Americans and the 2017 Eclipse

A final report on public viewing of the August total solar eclipse

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On August 21, 2017, a total solar eclipse crossed the United States from the west coast to the east coast, providing millions of Americans with the first opportunity to see a total solar eclipse in their life time. This experience represents an important stimulus to interest in our solar system and in cosmology broadly. It is important to understand how many American adults viewed the eclipse – in totality or partially – and what impact this experience has had on them.

As a part of an ongoing national study of the development of scientific literacy at the University of Michigan, NASA asked Jon Miller and his team to assess the impact of the August total solar eclipse in terms of the number of adults[1] who viewed the event directly or on some form of electronic media and to estimate the impact of that experience on subsequent interest in and understanding of the solar system and related cosmology.

The University of Michigan/NASA cooperative study[2] of the development of civic scientific literacy is a three-wave study. In February and March of 2017 a national probability sample of 2,915 adults was selected[3] and asked a set of baseline questions designed to estimate their level of civic scientific literacy and their interest in and engagement with science and space-related matters. To assess the preparation for and viewing of the total solar eclipse on August 21, the same sample of adults were asked to complete a short questionnaire – online or by phone – describing their actual viewing experience and their activities in the months prior to the eclipse.

A third survey was conducted with the same individuals in October, November, and early December of 2017 to measure the science and eclipse-related activities that eclipse viewers engaged in during the months following the eclipse. The full impact of engagement in an event like the total solar eclipse is a combination of (1) the actual viewing experience, the preparation for eclipse viewing, and short-term discussion and engagement activities directly related to the viewing experience, and (2) subsequent science information seeking activities and the increased learning that comes from additional information acquisition and

[1] The Michigan Scientific Literacy Study is designed to study the levels of scientific literacy in the adult population of the United States and is consistent with other Federal studies of adult science understanding, such as the National Science Board's Science and Engineering Indicators series. Other studies, such as the Longitudinal Study of American Life (sponsored by the National Science Foundation and the National Institutes of Health, have focused on the development of scientific literacy in pre-adults.

[2] The 2017 Michigan Scientific Literacy Study is supported by a collaborative agreement between the University of Michigan and the National Aeronautics and Space Administration (award NNX16AC66A). The author gratefully acknowledges this support, but any errors or omissions are the responsibility of the author and not of NASA or any of its staff or officers.

[3] The data collection for the Michigan Study is conducted by AmeriSpeak, an address-based national probability sample of U.S. households operated by the National Opinion Research Center at the University of Chicago. AmeriSpeak uses a combination of online questionnaires and telephone surveys, reflecting the preference of each respondent. A complete description of the AmeriSpeak Panel and its sample can be found at: http://d3qi0qp55mx5f5.cloudfront.net/amerispeak/i/research/AmeriSpeak_Technical_Overview_2017_05_09.pdf?mtime=1494625611.

discussion with friends, family, and colleagues. This report will analyze and discuss the results from all three surveys and provide an overview of the impact of the 2017 total solar eclipse on the interest, awareness, and understanding of American adults about our solar system and space science.

THE AUGUST VIEWING EXPERIENCE

To obtain an accurate estimate of the viewership of the total solar eclipse, all of the adults that were surveyed in February and March were asked to complete a short follow-up survey about their experiences on August 21st. The online survey and telephone interviewing began on the evening of August 21st hours after the eclipse and continued through the end of Labor Day. This short window was used to assure more accurate recall by respondents. Of the original 2,925 baseline respondents, a total of 2,175 participants were reached and persuaded to participate in the immediate follow up – a response rate of 74% of the baseline sample. An October-November follow-up survey was designed to assess the post-eclipse information acquisition activities of American adults, but also located and surveyed some additional respondents who were unavailable in August, increasing the total sample for this analysis to 2,212 (76% of the original February sample).

A total of 154 million American adults[4] – 63% of all adults age 18 or older – viewed the eclipse directly (see Table 1). An additional 62 million adults who did not see the eclipse directly viewed the eclipse electronically on a television, computer, tablet, or smart phone screen. Twelve percent of American adults – about 29 million – reported that they did not see the eclipse in person or electronically. A total of 216 million American adults viewed the eclipse directly or electronically, or 88% of American adults.

Table 1: Viewing of the total solar eclipse, 2017.

	Percent	Number*	N
Did not view the eclipse directly or electronically	11.9	29,130,000	263
Viewed the eclipse electronically, not directly	25.3	62,022,000	560
Viewed the eclipse directly in home town	54.4	133,083,000	1,203
Traveled to another city to view the eclipse	8.4	20,570,000	186
Total	100.0	244,807,000	2,212
* Population estimates are rounded to the nearest whole thousand.			

Although the total level of viewing directly and electronically is very high, it is important to ask whether some groups were significantly more likely to experience the eclipse than others. An analysis of some of the major demographic groups shows that there is no difference in the frequency of eclipse viewing by men and by women, but there are small, but statistically significant, differences by age and education (see Table 2).

[4] The number of adults is estimated from the populations defined for the original sample and population estimates from the Bureau of the Census. The estimations were constructed by the staff of the National Opinion Research Center at the University of Chicago and reflect the resident, non-institutional population of the United States during the months in which the surveys were conducted.

Younger adults were slightly more likely to view the 2017 total solar eclipse directly than were older adults and older adults were more likely to watch the event electronically than were young adults. When direct viewing and electronic viewing are combined, young adults were slightly more like to have seen the eclipse than older adults. The gamma[5] for this relationship is -0.18.

American adults with higher levels of formal education were more likely to have viewed the eclipse directly than were adults with less formal education. The differences were moderate – 11% of college graduates did not see the eclipse at all compared to 24% of adults who did not finish high school. Less well educated adults were more likely to have viewed the eclipse electronically than better educated adults (see Table 2). It is not clear whether this differential reflects a higher level of interest by better educated adults or a lack of job and time flexibility by less-well-educated adults. The gamma for this relationship is 0.21.

Table 2: Frequency of eclipse viewing, by selected demographic groups, 2017.

	Did not view	Viewed electronically only	Viewed in-person in home area	Traveled to view in another area	N
All U.S. Adults	12%	25%	55%	8%	2,212
Gender					
Female	11	27	54	8	1,141
Male	13	24	54	9	1,070
Age					
18 to 29 years	10	21	59	10	472
30 to 39 years	11	18	64	7	377
40 to 49 years	7	21	58	14	364
50 to 59 years	16	27	50	7	395
60 to 69 years	13	32	49	6	362
70 or more years	17	39	40	4	243
Education					
Less than high school	24	28	36	12	152
High school graduate/GED	11	30	53	6	1,104
Associate degree	10	25	60	5	187
Baccalaureate	10	19	57	14	453
Graduate/professional degree	11	15	63	11	308

[5] Gamma is an ordinal proportional reduction of error statistic and can be interpreted the same as a Pearson's r^2. For a discussion of gamma and other PRE statistics, see Costner (1965). It means that knowing an individual's age improves our prediction of the likelihood of eclipse viewing by 18%. The plus or minus sign tells us the direction of the relationship – in this case, it is negative because younger respondents were slightly more likely to view the eclipse than older adults.

