

Understanding the public, the visitors, and the participants in science communication activities

Public Understanding of Science

1–19

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Abstract

Despite the promotion of public engagement in science, there has been little empirical research on the sociocultural and attitudinal characteristics of participants in science communication activities and the extent to which such individuals are representative of the general population. We statistically investigated the distinctiveness of visitors to a scientific research institution by contrasting samples from visitor surveys and nationally representative surveys. The visitors had more cultural capital (science and technology/art and literature) and believed more in the value of science than the general public, but there was no difference regarding assessment of the levels of national science or of the national economy. A deeper examination of the variations in the visitors' exhibit-viewing behaviors revealed that individuals with more scientific and technical cultural capital viewed more exhibits and stayed longer at the events. This trend in exhibit-viewing behaviors remained consistent among the different questionnaire items and smart-card records.

Keywords

art and science, interaction experts/publics, public participation, public understanding of science, science attitudes and perceptions, science communication, science experts, science museums

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The promotion of public engagement is a major issue in the communication of science (Stilgoe et al., 2014), and the range of outreach activities designed to enhance public participation in science has increased remarkably over the past decade (Einsiedel, 2008). Despite such active dissemination of scientific information, a prominent communication gap still exists between scientists and the public (Gauchat, 2011). Criticism of the “deficit model” remains strong, and the tendency to think of lay publics as having a deficit of knowledge has shifted to a focus on scientific experts’ lack of communication or understanding beyond the scientific community (Bucchi, 2004, 2008; Yearley, 2004). Reflecting this change, researchers are now more aware of their preconceptions and increasingly conceptualize “the public” as “publics” (Bauer, 2008; Borchelt, 2008; Macdonald, 2006). However, few studies have actually examined the varieties of visitor behaviors during science communication activities per se to explore the ways in which the participants in such activities can be distinguished from the general public (Kato-Nitta, 2013).

The current research addresses these issues by focusing on visitor surveys from open-house events at a scientific research institution, as well as nationally representative sample surveys. The distinctiveness of the participants in science communication activities can be clearly elucidated by statistically contrasting them to the respondents of nationally representative surveys; nevertheless, empirical studies in science communication that have taken such approaches are scarce. To resolve this situation, the current study proposes an approach to deepen our understanding of public communication of science by applying statistical methods to analyze the contrasting data from different populations or different survey modes.

This study further proposes that the robustness of stability and reliability must be considered in visitor studies research in science. Empirical research on visitor behaviors that evaluates such activities tends to rely on reporting evidence from single-shot interactions in a single survey. The current study utilizes two scientific outreach events at the same institution on a periodic basis. It also checks the robustness of the conclusions based on the quantitative results by comparing different methods of measuring visitor behavior.

The remainder of this article is organized as follows. We, first, briefly review previous discussions in the fields of science communication and visitor studies research. We then explain our conceptual and methodological perspectives to describe the individuals who constitute the public. Second, we determine the sociocultural and attitudinal group distinctiveness of the visitors at scientific outreach activities by statistically contrasting the samples from visitor surveys and nationally representative social surveys. Third, we examine the variety of individual visitors by statistically analyzing the factors that influence visitors’ exhibit-viewing behaviors. To this end, we utilize two visitor surveys conducted at regularly scheduled open houses of a public scientific research institution and confirm the consistency of the results using different methods of measurement for the two surveys. Fourth, we discuss the implications derived from the results and draw some conclusions.

1. Theoretical framework and purpose

Participants in scientific outreach activities

For many public research institutions, communicating science has become increasingly important (Brossard and Lewenstein, 2009). Scientists or public relations experts at these institutions have mostly envisaged the general public as their audience when they engage in science communication activities, which has prompted survey research using large-scale nationally representative samples to understand the public interest in and attitudes toward science (Bauer, 2008). Consequently, some studies have critiqued the conceptualization of the public as monolithic (Collins and Evans, 2007),

and researchers have come to conceptualize the public as plural, recognizing that they vary by time, place, or issue (Einsiedel, 2008).

Usually, for scientific experts, the people with whom they engage in dialogue during scientific outreach activities are the ‘general public’. However, results of visitor surveys that focus on visitors’ attitudes toward or interest in science cannot be generalized to the attitudes and/or interest of the general public (Kish, 2004 [1987]). There are many national surveys of public attitudes toward science, and some of these are internationally comparable (Bauer, 2008; for example, Bauer and Howard, 2013; Ishiyama et al., 2012; National Institute of Science and Technology Policy Ministry of Education, Culture, Sports, Science and Technology, 2002). Nevertheless, there are few cross-level comparisons of attitudes toward science in the national population as a whole with those of interested participants in scientific activities.

Thus, this study aims to contribute to the current debate on the public communication of science by exploring why people participate in science communication activities and how the participants’ sociocultural and attitudinal characteristics related to science differ from those of respondents to large-scale nationally representative surveys. As a previous study examining the visitors to a Japanese national research institution noted regarding the possible demographic differences between science exhibit visitors and the general public (Kato-Nitta, 2013), simply contrasting the results of visitor surveys and nationally representative sample surveys may be subject to a variety of errors. To mitigate such errors, the current study applies a statistical method to control the disparity in distribution of the attribute variables between the surveys examining different population levels (Armitage and Colton, 2005).

