



MULTIMEDIA RESEARCH

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Summative Evaluation of
Earth & Sky Radio Shows on
Nanoscale Science and Engineering

Report for
Earth & Sky, Inc.

by
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Research Report No. 08-013
April 2, 2008



This material is based on work supported by the National Science Foundation under Award No. 0426417. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

INTRODUCTION

Earth & Sky (E&S) is a short-format science radio series airing daily on more than 1,000 commercial and public radio stations and translators in the U.S. as well as on satellite and Internet radio outlets. The series is also widely heard beyond U.S. borders. Produced by a small non-profit, Earth & Sky, Inc. of Austin, TX, the series is hosted by Deborah Byrd and Joel Block and consists of 90-second programs on a wide variety of topics mostly drawn from environmental sciences, earth sciences and astronomy but also including emerging technologies like nanotechnology. Over the previous three years, National Science Foundation has supported the development, broadcast and Internet archiving of more than 80 shows on nanoscale science and engineering. This report presents a small summative evaluation exploring the impact of *Earth & Sky* nanotechnology shows on listeners.

Nanotechnology, as described by *E&S*, “is all about making things that are less than 100 nanometers in size. A nanometer is one-billionth of a meter. A single strand of hair – sliced across like salami – would measure 100,000 nanometers across. The nanometer scale is the scale of atoms and molecules. The molecules of living things – such as proteins and DNA – have dimensions on the nanoscale. At this scale, atoms are in constant motion and quantum effects begin to be important. In the past two decades, tools such as the scanning tunneling microscope have let scientists see the world at the nanoscale and begin to manipulate it. Using nanotechnology, scientists and engineers are able to create molecular devices not found in nature. Materials act profoundly differently at the nanoscale. At this scale, a material’s properties – like electrical conductivity and mechanical strength – change. Manufactured nanoparticles have many applications that scientists are only now beginning to explore.”¹

Earth & Sky, Inc. has presented more than 80 shows on nanoscale science and engineering. These shows are also available for listening streamed online, as downloadable podcasts, and as written transcripts on earthsky.org. Most recently, from January to September, 2007, 32 nano-content 90-second shows were broadcast through public, commercial and international radio outlets. The 32 shows consider nanotechnology in medical diagnosis and treatment (7 shows), computer technology (5), privacy (4), health risks (3), fabrics (3), status of the field (3), solar energy (2), water (2), nanoscale properties (1), green technology (1) and informal education (1).

¹ See www.earthsky.org/blog/50688/top-10-things-to-know-about-nanotechnology for more.

METHOD

Study Design

Given a very small budget and no ability to control listening behavior, this study utilized a web-based explanatory survey design² comparing groups with different exposures to *E&S* and comparing *E&S* listeners with historical control groups. *E&S* e-list subscribers completed a self-administered web-based survey. Survey questions on nanotechnology awareness, factual knowledge, and risk and benefit attitudes were drawn from recent published surveys of random national samples. For each of the dependent measures of awareness, knowledge, and risk/benefit attitudes, the study design looked at responses of the *E&S* listener sample compared to data collected from participants in previous national surveys (historical control groups). Additionally, the study assessed differences between self-selected sub-samples of varying *E&S* exposure (i.e., low frequency listeners of *E&S* vs. higher frequency listeners; and listeners who recall having heard nanotechnology presented on *E&S* vs. listeners who did not recall such programs).

Procedure

The following survey invitation was emailed to all 1058 members of earthsky.org's e-list:

Subject header:

EARTH & SKY SURVEY – TELL US WHAT YOU THINK! – WIN GIFT!

Message:

EARTH & SKY wants to hear your thoughts so that we can make our programs as appealing and clear as possible. Please click on the link below to answer a 5-minute online survey. Upon completion of the survey, you can enter a drawing for one of five Bushnell NatureView 8x40 Birder Binoculars (a \$50 value).

Please do not pass this invitation to others; you are part of a specially chosen group, and others are not eligible for the binocular drawing. We hope that you will respond soon.

<http://www.earthsky.org/survey>

One week later the above message was sent again with an additional opening sentence:

If you have already responded to our feedback survey, thank you. If you have not, we'd appreciate hearing from you soon.