The August survey immediately after the eclipse asked each respondent to indicate whether they viewed the eclipse in their home area or whether they traveled to a different location for viewing. We obtained the name of the closest city (and state) to the place of observation for those who traveled and computed the degree of obscuration[6] for that location. Combined with the degree of obscuration computed for each individual's home area, we estimate that 10% of all direct viewers – approximately 24 million adults – were able to experience total obscuration (see Table 3). An additional 12% of adults (29 million) experienced 95% to 99% obscuration.

We assumed that traveling to view the eclipse would be an intentional act designed to improve the degree of obscuration, and there is some evidence for this assumption. Of the American adults who viewed the eclipse at a location other than their home area, 31% experienced total obscuration (see Table 3). But, 3% of American adults who viewed the total solar eclipse directly traveled to a location with a lower obscuration than their home area. On reflection, we conclude that some individuals had to be away from their home area on August 21 for reasons unrelated to the eclipse (business, family matters, and similar factors) and this may have resulted in viewing the eclipse at a place with a lower level of obscuration.

Table 3: Degree of obscuration observed, 2017.

	Degree of obscuration at place respondent viewed eclipse						N
	25 to 69%	**70-79%**	**80-89%**	**90-94%**	**95-99%**	**100%**	
All Direct Viewers	16%	21%	26%	15%	12%	10%	1,348
Place of Viewing							
Viewed in home area	17	21	26	16	13	7	1,175
Traveled to view	10	22	16	12	9	31	173

The nature of the viewing experience

Seventy-five percent of the 154 million America adults who viewed the solar eclipse directly watched the event with other friends, family, or co-workers (see Table 4). Adults who viewed the eclipse in their home area were slightly more likely to have viewed it alone than those who traveled to another site. A third of Americans who viewed the eclipse directly reported that they watched along with co-workers, suggesting that the mid-day viewing occurred on a break from normal work activities. Thirty percent of viewers

[6] Obscuration refers to the percentage of the Sun that is blocked by the Moon in a solar eclipse. The August solar eclipse is referred to as a total solar eclipse because 100% of the Sun was blocked for viewers at various locations.

Table 4: The August solar eclipse viewing experience, 2017.

	Used solar glasses	Made photo or video recording	Posted on social media	Viewed …. *						N
				Alone	With spouse or partner	With children or grandchild	With co-workers	With friends	At organized event	
All direct viewers	74%	34%	18%	24%	30%	23%	33%	29%	3%	1,366
Viewers in home area	73	34	17	27	29	23	32	29	3	1,191
Viewers in other area	83	38	27	9	37	22	37	30	5	175

* Note: The percentages will exceed 100% because a respondent may have viewed the eclipse with various combinations of viewers (i.e., spouse, children, and friends).

indicated that they viewed the eclipse with their spouse or partner, and 24% said that they watched the eclipse with their children or grandchildren.[7] Only three percent of all viewers reported that they watched the eclipse as a part of a group activity organized by a local astronomy group, planetarium, science center, or similar organization.

Seventy-four percent of adult viewers indicated that they used special solar glasses to observe the eclipse. Eighty-three percent of adults who traveled to another location to get a better view indicated that they used solar glasses (see Table 4).

A third of adult viewers reported that they photographed the eclipse or made a video recording of the event. About one in five adults who viewed the eclipse indicated that they posted a picture or commentary on social media to share the experience. Twenty-seven percent of adults who traveled to another location to view the eclipse reported posting their pictures or experiences on social media (see Table 4).

Most adult viewers of the eclipse characterized it as enjoyable and educational. When asked to agree or disagree with the statement "watching the eclipse was an enjoyable experience," American adult viewers of the eclipse gave the experience a mean rating of 7.6 using a zero-to-10 scale. When asked to agree or disagree with the statement that "watching the eclipse was an educational experience," the same adults gave a mean rating of 7.0 using a zero-to-10 scale (see Table 5).

When asked more specifically about learning more about "the Sun and the solar system" from watching the eclipse, the mean level of agreement dropped to 4.9 – just below the mid-point on a zero-to-10 scale (see Table 5). For a statement that they planned to "learn more about the Sun and the solar system in the near future," the mean level of agreement dropped to 4.5 on the same zero-to-10 scale. These results suggest that many adults found the eclipse viewing experience to be enjoyable, but only a smaller proportion were stimulated to plan additional solar learning activities in the coming months.

Table 5: Mean viewer assessment of the 2017 viewing experience.

	All viewers	**Viewed in home area**	**Traveled to view in another area**
Watching the eclipse was an enjoyable experience.	$7.6_{(0.07)}$	$7.5_{(0.08)}$	$8.1_{(0.19)}$
Watching the eclipse was an educational experience.	$7.0_{(0.08)}$	$6.9_{(0.09)}$	$7.5_{(0.21)}$
I learned about the Sun and the solar system by watching the eclipse.	$4.9_{(0.09)}$	$4.9_{(0.10)}$	$5.0_{(0.23)}$
I plan to learn more about the Sun and the solar system in the near future.	$4.5_{(0.09)}$	$4.5_{(0.10)}$	$4.6_{(0.24)}$
Note: Cell entries are the mean score on a zero-to-10 scale, with zero representing complete disagreement with the statement and 10 meaning complete agreement with the statement. The standard error of the mean is shown in the subscript parentheses.			

[7] The 2017 surveys did not ask about the number of children or grandchildren who viewed the eclipse with the survey respondent, but if only one child or grandchild accompanied the respondent, the total number of viewers would increase by 35 million. If each respondent was accompanied by two children or grandchildren, the total number of viewers would increase by 70 million. Viewing with other adults would not increase the estimated number of viewers because all adults had a probability of being selected for the original sample and they are included in the 215 million estimate reported earlier.

What was the impact of prior understanding of an eclipse on actual viewing?

Half of American adults understood the meaning of a total solar eclipse six months prior to the August event. In the February-March baseline survey, each respondent was asked to provide an explanation of a total solar eclipse in an open-ended question and 48% of American adults were able to provide a scientifically correct answer. Were those adults who understood the idea of a total solar eclipse prior to the event more likely to view the eclipse than adults who did not have a prior understanding of an eclipse? The results of the 2017 Michigan study indicate that American adults who had a prior understanding of a total solar eclipse were slightly more likely to view the eclipse directly than were adults who did not have this understanding six months prior to the event (see Table 6).