In the field of science communication studies, Burns et al. (2003) used terms such as “scientists,” “mediators,” “general public,” and “interested public” to describe members of the public. By contrast, we consider these categories from a survey methodological perspective. To clarify our approach, we conceptualize the survey population levels using a simplified model (Figure 1). In this model, we express the survey population into three levels. The largest ellipse represents the general public, for example, all Japanese citizens. Furthermore, we differentiate visitors into two categories: The mid-ellipse, simply visitors, refers to all the people who came to a science communication activity. The smallest ellipse represents participants, referring to highly engaged visitors who cooperated with the science communication questionnaire. The current study features data from all three levels of measurement shown in Figure 1 for cross-level comparisons.¹

This article has two purposes. The first is to determine how the group of visitors to scientific outreach activities is distinct from the general public. The second is to examine the variations among the exhibit-viewing behaviors of the individual visitors. In the following subsections, we briefly review previous discussions related to each purpose and present our hypotheses.

Purpose 1: Group distinctiveness of participants

Sociocultural distinctiveness. To explore the sociocultural characteristics of visitors participating in science communication activities, the current study employs Bourdieu’s (1984; 2001 [1986]) theory of cultural capital as a lens through which to examine the habitual behaviors related to culture that reflect people’s lifestyles. People who frequently participate in activities such as science cafés or visit science museums accumulate substantial amounts of scientific and technical cultural capital (STC); similarly, people who frequently participate in activities such as traditional art performances and read histories and novels accumulate substantial amounts of literary and artistic cultural capital (LAC). This study examines how such capital characterizes the group distinctiveness of visitors to open-house events at a scientific research institution. The previous study on public communication of science exploring this concept showed that visitors with more STC

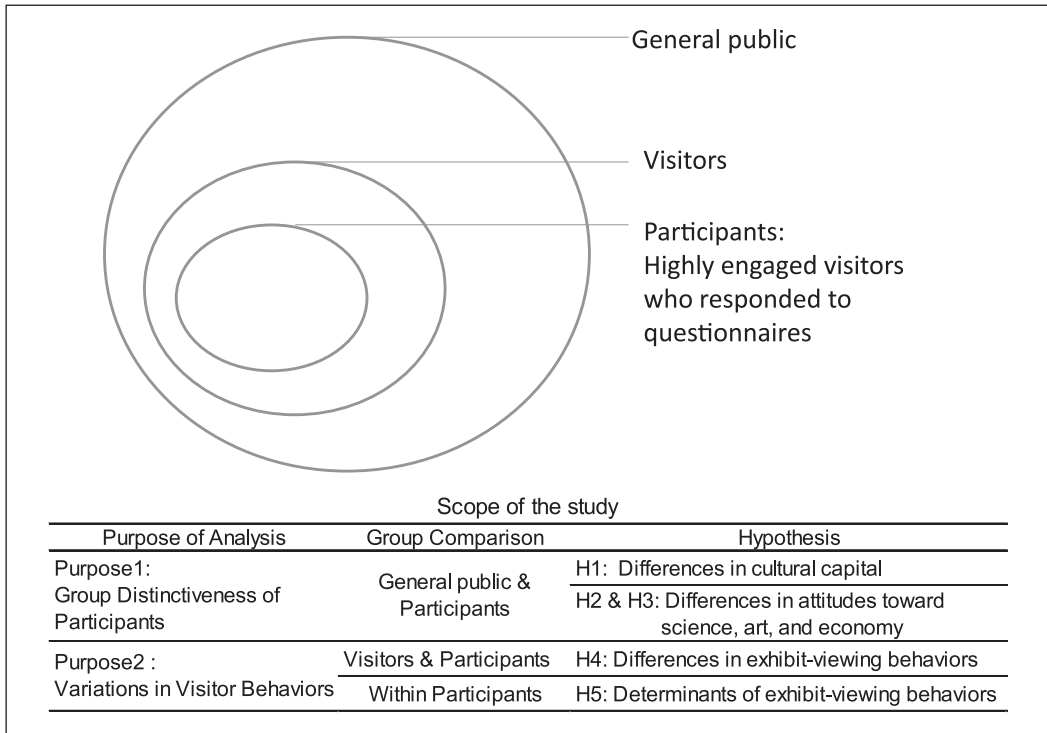


Figure 1. Conceptual three-level model of survey population.

viewed more exhibits and spent longer hours viewing the exhibits (Kato-Nitta, 2013). It also indicated that visitors' STC and their LAC were positively correlated. These findings lead to the following hypotheses:

H1-1. Participants in scientific outreach activities hold greater STC than the general public.

H1-2. Participants in scientific outreach activities hold greater LAC than the general public.

Attitudinal distinctiveness. This study further explores the attitudinal characteristics of active visitors to science communication events. Because people's attitudes toward scientific culture can be better understood when contrasted with attitudes toward other aspects of culture, we examined how the participants' attitudes toward science, art, and the economy differ from those of the general public. According to Bourdieu's theory of cultural capital and the results of the previous empirical study on the public communication of science (Kato-Nitta, 2013), people with greater STC tend to express more practical behaviors related to scientific culture. As familiarity acts as a cultural filter for aesthetic perception (Redies, 2007), visitors participating in science communication activities should draw influences from both the "national culture" and the "scientific culture." By contrast, the general public is influenced only by the national culture. Therefore, we assumed that participants would attribute a more universal value to science than the population as a whole, which would shape their sensitivity and esthetic disposition toward it (Bourdieu, 2001 [1986]; Bucchi, 2013; Kato-Nitta, 2013):

H2. Participants in scientific outreach activities show more favorable attitudes toward the value of scientific research than the general public.

By contrast, the participants' assessments not including practical value to national culture (i.e. science, art, or economy in Japan) should be no different from those of the general public.

H3-1. Participants' assessments of the level of science in their own country are not different from those of the general public.

H3-2. Participants' assessments of the level of art in their own country are not different from those of the general public.

H3-3. Participants' assessments of the level of the economy in their own country are not different from those of the general public.