² Smith, M. L. & Glass, G.V. (1987). *Research and evaluation in education and the social sciences*. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Clicking on the URL, earthsky.org/survey, directed respondents to a questionnaire hosted on surveymonkey. The survey included questions about

- Demographics: gender, age, education, and ethnicity;
- E&S media habits: typical source for hearing *E&S*; frequency of hearing *E&S* last week
- Nanotechnology: awareness, factual knowledge, and risk/benefit attitudes.

Prior to answering questions about nanotechnology, respondents read the following:

Earth & Sky is planning future programs about the emerging field of science called nanotechnology. To help us plan these programs, we'd like to know what our listeners already know about this field and what their interests are.

Most of the nanotechnology questions were drawn from national surveys in order to use the representative national samples as historical comparison groups for the *E&S* sample. The national questions dealt with

- Awareness: “How much have you heard about nanotechnology?”³
- Knowledge: “Indicate which of these statements you feel is true and which is false.” (List of 6)⁴
- Risk/benefit attitude: “In general, how risky do you consider nanotechnology to be for the United States society as a whole? In general, how beneficial do you consider nanotechnology to be for the United States society as a whole?”⁵

Additional questions of those who had heard of nanotechnology included:

- Exposure source: “In which of the following do you clearly remember reading, seeing or hearing about nanotechnology?”
- Awareness of applications: “Have you heard of nanotechnology being used in the following applications?” (List of 8)
- E&S nanotechnology programs: “Do you recall hearing any programs on *E&S* about nanotechnology?” “As a follow-up to hearing an *E&S* program about nanotechnology, have you done any of the listed activities?” “Describe, as best you can, what you recall about nanotechnology from any *E&S* program you have heard.”

³ Used in Peter D. Hart Research Associates, Inc. (2007 Sept.). Awareness of and attitudes toward nanotechnology and federal regulatory agencies. Available at Project on Emerging Technologies at www.wilsoncenter.org. Kahan, D. M., Slovic, P., Braman, D., Gastil, J., & Cohen, G. (2007 March). Nanotechnology risk perceptions: The influence of affect and values. Available at Cultural Cognition Project at Yale Law School at <http://research.yale.edu/culturalcognition/>. National Science Board (2008 Jan.). Science and Technology: Public Attitudes and Understanding. Chapter 7 in Science and Engineering Indicators 2008. Available at National Science Foundation at www.nsf.gov/statistics/seind08/.

⁴ Used in Brossard, D., Scheufele, D., & Kim, E. (forthcoming) Religiosity as a perceptual filter: Examining processes of opinion formation about nanotechnology. Public Understanding of Science. Made available by Dietram Scheufele, Dec., 2008.

⁵ Used in Currall, S.C., King, E.B., Lane, N., Madera, J. & Turner, S. (2006). What drives public acceptance of nanotechnology? *Nature Nanotechnology*, 1, 153-155.

Sample

The survey invitation was emailed in February, 2008, to all 1058 members of earthsky.org's e-list. No e-mail invitations were bounced back due to incorrect addresses; thus, our respondent sample is a non-probability volunteer sample of subscribers to the e-list.

Return rate. The survey remained open for three weeks and elicited 462 unique respondents of the 1058 recruited, yielding a response rate of 44% (462/1058). The response rate refers to those who started the survey by answering the first background question about their source of hearing *E&S*. This return rate compares favorably with an average rate of 39.6% reported in a meta-analysis of 68 web-based surveys.⁶

Completion rate. Nine participants did not proceed beyond the first survey question. Another 28 participants completed demographic and background questions and the initial nanotechnology awareness question but did not complete the remaining nanotechnology questions. Thus, the completion rate for the survey is 92% (425/462). Respondents who did not fully complete the survey did not differ from those who did complete the survey in terms of demographics and background characteristics (gender, age, education, ethnicity, familiarity with nanotechnology).

Listeners. The study is focused only on *E&S* listeners, so 57 respondents who reported "never" hearing *Earth & Sky* were dropped from the study as not being listeners of the radio series. These non-listeners did not differ from listeners in demographics and background characteristics.

The sample characteristics for the set of 368 *E&S* listening respondents are given on the next page in Table 1. Our sample has a fairly equal gender distribution and a normal age distribution from 15 to 94 years, with a mean of 53. Respondents with more education than a college degree comprise 51% of the sample. The sample includes 14% minorities, which are mostly international respondents. A 2005 national sampling of 1714 public radio *E&S* listeners showed comparable demographics (19 to 100 years; $M = 53$ years; 60% post-college education), with lower minority representation (2%).⁷

Almost half (47%) of our sample reports listening to *E&S* online or via podcast; this percentage is likely a function of using the e-list for respondent recruitment. The other half listen via public radio (45%) or other off-line sources (8%).