A second measure of prior understanding uses a question about the relative position of the Earth and the Sun. This question has been asked of national probability samples of Americans since 1988 and is a component of Miller's Index of Civic Scientific Literacy (Miller, 1983, 1987, 1995, 1998, 2000, 2004, 2010a, 2010b, 2012; Miller, Pardo, & Niwa, 1997), but it is a useful stand-alone question because it demonstrates an understanding of the rotation of the Earth and the Sun. The first part of this question asks whether the Earth rotates[8] around the Sun or the Sun rotates around the Earth. Those respondents who indicated that the Earth rotates around the Sun were then asked if the Earth rotates around the Sun once a day, once of month, or once a year. Individuals who were able to report that the Earth rotates around the Sun once a year are classified as having provided a correct response and all other responses are coded as incorrect. In early 2017, 63% of American adults were able to describe the relationship of the Earth and the Sun correctly.

Table 6: The impact of prior understanding on the likelihood of viewing the 2017 eclipse.

	Did not view	Viewed electronically only	Viewed in-person in home area	Traveled to view in another area	N
All U.S. Adults	12%	26%	54%	8%	2,499
Understanding of total solar eclipse [G = 0.20]					
Incorrect	15	28	50	7	1,288
Correct	9	24	57	10	1,211
Understanding of Earth and Sun [G = 0.25]					
Incorrect	17	32	44	7	926
Correct	10	23	58	9	1,573
Civic Scientific Literacy [G = 0.31]					
Not scientifically literate	13	31	50	6	1,705
Scientifically literate	10	16	62	12	795

[8] Some astrophysicists have observed that this statement implies that the Sun is stationary and that the Earth rotates around it. The authors of this question understand that our heliosphere is rotating around the center of a large spiral galaxy at a substantial speed and that none of these objects are stationary. Given the limits inherent in questionnaire wording, nearly 30 years of experience with this question leads us to conclude that most respondents do not think that it implies a stationary Sun and that those that might be confused often have a more fundamental misunderstanding of the solar system and the universe.

American adults who understood the relationship of the Earth and the Sun were slightly more likely to view the August total solar eclipse directly than adults who did not understand this relationship. Sixty-seven percent of adults who understood this relationship viewed the eclipse directly (at home or elsewhere) compared to 51% of adults who did understand this relationship. The gamma for this relationship is 0.25, meaning that 25% of the variance in viewing can be attributed to this form of prior understanding.

A third – and more comprehensive measure – of prior understanding is Miller's Index of Civic Scientific Literacy (Miller, 1983, 1987, 1995, 1998, 2000, 2004, 2010a, 2010b, 2012; Miller, Pardo, & Niwa, 1997). The CSL Index is a measure of an individual's understanding of a core set of scientific constructs – the nature of matter, energy, and life – and should be thought of as an indicator of an individual's cognitive toolbox for reading and understanding quality science journalism. Approximately 30% of American adults age 18 and older qualify as civic scientific literate. American adults who are scientifically literate were more likely to view the eclipse directly (at home or elsewhere) than adults who are not scientifically literate (see Table 6). The gamma for this relationship is 0.31.

The strength of association between these three measures of prior understanding and subsequent viewing behavior was consistently positive and ranged from 0.20 to 0.31, indicating that some level of prior understanding serves as a foundation for thinking about a forthcoming event and enables an individual to know where and how to obtain additional information about an event – the total solar eclipse in this case – prior to the event or experience. This relationship has been documented in the informal science learning literature for several decades, but it has been observed more often in regard to an exhibit or staged event rather than a major natural event like the 2017 eclipse.

PREPARING TO VIEW THE ECLIPSE

The preceding analyses have outlined the magnitude of the public viewing experience on August 21 but it is useful to inquire about the level of information seeking and preparation in the months prior to the event. For several months prior to the August eclipse, NASA and a national coalition of informal science learning organizations worked to raise public awareness about the August eclipse and to improve public understanding of some of the safety issues involved in direct observation of the Sun. For future programming efforts for similar natural and planned events, it is important to examine the kinds and frequency of information acquisition activities that interested adults used to improve their understanding of the forthcoming eclipse and related solar system questions.

Respondents to the post-eclipse survey were asked to identify the kinds of eclipse-relevant information acquisition activities they engaged in and report how many times they engaged in each activity in the two months prior to the eclipse (see Table 7). The two most common activities – talking to one's co-workers and family – involved interpersonal communication rather than broadcast or electronic media. Using this two-month window, American adults reported an average of four conversations with friends and co-workers during the two months prior to the eclipse. More than 60 years ago, Katz and Lazarsfeld (1955) outlined the power of personal influence in a landmark study and these data confirm the continuing importance of interpersonal conversation in the development of interest and the sharing of information. The same adults reported an average of 2.8 conversations with other family members during the two months prior to the eclipse and 1.4 conversations or discussions with their children or grandchildren.

Newspaper and magazine stories (printed or online) were the third most frequent source of information about the forthcoming solar eclipse, with adults reporting that they read an average of 2.3 stories relevant to the eclipse during the two months prior to the event. During the same period, adults reported an average of 2.0 internet searches about the solar eclipse (see Table 7). These adults also reported using a public

library (in-person or online) at least once during the two months prior to the eclipse. It is possible that some newspapers or magazines were consulted during library visits, but the granularity of the survey does not allow us to discern what kinds of materials were consulted or used.

In contrast, the adults in the 2017 eclipse follow-up study reported watching a television show about the solar eclipse slightly less than one time during the two months prior to the event. The use of podcasts,

Table 7: Information acquisition activities in the months prior to the 2017 eclipse.

Information Acquisition Activity	All Adults	Did not View	Viewed electronically only	Viewed in-person in home area	Traveled to view in another area
Talked to your friends or co-workers about the solar eclipse?	4.1	2.0	3.1	4.8	6.0
Talked to other members of my family about the solar eclipse?	2.8	1.3	2.1	3.2	4.0
Read a story about the solar eclipse in a newspaper or magazine (printed or online)?	2.4	0.9	1.7	2.7	3.8
Looked for information about solar eclipses on the Internet?	2.0	0.5	1.3	2.3	4.5
Talked to my children about solar eclipses?	1.4	0.5	0.8	1.7	2.0
Looked for information about the solar eclipse at a public library (in person or online)	1.0	0.3	0.6	1.2	1.7
Watched a television show about solar eclipses?	0.7	0.2	0.7	0.8	0.7
Listened to a podcast about solar eclipses?	0.2	0.1	0.2	0.3	0.4
Printed or saved an Internet article or report about the solar eclipse?	0.2	0.1	0.1	0.3	0.7
Read or contributed to a blog about solar eclipses?	0.2	0.0	0.1	0.2	0.1
Read a book (print or electronic) about solar eclipses?	0.1	0.1	0.1	0.1	0.2
Attended or streamed a lecture about solar eclipses?	0.1	0.0	0.1	0.1	0.2
Visited a planetarium or science center/museum to learn about solar eclipses?	0.1	0.0	0.0	0.1	0.1
Mean number of eclipse information acquisition activities	$15.3_{(0.41)}$	$6.2_{(0.64)}$	$10.9_{(0.61)}$	$17.8_{(0.57)}$	$24.6_{(1.94)}$

Note: Cell entries are the mean number of times survey respondents reported doing an eclipse-related information acquisition activity during the two months prior to the eclipse. The number of reported information acquisition activities ranged from zero to 131 for the two-month reporting period. The standard error of the mean is reported for only the total number of information acquisition activities and is shown in subscript parentheses.

books (printed or electronic), lectures (attended or streamed), and reading or contributing to a blog was cited less often that once every two months (see Table 7). Few adults reported visiting a planetarium, science center/museum, or similar facility as a means to obtain information about the forthcoming solar eclipse.