To explore the sociocultural and attitudinal characteristics of visitors participating in science communication activities, this study statistically tested *H1–H3*.

Purpose 2: Variations in visitors' exhibit-viewing behaviors

Comparison of visitor questionnaire respondents and nonrespondents. The questionnaire survey is one of the most frequently used research methods for quantifying visitors in science communication research. Visitor surveys generally assume that the population is "all the visitors" to a specific institution or a specific event. However, even under complete or equal probability sampling conditions, there are always respondents and nonrespondents in a questionnaire survey. The effects of nonresponse bias have been extensively addressed in the social and behavioral sciences (e.g. Groves and Peytcheva, 2008; Martikainen et al., 2007) but have not been adequately discussed in the field of public communication of science. If there are significant behavioral differences between respondents and nonrespondents among visitors, then the effects of such bias should be considered when interpreting visitor behaviors.

In this study, visitor behaviors were quantified in terms of two variables: (a) the total number of exhibits viewed and (b) the total amount of time spent at the event. As these are two of the most frequently measured fundamental behavioral variables in visitor studies research (Serrell and Adams 1998; Serrell, 2016 [2010]), comparing the respondents' and nonrespondents' scores on these variables should lead to a basic understanding of visitor behaviors in science communication. As completing the questionnaire requires additional work, those who volunteer to do so show more cooperative behavior toward scientific activities. Therefore, we assumed the following:

H4-1. Total viewing time is longer for questionnaire respondents than for nonrespondents.

H4-2. The total number of exhibits viewed is greater for questionnaire respondents than for nonrespondents.

The influence of cultural capital on exhibit-viewing behaviors. In the previous study on this topic, Kato-Nitta (2013) empirically determined the demographic distinctiveness of visitors to an open-house event at a public scientific research institution. The visitors tended to be highly educated adults and their school-aged children. Visitors to museums are similarly likely to be highly educated and of a higher social class than the population as a whole (Falk, 2009; Hooper-Greenhill, 2006; Seiyama and Hara, 2006). Scholars of museum visitor studies (Falk, 2009; Falk and Dierking, 2012; Macdonald, 2006) have claimed

that such demographic variables provide a poor explanation for museum going and have explored another dimension, namely, that a sociocultural context such as group formation (e.g. whether a visitor came alone or as part of a group) is a variable that may affect visitor behaviors.

Kato-Nitta (2013) explored the different aspects of the visitors' sociocultural context and concluded that the visitors' cultural capital (Bourdieu, 2001 [1986]), which is accumulated through various cultural activities in which they engage with their family members, influenced their exhibit-viewing behaviors at the scientific outreach event. Those who had previously accumulated substantial amounts of STC viewed more exhibits and spent more hours at the current event. This finding has the potential to contribute to a theoretical deepening of science communication studies because it partially explained why people participate in science communication activities and empirically demonstrated how their sociocultural background influences their current behaviors. Nonetheless, it must be tested against extant observations because in the social and behavioral sciences, the obtained results are often unstable and sometimes change dramatically even when data are analyzed with the same statistical models. If the empirical knowledge obtained from the different surveys conducted at different occasions with different methods of measurement is stable, then the results can be interpreted as robust and may provide an insight that can be generalized.

As replication tests the stability of the findings from previous empirical studies and reduces the effects of random fluctuations (Open Science Collaboration, 2012), the current study replicates the findings of Kato-Nitta (2013) and enhances them by incorporating the following two approaches. First, we discuss the influence of STC on visitors' exhibit-viewing behaviors by incorporating additional control variables of attributes, as well as the variable of social arrangement (group formation), into the statistical models and compare the strength of each variable's effect on the visitors' exhibit-viewing behaviors. For this purpose, we test the hypotheses below:

H5-1. Participants with higher STC scores view more exhibits than those with lower STC scores.

H5-2. Participants with higher STC scores spend more hours viewing exhibits than visitors with lower STC scores.

This approach was expected to provide valuable quantitative insights into the deeper issues of understanding variations in visitor behaviors.

Second, we confirm the stability of the results from the statistical analyses based on *H5* with two methods of measurement: the questionnaire survey and electronic recording devices. A recent trend in visitor studies is to actively utilize electronic devices and software to collect and record data on visitor behaviors (Moussouri and Roussors, 2013; Rennie, 2014). However, these materials are relatively cost-inefficient and are, thus, not always available to researchers interested in the public communication of science. By assessing visitors' exhibit-viewing behaviors using multiple methods of measurement, we contrast the results of the statistical analyses to examine to what extent the two measurements vary quantitatively. This approach should, thus, provide the fundamental information required for interpreting visitor surveys in science communication activities.

2. Materials and methods

Data

The statistical analyses² used data from the following four surveys:

Survey 1: a 2009 visitor survey at the Institute for Molecular Science (IMS),

Survey 2: a 2012 visitor survey at the IMS,

Survey 3: the 2013 Japanese National Character Survey,

Survey 4: a 2014 web-based Internet survey of Japanese citizens.

Surveys 1 and 2 were visitor surveys conducted at the open-house event at the IMS.³ It is in Okazaki city, located at the east end of Chūkyō Metropolitan Area of Japan which has currently a population of about 380,000. The city is considered as education-oriented area, and several national scientific research organizations are based in this city. The IMS open-house events are held every 3 years. The exhibit contents not only introduce cutting-edge research results in molecular sciences but also demonstrate various aspects of the molecular sciences with interactive elements understandable to elementary-level students. The IMS also owns large-scale experimental devices, for example, the Ultraviolet Synchrotron Orbital Radiation (UVSOR) Facility (a synchrotron light source) and supercomputers, and the exhibitions include guided tours to such facilities. The IMS researchers prepare the exhibits to present their field of research as an outreach activity.

