie made it feel real.*
- *Visual splendor!*

Six-percent of coded responses mentioned audio as well, like the quote below, for example:

- *I thought the music and sound effects greatly enhanced the production*

Educational and Easy to Understand

Twenty-percent of coded-responses to the open-ended question about what viewers liked most mentioned things that were learned, or the general informative and educational nature of the show. Viewers also appreciated the fact that content was presented in a way that made it easier to grasp challenging concepts, and for the inclusion of current information. Examples of specific comments include the following:

- *The educational value of it! we learned some very interesting facts/*
- *Informative and provocative.*
- *New perspective on universe and our place in it.*
- *New theory regarding how dark energy structures cosmos*
- *Effort to make the complex relevant and increase my understanding. it also made me understand how little I really know.*
- *The scientific explanation - really added to my knowledge about the matter in the universe.*
- *It explained current thinking in a simple to understand way.*

Narration

In the past there seemed to be mixed opinions about the narrator, most of which stemmed from celebrity narrators having less scientific clout. With *Dark Universe*, however, there was overwhelming praise for narrator Neil deGrasse Tyson, both in terms of the quality of his voice, but also in terms of his authority on these subjects and his unique ability to explain concepts clearly enough for lay audiences to understand. Obviously, the later point also reflects the quality of the script as well.

The only negative (and arguably sarcastic) comments about Tyson stemmed from his role in demoting Pluto. Thirteen-percent of coded responses mentioned the narration or narrator. Examples of viewers' comments about the narration included the following:

- *I was excited to hear Neil Degrasse Tyson as the narrator - he makes it easy to grasp*
- *Neil DeGrasse Tyson's narration. It provided a lot of depth to the show that would not have been there is someone else narrated it.*
- *The narrator was extremely good. the topic was explained in a simple and understandable way.*

General comments

Ten-percent of coded responses said they liked everything about *Dark Universe*. The following quote is an example of the accolades viewers gave for the show:

- *Another well-done, top-notch AMNH production. I felt like a kid again. bravo!*

What Viewers Liked Least

We also analyzed viewers' responses to an open-ended survey question that asked respondents to indicate what they liked least about the show. We coded 456 responses to this question. It is first important to note that of those viewers who shared comments in response to this question, nearly a quarter (24%) said that they liked everything (i.e., there was nothing that they didn't like). The major categories for things viewers said they disliked were logistical features about the viewing environment itself and the depth and type of content presented (though interesting, some viewers thought the content was too deep or too complex, while others thought that the show didn't go deep enough). There were also comments shared about the distracting behaviors of other viewers, the length/pacing of the show, and the music.

Viewing environment and logistics

Thirty-one percent of respondents shared comments about the viewing environment. There were more comments about seating from viewers in New York, where respondents felt that having to look up and constantly be turning their head throughout the show to see everything, could contribute to neck pains or headaches. On the opposite end of the spectrum, some viewers felt the seating was too comfortable and a few admitted that this caused them to doze off during parts of the show. Some viewers suggested that the video seemed "out of focus." Others shared comments about the level of lighting, the temperature, and the volume within the theater. Overall, however, the vast majority of comments about the viewing environment were focused on the seating and its relation to the screen.

Content

Viewers' comments about the content of the show were varied, and reflected a trend that we saw elsewhere in our data, i.e., some viewers felt that the show's content was too basic, while others felt that it was too advanced. Even more interesting, perhaps, is the fact that there was a fairly even split of comments from those thinking the content was too advanced, and those thinking the content was not advanced enough. Examples of the content-related comments include the following:

From those who thought the content was too advanced:

- *Seemed to be written for astronomers or scientists with base level of knowledge - not for average person.*
- *The lingo was a bit technical, sometimes required more pre-knowledge of astronomy.*
- *Very high level, some knowledge required, grade 10 or more.*

From those who thought the program was not advanced enough:

- *More scientific data needed. but then again the target audience is not doctorates, so it's ok.*
- *Had nothing that I did not already know about.*
- *Was not a whole new stuff for me, a lot repetition.*
- *Did not go into depth about topics. Could focus 2-3 concepts and explain them in more detail.*

There were also some viewers who felt that the show raised more questions than it answered. Again, for some viewers this seemed to be engaging, however, it seemed to be frustrating for other viewers as evidenced by the comments below:

- *Some of the observations sounded strongly opinionated on less than concrete data and theories.*
- *Seemed like more speculation than fact did not seem to have sufficient scientific fact or detail to substantiate the statements and assertions that were made and presented as fact.*
- *Presented as fact while it appeared to be all theory about the origins of the universe.*

Length and Pacing

Twelve-percent of the comments about what viewers' liked least about Dark Universe were about length or pacing. Specifically, the majority of these comments indicated a desire for the show to be longer, or a feeling that it had ended too soon or too abruptly. Generally speaking, this finding suggests that viewers liked what they were seeing. Others suggested that a slightly longer show may have allowed more time to digest complex topics. A few respondents suggested that the time spent

waiting to enter the theater could have been spent more constructively to introduce topics and prepare viewers for what they were about to see.

Other Things Viewers Disliked

There were a few respondents who said they disliked the music (however, only 5% of the comments). Some felt that it was not a good fit for the program, while others indicated that it simply wasn't the type of music that they enjoyed. Lastly, viewers commented on distractions from other members of the audience that detracted from the viewing experience, most notably young children or people using cell phones. Again, this later point seemed to indicate a general interest in the show, and viewers' frustration when the immersive experience was interrupted.

FINDINGS: **LIVE PRESENTATION**

Typically, *Dark Universe* screenings at the CalAcademy include a five-minute live presentation segment in the middle of the show. During this segment, a trained planetarium staff member presents information on current research efforts around the world that relate to dark energy and dark matter. During this live segment, a series of images are displayed on the dome screen and explained via a wireless microphone. Each staff member is given the freedom to customize what they say, but the images remain the same from show to show. The table below shows our data collection schedule, indicates whether the show included the live presentation, and shows how many surveys were gathered during each time-slot.