When these information acquisition activities are combined, America adults engaged in an average of 15 information seeking activities in the two months prior to the eclipse. Those adults who eventually viewed the solar eclipse directly were more likely to have engaged in a larger number of information seeking activities than adults who saw the eclipse only on television or a computer or phone screen or who did not see it at all (see Table 7). Adults who traveled to see the eclipse in an area of higher totality reported an average of 24.6 information seeking activities prior to the eclipse, and individuals who watched the eclipse in their home city or area reported an average of 17.8 information seeking activities in the two months before the eclipse. In contrast, adults who did not see the eclipse at all reported only 6.2 information acquisition activities in the months prior to the event.

THE IMPACT OF THE ECLIPSE ON SCIENCE LEARNING AND ATTITUDES

The preceding analyses have focused on the factors that predict direct viewing of the 2017 solar eclipse and it is important to understand the factors that encouraged individuals to make the effort to view the eclipse directly. But it is equally important to examine the consequences of engagement with an event such as the total solar eclipse as a stimulus to improving adult understanding of science broadly and space science specifically. In this section, we examine some of the major changes in adult knowledge and information acquisition in regard to science and space science.

What was the impact of eclipse viewing on science information seeking?

Our preceding analyses found that a large portion of American adults were aware of the August solar eclipse prior to the event and engaged in a number of information seeking activities to learn more about it. The finding that the average American adult engaged in 15 distinct eclipse-related information seeking activities prior to the event demonstrates (1) the large latent public interest in science and space science, and (2) the result of a large national collaboration between numerous groups and organizations – from public libraries to the Girl Scouts to school-based groups – over a period of approximately a year prior to the eclipse.

The kinds and frequency of post-eclipse information seeking activities is equally important and may tell us a good deal about adult science learning in the Electronic Era. There can be little doubt that we are in the early stages of a fundamental transformation in the ways that adults seek and acquire information (Miller, 2010b). The eclipse is a rare opportunity to examine adult science information seeking activities for a natural event that would occur at a known time and in known locations throughout the United States. Unlike unforeseen events such as a tsunami or a nuclear plant accident or similar events, many American adults were aware of the forthcoming eclipse and engaged in overt activities to acquire information about the nature and meaning of the eclipse – and hopefully some other information related to our solar system.

To assess the kinds and frequency of post-eclipse information seeking activities, respondents in the October-December survey were asked how many times they had engaged in specific activities since the August eclipse. Some respondents were asked about this activity within two months of the eclipse and others were asked three or four months later. Previous research suggests that most of the post-event information seeking activity will cluster closer to the event, thus we do not think that variation in the time since the eclipse will have a major influence on the results.

In broad terms, the post-eclipse science information seeking activities of survey respondents was similar to their reported pre-eclipse information acquisition activities. This is not surprising *per se* because many adults display a near habitual use of selected information resources. It is slightly more surprising that the volume or frequency of post-eclipse information seeking activities was essentially the same as the levels reported pre-eclipse (see Tables 7 and 8). This pattern indicates that many individuals continued to talk with their friends, family, and co-workers about the eclipse in roughly the same way that they talked about the eclipse before it occurred.

Table 8: Information acquisition activities in the months after the 2017 eclipse.

Information Acquisition Activity	All Adults	Did not View	Viewed electronically only	Viewed in-person in home area	Traveled to view in another area
Talked to your friends or co-workers about the solar eclipse?	4.1	1.8	3.0	4.8	6.2
Talked to other members of my family about the solar eclipse?	2.3	1.1	1.7	2.7	3.3
Read a story about the solar eclipse in a newspaper or magazine (printed or online)?	2.1	1.2	1.7	2.4	2.5
Looked for information about solar eclipses on the Internet?	1.8	0.8	1.1	2.3	2.9
Talked to my children about solar eclipses?	1.5	0.8	0.9	1.9	2.2
Look for information about the solar eclipse at a public library (in person or online)	1.1	0.6	0.8	1.3	1.6
Watched a television show about solar eclipses?	0.8	0.6	1.0	0.9	0.6
Watched a video about solar eclipses on YouTube?	0.7	0.3	0.6	0.8	1.0
Listened to a podcast about solar eclipses?	0.3	0.3	0.3	0.2	0.4
Printed or saved an Internet article or report about the solar eclipse?	0.3	0.1	0.1	0.3	0.4
Read a book (print or electronic) about solar eclipses?	0.2	0.1	0.1	0.2	0.1
Visited a planetarium or science center/museum to learn about solar eclipses?	0.2	0.1	0.1	0.2	0.2
Read or contributed to a blog about solar eclipses?	0.2	0.2	0.2	0.2	0.4
Attended or streamed a lecture about solar eclipses?	0.1	0.0	0.1	0.2	0.2
Mean number of eclipse information acquisition activities	$15.7_{(0.40)}$	$7.8_{(0.72)}$	$11.5_{(0.64)}$	$18.5_{(0.58)}$	$22.1_{(1.74)}$

Note: Cell entries are the mean number of times survey respondents reported doing an eclipse-related information acquisition activity during the months after the eclipse. The number of reported information acquisition activities ranged from zero to 183 for the remainder of 2017. The standard error of the mean is reported for only the total number of information acquisition activities and is shown in subscript parentheses.

Given the number and mix of eclipse-related information seeking activities, it is clear that most adults utilize a variety of information sources rather than only one or two primary sources. This pattern suggests that in the transition from a warehouse model of information acquisition to a just-in-time model of information acquisition, many adults continue to use some traditional sources, although often in a new mode. For example, an individual who has read a daily newspaper for decades may continue to do so, but may begin to read online newspaper reports rather than printed copies of newspapers. Similarly, adults who have been frequent library users in previous years may continue to utilize the library resources with which they are already familiar, but may now consult those resources online.

To understand the changes in science information acquisition, it is useful to compare the ways that today's adults sought to acquire information about the eclipse with the ways that American adults reported seeking information after the explosion of Challenger in January, 1986 (Miller, 1987b). At the time of the Challenger explosion in 1986, there was no home internet service, no smart phones, no wireless communication technologies, no World Wide Web, and no social media. Most of the information sources listed in Tables 7 and 8 did not exist in 1986, forcing adults at that time to rely on radio news reports, television news reports, printed newspapers, and printed magazines. Public libraries would have provided access to an array of print resources, but would not have had computer terminals available to allow patrons to connect to the internet and search for online information. Just-in-time information acquisition did not exist in 1986 and many of the eclipse information seeking activities reported in these 2017 surveys were not available – and largely not imagined – by American adults as they attempted to learn more about the explosion of Challenger.