⁶ Cook, C., Heath, F., & Thompson, R. L. (2000). A meta-analysis of response rates in Web- or Internet-based surveys. *Educational and Psychological measurement*, 60, 821-836.

⁷ Flagg, B. N. (2005). Can 90 seconds of science make a difference? *The Informal Learning Review*, 75(2-3), 22-23.

Table 1. Demographic and Background Characteristics of *E&S* Listeners Who Completed Survey

		% of N = 368
Gender	Male	57%
	Female	43%
Age	Range: 15-94 years Mean = 53.1 years Median = 55 years	
Race/Ethnicity	White, not of Hispanic origin	86%
	Minority ⁸	14%
Highest level of education	High school graduate or less	3%
	Some college or technical	24%
	College graduate	22%
	Courses or degrees beyond college	51%
Typical source for hearing <i>E&S</i>	<i>E&S</i> 's podcast or online at earthsky.org	47%
	Public radio	45%
	Commercial radio	4%
	Satellite radio (Sirius, XM)	2%
	Voice of America or World Radio Network or American Forces Radio	2%
	Cell phone	0%
Frequency of hearing <i>E&S</i> in past week	Not heard in past week = 41%	
	Once = 19%	
	Lower exposure (heard once or not at all)	60%
	Twice = 13%	
	3 times = 10%	
	4 times = 5%	
	5 times = 7%	
	6 times = 1%	
	7 times = 4%	
Higher exposure (heard 2-7 times)	40%	
Recall of ever hearing <i>E&S</i> programs about nanotechnology (n = 357) ⁹	Yes	35%
	No	65%

E&S Sub-samples

The study design compares groups with different exposures to *E&S* (see bottom rows of Table 1). The multiple-choice answers to the question of how many times the respondent has heard *E&S* in the past week were combined to form two groups: “lower exposure” defined as heard once or not at all in the past week (60%) and “higher exposure” defined as heard 2 to 7 times in the past week (40%). Frequency of exposure is not independent of gender. Men tend to report higher listening frequency than women: 45% of men fall into the higher exposure group compared with 34% of women, and 66% of women fall into the lower exposure group compared with 55% of men.¹⁰

⁸ Minorities included 7% Asian, 3% Hispanic, 3% Black, 1% American Indian/Alaskan Native. These include both American and international respondents.

⁹ The N for this group does not include 11 respondents who had “never heard of nanotechnology.”

¹⁰ A 2 x 2 chi-square test indicated a significant relationship, $\chi^2(1, N=360) = 4.838, p=0.0278, V = .115$. The Cramer's V effect size is small.

Those respondents who had heard of nanotechnology (n = 357) were asked if they recalled ever hearing any programs on *Earth & Sky* about nanotechnology. About one-third (35%) reported having heard a nanotechnology program, and two-thirds (65%) had not. For men, hearing a nanotechnology program is significantly related to *E&S* exposure level. More than half (54%) of the men in the high exposure group had heard a nanotech program compared with 27% of men in the low exposure group.¹¹

Dependent variables were explored for significant group differences between those with higher and lower *E&S* exposure and between those who did and did not recall hearing an *E&S* nanotechnology program. Statistical tests reaching significance at $p \leq .05$ are reported in the results sections that follow.

Historical Control Groups

Several recent national studies provide the nanotechnology questions and data for the historical comparison groups:

- Awareness:
 - Peter D. Hart Research Associates, Inc. (2007 Sept.). Awareness of and attitudes toward nanotechnology and federal regulatory agencies. Available at Project on Emerging Technologies at www.wilsoncenter.org. In August, 2007, Hart Research Associates conducted a representative national telephone survey of 1014 adults.
 - Kahan, D. M., Slovic, P., Braman, D., Gastil, J., & Cohen, G. (2007 March). Nanotechnology risk perceptions: The influence of affect and values. Available at Cultural Cognition Project at Yale Law School at <http://research.yale.edu/culturalcognition/>. In December, 2006, Knowledge Networks conducted a nationally representative online survey of 1500 adults.
 - National Science Board (2008 Jan.). Science and Technology: Public Attitudes and Understanding. Chapter 7 in Science and Engineering Indicators 2008. Available at National Science Foundation at www.nsf.gov/statistics/seind08/. In 2006, the University of Chicago National Opinion Research Center interviewed face-to-face a representative national sample of 1854 adults.
- Knowledge:
 - Brossard, D., Scheufele, D., & Kim, E. (forthcoming). Religiosity as a perceptual filter: Examining processes of opinion formation about nanotechnology. *Public Understanding of Science*. Made available by Dietram Scheufele, Dec., 2008. This study uses a representative telephone survey of 706 adults from fall of 2004.
- Risk/benefit attitudes:
 - Currall, S. C., King, E. B., Lane, N., Madera, J. & Turner, S. (2006). What drives public acceptance of nanotechnology? *Nature Nanotechnology*, 1, 153-155. In August, 2005, Zogby International conducted a representative telephone survey of 503 adults.

¹¹ A 2 x 2 chi-square test indicated a significant relationship, $\chi^2 (1, N=204) = 15.83, p \leq 0.0001, V = .278$. The Cramer's V effect size is small.

AWARENESS OF NANOTECHNOLOGY

Several recent national studies, described in the previous section, asked a multiple-choice question about awareness of nanotechnology, as presented in the left-hand column of Table 2. Table 2 presents the question results from the *E&S* sample and three national studies.

Table 2. Awareness of nanotechnology

How much have you heard about nanotechnology?	<i>E&S</i> 2008 Sample N = 368	Peter D. Hart, 2007 Sample N = 1014	U. of Chicago, 2006 Sample N = 1864	Kahan et al, 2006 Sample N = 1500
Heard a lot	23%	6%	5%	5%
Heard some	46%	21%	15%	14%
Heard a little	24%	29%	25%	28%
Heard nothing at all	3%	42%	54%	53%
Not sure	3%	2%	2%	NA

Historical control comparisons

Clearly the *E&S* sample feels significantly better informed about nanotechnology than the national samples: 69% of *E&S* listeners report having heard “a lot” or “some” about nanotechnology compared with 27%, 20%, and 19% in the national studies. However, the *E&S* sample is also much better educated than the national population. The U.S. census bureau¹² estimated in 2006 that 27% of the nation had bachelor’s degrees compared with our sample’s 73%, and the census bureau estimated that 10% of the nation had graduate degrees compared with our sample’s 51%.

For the national data available by education level, we find in the Hart study that 39% of those with a college education report hearing “some” or “a lot” about nanotechnology compared with 74% of *E&S* college-educated listeners reporting the same. In the Chicago study, 33% of those with a post-graduate degrees report hearing “some” or “a lot” about nanotechnology compared with 73% of *E&S* post-graduate-educated listeners.

Our self-selected sample of *E&S* listeners is also more likely to be attentive to science as compared to a nationally representative sample. The closest comparison in the national studies for a “science-attentive” group is a sub-sample reported in the Chicago study of those who have taken nine or more science/math courses (n = 408): 37% of this group report hearing “some” or “a lot” about nanotechnology.

E&S sub-sample comparisons

Awareness of nanotechnology was not significantly related to frequency of exposure to *E&S*. Of those who reported having heard “a lot about nanotechnology,” 52% were in the “lower exposure” group and 48% in the “higher exposure” group.

¹² Retrieved from http://factfinder.census.gov/servlet/ADPTable?_bm=y&-geo_id=01000US&-qr_name=ACS_2006_EST_G00_DP2&-ds_name=&-lang=en&-redoLog=false

A significant relationship was found between awareness of nanotechnology and recall of having heard an *E&S* program about nanotechnology.¹³ Of those who recalled having heard a nanotechnology *E&S* program (n = 125), 81% had heard “a lot” or “some” about nanotechnology compared with 66% of those who had not heard an *E&S* nanotechnology program (n = 232).

SOURCE OF EXPOSURE TO NANOTECHNOLOGY

Respondents who had heard of nanotechnology were asked whether or not they clearly remember reading, seeing or hearing about nanotechnology in each of the following sources listed in Table 3. More than half of the sample remember nanotechnology in print, Internet, radio and television sources.