Data Collection Schedule at The CalAcademy

Time	Live Presentation?	Thursday June 12th	Friday June 13th	Saturday June 14th
10:30AM	no		n=32	n=44
11:15AM	yes		n=19	n=33
12:00PM	no		n=31	n=30
12:45PM	yes		n=36	n=24
1:30PM	no		n=2	n=9
2:15PM	yes		n=40	n=21
3:00PM	no		n=11	n=44
3:45PM	yes		n=13	n=18
4:30PM	no		n=19	n=20
7:30PM	yes	n=72		
8:30PM	yes	n=59		

Note: There were also 23 survey forms that were left in the planetarium over the course of the three days we were collecting data. We were not able to assign these forms to a specific time slot, however, because of different colors used for the survey handed out during shows with the live segment, we do know that 15 were from shows with live segments and 8 were from shows without a live segment.

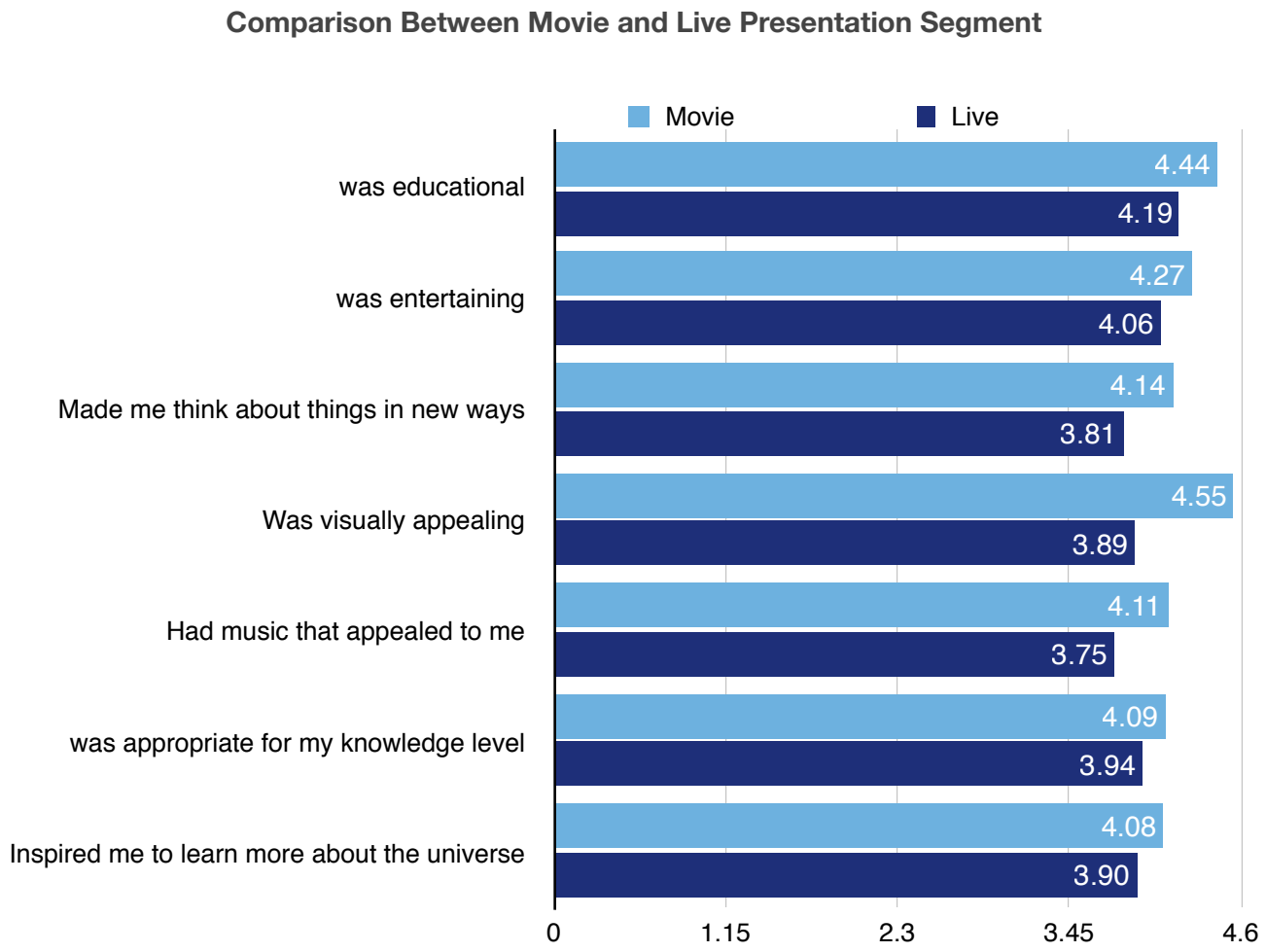
Over the course of the three-day data collection effort at CalAcademy, data were gathered from ten screenings that included a live presentation and ten screenings that did not, including 350 surveys from screenings that included a live presentation and 241 from screenings that did not include a live screening. It is also important to note that the two screenings on Thursday took place during NightLife, a weekly event held at the museum that attracts younger adults; both screenings that evening included the live presentation segment. Aside from slight differences in ages (largely due to the data gathered during NightLife skewing younger), there were no notable nor statistically significant differences in viewer demographics for those who attended screenings that included a live presentation versus those who did not.

COMPARED RATINGS FOR LIVE AND RECORDED SEGMENTS

The survey administered to visitors who attended Dark Universe screenings that included the live presentation segment included an additional set of questions about the live presentation. All questions analyzed had a five-point response scale where 1 was "strongly disagree," and 5 was "strongly agree." Data from these surveys were analyzed using paired samples t-tests, so as to compare respondents' ratings on identical questions about the live presentation given by a CalAcademy staff member and the recorded portion of the show (i.e., the movie, narrated by Neil deGrasse Tyson). Ratings for each item were higher for the movie than they were for the live presentation and all differences were statistically significant with a p value of .004 or less. The figure and table below summarize these findings:

Comparison Between Movie and Live Presentation Segment

		MOVIE		LIVE	
The movie/live presentation…	N	Mean	SD	Mean	SD
was educational	268	4.44	0.65	4.19	0.80
was entertaining	266	4.27	0.81	4.06	0.90
Made me think about things in new ways	262	4.14	0.86	3.81	0.95
Was visually appealing	256	4.55	0.66	3.89	0.94
Had music that appealed to me	258	4.11	0.91	3.75	1.02
was appropriate for my knowledge level	261	4.09	0.94	3.94	0.92
Inspired me to learn more about the universe	259	4.08	0.85	3.90	0.89



Respondents tended to rate the movie portion of the show slightly higher than the live presentation segment of the show. Open-ended comments suggested that some presenters had a more positive impact than others, but overall the amount of variation in response to the close-ended questions was commensurate with the amount variation in viewers' responses to questions about the recorded portion of the show.