Changes in adult science learning and understanding during 2017

Adults seek and acquire science information for a variety of reasons and it is difficult to attribute causality without a rigorous experimental study. The three waves of the Michigan survey conducted in 2017, however, allow us to monitor changes in adult science knowledge and understanding over this time period and we can infer that engagement with the eclipse – through direct viewing or electronic viewing – would be one of the factors responsible for changes that we observe in our measures.

During the months prior to and following the eclipse, there was frequent media coverage and many organizations – public libraries, schools, community clubs, and scouting groups – conducted programs about the eclipse. Given this growing volume of information availability about the eclipse, we would expect that many adults with some level of prior interest in science or space would follow some of the news about the eclipse and many might be expected to actively seek additional information about it either prior to the viewing or after the eclipse. In this sense, the eclipse can be seen as an important stimulus to adult science learning.

To measure changes associated with the eclipse, we measured the understanding of each of our survey respondents in February-March and again in October-December about selected scientific concepts related to the eclipse. The most direct measure is a question about the meaning of the term *total solar eclipse*. In our February-March baseline survey and our October-December follow-up survey, we asked each respondent if they had "a clear understanding of, a general sense about, or little understanding of the term a total solar eclipse." We then asked each individual who claimed to have a clear understanding or a general sense of the meaning of a total solar eclipse to describe his or her understanding of the meaning of the term. All online respondents (about 70%) provided a short written explanation in a text box. Responses from individuals interviewed by telephone (about 30%) were recorded verbatim by the survey interviewer using AmeriSpeak's interview software. Each verbatim response was coded by three independent coders and checked by supervisors.

The results indicate that half of American adults understood the meaning of a total solar eclipse in February-March and that 70% were able to explain the meaning of a total solar eclipse by the end of 2017 (see Table 9). An examination of the level of understanding of a total solar eclipse was significantly higher at the beginning of 2017 for individuals who eventually watched the eclipse in person (at home or elsewhere) than adults who did not watch it or only viewed it electronically. The rate of improvement in the level of understanding the meaning of a total solar eclipse was highest among respondents who viewed the eclipse from their home town or area. But, it is interesting to note that the increased media coverage and discussion of the total solar eclipse seems to have increased the level of understanding of an eclipse even for those respondents who did not view the eclipse in person or electronically.

Table 9: Percent of American adults able to define Total Solar Eclipse, 2017.

Type of viewing experience	Correct definition of total solar eclipse		Change	N
	February-March	October-December		
Did not view eclipse	38%	50%	+12	262
Viewed electronically only	45	64	+19	559
Viewed in-person at home	52	77	+25	1,188
Travelled to view in-person	59	74	+15	183
All adults	49	70	+21	2,192
Cell entries are the percent correct, the percent change, and the number of cases in each group.				

A second measure of information gain examined the level of understanding of the relationship between the Earth and the Sun. The idea that the Earth rotates around the Sun was contested for centuries and Galileo and Copernicus were persecuted for advocating a heliocentric solar system. Today, most students learn about out solar system and galaxy in school and it is not a subject of societal division. Several decades of survey research has found that numerous adults remain confused about this relationship. Beginning in 1988, Miller and his colleagues have asked national samples of American adults whether the Earth rotates around the Sun or the Sun rotates around the Earth. Respondents who know that the Earth rotates around the Sun are asked if the Earth rotates around the Sun once a day, once a month, or once a year.

We expected that the substantial media and interpersonal discussion about the August total solar eclipse would increase the level of public understanding about the relationship between the Earth and the Sun. All of the respondents in the February-March 2017 survey were asked the two-question sequence described above and the same respondents were asked the same questions in the November-December survey. At the beginning of 2017, 63% of American adults were able to identify the relationship between the Earth and the Sun, and 65% were able to provide a correct response at the end of 2017 (see Table 10). This is not a statistically significant result at the .05 level, meaning that there was no change between the two surveys greater than chance variation. This is a disappointing, but not totally surprising, result. A great deal of the information provided by media and various informal science education organizations focused on the meaning of a total solar eclipse with little attention to related constructs like the Earth-Sun relationship. As demonstrated above, there was significant growth in the level of understanding of a total solar eclipse during 2017, but these data suggest that the transfer to related constructs is not automatic. We will return to this issue in our final discussion.

Table 10: Percent of American adults able to define Earth-Sun relationship, 2017.

Type of viewing experience	Earth around the Sun once a year		Change	N
	February-March	October-December		
Did not view eclipse	52%	54%	+2	264
Viewed electronically only	56	57	+1	561
Viewed in-person at home	69	70	+1	1,202
Travelled to view in-person	68	67	-1	186
All adults	63	65	+2	2,213
Cell entries are the percent correct, the percent change, and the number of cases in each group.				

A third measure of understanding was respondent recognition of an image of the surface of the Sun taken by a NASA instrument (see Figure 1). Each respondent was shown this image online (for online respondents) and a copy was mailed to all telephone respondents prior to the actual interview. Each respondent was asked to identify the image without any additional information or prompt and to enter the response into a text box (for online respondents) and to describe it to the interviewer (for telephone respondents) who recorded it verbatim. The responses were coded by three independent coders and the codes were reconciled by supervisors.

Following the unaided open-ended description, each online and telephone respondent was offered a six choice multiple choice question about the meaning of the image. The six choices were:

(1) A picture of the surface of the planet Saturn.
(2) A picture of forest fires in California.
(3) A picture of the surface of the Sun.
(4) An x-ray image of the black hole at the center of the Milky Way.
(5) A computer-generated image used in a Hollywood science fiction movie.
(6) I am not sure what it is.

To be classified as providing a correct response, a respondent had to provide a correct open-ended response and to identify the image as the surface of the Sun in the multiple-choice question.

The results from the October-December follow-up survey indicate that 58% of American adults were able to provide a correct identification of the image in both an open-ended and a multiple-choice format (see Table 11). An additional 10% were able to select the correct multiple choice response, but were unable to provide a satisfactory open-ended description of the image. An analysis of the level of understanding of the image by viewer group found that adults who viewed the eclipse in person (at home or elsewhere) were significantly more likely to be able to identify the image than individuals who did not see the eclipse or watched only an electronic image of the event. Although we did not attempt to measure the level of adult recognition of the image prior to the eclipse – in large part to avoid stimulating subsequent viewing behaviors – this pattern of understanding suggests that many of the adults who viewed the eclipse had a higher level of interest in science and space prior to the eclipse event, but that the viewing experience may have provided an additional stimulus and fostered increased information acquisition activities and increased retention of that information.

As noted earlier, causality is hard to determine with certainty in human behavior when numerous events and influences are occurring simultaneously. It is likely that the media coverage and interpersonal discussion of the forthcoming eclipse stimulated and reinforced interest in many individuals and the availability of increased relevant information stimulated additional interest. The viewing experience itself may have been another positive reinforcement and the collective pre-eclipse and post-eclipse experiences produced an increased awareness of space science and intriguing cosmological questions.