Table 3. Source of exposure to nanotechnology

Respondents clearly remember reading, seeing or hearing about nanotechnology in:	N = 357 % Yes
Print: Newspapers, magazines, journals, books	80%
Internet	75%
Radio	64%
Television	53%
Word of mouth: Family, friends, coworkers	39%
Museums, Science centers	32%
Movies	29%
Consumer product labels	5%

Those with more frequent exposure to *E&S* were more likely to report being exposed to nanotechnology through the Internet¹⁴, radio¹⁵, television¹⁶, and movies¹⁷, compared to those who listened to *E&S* less frequently.

A significant relationship was found between sources of exposure and recall of having heard an *E&S* program about nanotechnology. Of those who recalled having heard a nanotechnology *E&S* program (n = 125), 80% reported radio as a source compared with 55% of those who did

¹³ A 2 x 4 chi-square test indicated a significant relationship, $\chi^2 (3, N=357) = 8.58, p=0.035, V = .155$. The Cramer’s V effect size was small.

¹⁴ A 2 x 2 Fisher exact test indicated a significant relationship, $\chi^2 (1, N=357) = 4.910, p=0.0352, V = .117$. The Cramer’s V effect size was small.

¹⁵ A 2 x 2 Fisher exact test indicated a significant relationship, $\chi^2 (1, N=357) = 5.952, p=0.0186, V = .128$. the Cramer’s V effect size was small.

¹⁶ A 2 x 2 Fisher exact test indicated a significant relationship, $\chi^2 (1, N=357) = 4.883, p=0.0309, V = .117$. The Cramer’s V effect size was small.

¹⁷ A 2 x 2 Fisher exact test indicated a significant relationship, $\chi^2 (1, N=357) = 9.158, p=0.0030, V = .160$. The Cramer’s V effect size was small.

not recall an *E&S* nanotechnology program (n = 232).¹⁸ Also, of those who heard a nanotechnology *E&S* program, 87% reported the Internet as a source compared with 68% of those who did not recall an *E&S* nanotechnology program.¹⁹ As indicated in Table 1, almost half of our sample listen to *E&S* via the Internet.

AWARENESS OF NANOTECHNOLOGY APPLICATIONS

Those who had heard of nanotechnology (n = 357) were asked if they had heard of it being used in applications, as listed in Table 4. The *E&S* survey presented alternative responses of “yes,” “no,” and “Don’t Know.” The applications were presented in a random order for each respondent.

Table 4. Awareness of nanotechnology applications

Respondents have heard of nanotechnology being used in the following applications:	<i>E&S</i> n = 357 % Yes
Computing technologies	81%
Medical diagnostics and treatment	79%
Clothing; Fabric	46%
Solar technology	43%
Air and water purifiers	35%
Cosmetics; skin lotions	31%
Sports equipment	18%
Washing machines	8%

Those with more frequent exposure to *E&S* were more likely to report an awareness of nanotechnology in air and water purifiers²⁰ compared to those who listened to *E&S* less frequently. In addition, those who reported having heard an *E&S* nanotechnology program were significantly more aware of nanotechnology in the applications of clothing and fabric,²¹ cosmetics and skin lotions,²² sports equipment,²³ and washing machines.²⁴ However, these are not applications that were covered by *E&S* programs in any significant manner.

¹⁸ A 2 x 2 Fisher exact test indicated a significant relationship, $\chi^2 (1, N=357) = 2.38, p \leq 0.0001, V = .250$. The Cramer’s V effect size was small to moderate.

¹⁹ A 2 x 2 Fisher exact test indicated a significant relationship, $\chi^2 (1, N=357) = 16.31, p \leq 0.0001, V = .214$. The Cramer’s V effect size was small to moderate.

²⁰ A 2 x 2 Fisher exact test indicated a significant relationship, $\chi^2 (1, N=356) = 12.31, p = 0.0006, V = .186$. The Cramer’s V effect size was small.

²¹ A 2 x 2 Fisher exact test indicated a significant relationship, $\chi^2 (1, N=356) = 20.39, p = 0.0001, V = .239$. The Cramer’s V effect size was small to moderate.

²² A 2 x 2 Fisher exact test indicated a significant relationship, $\chi^2 (1, N=356) = 14.98, p = 0.0002, V = .205$. The Cramer’s V effect size was small to moderate.

