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Article

Brains Rule!: A Model Program for Developing Professional Stewardship among Neuroscientists

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Brains Rule! Neuroscience Expositions, funded through a National Institute on Drug Abuse Science Education Drug Abuse Partnership Award, has developed a successful model for informal neuroscience education. Each Exposition is a "reverse science fair" in which neuroscientists present short neuroscience teaching modules to students. This study focuses on results of assessments conducted with neuroscientist presenters during Expositions at two sites, Atlanta, Georgia and Corpus Christi, Texas. The effects of participating in the Expositions on presenters' perceptions of their own presentation and communication skills were evaluated, as was the potential for increased active participation by neuroscientists in future outreach programs. In four of the five Expositions studied, pre- versus post-event surveys demonstrated significant changes in presenters' perceptions of their own abilities to explain neuroscience concepts to children. Over the course of an Exposition, presenters learned to fit their approaches to conveying neuroscience concepts to fifth through eighth graders and learned to link information they presented about the brain and nervous system to children's past experiences to improve comprehension. The present data suggest that Brains Rule! Neuroscience Expositions are effective in improving communication and teaching skills among neuroscience professionals and contribute to professional stewardship by increasing motivation to participate in future informal education programs.

INTRODUCTION

The importance of a general public that is literate in science drives the current nationwide efforts to redefine the role of scientists as frontline communicators about science and research to kindergarten through 12th grade, undergraduate, graduate, professional, and public audiences. Scientific societies, such as the Society for Neuroscience (SfN) specifically and the American Association for the Advancement of Science (AAAS) generally, promote scientist involvement in public education via programs such as "Brain Awareness Week" that aim to increase public awareness of the sciences, as well as informed participation in government decisions related to science.

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To achieve such aims in the neuroscientific field, neuroscience professionals (or neuroscientists, defined as individuals who conduct basic research, apply neuroscience in clinical practice, or teach neuroscience) must themselves be literate in neuroscience education. In other words, they need to understand what constitutes "neuroscience literacy," be aware of its societal implications, and participate in programs and efforts that teach the general public about neuroscience. As previously defined, neuroscience literacy is the knowledge and understanding of concepts and processes related to diseases and disorders of the brain and behavior, in addition to how and why humans interact with their environment and each other based on their unique nervous system characteristics (Zardetto-Smith *et al.*, 2002). Neuroscience literacy gives individuals the capacity to 1) make informed decisions about personal or family healthcare to promote optimal nervous system function from infancy through senescence; 2) use knowledge of nervous system processing to design or redesign environments that support comfortable and effective social interactions targeted for specific populations; 3) understand and critically evaluate neuroscience-related media, such as health information Web sites; and 4) participate from an informed perspective in government decisions regarding research initiatives and new medical treatments (Zardetto-Smith *et al.*, 2002). Thus, neuroscience professionals participating in neuroscience education can address any or all of these aspects of neuroscience literacy.

Regardless of the specific aims of a neuroscience education program, professionalism is critical in raising neuroscience literacy. Therefore, altruistic attitudes, values, and behaviors toward that aim need to be integrated with training of knowledge and skills in the field. The clinical and teaching professions have long recognized this challenging process as part of "professional development" and the meaning of including oneself as part of a profession with goals toward some "greater good." In that context, professional development is an integral and ongoing aspect of a successful and fulfilling career.

A concept embedded in professional development, particularly in clinical professions, is that a member of a profession has an obligation or responsibility to invest in its continued development and success. "Giving back to the profession" can be accomplished through formal education and training as well as community education endeavors that influence the next generation of trainees in the field. Some societies incorporate such activity in criteria for inclusion in the profession. For example, the American College of Clinical Engineering describes "Clinical Engineers" as follows:

> Clinical Engineers, by education and training, are members of a proud profession. Through their professional society, the American College of Clinical Engineering (ACCE), they have established a code of ethics, pursued peer recognition and certification programs, and developed a heritage of publishing, teaching and humanitarian programs designed to "give back" to society and to prepare the next generation of practitioners.

http://www.accenet.org/default.asp?page=about&section=definition.

Moreover, the Carnegie Initiative on the Doctorate states that professional stewardship involves "educating and preparing those to whom the vigor, quality, and integrity of the field can be entrusted" (http://www.carnegiefoundation.org/CID/). In the field of neuroscience, some forms of stewardship are common: many neuroscientists advise or mentor undergraduate, graduate, and postdoctoral trainees in their classrooms and laboratories. Another form of stewardship is political activism to assist in gaining legislative actions favorable to the development and growth of the profession, and it is supported through professional societies such as the SfN, whose mission statement specifies that it will "Inform legislators and other policy makers about new scientific knowledge and recent developments in neuroscience research and their implications for public policy, societal benefit, and continued scientific progress" (http://web.sfn.org/content/AboutSfN1/Mission/mission.htm). However, stewardship is further described as volunteerism outside the university or college community. Although another tenet of the SfN mission is to "Promote public information and general education about the nature of scientific discovery and the results and implications of the latest neuroscience research," this does not necessarily encourage direct volunteerism in science education (Cameron and Chudler, 2003). Using any of these connotations, increased emphasis on stewardship as a professional attribute of good neuroscientists may help to elevate neuroscience literacy. Using either connotation, "giving back" is unfortunately not yet emphasized as a professional attribute of good neuroscientists.