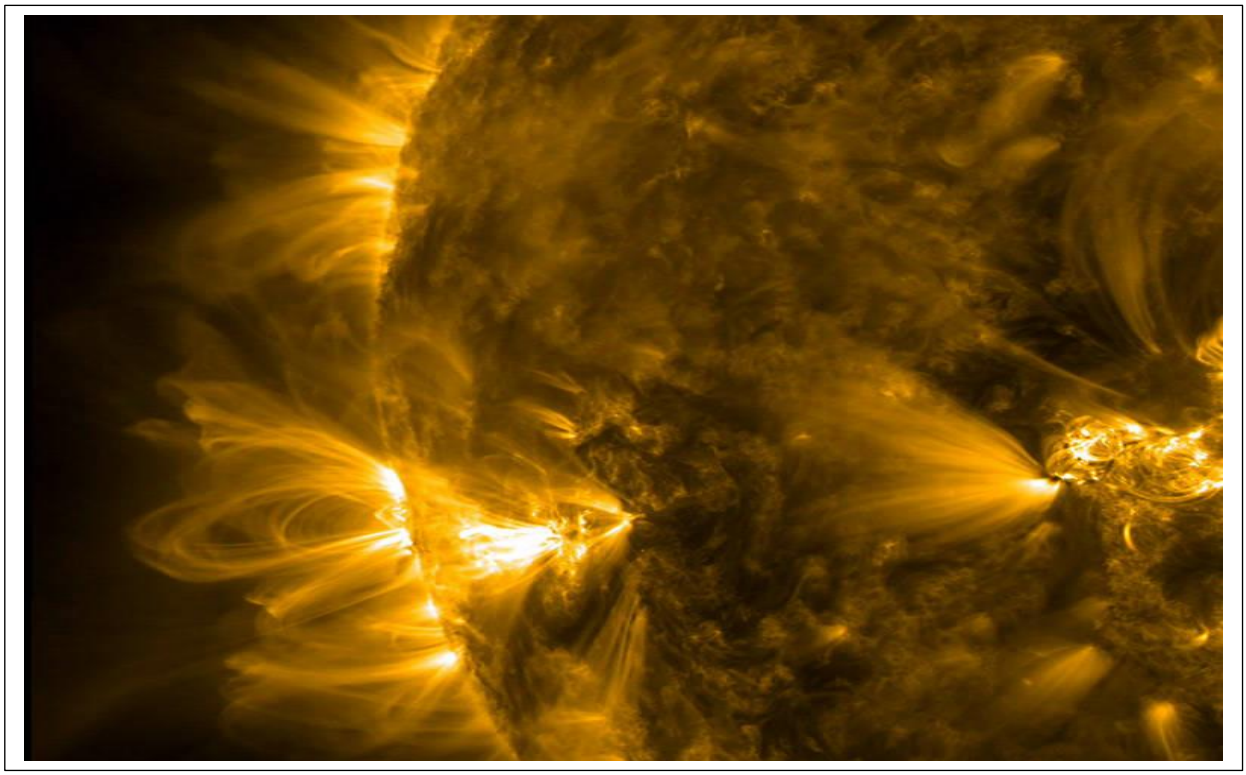

Figure 1: An image of the surface of the Sun.

Table 11: Percentage of adults able to identify an image of the surface of the Sun, 2017.

	Correctly identified Sun surface image		N
	Incorrect	Correct	
Did not view eclipse	56%	44%	263
Viewed electronically only	51	49	559
Viewed in-person at home	36	64	1,189
Travelled to view in-person	34	66	183
All adults	42	58	2,194

This raises the possibility that an event such as the 2017 total solar eclipse can foster an increased level of interest in and attentiveness to space science and related policy issues. We turn now to an examination of some of the possible longer-term effects of the eclipse experience on the interest and attitudes of American adults toward space science and space exploration.

Changes in interest in and attentiveness to space and science

The preceding analyses demonstrate that the viewing of the August solar eclipse and the surge in eclipse-related information acquisition produced an immediate expansion of public interest in and knowledge about the solar system and space science. A critical question is whether this short-term surge in interest and information acquisition will translate into a longer-term sustained interest in science broadly and space science specifically. We will assess the longer-tern impact in subsequent surveys in 2018, 2019, and 2020, but it is possible to gain some insight into the possible longer-term impact by examining changes in interest in, sense of knowing about, and attentiveness to space science and space exploration.

Building on the seminal work of Gabriel Almond (1950), Miller has defined and measured the interest, self-assessed knowledgeability, and attentiveness to science and technology policy broadly and to space exploration over the last 30 years (Miller, 1983a, 1987b, 2004b; Miller and Inglehart, 2012). Given the range and complexity of public policy issues, it is imperative that individuals focus their interest and information seeking activities on a limited number of issues or topics. This is not as much a conscious decision as the inevitable result of competing demands for time and attention in modern life. No American can assert honestly that they are interested in and well informed about foreign policy, economic policy, agricultural policy, education policy, transportation policy, housing policy, tax policy, and science and technology policy.

In this marketplace for time and attention, we measure the self-reported level of interest in various topics or issues and the self-assessed level of being informed about the area. Citizens who have a high level of interest in an area or issue and who feel that they are well-informed about that area or issue are referred to as *attentive* to that issue. Thus, we can estimate the size of the attentive public for economic issues, science and technology issues, and space exploration. Over the last 60 years, the proportion of American adults with a high level of interest in space exploration increased from approximately 10% just before the launch of Sputnik and the beginning of the space race to 34% in 1988 in the aftermath of the Challenger accident (see Figure 2). Interestingly, the short term effect of the Challenger accident was to significantly increase public interest in and support for the space program. The level of interest declined in the years during which the space shuttles were grounded and grew gradually after the resumption of space operations in the 1990's. The impact of the 9-11 attack was to diminish public interest in numerous topics other than the threat of terrorism, but public interest in space exploration has grown during the last decade, reaching 29% in 2017.

The sense of being well informed about space exploration was not measured until 1981 and has hovered about 10% in the decades since (see Figure 2). This pattern is common to almost all public policy areas with the level of interest exceeding the sense of being informed about an issue.

The combination of a high level of interest in an area or issue and a sense of being well informed produces attentiveness to that issue. Decades of research on public engagement in various policy domains has found that citizens who do not think that an issue is important are unlikely to follow or seek to become or stay informed about that area or issue. But the same research demonstrates that individuals with a high level of interest and a sense of being well-informed are significantly more likely to follow that area or issue and to engage in policy contacting when there is a dispute about a policy issue in that area. In the 20th century, most of policy contacting involved sending letters or signing petitions, but in the 21st century the Internet has made possible wider public participation through emails to public officials, donations to advocacy groups, and commentary in social media.

The relatively stable size of the attentive public for space exploration over the last three decades is an indication of the difficulty of changing the salience of major issues in the broader public. It is important to see the relative salience of space exploration in the context of the larger marketplace for the time and attention of American adults. Life has become increasingly complex over the last century and most adults

find it difficult to find enough time to do all of the things that they want to do in regard to family, work, personal health, and similar demands. Public affairs broadly must compete in a marketplace for time and attention with all of these other life factors.