In Survey 1, the questionnaires were administered to all 1126 open-house visitors on 17 October 2009, and 785 anonymous responses were obtained (response rate 58.1%; male 421, female 360, unknown 4). The Survey 1 data were the same as those used in Kato-Nitta (2013), the precursor to the current study. In Survey 2, the questionnaires were administered to all 1126 open-house visitors on 20 October 2012, and 566 anonymous responses were obtained (response rate 50.3%; male 327, female 237, unknown 2). Both questionnaires were individually distributed at the reception desk and collected as the visitors left. The samples in Surveys 1 and 2 represent the participants' population shown in Figure 1.

In Survey 2, smart cards were distributed to the visitors with the questionnaires. The ID numbers for each card-questionnaire pair were matched in advance. The visitors were asked to touch the cards to recording devices placed near the entrance/exit gates and the exhibits viewed to provide electronic records of the total viewing time and total number of exhibits viewed for all 1350 visitors. The smart-card records represent the visitors' population shown in Figure 1.

The data for Survey 3 were drawn from the 2013 Japanese National Character Survey, which is a repeated cross-sectional survey conducted every 5 years since 1953 by the Institute of Statistical Mathematics that aims to determine Japanese attitudes and ways of thinking. The 2013 survey used a stratified two-stage probability sampling, and a nationally representative sample of 6400 was drawn from the Japanese population aged between 20 and 84 years. Two types of questionnaire were used in the study, one for each half of the sample; 1591 and 1579 respondents, respectively, completed the items that were used (response rate 49%). The sample in Survey 3 represents the general Japanese public.

Survey 4 was a web-based survey conducted in August 2014. The survey operation, entrusted to a survey company, used a quasi-representative sample from a large opt-in panel of online population. Participants aged between 20 and 69 years were drawn from these online panels, with a sample size of 1000 (male 500, female 500). To reduce the potential response bias, the samples were allocated in proportion to the population size according to region, gender, and age based on 2010 Japan national census data. The sample in Survey 4 quasi-represents the general Japanese public.

Variables

The categorical variables were the attributes of age (increments of 10 years), gender (female=1, male=0), education (adults who had completed junior college, technical college, university, or

graduate school were categorized as highly educated = 1; the others were categorized as 0), and group formation (came alone = 1, came as a group = 0).

To quantify the respondents' cultural capital (Surveys 1, 2, and 4), we used a cultural capital scale developed by Kato-Nitta (2013). The scale consists of eight items that load according to two factors: STC and LAC. The scale measures the frequency of participation in activities involving science, art, music, and literature in the previous years using a five-point scale. The variables of STC and LAC were constructed by totaling the scores of the four items in each category after confirming the reliability and validity of the scales using data from Surveys 2 and 4.⁴

To quantify the attitudes toward various facets of culture (Survey 2), four items were used to assess (a) the value of scientific research, (b) the level of Japanese science, (c) the level of Japanese art, and (d) the level of the Japanese economy; these were drawn from the 2013 Japanese National Character Survey (Survey 3):⁵

Item 1 (a): To what extent do you think that science and its applications bring improvements to your everyday life? (*H2*);

Item 2 (b): How would you rate the level of science and technology in Japan today? (*H3-1*);

Item 3 (c): What about the level of artistic achievement? How would Japan rate? (*H3-2*);

Item 4 (d): What about the level of economic achievement? How would Japan rate? (*H3-3*).

Visitor behaviors were measured in several ways. The questionnaires measured exhibit-viewing time on a five-point scale (Survey 1), the number of exhibits viewed using self-report boxes representing exhibits (Survey 1), and the number of exhibits viewed using a self-reported unique number (Survey 2). The smart cards assessed viewing time (Survey 2) and the number of exhibits viewed (Survey 2).

Analysis

To determine the distinctiveness of the open-house visitors, the statistical analysis used the following two procedures:

1. A Mann–Whitney U test was used to assess the distribution of values between the participants and the general public for STC and LAC (*H1*);
2. A chi-squared test was used to assess the distribution of values for attitudes toward science, art, and economy between the participants and the general public (*H2*, *H3*).

The above comparisons include analyses of crude estimates of means and proportions and estimates adjusted for the distributions of the attribute variables of age, gender, and education. Adjustment was carried out using the direct method of standardization to statistically control the effects of these variables (Armitage and Colton, 2005). Although the respondents to Survey 1 and Survey 2 included visitors under the age of 20, the above analyses used data only from visitors aged 20 or older for purposes of comparison with Surveys 3 and 4.

To examine the exhibit-viewing behaviors of the open-house visitors, the following statistical analyses were used:

1. The total viewing time and number of exhibits viewed for questionnaire respondents and nonrespondents were statistically contrasted using Student's *t*-test (*H4*).

The above analysis used data from both adults and children who responded to Survey 2.

2. The influences of cultural capital on the participants' exhibit-viewing time and number of exhibits viewed were examined using regression analysis to confirm the stability and agreement between the different methods of measurement (H5).

The above analysis used data only from visitors aged 20 years or older for replication purposes.

3. Results

Distinctiveness in cultural capital

Comparisons of the responses of the participants in the IMS open house (Survey 2) and the general Japanese public (Survey 4) to the eight items measuring STC and LAC are shown in Table 1.

The mean values of all eight items were higher for the participants than for the general Japanese public. There were statistically significant differences between the distributions for the participants and the public, not only for all items of STC but also for all items of LAC for the crude results (all p -values were less than .001). The result was the same even after statistical adjustments for the distributions of the attribute variables of age, gender, and education for all eight items with direct methods of standardization (all p -values were again less than .001). Thus, H1-1 and H1-2 were supported. The participants in scientific outreach activities hold greater cultural capital than the general public as a whole regarding both STC and LAC. The participants in the IMS outreach activity were involved more actively not only in scientific activities but also in literary and artistic activities.