Viewers responded favorably to the presenters' level of knowledge and found the live-segments to be "entertaining and informative." Viewers also shared positive comments about the fact that the live segment shared new, up-to-date information and "shows the movie was made with progress in mind." In fact, one viewer who had seen the show on a previous visit, commented on the fact that the information presented during the live segment was different on this occasion than it had been on their previous visit. The live segment also seemed to enhance viewers' sense that the overall show was about the process of scientific discovery and helped to drive that particular theme home for viewers. Viewers were also appreciative of the humor that was infused during some live presentations and generally seemed to respond most favorably to live presentations that were more lively and humorous.

Most criticisms of the live segment are easily correctable, including the volume of the live presentation being too low in comparison with the movie and the rate of speech of some presenters being much quicker and therefore harder for some audience members to follow. Respondents also commented on there being some vocabulary words used during the live presentation that weren't well-known by lay audiences, and the information generally seeming more dense. The most common criticism of the live presentation, however, was the fact that it felt like an interruption to the movie and might be better received by viewers if it occurred at the beginning or end of the show so that it does not disrupt the flow of the movie presentation and the sense of immersion that the movie generates.

INTERVIEW: THEMES AND TRENDS

Viewer interviews enabled the research team to go into greater depth about what viewers learned and what they thought about the show. Pairs or small groups of potential interviewees were recruited as they exited the theater. A total of fourteen group interviews were conducted at the CalAcademy and fifteen group interviews were conducted at AMNH. Overall we spoke with 38 people in San Francisco and 33 people in New York, for a total of 71 interviewees. We deliberately sought a mix of adult groups as well as groups that included youth of varying ages.

GENERAL IMPRESSIONS

Interviewees were positive about their experience viewing *Dark Universe*. When asked to describe the show, the following terms were shared most frequently: "educational," "interesting," "informative," and "visually stunning or "visually appealing." The word cloud below shows other terms that viewers mentioned when they were asked to describe the show.

A more in-depth analysis of viewers' descriptions of the show yielded two general categories: 1) what they experienced (including many of the ride-like attributes of the show) and, 2) what they learned. This finding emphasizes the fact that viewers saw the experience as being both entertaining and educational—and a firm belief that one is not exclusive of the other.

What they experienced:

- *It's a different experience than a normal planetarium show - you're in it.*
- *The opening—feeling like you are flying.*
- *A sense of traveling—especially the opening scene— getting closer and closer!*
- *Stunning use of digital technology…this is how 3D should be used.*

What they learned:

- *The discussion and visualizations of what the universe looks like when viewed from a different point*
- *We are moving away from where we were yesterday.*
- *There's more out there than we know about.*

We will present more information about the things viewers learned in the following sections as well.

WHAT VIEWERS LIKED

The viewers who we interviewed were generally positive about their viewing experience. Below are brief summaries of the themes that emerged from the things that viewers said they "liked most" about *Dark Universe*.

Visual Aspects The most frequently mentioned things that viewers "liked most" about the show were the visualizations and the overall visual look-and-feel of the show. They indicated that there is something about seeing the science that helps it come alive and seem more interesting and engaging. They appreciated the 3D-nature of these images that created a sense of immersion. Viewers also appreciated the overall beauty, as well as the underlying scientific accuracy of these visualizations. *Dark Universe* takes data and information that scientists can read about and understand and turns it into visualizations that enable a lay person to understand the underlying concepts. Even if they didn't fully understand the underlying scientific concepts, viewers were still able to appreciate the beauty of what they were seeing. A few viewers used the term "poetic" to describe the visual elements within the show, and one viewer suggested that the visualizations are a poetic spin on science that "regular people can relate to." Another viewer who described the visualizations as a "poetic approach to science" explained that the visualizations enable people to understand data that would otherwise be

hard to interpret; “The average person needs the art to make it more tangible.” For example, an interviewee who said that he had previously seen 2D visualizations of how cosmic radiation is mapped in *Sky and Telescope*, explained that he understood things better after seeing the 3D visualization included in *Dark Universe*. Interviewees shared the following comments about the visualizations in *Dark Universe* as well:

- *The visuals [are] things you can’t get from a textbook…like seeing the tentacles of dark matter and how it’s holding everything together.*
- *You see the same things on TV but you learn more if you are able to see it like this because it’s an experience.*

Learning Viewers liked learning new things and coming to see things in new ways. They were able to recite many of the things they had learned about, especially things that tied into specific narratives, e.g., seeing into the past and the expansion of the universe as seen from different points of view. These concepts, along with the content related to dark matter, were new for many viewers.

The following are a sample of viewers’ comments related to what they learned, in response to the interview question about what they liked most:

- *It stimulates us to think more deeply about the universe and to be more inquisitive.*
- *[liked] satellite imaging, seeing those and how they mapped things.*
- *How they measure our universe using light.*
- *It gives a great sense of the size and complexity of the system.*

Relatable Content Viewers expressed appreciation for the fact that efforts were made to provide context, for example, using the size of the theater as a point of comparison. They also appreciated seeing images of places they were familiar with, e.g., the Mount Wilson observatory and the state of Florida. Things that relate to our planet and viewers’ personal experiences (e.g., familiarity with the different observatories and research sites mentioned in the show) helped to create stronger connections to the content. The historical elements of the show also sparked personal connections, as was the case with one viewer who grew up when this research was being conducted and who remembers his father working for AeroJet on one of the satellites used to gather important astronomical data. Generally speaking, viewers liked learning about things happening at the far reaches of our galaxy, but they were also appreciative of aspects of the show that were more applicable and relatable to their experiences here on Earth.