Moreover, for those adults who decide to devote some time and attention to public policy issues, there is a growing range of important issues and each issue seems to have a rising threshold in terms of the amount of information or understanding required to make sense of those issues. Economic issues, foreign policy issues, educational issues, health care and policy issues, and numerous other issues all compete for the time and attention of policy interested adults. In this context, some adults will find space exploration and the space sciences to be highly salient and important, but other will find them interesting but less compelling than other pressing national problems.

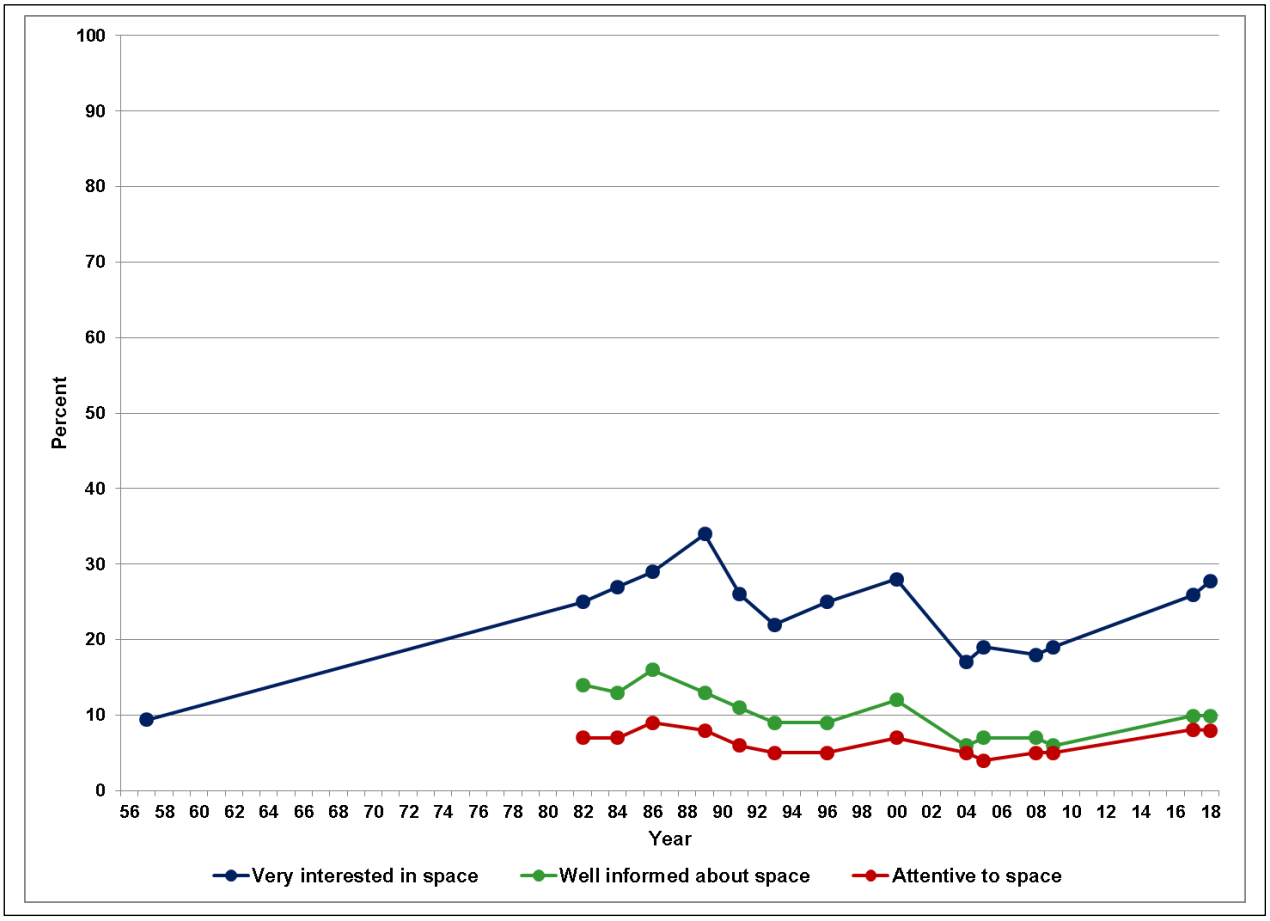

Figure 2: Public interest in, informedness about, and attentiveness to space exploration: 1957-2018.

Data from the last four decades show that seven or eight percent of American adults are attentive to space exploration and space policy, and our 2017 survey found that 8.5% of adults were attentive to space exploration and policy in February and March of 2017 – six months prior to the total solar eclipse (see Table 12). Our follow-up survey of the same adults in November and December of 2017 found that 9.2% of adults were attentive to space exploration and policy – an increase of 1.5 million adults.

This is a remarkable change that appears to be related to the experience of preparing for, watching, and following up on the total solar eclipse of 2017. In the literature on issue attentiveness, the available evidence has pointed to longer-term factors like the growth of educational attainment or an increase in the number of individuals who have taken college-level science courses as factors promoting growth in an attentive public (Miller, 1983a, 1987a). The is the first evidence of the growth of an attentive public related to the occurrence of a natural event – coupled of course with substantial outreach and educational activity before and after the event.

Table 12: The Attentive Public for Space Exploration and Policy, 2017.

	Pop/%	2017		Change
		Feb-Mar	Nov-Dec	
Attentive public for space	Pop	20,889,873	22,429,336	1,539,463
	%	8.5%	9.2%	0.7%
Interested public for space	Pop	45,811,416	45,774,197	-37,219
	%	18.7%	18.7%	0.0%
Residual public for space	Pop	178,105,247	176,603,303	-150,194
	%	72.8%	72.1	-0.7%
All U.S. adults	Pop	244,806,536	244,806,536	
	%	100.0%	100.0%	

The importance of the attentive public for space exploration. The attentive public for space exploration plays an important role in the formulation of space policy when there are policy-related disputes that cannot be resolved by policy leaders. For the last six decades, space exploration has been a policy area that operates under a broad bipartisan consensus, unlike climate change that has become more of a partisan issue than a science issue (Miller, 1983a, 2004b; Miller and Inglehart, 2012).

Because members of the attentive public for space exploration follow the news and issues pertaining to space exploration, they maintain an awareness of the major relevant information sources relevant to space and turn to those sources when a policy dispute erupts. The fall 2017 Michigan Scientific Literacy Survey asked respondents how much they would trust each of several information sources on matters pertaining to the Sun or the nature of the Universe (following a set of questions about the Sun and a picture of the surface of the Sun). The results of these inquiries illustrate the importance of the attentive public for space exploration and the high level of trust citizens who are attentive to space policy have for information from NASA (see Table 13).