Distinctiveness of attitudes toward cultures

Attitudes toward various facets of culture were compared for the participants (Survey 2) and the general Japanese public (Survey 3). Table 2 shows the results of the statistical tests for the four items based on H2 and H3.

More IMS visitors than the general Japanese public considered that "science improves daily life" (Item 1). The chi-squared test was statistically significant ($\chi^2=277.022$, $df=3$, $p<.001$). As shown in Table 2, this result did not change even after statistical adjustments for the distributions of age, gender, and education. Therefore, H2 was supported.

There was no significant difference between the IMS participants and the general Japanese public in attitudes toward the level of Japanese science (Item 2). This result did not change even after statistical adjustments for age, gender, and education. Therefore, H3-1 was supported.

More IMS participants had a negative attitude than the general Japanese public toward the level of Japanese art (Item 3). The chi-squared test was statistically significant ($\chi^2=27.557$, $df=3$, $p<.05$). This result changed to marginal significance ($p=.053$) after statistical adjustments were made for age, gender, and education. Therefore, H3-2 was not supported, but this conclusion is tentative, as the results were not clear.

With regard to positive attitudes toward the level of the Japanese economy (Item 4), there was a significant difference between the IMS participants and the general Japanese public before adjustment for attribute variables. However, this difference disappeared after statistical adjustments were made for age, gender, and education. Therefore, we accept the latter result (no significant difference), and thus, H3-3 was supported.

Table 1. Results of the statistical tests for the eight items of cultural capital scale based on HI.

Items ^c	Survey 4 (n = 974)		Survey 2							
	Mean	SE	Crude (n = 287–299)				Adjusted (n = 269–286) ^{a,b}			
			Mean	SE	Mann–Whitney’s U	p	Mean	SE	Mann–Whitney’s U	p
1. Science museum	1.42	.024	2.17	.047	14.996	<.001	2.07	.049	12.255	<.001
2. Science café	1.19	.018	1.87	.054	14.541	<.001	1.73	.052	13.200	<.001
3. Science TV	1.44	.029	2.80	.072	18.175	<.001	2.64	.076	15.943	<.001
4. Science magazine	1.89	.038	3.25	.068	15.210	<.001	3.06	.075	13.338	<.001
5. Classic music	1.49	.026	2.06	.060	9.006	<.001	1.90	.060	6.796	<.001
6. Art museum	1.75	.030	2.65	.052	13.140	<.001	2.47	.054	11.098	<.001
7. Novels	2.45	.047	3.29	.073	8.286	<.001	3.16	.080	7.115	<.001
8. Kabuki	1.29	.021	1.50	.047	4.592	<.001	1.47	.045	4.666	<.001

SE: standard error.

^aEffective sample size was lessened because of missing values in attribute variables.

^bAdjustment are made for gender, age, and educational background with direct methods of standardization.

^cItem contents are as follows:

STC: 1–4. LAC: 5–8.

1. Going to a science museum or planetarium.
2. Going to a science lecture, science event, or science café.
3. Reading a science magazine or science book.
4. Watching a science program on television or going to see a science movie.
5. Going to a classical music performance or concert.
6. Going to an art museum or other (nonscience) museum.
7. Reading novels or history books.
8. Going to Kabuki, Noh, Bunraku, or other traditional Japanese art performances.

Table 2. Results of the statistical tests for the four attitudinal items based on H2 and H3.

Items/categories	Survey 3 ^{a,c} (n = 1585/1572)		Survey 2 (n = 299–302)				Adjusted (n = 261–292) ^{a,b}			
			Crude		Diff		%		Diff	
	%	SE	%	SE	test's Z ^d	Chi-squared test and p-value	%	SE	test's Z ^d	Chi-squared test and p-value
Item 1. Science improves daily life?										
1. A lot	38.9	1.224	70.9	2.658	10.942	277.002 (df=3)	61.9	4.402	5.037	85.883 (df=3)
2. A little bit	45.7	1.251	23.6	2.486	-7.945	<.001	31.2	4.318	-3.229	<.001
3. Not at all	10.4	.767	1.0	.590	-9.695		1.3	1.027	-7.073	
4. Other/don't know	5.0	.547	4.5	1.207	-.402		5.6	2.225	.248	
Item 2. Level of S & T in Japan										
1. Very high	34.7	1.201	35.7	2.809	.329	2.624 (df=3)	38.5	4.528	.810	3.070 (df=3)
2. Fairly high	52.2	1.260	49.1	2.931	-.967	.453	46.1	4.550	-1.299	.381
3. Low (fairly/very)	7.3	.657	9.6	1.729	1.247		9.6	2.650	.853	
4. Other/don't know	5.7	.586	5.5	1.336	-.156		5.7	2.332	.003	
Item 3. Artistic achievement of Japan										
1. Very high	16.0	.924	18.8	2.417	1.085	27.557 (df=3)	19.2	3.797	.825	7.704 (df=3)
2. Fairly high	60.9	1.231	51.7	3.093	-2.750	<.001	53.7	4.760	-1.459	.053
3. Low (fairly/very)	15.8	.919	25.7	2.704	3.465		22.9	3.892	1.772	
4. Other/Don't know	7.4	.659	3.8	1.188	-2.611		4.2	2.274	-1.324	
Item 4. Economic achievement of Japan										
1. Very high	5.4	.570	8.3	1.623	1.684	9.882 (df=3)	7.9	2.546	.945	5.470 (df=3)
2. Fairly high	43.8	1.251	37.4	2.846	-2.057	.020	39.8	4.482	-.854	.140
3. Low (fairly/very)	47.5	1.259	51.9	2.939	1.391		50.6	4.471	.680	
4. Other/don't know	3.4	.455	2.4	.904	-.938		1.7	.772	-1.840	

SE: standard error.