Broad Appeal Our pool of interviewees ranged from those who had little to no familiarity with the concepts presented in *Dark Universe* to those who had advanced degrees in physics or astronomy enthusiasts and who were, therefore, somewhat versed in the topics of dark matter and dark energy. No matter what their level, viewers felt that the show was appropriate for mass audiences but still had elements that could entice and engage experts. Interviewees acknowledge the fact that it must be challenging to strike the right balance between presenting rigorous scientific information while remaining understandable and meaningful to lay audiences: "To bring information like this to diverse crowds is difficult, but they handled it perfectly." One interviewee commented on how ambitious it was, stating that it was "intellectually complex," yet presented concepts "in ways even third graders could understand." Another suggested that it was "informative, but not so high up that a common person couldn't understand." This was due in part to use of, what one interviewee described as, "layman's terms," that were "detailed but not confusing." Experts and laypeople alike felt that there was a lot to take in, but still felt that the show was entertaining and educational.

Narration Interviews felt that Neil deGrasse Tyson was a perfect choice for narrator. Many viewers had previously seen or heard about the new *Cosmos* series which he hosted, and others had seen him appear as a guest on popular talk shows. Even those who weren't familiar with him as an academic celebrity liked his voice and felt that he was easy to understand. The fact that he is a respected scientist and astronomy expert leant credibility to the show, but lay audiences also appreciated the fact that he explained things in ways that were easy to follow.

WHAT VIEWERS DISLIKED

Logistics When asked to share information about things they did not like, viewers frequently mentioned logistics about the viewing experiences, such as seating and disruptions within the theater rather than elements of the show itself. They acknowledged the fact that these details were beyond the control of the show's producers, but stress the importance of providing a viewing experience that is as comfortable and as free from disruptions as possible.

Length It is a positive finding that there tended to be far fewer responses when we asked viewers to indicate what they "liked least" about their viewing experience as compared to our prompts for what they "liked most," and it is also a positive finding that, when further prompted, one of the most frequent responses was the fact that the show was too short. Specifically, interviewees asserted that the show could have been about ten to fifteen minutes longer.

Complex Topics Some concepts were harder for viewers to follow and understand but overall there was a general sense of immersion and engagement throughout the show. Some viewers felt that the show could be enhanced by including more details, while others felt that it would be better if there were fewer details. Related to this theme is the fact that some novice viewers felt that the amount of

content seemed, at times, to be overwhelming. However, they acknowledge that having more description and more explanation might have detracted from the entertaining nature of the program. Novice viewers also stressed that they were still able to appreciate the visualizations and being exposed to new ideas and concepts.

OPINIONS ABOUT LIVE PRESENTATION SEGMENTS

At the CalAcademy our research team made a point of speaking with a mix of attendees who had seen the show with the live presentation segment as well as those who viewed the version of the show with no live segment. The most frequent comment about the live segment was the fact that it seemed to be somewhat disruptive in the middle of the program, though most said they would be more open to, and appreciative of, a segment like this at the end of the show, especially if it would allow audience members a brief opportunity to ask questions. The experience level and "presence" of the staff member doing the live presentation also seemed to have an impact on viewers' impression of the live segment of the show. In some cases, viewers felt that going from a very polished and immersive movie, to a live presentation that felt less rehearsed and sometimes less fluid, could be a bit jarring. None the less, viewers appreciate the inclusion of current research and feeling like they are getting even more up-to-date information than the movie can provide over time.

LEARNING OUTCOMES

Dark Matter/Dark Energy The concepts of dark matter and dark energy were new to many of the viewers with whom we spoke. They indicated learning things about what it is, how much there is in relation to other types of matter, what it does, and how scientists know it is there. Even though they gained a basic understanding of the concept, there was a great deal of variation in how much viewers were ultimately able to explain what they had learned. The viewers with whom we spoke were generally able to explain that dark matter makes up the bulk of the universe, and some were able to cite the specific statistic about the relation of dark matter to more conventional forms of matter that we can see. Some were able to describe the process by which scientists came to believe dark matter must exist, based on other phenomena that were observed. Examples of their comments about dark matter and dark energy are presented below:

- *We don't know what it is, but we know it's there because it holds everything together.*
- *Something that holds things together that we can't see.*
- *Matter that must be taken into account to explain galaxy clusters.*
- *[the matter] we know is only 5% of what's out there. Most of the the universe is made up of [dark matter].*

- *It's the majority of our universe but we don't know much about it. Everything is connected to it….The thing that makes everything go.*
- *It's a force that keeps everything in place.*
- *For the first time, I actually understood the explanation of dark matter. I read about it but I never visualized it this way.*

Interestingly, we found that children were sometimes more open to explaining the concept of dark matter than the adults in their group, perhaps because they were less inhibited by the underlying complexities and enigmatic nature of the topic. In family groups, parents would often prompt their children to respond first, and then echo many of the things that their children said. This finding suggests that children are able to grasp many of the basic concepts and retain some of the facts that are shared in the program.

Viewers who were previously familiar with the concept of dark matter thought that *Dark Universe* contained one of the best descriptions of the topic they had ever heard. Combined with the visualizations of data and information they had read about in the past, even the most knowledgeable viewers came away with a better grasp on the topic and new ideas to ponder and explore.

Questions to Ponder There were many concepts in the show that seemed to intrigue viewers, e.g., "What is at the edge of the universe and can there be an edge in an ever expanding universe?," "How can there be a beginning or end to something that is infinite?,"and "Can we ever know everything if there will always be places that we cannot see?" Viewers were also intrigued by the fact that scientists now believe that the universe is expanding at an increasingly rapid rate (rather than a slower rate as previously thought). This concept led viewers to make connections with things they had heard or learned about in the past and several pondered whether the universe would eventually contract back in upon itself. These questions seemed to facilitate meaningful thought and discussion following the show. In fact, one family group was recruited to participate in a follow-up interview because they were one of several groups overheard talking about the show in the museum's cafeteria. The fact that the show sparked further conversation and reflection at later points during their museum visit is a testament to its impact on viewers.