KNOWLEDGE OF NANOTECHNOLOGY

Those *E&S* listeners who had heard of nanotechnology were asked six true-false items as listed in the left-hand column of Table 5. Statements were presented in a random order for each respondent, and all statements are true. *E&S* listeners are correct beyond chance for those statements with an asterisk.²⁵

Table 5. Knowledge of nanotechnology

Respondent feels statements listed below are true	<i>E&S</i> N = 357 % True/Correct
*Nanotechnology involves materials that are not visible to the naked eye.	82%
*Experts consider nanotechnology to be the next industrial revolution of the U. S. economy.	75%
*U. S. corporations are using nanotechnology to make products sold today.	63%
A nanometer is a billionth of a meter.	53%
Nanotechnology allows scientists to arrange molecules in a way that does not occur in nature.	51%
A nanometer is about the same size as an atom.	23%

Historical control comparison

Brossard, Scheufele, and Kim (forthcoming) used these six statements as dichotomous true/false items. Their telephone study of 706 adults yielded an additive scoring range from 0 to 6 with a mean of $M = 3.90$ ($SD = 1.55$). Treating “don’t knows” as incorrect, the range for the *E&S* respondents is 0 to 6 with a mean of $M = 3.47$ ($SD = 1.52$). As measured by these six statements, the *E&S* sample does not have a knowledge level higher than that of the national survey sample. The sub-sample of those who recall hearing *E&S* nanotechnology programs also do not show a higher knowledge level than the national sample ($M = 3.90$; $SD = 1.30$).

E&S sub-sample comparisons

Those with higher exposure to *E&S* scored significantly higher on the knowledge questions than those with lower exposure (means = 3.7 vs. 3.3, respectively).²⁶ Also, those who had heard an *E&S* nanotechnology program scored significantly higher than those who had not heard such a program (means = 3.9 vs. 3.2, respectively).²⁷

²³ A 2 x 2 Fisher exact test indicated a significant relationship, χ^2 (1, $N=356$) = 8.898 $p=0.0038$, $V = .158$. The Cramer’s V effect size was small.

²⁴ A 2 x 2 Fisher exact test indicated a significant relationship, χ^2 (1, $N=355$) = 5.053 $p=0.0285$, $V = .119$. The Cramer’s V effect size was small.

²⁵ One-sample χ^2 tests, $p < .0001$.

²⁶ Independent groups t test: t (340) = 2.518, $p=0.0123$, $d = .27$. Cohen’s d shows a small to medium effect size.

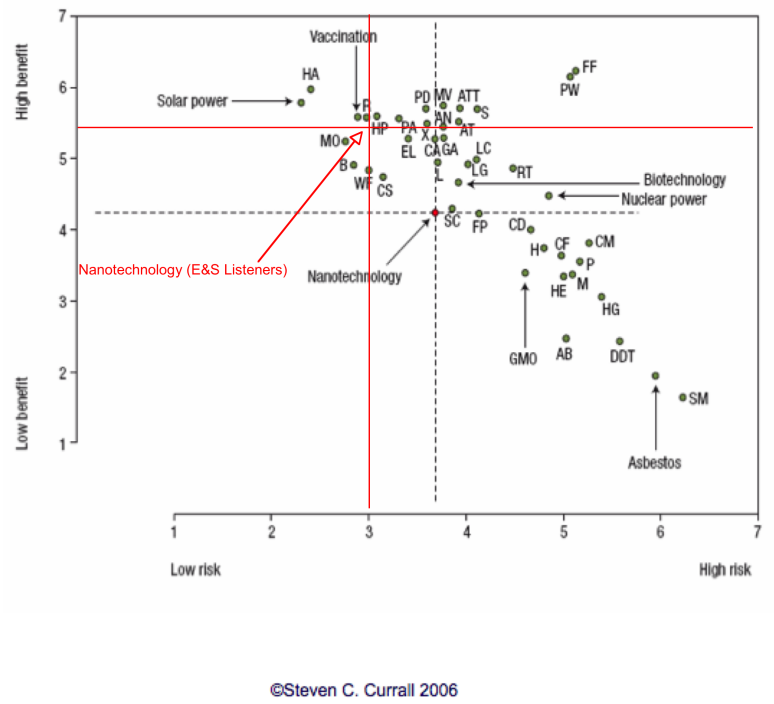
²⁷ Independent groups t test: t (297) = 4.299, $p<0.0001$, $d = .48$. Cohen’s d shows a medium effect size.