^aEffective sample size was lessened because of missing values in attribute variables.^bAdjustment are made for gender, age, and educational background with direct methods of standardization.^cEffective sample size of Survey 3 was 1585 for Item 1 and was 1572 for Items 2–4.^dApproximate Z statistic testing the difference in the proportion of two surveys for each category.

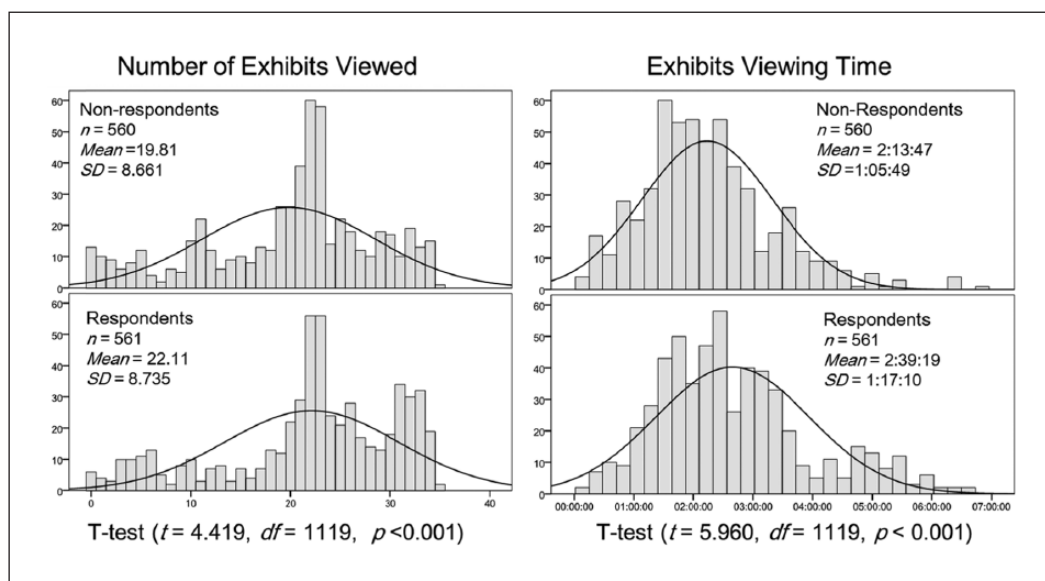


Figure 2. Results of comparison of questionnaire respondents' and nonrespondents' exhibit-viewing behaviors.

Each bin of the histograms represents the number of cases.

Solid line in each figure represents the normal curve with the same mean and SD.

Exhibit-viewing time unit: hh:mm:ss.

Comparison of questionnaire respondents' and nonrespondents' exhibit-viewing behaviors

The exhibit-viewing time and number of exhibits viewed were compared for the questionnaire respondents and nonrespondents (Survey 2; *H4-1*, *H4-2*). The results are shown in Figure 2.

The mean exhibit-viewing time for nonrespondents was 2: 13: 47 (2 hours, 13 minutes, and 47 seconds); the mean viewing time for respondents was 2: 39: 19 (Figure 2). Student's *t*-test was statistically significant ($t = 5.960$, $df = 1119$, $p < .001$). Therefore, the questionnaire respondents viewed the exhibits for a longer time than the nonrespondents, and *H4-1* was supported.

The average number of exhibits viewed by nonrespondents was 19.81, and the average number viewed by respondents was 22.11 (Figure 2). Student's *t*-test was statistically significant ($t = 4.419$, $df = 1119$, $p < .001$). Therefore, the questionnaire respondents viewed more exhibits than did the nonrespondents, and *H4-2* was supported.

Stability tests for the influence of cultural capital on visitor behaviors with different methods of measurement

H5-1 and *H5-2* were tested using regression analyses. The dependent variables were the participants' total number of exhibits viewed and total exhibit-viewing time. These variables were measured using both the questionnaires and the smart-card records.

The independent variables were STC and LAC, and the control variables were gender, age, education (educational capital), and group formation. The results are shown in Table 3.

Table 3. Comparison of regression analyses for the influence of cultural capital on visitor behaviors.

Variables	Exhibit-viewing behaviors									
	Survey 1					Survey 2				
	Number		Time			Number		Time		
	Model 1 (questionnaire)		Model 2 (questionnaire)			Model 3 (questionnaire)		Model 4 (smart-card record)		
	B	95%CI	β	B	95% CI	β	B	95% CI	β	B
Constant	6.271 [†]	[-2.11, 12.752]		1.390***	[.750, 2.031]		28.159***	[17.016, 39.302]		129.501***
Gender	-1.792	[-4.312, 7.28]	-.078	.084	[-.167, .335]	.039	.265	[-3.438, 3.967]	.009	-3.475
Age	.579	[-.385, 1.542]	.067	.059	[.038, .156]	.072	-.809	[-2.338, .720]	-.073	-1.158
Education	-3.056*	[-5.839, -.272]	-.117	.142	[-.133, .418]	.058	-4.105*	[-8.115, -.096]	-.130	-1.288
Group formation	-.664	[-3.545, 2.217]	-.025	-.032	[-.318, .254]	-.013	2.272	[-2.744, 7.287]	.060	2.586 [†]
STC	.754***	[.364, 1.144]	.225	.073***	[.035, .111]	.236	.748*	[.163, 1.333]	.167	.081
LAC	-.024	[-.485, .436]	-.006	-.015	[-.060, .030]	-.043	-.319	[-.992, .354]	-.062	.032
F (df 1, df 2)		4.601*** (6, 354)			3.286** (6, 325)			1.975 [†] (6, 247)		
R ²		.072			.057			.046		.027
Adjusted R ²		.057			.040			.023		.008
n		361			332			254		312
										309

CI: confidence interval; STC: scientific and technical cultural capital; LAC: literary and artistic cultural capital.