Process of Discovery People noted the fact that they learned new things about how we are discovering things about our universe through satellites, probes, space stations, and other new technologies. They appreciated learning about past and present discoveries and indications about what the next chapter of discovery holds in store. Viewers felt that *Dark Universe* does a good job of showing that the discovery process takes time and highlighting the fact that some discoveries are serendipitous surprises. Several people referenced the fact that we have only learned what we know

in the last 100 years, i.e., only one-percent of human history. This fact was touted as another indicator that there is so much more discovery to come! The following are examples of comments that viewers shared about what they had learned about the process of scientific discovery:

- *It takes a long time to put everything together.*
- *[Scientists] watch a lot for a long time, and sometimes they are lucky enough to catch it. Sometimes they are looking for one thing and find another. They have to pay attention all the time.*
- *The narration brought it alive, when they talked about Andromeda—the excitement of finding it when they aren't looking for it and how they realized what they found.*

EMOTIONAL OUTCOMES

As was the case with past space shows, *Dark Universe* viewers came away feeling small and insignificant in relation to everything else that exists in the universe. Yet, unlike past space shows, viewers also came away with a sense of being connected. They shared the following comments about the emotions they experienced as a result of viewing *Dark Universe:*

- *We are so small and it is such a big universe…love feeling the 'wow' factor.*
- *The scale of the universe boggles my mind…I've never seen it done so well.*
- *I will never forget the pie chart…and that all we know makes up less than 5% of our universe.*
- *Nice to remember how tiny we are, obscenely tiny…it's inspiring because I look at it as 'I am it, it is me. It's the fabric, and we are all connected.*
- *Salvation for the human condition—it makes me feel more connected to everything.*

BEHAVIORAL OUTCOMES

Info-Seeking Some viewers were content to ponder what they had learned about in the show, but others indicated a desire to look up more info online via Google, Reddit, and/or YouTube. They were interested in finding astronomy podcasts and programs like *StarTalk*—especially programs hosted by Neil deGrasse Tyson. Viewers specifically mentioned a renewed interest in watching programs like the new *Cosmos* series—or viewing it and related programs again. One viewer who was initially less interested in astronomy stated that "I will watch programs that I wouldn't have watched before." Viewers also indicated a desire to read or finish reading books and articles about related subjects. Lastly, a few viewers expressed a desire to purchase a DVD copy of the show so that they could watch it again in the future.

Stargazing Viewers indicate that they will think differently when they look at the stars at night. One viewer indicated that she and her granddaughter were getting ready to travel to the French countryside where they were likely to "enjoy looking at the stars and thinking about what we learned." Another viewer explained that she will do more observing and "reflect on the fact that there is more dark matter than [the matter] we can see."

Academics Many of the youth with whom we spoke indicated that they would feel more confident talking about the topics presented in *Dark Universe* and were more likely to be engaged in science classes in the future. Some of the youth with whom we spoke were interested in pursing a career in astronomy. They felt that *Dark Universe* gave them a good understanding of topics and information about potential areas of study they could explore one day. Another student, currently pursuing a doctorate in physics, noted that "it is more exciting to do this type of science when its visual…not just memorizing."

Support Funding In a few separate interviews, respondents mentioned the fact that shows like this foster support for funding for continued research and exploration of our universe. Likewise, people indicated that things we were taught in school are out-dated and in some cases now known to be untrue, so there is great value in educational shows like *Dark Universe* that help to update peoples' understanding of science. Lastly, the show generates a sense of excitement about everything we are now poised to learn, and how so much of what we know about the universe has been learned in the past few years (compared to the whole of human existence).

- *Invigorating to know that we aren't resting on our laurels. [Exploration] is just as important now as it was before we went to the moon.*
- *Its interesting to think about what we knew…what we know now…and what we will know in the future. In the last 100 years, we've made leaps and bounds.*

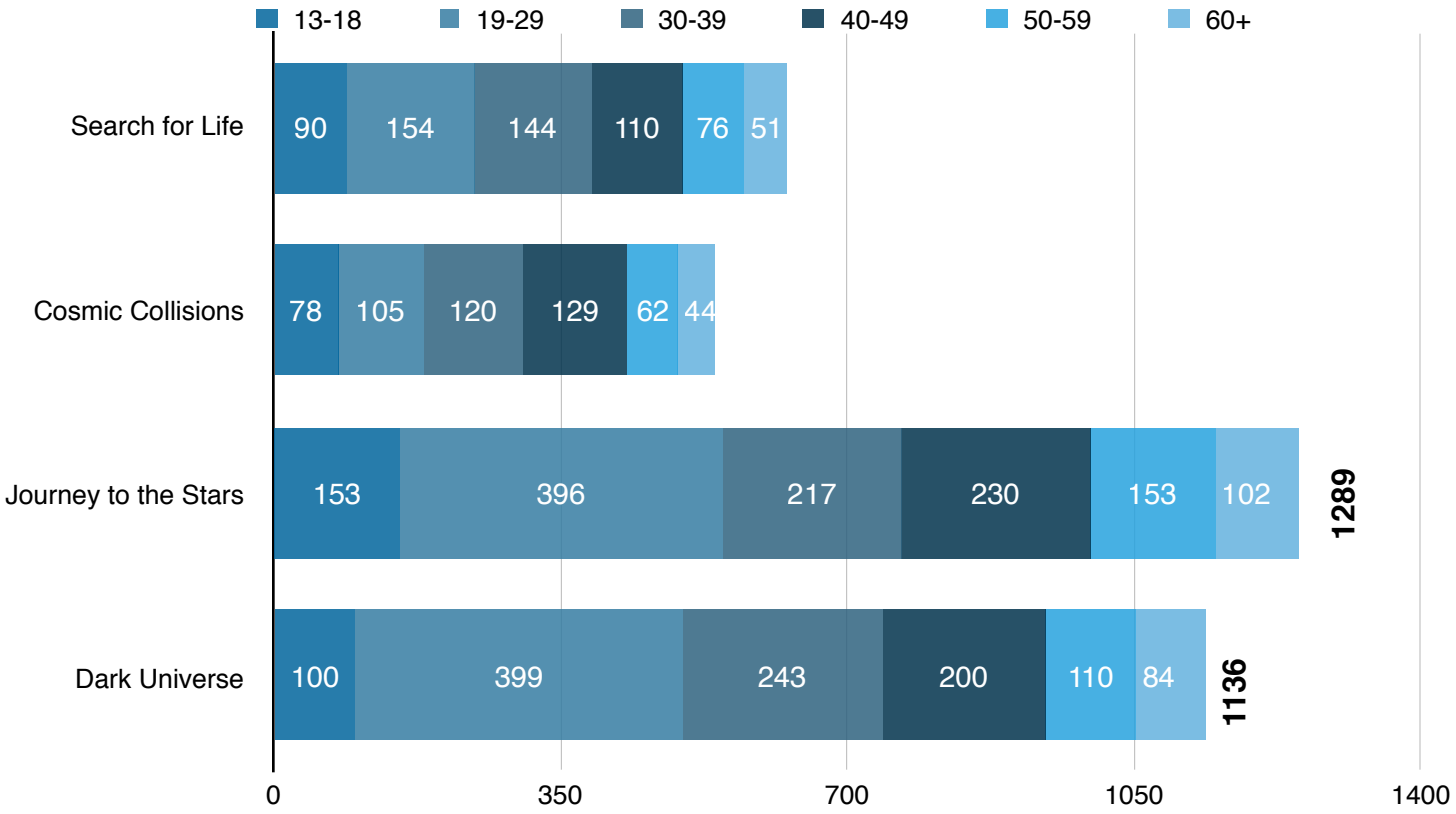
Seeing *Dark Universe* Again Perhaps the best indicator of enjoyment and engagement with a space show like *Dark Universe* is a willingness to devote time to seeing it more than once. Even in our relatively small sample of interviewees, there were many who had seen *Dark Universe* before on previous visits, including one family group who had seen the show at the CalAcademy and then opted to see it again while on vacation in New York. Seeing the show multiple times is a very tangible example of people's appreciation and interest in *Dark Universe.*