RISK/BENEFIT ATTITUDE

Two survey questions related to assessing risk/benefit attitudes were asked of those respondents who had heard about nanotechnology. One question asked respondents: “In general, how risky do you consider nanotechnology to be for the United States society as a whole?” The second question substituted ‘beneficial’ for ‘risky.’ Respondents chose one number on a scale from 1 (low risk/low benefit) to 7 (high risk/high benefit). The mean risk level was 3.0 (n = 349) and the mean benefit level was 5.4 (n = 349). Listeners rate nanotechnology as significantly more beneficial than risky.²⁸

Historical control comparison

In a 2005 telephone study of 503 adults, Currall, King, Lane, Madera & Turner (2006) asked the two questions on risk/benefit of nanotechnology along with similarly formatted paired questions for 43 other technologies. The chart to the right presents the risk/benefit means for all the technologies. The dotted black lines indicate the risk/benefit mean x,y intersection for the national sample. The red solid lines superimposed on Currall’s original chart indicate the intersection for the *E&S* listeners. Although the numerical means for the national sample are not available, visually it appears that the *E&S* listeners rate nanotechnology as higher in benefit and lower in risk compared to the national sample.



E&S sub-sample comparisons

Those with higher exposure to *E&S* did not differ from listeners with less frequent exposure in either their mean risk ratings or their mean benefit ratings. Those who reported having heard an *E&S* nanotechnology program also did not differ significantly on mean risk and benefit ratings compared with those listeners who had not heard such a program.

²⁸ Paired groups *t* test: $t(348) = 17.40, p < 0.0001$.

EARTH & SKY NANOTECHNOLOGY PROGRAMS

About one-third (35%, n = 125) of those who were aware of nanotechnology reported having heard a nanotechnology *Earth & Sky* program. This sub-sample was asked if they had done any of a list of activities in Table 6 as a follow-up to hearing an *E&S* program about nanotechnology. More than half of those who recalled hearing a nanotechnology *E&S* program said they had “paid more attention to nanotechnology in other media” (74%) or “discussed nanotechnology with others” (51%).

Table 6. Impact of *E&S* on activities

Respondent has done activity listed below as follow-up to hearing <i>E&S</i> nanotechnology program	<i>E&S</i> n = 125 % Yes
Paid more attention to nanotechnology in other media	74%
Discussed nanotechnology with others	51%
Read transcript of a nanotechnology show on earthsky.org website	42%
Looked for additional nanotechnology information on earthsky.org website	37%
Listened to another nanotechnology show on earthsky.org website	34%

Respondents were asked to describe, as best they could, what they recall about nanotechnology from any *E&S* program they had heard. Most responded with remembering something about what nanotechnology is (28%) and/or something about applications of nanotechnology (28%).

- 44% gave no response or reported that they could not recall anything.
- 28% provided statements of what nanotechnology is and what it involves as a science:
 - 18% described nanotechnology as occurring on a very small scale; e.g.,
Nano = very small
Nanotech examines the very, very small aspects of the world
Science of the incredibly small, head-of-a-pin type stuff. Hard to grasp.
 - 7% described nanotechnology as occurring on a molecular, atomic scale; e.g.,
It's the science of the very small – atoms and molecules.
Creating products at a molecular level.
 - 7% described nanotechnology as permitting manipulation and manufacture at a very small scale; e.g.,
Nanotechnology is about engineering materials at the scale of atoms and molecules.
It relates to controlling matter on an extremely small scale.
 - 4% described nanoscale structures or machines; e.g.,
I remember best about nanotubes.
Machines that are on such a small scale it is like science fiction in the ways that they can be applied.

- 28% described applications of nanotechnology:
 - 12% described medical applications; e.g.,
 - The program had something to do with using nanotechnology for repairing damage to the human body done by disease. There might have been a mention of using nanotechnology to repair injury as well.
 - Using nanotech to detect the cancer cells in human bodies.
 - Changes at nanoscale can develop new medical examination techniques and even new drugs or other medical treatments.
 - 6% described general applications; e.g.,
 - That products made through the use of nanotechnology have doubled in one year.
 - Great commercial potential.
 - It has potential application in almost every arena of life.
 - 4% described computer applications; e.g.,
 - Can made our computers smarter and faster.
 - Would lead to computers vastly reduced in size.
 - 4% described space applications; e.g.,
 - Building a carbon bridge to space.
 - Sky elevator.
 - 8% described other applications related to energy, water, retail goods; e.g.,
 - Has many different applications. Can turn salt water into drinking water, can help the environment, transparency.
 - Nanofabric, nanofashion.
 - Already used in sunscreens.
 - Uses of such in retail goods, exhibitions touring mentioned, pros and cons of, water treatment.
 - Solar panel improvements.