Number = numbers of exhibits viewed. Time = exhibits viewing time. B = Unstandardized regression coefficients, β = Standardized regression coefficients

Time unit: five-point scale (Model 2), Minute (Model 3).

Gender = female 1, male 0. Age = increments of 10 years. Education = highly educated 1, others 0. Group formation = came alone 1, came as a group 0.

i = $p < .1$, * = $p < .05$, ** = $p < .01$, *** = $p < .001$.

Although Models 1 and 3 featured different self-response items from questionnaire surveys conducted in different years, they produced similar results. STC had a positive effect and education a negative effect on the total number of exhibits viewed. The results for LAC were not significant. These results were consistent with the findings of Kato-Nitta (2013) even after including the additional control variables of gender, age, and group formation.⁶ Therefore, *H5-1* was supported by Models 1 and 3.

Model 4 was not statistically significant. This may be attributed to noise arising from a Bingo game during the event in which all the visitors were able to participate by using their smart cards. Additional statistical analysis with multivariate normal mixture modeling (Arbuckle, 2012; Arminger et al., 1999; McLachlan and Peel, 2000) that used two variables of the number of exhibits viewed (questionnaire data and smart-card record) revealed that 13.6% of the participants were estimated to have stopped touching their smart cards to the recording devices during the Bingo game.⁷ Therefore, the participants' involvement level in the incentives for this game may have influenced the results.

Models 2 and 5, which used different methods of time measurement, produced similar results. STC had a positive effect, and the effects of education and LAC were not significant. These results are consistent with those of Kato-Nitta (2013) even after including the control variables of gender, age, and group formation (see Note 6). Therefore, *H5-2* was supported.

4. Discussion and conclusion

The results of the current study provided quantitative evidence for the sociocultural and attitudinal group distinctiveness of participants in a scientific outreach activity at the IMS. Participants tended to have more cultural capital than the general Japanese population with regard to both science and technology and art and literature. Their assessments of the level of national science or the level of the national economy were no different from those of the general Japanese public, but their attitudes toward the universal value of scientific research were much more positive than those of the general public. Thus, participants in science outreach activities can be characterized as people who affirm the value of scientific culture more positively and who possess more cultural capital than the Japanese public as a whole. Using the approach of cross-level comparisons between the visitor surveys and the nationally representative surveys, we proposed a research framework for determining the disparity of the distribution of variables in different levels of the population in science communication activities.

As scientific experts may take the value of scientific research for granted, they would be surprised to know that more than 10% of the general public answered "Not at all" to the question "Does science improve daily life?" The distributions of this category range from approximately 6% to 10% in the past 30 years and remain relatively stable in Japan (Nakamura et al., 2008; The Institute of Statistical Mathematics, 2013). This study's results show a statistically significant difference between the participants and the general public: The participants in the scientific outreach activity showed much more positive attitudes toward the value of science (only 1% of the visitors answered "Not at all"). Such differences remained even after adjustments were made for the disparity in distributions of gender, age, and education between the two groups. This finding indicates that people who participate in dialog with scientific experts at scientific outreach activities tend to show more positive attitudes toward science than the general public as a whole.

The following findings only strengthen the above concern. There were significant differences even among visitors at the same scientific event. When the visitors were categorized as either questionnaire respondents or nonrespondents, there were statistically significant behavioral differences

between them. The respondents viewed more exhibits and stayed longer at the event than the non-respondents. Furthermore, there were statistically significant behavioral differences even within the relatively homogeneous group of questionnaire respondents. Those with higher STC viewed more exhibits and stayed longer at the event.

Such findings suggest the following conclusions. There are not only differences between visitors to the exhibitions and the general public but also differences between visitors who participated by completing the questionnaire and those who did not. Participants tended to appreciate the value of science, have more cultural capital than the general public, and hence, participate in scientific activities, and they also engaged in more exhibit-viewing behaviors than other visitors. Hence, the participants of science communication are, indeed, distinct not only from the general public but also from the lower engaged visitors.

The current study, which statistically compared visitor surveys and nationally representative sample surveys, provides essential information for scientific experts or practitioners involved in the institutional communication of science who are interested in understanding their visitors and the extent to which such visitors are or are not representative of the general population. These data should also be useful for science communication researchers who are unable to conduct large-scale nationally representative surveys by providing insight into potential or nonattending visitors.

Our results of statistically confirming both *H1-1* and *H1-2* indicated that the participants in science communication had previously been more actively involved in not only scientific and technical cultural activities but also in literary and artistic cultural activities than the Japanese people as a whole. This finding implies that outreach activities by scientists in collaboration with artists may promote visitors' interest in science (Drumm et al., 2013; Ede, 2002; Halpern, 2011). Although the variable LAC was not statistically significant for all the models in Table 3, it may have affected the visitors' exhibit-viewing behaviors at the scientific event by the use of artistic elements. Therefore, the effects of this variable should be further discussed in future surveys that investigate scientific outreach activities that include artists.