CROSS SHOW: **COMPARISONS**

Our evaluation of *Dark Universe* also included a comparative component wherein we explored the differences between this most recent space show and previous space shows produced by the American Museum of Natural History. Previous studies included an evaluation of *Search for Life* (conducted in 2005), *Cosmic Collisions* (conducted in 2006), and *Journey to the Stars* (conducted in 2009).

In terms of respondent demographics, the sample of viewers who were surveyed for *Dark Universe* were more similar to the sample of viewers surveyed for *Journey to the Stars* than for the previous two space shows.

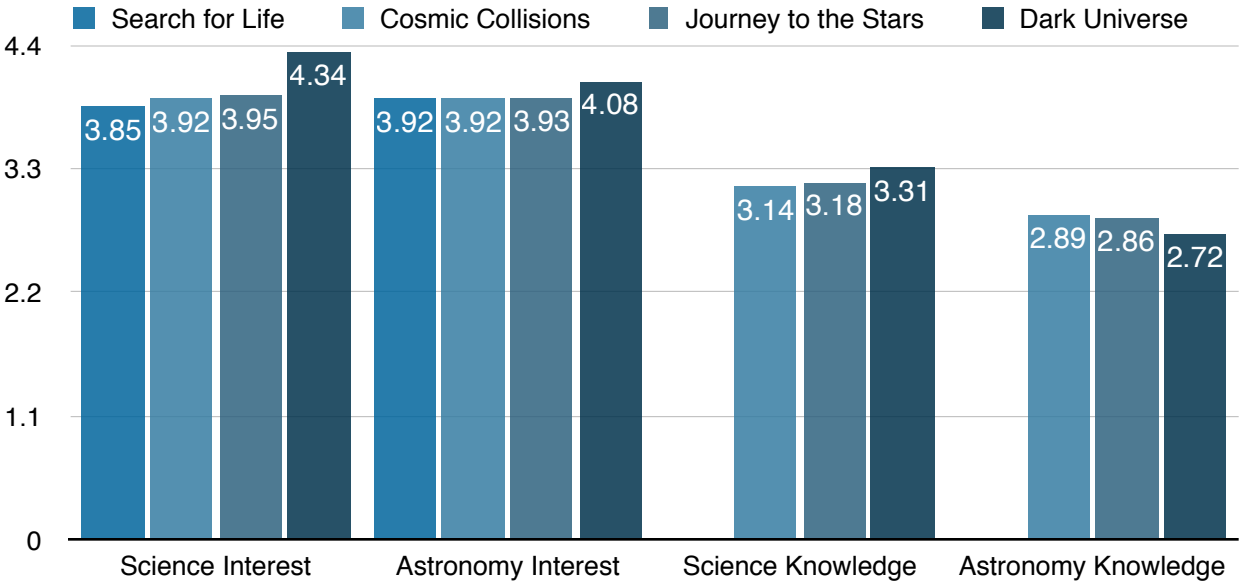
Distribution of Respondent Ages (Across Shows)



Data in the figure above do not include respondents for whom no age data was provided. Data for *Journey to the Stars* and *Dark Universe* both included higher numbers of 19-29 year-old respondents.

Survey respondents for each show were asked a series of questions about their level of science and astronomy interest and knowledge; however, the knowledge question was not added to the survey form until the study of *Cosmic Collisions (*i.e., the knowledge questions were not asked of survey respondents in the *Search for Life* evaluation). On each survey form, a five-point response scale was used for each question and in each case, a response of 1 was lowest, and 5 was highest.

Comparative Agreement with Statements About Each Show

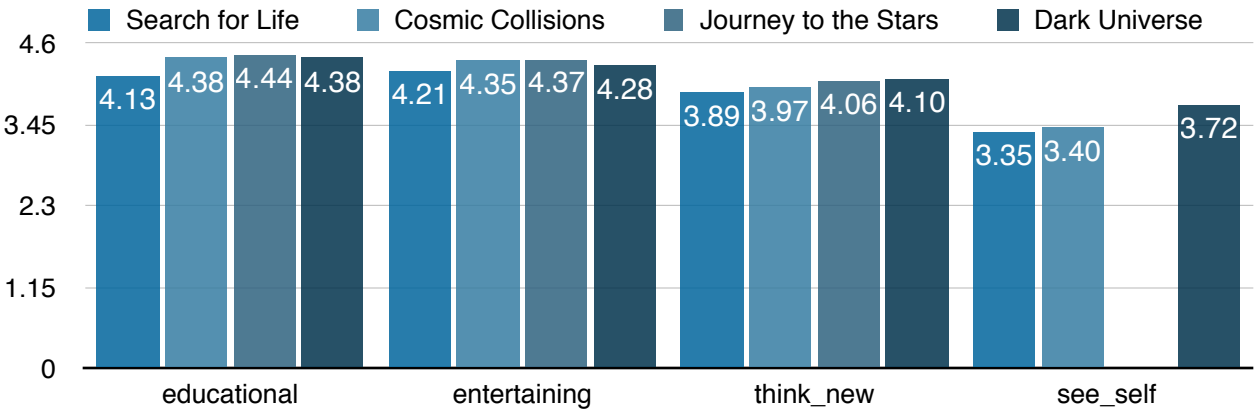


Knowledge and interest levels were fairly consistent across the sample of viewers surveyed for each show, with the exception that viewers sampled for *Dark Universe* were slightly more interested in science. (Note: data about science and astronomy knowledge is not available for *Search for Life.)*

The figure on the following page summarize comparative outcomes for viewers' ratings of how much they agree with the following statements:

- The show was educational.
- The show was entertaining.
- The show made me think about things in new ways.
- The show changed the way I see myself in relation to the universe.