- 8% mentioned risks and/or benefits of nanotechnology; for example,
 - Beneficial technology, but risks not known. Little regulation.
 - Safety issues with nano.
 - Some applications are very beneficial, some could be destructive, some could be very invasive.
 - I do find the technology somewhat uncomfortable in that we do not know where these nano particles will go and what they will do in the environment.

- 6% noted the future potential of nanotechnology; for example,
 - Exciting breakthroughs – great potential.
 - I recall listening to something about the structure and that it is an exciting movement as to what might be possible.
 - It's one of the most innovative technologies that will create major changes in various fields in science.

- 2% recalled reading articles on earthsky.org:
 - I've read Top 10 things to know about nanotechnology, no secrets in a future with nano sensors, Too Small to See.
 - I recall several articles about this subject while I was doing research for a playwriting contest I was involved in through the Exploratorium in San Francisco. What I remember about the specific Earth & Sky articles is that they furthered my understanding of directions the field could go in, and what they had discovered so far to be possible.

DISCUSSION

In the previous three years, over eighty 90-second *Earth & Sky* radio shows have been produced on nanoscale science and engineering, under sponsorship of the National Science Foundation. The possible impact of these shows was explored with a web-based explanatory survey design comparing groups with different exposures to *E&S* and comparing *E&S* listeners with historical nationally representative control groups.

E&S listeners feel significantly better informed than national samples, when both groups are asked the same question of how much they have heard about nanotechnology. About 70% of our self-selected sample have heard “a lot” or “some” about nanotechnology compared with 30-40% of similarly educated or science-attentive nationally represented groups. More than half of the *E&S* sample clearly remember reading, seeing or hearing about nanotechnology in print (80%), Internet (75%), radio (64%) and television (53%) sources. *E&S* listeners rate nanotechnology as lower in risk and higher in benefit than a representative national sample; however, on a true-false test, *E&S* listeners do not score at a higher knowledge level than a national sample.

Of our responding sample, 60% had heard *E&S* once or not at all in the past week and are defined as the “lower exposure” group; whereas 40% had heard *E&S* 2 to 7 times in the past week and are defined as the “higher exposure” group. Exposure level was not significantly related to awareness of nanotechnology or risk/benefit attitudes. Compared to those with lower exposure to *E&S*, those with higher exposure were significantly more knowledgeable about nanotechnology given a true-false test; more likely to report being exposed to nanotechnology through the Internet, radio, television and movies; and more likely to report an awareness of nanotechnology in one of eight applications (air and water purifiers).

Of those familiar with nanotechnology, 35% reported having heard an *E&S* nanotechnology program. From their listening, they recalled something about what nanotechnology is (28%) or something about nanotechnology applications (28%), reflecting the fact that most of the *E&S* nanotechnology programs cover the scale of nanotechnology and some type of application. More than half of this group said that as a follow-up to hearing *E&S* they had paid more attention to nanotechnology in other media (74%) or discussed nanotechnology with others (51%).

Compared with those unfamiliar with such programming, those who had heard an *E&S* nanotechnology program were significantly more likely to be aware of nanotechnology; more knowledgeable about nanotechnology given a true-false test; and more likely to report radio and the Internet as a source of nanotechnology information. Almost half of our sample listen to *E&S* via the Internet. Listeners of nanotechnology programming were also more likely to claim familiarity with nanotechnology applications that were not covered much in *E&S* programs, like applications of clothing and fabrics, cosmetics and skin lotions, sports equipment, and washing machines. Risk/benefit attitudes were independent of familiarity with *E&S* nanotechnology programming. Although the study design does not permit a conclusion that *E&S* “causes” changes in nanotechnology awareness, knowledge and attitudes, the results reveal that exposure specifically to *E&S* nanotechnology shows relates significantly to higher awareness and knowledge about nanotechnology.