H3-2 was not supported. The participants' assessments of the level of Japanese art were slightly lower than those of the general Japanese public in the crude analysis, and the difference was marginally significant ($p = .053$) after statistical adjustments were made for age, gender, and education. Because the purpose of distributing the questionnaires to the visitors who participated in the current study was not exclusively research, the questionnaire space was constrained, and we were unable to include additional items. Hence, the interpretation of this inconsistent result requires further surveys on artistic activities (in addition to scientific activities) that include items regarding the universal value of those activities.

STC was the only variable that was statistically significant for all the significant regression models (Models 1, 2, 3, and 5) across the different methods of measurement of visitor behaviors. This variable should be the essential one of interest in understanding visitor behaviors in the public communication of science, as Falk (2009) has pointed out in museum visitor studies, the key to understanding the visitor experience is the construct of identity, and Cote and Levine (2002) have stated that people's construct of identity is closely related to the concept of cultural capital.

The variable of group formation was statistically significant in Model 5. This indicates that the participants who came alone viewed more exhibits than those who came as a group. Social arrangements, such as group formation (see Note 6), have been identified by scholars in museum visitor experiences as variables that are much more valuable than demographics in understanding visitor behaviors (Falk, 2009; Falk and Dierking, 2012; Macdonald, 2006), and it is understandable that the visitors who came to the event of their own accord would be relatively more enthusiastic. However, this variable was not significant in the other significant models, Models 1, 2, and 3. Therefore, this result may also be attributed to the noise caused by the participants' involvement in

the Bingo game. Further discussion and elaboration of the survey methodology for visitor behaviors are warranted (Moussouri and Roussors, 2013; Rennie, 2014; Serrel, 2016 [2010]).

Our conclusions regarding the distinctiveness of participants in science communications are based on visitor surveys at regularly held open-house events at a public scientific research institution compared with nationally representative sample surveys. Thus, the results of the current study cannot directly apply to specific issues or risks of participants in science communication activities. When conducting visitor surveys, scientists or researchers must clearly set their respective target populations based on their interests to understand their visitors.

Our approach of statistically adjusting the different distributions of the attribute variables among the different groups reduced diverse errors when interpreting sociocultural and attitudinal characteristics of participants in science communication. As this approach is also suitable for statistical comparisons between different countries, as well as different visitors, it provided a deeper insight into public communication of science.

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Notes

1. For each level, there were both a population (subpopulation) and a sample drawn from the population. Our survey used the latter. For simplicity, Figure 1 does not differentiate the population and the sample drawn from the population.
2. All statistical analyses were conducted with SPSS ver21 and AMOS ver21.
3. We statistically contrasted the distribution of the questionnaire items pertaining to the visitor attributes (gender, region, age, education, and occupation) of Survey 1 (year 2009) and Survey 2 (year 2012) using chi-squared statistical tests and confirmed that there was no significant difference between the two surveys. This procedure ensured that both the samples represent the target visitor population to the same degree.
4. Cronbach's alpha reliability coefficients were calculated for scientific and technical cultural capital (STC), .708 (Survey 2) and .771 (Survey 4), and for literary and artistic cultural capital (LAC), .618 (Survey 2) and .733 (Survey 4). We further conducted confirmatory factor analyses with the two cultural capital sub-scales as factors and eight questionnaire items as observed variables explained by the corresponding factors. Results similar to those of Kato-Nitta (2013) and Tachikawa et al. (2015) were obtained: a two-factor structure was confirmed (STC and LAC). Correlation coefficients between the two factors were .458 for Survey 2 and .778 for Survey 4, and both were statistically significant ($p < .01$). A relatively weak correlation between the two factors was obtained for Survey 2, which was conducted using a more homogeneous group of open-house visitors than the general Japanese citizens in Survey 4. This is a general phenomenon in truncation data; when there is a relatively strong correlation between the two variables, a weaker correlation in the upper right corner of the scatter diagram is generally observed (Dodge, 2004).
5. Maeda (1995) used two of the same items (level of Japanese science and level of Japanese economy) as independent variables. According to his study, people who scored higher on these two items tended to

- score higher on the item that assessed the degree of satisfaction with the society. For Survey 3 data used in this study, results similar to those of Maeda (1995) were obtained; that is, people who scored higher on the three items (level of Japanese science, art, and economy) also scored higher on the item “satisfaction with the society.” The current study’s statistical analyses using the three items (Table 2) controlled for gender, age, and education; therefore, we do not further discuss the effects of these attribute variables.
6. In visitor studies research, visit frequency (whether a visitor came for the first time or came as a repeated visitor) is a variable also identified as affecting visitor behaviors (Falk, 2009). Therefore, we confirmed the results with models that included the control variable of visit frequency. However, this variable was not statistically significant for all the models, and the results were essentially unchanged. Therefore, we present the models without the variable of visit frequency in Table 3.
 7. The result of statistical analysis with multivariate normal mixture modeling ($n=394$) showed that there were four subgroups among the participants. Group 1 (9.5%), relatively small numbers of exhibits viewed: estimated mean values 13.155 for questionnaire and 12.489 for smart card; Group 2 (47.4%), relatively moderate numbers of exhibits viewed: estimated mean values 22.949 for questionnaire and 22.557 for smart card; Group 3 (29.5%), relatively large numbers of exhibits viewed: estimated mean values 36.493 for questionnaire and 31.308 for smart card; Group 4 (13.6%), relatively disproportionate numbers of exhibits viewed between the two measurements: estimated mean values 12.378 for questionnaire and 3.814 for smart card. Therefore, the existence of Group 4 may manifest as noise on the smart-card record and lead to bias toward weaker correlations with other variables. Because the purpose of the visitor survey at the event was not exclusively for research use, such incentive effects should be discussed further in studies that focus on survey methodology.

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