Comparative Agreement with Statements About Different Components of Each Show

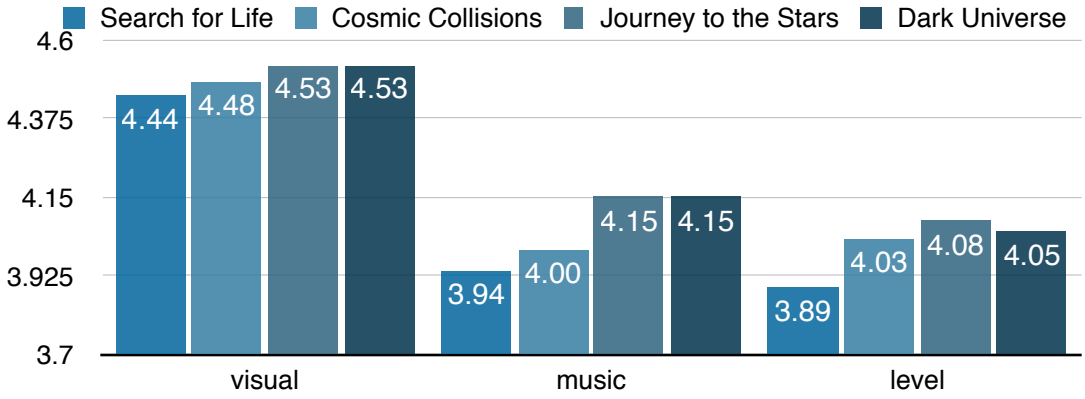


On the whole, the agreement levels for statements about Dark Universe were very similar to those of past shows. However, in the case of having an impact on how viewers see themselves in relation to the universe, Dark Universe seemed to have a greater impact than previous shows.

Next, we compared viewers' level of agreement with structural elements of the show and the level at which content was presented. The figure below summarizes findings from the past four studies and specifically presents a summary of findings related to viewers' level of agreement with the following statements:

- The show was visually appealing
- The show had music that appealed to me.
- The show was appropriate for my knowledge level.

Comparative Agreement with Statements About Different Components of Each Show

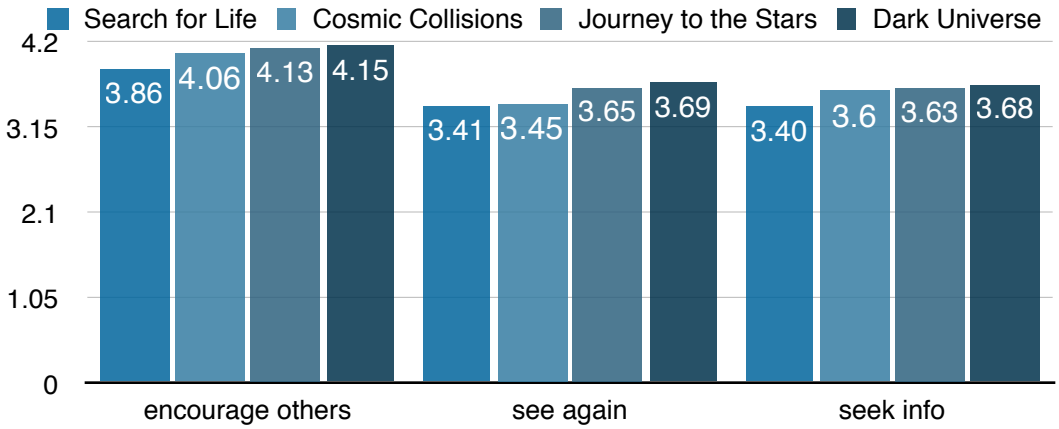


Generally speaking, it appears that *Dark Universe* viewers' responses were consistent with those of *Journey to the Stars* viewers in terms of the appeal of the visual elements and music, as well as the for level of the program. Both of these programs showed slight improvements over their predecessors.

Lastly, viewers' comparative levels of agreement about what they plan to do after watching each space show were compared. Specifically, the figure below compares average levels of agreement with the following statements:

- I will encourage others to see this show.
- I would see this show again on a future visit to this museum
- I plan to seek out additional information about one or more topics that I learned about in this show.

Comparative Agreement with Statements About What Viewers Plan To Do



Again, we found that *Dark Universe* viewers were fairly consistent with viewers of previous shows in terms of what they plan to do. However, in each case, *Dark Universe* viewers were slightly more likely to encourage others, to see the show again or to seek out information than viewers for previous space shows—indicating that *Dark Universe* is slightly more likely to prompt specific actions or behavioral outcomes among viewers.

In sum, findings for *Dark Universe* are fairly consistent with findings from past space show studies. The lack of more noticeable differences indicates a possible ceiling effect, wherein there is little room for subsequent programs to improve upon the great successes of previous shows. None the less, the consistency of findings across shows, also indicates that the American Museum of Natural History is succeeding in its continuing commitment to provide high quality scientific programming that is also engaging and entertaining to mass audiences.