On a zero-to-10 scale, with 10 representing the highest level of trust an individual can hold in information from any given information source, information about the Sun and the Universe from a NASA website was ranked first in trustworthiness, with a mean score of 6.4 for all adults and 7.3 for the attentive public for space exploration. The interested public for space exploration – adults with a high level of interest in space exploration but less certain about their own level of understanding – was equally trusting of information from NASA (see Table 13).

Information from the National Academy of Science ranked second in trustworthiness, with a mean score of 6.0 for all adults and 7.0 for the attentive public for space exploration. NOVA and the Discovery Channel ranked third in trustworthiness, following by science museums and planetariums, and a university professor of astronomy being interviewed on television. The Weather Channel and National Public Radio also ranked high in trustworthiness.

This level of trust in information is important for any group, including scientific agencies. Policy disputes sometimes erupt without extensive prior warning and it is essential to have a reserve level of public trust. It takes time to build public trust and it is especially difficult to build in the midst of a policy dispute.

Although the growth in the attentive public for space exploration during the months prior to and following the total solar eclipse was modest in raw numbers, the expansion of this attentive public by 1.5 million citizens may prove useful to the space program in the years ahead. The Michigan Scientific Literacy Survey has monitored and will continue to monitor the size and composition of the attentive public for space exploration and report its findings each year.

Table 13: Trust in Selected Information Sources, by Attentiveness to Space Exploration, 2017.

Trust in information from ….	All Adults	Attentiveness to Space Exploration		
		Attentive Public	Interested Public	Residual Public
NASA website	6.4(.07)	7.3(.23)	7.5(.15)	6.0(.09)
National Academy of Science	6.0(.07)	7.0(.22)	6.9(.15)	5.6(.09)
NOVA/Discovery channels	5.8(.07)	6.7(.23)	6.7(.15)	5.4(.08)
Science museums/planetariums	5.7(.07)	6.5(.24)	6.7(.15)	5.3(.09)
Professor of astronomy on TV	5.3(.07)	6.5(.24)	6.0(.16)	5.0(.08)
Weather Channel	4.7(.07)	5.4(.23)	5.1(.15)	4.5(.08)
National Public Radio	4.4(.07)	5.4(.24)	5.1(.17)	4.1(.09)
Network TV news (ABC, NBC, …)	4.3(.07)	4.8(.22)	4.9(.15)	4.1(.08)
New York Times/Wall Street J.	4.3(.07)	4.9(.24)	5.1(.16)	4.0(.08)
Cable news (CNN, MSNBC, ….)	4.2(.07)	4.8(.24)	4.7(.15)	4.0(.08)
Local TV news	3.9(.06)	4.4(.22)	4.3(.14)	3.7(.07)
Local newspaper	3.8(.06)	4.5(.22)	4.3(.13)	3.5(.07)
Wikipedia	3.7(.06)	4.5(.22)	4.2(.15)	3.4(.07)
Cable news (Fox)	3.3(.06)	3.9(.23)	3.4(.15)	3.2(.08)
Podcast	2.7(.06)	3.3(.22)	3.1(.14)	2.6(.07)
Religious Leader	2.2(.06)	2.4(.21)	2.2(.14)	2.2(.07)
N =	2,210	203	414	1,594
Note: Cell entries are the mean on a zero-to-10 scale with the standard error shown in parentheses.				

CONCLUSIONS AND IMPLICATIONS

The first two waves of the 2017 Michigan Scientific Literacy Study found that approximately 154 million American adults watched the total solar eclipse on August 21, 2017. An additional 61 million adults viewed the total solar eclipse on a television, computer, tablet, or smartphone screen (but not directly). This is a level of exposure that dwarfs the viewership of Super Bowl games and ranks among the most viewed events in American history.

Most of the adults who viewed the eclipse found it to be enjoyable and educational. Three-quarters of eclipse viewers obtained and used special solar viewing glasses. Most adults viewed the eclipse with friends, family, children, or co-workers. Nearly 20 million American adults traveled to a place other than their home city to improve their view of the eclipse and to increase the level of totality observed.

During the two months prior to the eclipse, millions of American adults engaged in a wide array of information seeking and acquisition activities to improve their understanding of the forthcoming event. The average American adult reported 15 information seeking activities in the months prior to the eclipse, and those adults who viewed it directly or who traveled to another location to improve their view reported even higher levels of eclipse-related information seeking prior to the event itself.

The October-November follow-up survey of these same individuals found a similar level of information seeking after the eclipse (see Table 8). This result indicates that adults seek and acquire science and space related information both before and after a major event such as the eclipse. The event itself may stimulate additional information seeking activities, building on the information obtained prior to the eclipse to expand and enhance an individual's level of understanding. It is important for educational and outreach planners to recognize that post-event (or post-visit in the case of museums, libraries, and similar informal learning facilities) learning is at least equally important and perhaps even more important to the extent that it allows individuals to integrate their experiences and form longer-term perspectives on their experience.

The results point to a significant increase in the level of the public's understanding of a total solar eclipse. At the beginning of 2017, about half of American adults were able to provide an adequate definition of a total solar eclipse, but by the end of 2017 the proportion of adults able to define a total solar eclipse jumped to 70% (see Table 9). This growth was highest among adults who viewed the eclipse in-person or electronically. Even adults who did not see the eclipse displayed some growth in understanding a total solar eclipse, undoubted reflecting the substantial media and public outreach programs of various organizations and groups.

Many communicators and educators involved in outreach expected a similar growth of understanding of related scientific constructs, but these data provide little support for that expectation. For example, the proportion of American adults able to correctly describe the relationship of the Earth and the Sun remained essentially unchanged during 2017 (see Table 10). The lesson from this finding is that adult educators and science communicators cannot assume that individuals will make a correct linkage between one scientific event and other related concepts or constructs. We must seek to communicate and explain all of the constructs we want citizens to understand.

Taken together, these results point to the potential for substantial adult science learning from natural events when there is focused programming prior to, during, and after such events. It is not sufficient to rely on media coverage, although media coverage is important. In 2017 and during the months prior to the eclipse, numerous organizations from public libraries to the Girl Scouts to museums engaged in focused and coordinated programming. These results show the potential for short-term pre-event and post-event outcomes. The Michigan Scientific Literacy Survey will continue to monitor public engagement with

science broadly and space science specifically in the months and years ahead and we expect to be able to report on longer-term outcomes in future reports.

Although almost all of the overt programming efforts were directed to broad segments of the public, the Michigan Survey found that the eclipse experience produced a small, but significant, growth in the attentive public for space exploration. These interested citizens follow and monitor the space program and are an important part of the democratic process. The Michigan Surveys documented a growth of 1.5 million citizens attentive to space exploration.

Finally, the 2017 Michigan Surveys found a high level of public trust in information from NASA about the Sun and the Universe – the topics of much of the public information related to the August eclipse. The level of trust in NASA information was highest among citizens attentive to space policy, but it was uniformly high across all major segments of the adult population. This level of trust is important for current and future NASA information programs and needs to be carefully nurtured and advanced.

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