APPENDIX A: SURVEY INSTRUMENT

Dark Universe - Viewer Survey

1) Gender: ❑ Male ❑ Female **2)** Age: ❑ 14-18 ❑ 19-29 ❑ 30-39 ❑ 40-49 ❑ 50-59 ❑ 60+

3) Where do you live: City: _____ State: _____ Country: _____

4) Are you a member of this museum? ❑ No ❑ Yes

5) In the **past year** (June 2013- June 2014) and including your visit today…
- **a)** How many visits have you made to this museum? ____ Times
- **b)** How many total visits have you made to any museum (including this one?) ____ Times
- **c)** How many times did you see a planetarium show during your visits to museums?____ Times

6) How **interested** are you in each of the following:

1=low/5=high	Not Interested At All(1)				Very Interested(5)
a) Science in general	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
b) Astronomy	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

7) How often do you do each of the following:

	Never (1)	Rarely (2)	Monthly (3)	Weekly (4)	Daily (5)
a) Watch TV programs about science	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
b) Read science books/articles	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
c) Listen/watch science podcasts	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
d) Attend science lectures/classes	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
e) Stargaze/do astronomical observations	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

8) How much do you **know** about each of the following:

1=low/5=high	Nothing(1)	Very little(2)	Moderate Amount(3)	A lot(4)	Expert(5)
a) Science in general	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
b) Astronomy	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

9) a) Are you currently in school? ❑ No ❑ Yes If yes, what grade level:_____

b) Highest Grade Level Completed: ❑ High School ❑ Associates ❑ Bachelors ❑ Masters ❑ Doctorate ❑ Other:

c) Are/were you employed in a scientific field? ❑ No ❑ Yes (currently) ❑ Yes (previously)

10) With whom did you attend today's show? (check all that apply)
- ❑ By myself
- ❑ With friend(s)
- ❑ With my spouse/significant other
- ❑ With my children/grandchildren
- ❑ With children other than my own
- ❑ With my parent(s)
- ❑ With another relative (sibling, aunt, etc.)
- ❑ Other:_____

11) Please rate the importance of each of the following factors in deciding to view this show?

1=low/5=high	Not important at all(1)		Moderately Important(3)		Very Important(4)
a) Title ("Dark Universe")	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
b) Narrator (Neil deGrasse Tyson)	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
c) Educational value	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
d) New/hadn't seen it before	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

12) In general, I select planetarium shows that…

	Strongly Disagree(1)	Disagree(2)	Neutral(3)	Agree(4)	Strongly Agree(5)
a) are educational	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
b) are entertaining	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
c) have topics that interest me	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
d) appeal to my family/group	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

Please complete this side <u>after</u> the show

13) The show I viewed today…. (Please rate your level of agreement with each statement below)

	Strongly Disagree(1)	Disagree(2)	Neutral(3)	Agree(4)	Strongly Agree(5)
a) was educational.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
b) was entertaining.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
c) made me think about things in new ways.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
d) was visually appealing.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
e) had music that appealed to me.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
f) was appropriate for my knowledge-level.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
g) inspired me to learn more about the universe.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
h) changed the way I see myself in relation to the universe.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
i) helped me understand the process of scientific discovery.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
j) helped me understand how scientists know what they know.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
k) contains visualizations that are based on scientific data.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
l) had accurate placement of stars and galaxies	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

14) Please rate your level of **agreement** with the following statements about the show:

	Strongly Disagree(1)	Disagree(2)	Neutral(3)	Agree(4)	Strongly Agree(5)
a) I plan to seek out additional information on one or more topic that I learned about in this show.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
b) I will encourage others to see this show.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
c) I would see this show again on a future visit to this museum.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
d) This show is what I expected.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

<u>If it wasn't what you expected</u>, how did it differ from your expectations?

15) What did you like **<u>most</u>** about this show?

16) What did you like **<u>least</u>** about this show?

APPENDIX B: **LIVE-SHOW VERSION**

13) The movie, **DARK UNIVERSE**…. (Please rate your level of agreement with each statement below)

	Strongly Disagree(1)	Disagree(2)	Neutral(3)	Agree(4)	Strongly Agree(5)
a) was educational.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
b) was entertaining.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
c) made me think about things in new ways.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
d) was visually appealing.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
e) had music that appealed to me.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
f) was appropriate for my knowledge-level.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
g) inspired me to learn more about the universe.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
h) changed the way I see myself in relation to the universe.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
i) helped me understand the process of scientific discovery.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
j) helped me understand how scientists know what they know.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
k) contains visualizations that are based on scientific data.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
l) had accurate placement of stars and galaxies.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

14) The **LIVE PRESENTATION**…. (Please rate your level of agreement with each statement below)

	Strongly Disagree(1)	Disagree(2)	Neutral(3)	Agree(4)	Strongly Agree(5)
a) was educational.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
b) was entertaining.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
c) made me think about things in new ways.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
d) was visually appealing.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
e) had music that appealed to me.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
f) was appropriate for my knowledge-level	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
g) Inspired me to learn more about the universe.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

15) Please rate your level of agreement with the following statements about the **ENTIRE SHOW.**

	Strongly Disagree(1)	Disagree(2)	Neutral(3)	Agree(4)	Strongly Agree(5)
a) I plan to seek out additional information on one or more topic that I learned about in this show.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
b) I will encourage others to see this show.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
c) I would see this show again on a future visit to this museum.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
d) Overall, this show is what I expected.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

If it wasn't what you expected, how did it differ from your expectations?

	DARK UNIVERSE (the movie)	The Live Presentation
16) What did you like **most** about…		
17) What did you like **least** about….		

APPENDIX C: **FAMILY QUESTIONS**

Dark Universe – Questions for Families

1) Who else (other than you) watched *Dark Universe* with you today:

a) Number of children 5 & under: _____
b) Number of children 6-12: _____
c) Number of children 13-17: _____
d) Other adults: _____

2) Please rate your level of **agreement** with each of the following statements:

		Strongly Disagree(1)	Disagree(2)	Neutral(3)	Agree(4)	Strongly Agree(5)
a)	This show was **entertaining** for everyone in my group.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
b)	This show was **educational** for everyone in my group.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
c)	This show was **understandable** to everyone in my group.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

3) What did your children like best about the show?

4) Was there anything that your children did not like about the show?

APPENDIX D: **INTERVIEW PROTOCOL**

General Impressions

1. What was your general impression of this show?

2. How would you describe this show to someone else?/What was it about?

Likes/Dislikes

3. What did you like most? (in general and more specifically) Why?

4. Was there anything that you didn't like? (in general and more specifically) Why?

5. What would have made it better/How could it have been improved?

Learning Outcomes (knowledge)

6. Tell me a little more about what you learned from the show? (vs. what you knew before)

   a) ... What is dark matter?

   b) ... How do scientists discover new things about our universe?

7. Was there anything that didn't make sense to you? What/why?

Behavioral Outcomes (thinking/doing)

8. Do you think this show has had an impact on how you'll think about things in the future?

9. What will you do, if anything, to learn more about the topics presented in this show? (prompt: follow-up with magazines, web, television, book, lecture?).