How can we promote such professional development in neuroscience and thereby elevate and sustain neuroscience literacy? Actively engaging neuroscience professionals in formal and informal science education programs is fundamental. Several additional components are essential, including the execution of activities in the context of practice, directly connecting activities to student learning, implementing a variety of learning experiences, building evaluation into all programs, and allowing time for inquiry, reflection, and mentoring on an ongoing basis. Most importantly, this kind of professional development will not survive without institutional recognition of its value, administrative support, adequate resources, and continuous funding (Cameron and Chudler, 2003).

The Brains Rule! Neuroscience Exposition project is designed to help change the field of neuroscience by elevating awareness of neuroscience education among neuroscience professionals, emphasizing neuroscience education in the process of professional development, and engaging neuroscientists in active, applied, and varied teaching and learning opportunities. The project emphasizes improvement of presentation and communication skills among neuroscience professionals who present neuroscience information to middle school students. It also probes the likelihood of active participation by neuroscience professionals in future informal science education programs. In the early stages of the project, data indicated that participating in a Brains Rule! Neuroscience Exposition significantly raises professionals' perceptions of their abilities to communicate science content to children and that presenting neuroscience concepts to children is not as difficult as they had anticipated before the event (Zardetto-Smith *et al.*, 2000). Also, after engaging in activities with children, neuroscience professionals rated the children's interest in neuroscience higher than anticipated; they discovered that not only do children have a great interest in the brain and nervous system, but also they are motivated to learn more about neuroscience (Zardetto-Smith *et al.*, 2000, 2002).

The major hypothesis underlying the present study is that among neuroscience professionals—a primary target group of the Brains Rule! project—"change leaders" can be developed who will engage more fully both individually and collectively (in the local community and through professional organizations) in efforts to improve neuroscience literacy. This report describes the results of formative assessment studies conducted with neuroscience professionals during project Expositions at two partnership sites and evaluates the impact of the Exposition experience on neuroscience professionals. Preliminary results were reported previously (Zardetto-Smith *et al.*, 2004).

METHODS

Description of the Model

The Brains Rule! Neuroscience Expositions project is funded through a Science Education Drug Abuse Partnership Award to the University of Nebraska at Omaha from the National Institute on Drug Abuse (R25 DA 13322). The project has two components, one "live" and one "virtual." For its "live" component, an innovative, flexible, science education outreach model, the Exposition, is used to bring "neuroscience professionals" into local communities to help children and adults learn about the nervous system through engaging, interactive, hands-on activities. In this context, "neuroscience professionals" is a term used with wide definition and includes those who are involved in neuroscience research (neuroscientists and trainees), medicine (neurologists and neuroscience nurses), and applied neuroscience (occupational and physical therapists and pharmacists).

The Exposition is a modified "reverse science fair" (Zardetto-Smith *et al.*, 2000; Rose *et al.*, 2004). Small groups or pairs of neuroscience professionals present short (10–20 min) teaching modules to small groups of fourth- through eighth-grade school students (4–8 per group) who rotate among 10 and 12 teaching modules over several hours. True to the definition of the word, exposition, it is a "setting forth of the meaning, and a discourse, designed to convey information" about neuroscience. Thus, ideas presented in the modules address the nervous system and behavior. In this case, the information includes concepts about the brain, overall nervous system, and behavior. In this model, emphasis is placed on the neuroscience professionals and their participation by asking child participants to vote on who presented the best (and most fun) activity at the end of the event. Further focus of analysis is on the learning process of the neuroscience professionals as they learn to communicate their chosen material in a short time period. Finally, the structure of the project helps establish sustainable regional partnerships to fit the style and needs of the local community; Brains Rule! funds the first Exposition entirely, assists in funding a second Exposition, and then participates in a pure consultative role in a third Exposition. For each Exposition, the Brains Rule! team leads the design and conduct of assessment and evaluation to ensure consistency and enable future meta-analysis of the nationwide project.

The Web site, http://www.brainsrule.com, was designed to bridge the live learning experience to follow up independent learning by providing an Internet location for basic and applied neuroscience concepts to be explored by children, parents, teachers, neuroscientists, and health professionals. The Brains Rule! Web site address and a logo "brain character" that appeals to children and is genderless were disseminated throughout Expositions and on the Internet via fun, utilizable, age-appropriate, and memorable giveaways for school or home, such as rulers, magnets, notebooks, lunch bags, and t-shirts. Presenters at the Expositions even used "Brains Rule!" as a cheer to get middle school students excited about the brain and neuroscience. The logo and the Web site address are used on all project materials and serve as a means of project dissemination, strategically designed to drive traffic to the site (which has over 99,000 "hits" as of January 2006).

Presenter Recruitment and Orientation

The participating neuroscience professionals for the Expositions were recruited through local chapters of national partnering organizations, such as Women in Neuroscience, the American Occupational Therapy Association, the American Physical Therapy Association-Neurology Section, the National Institute of Mental Health Neuroinformatics Program, the American Association of Neuroscience Nurses, and The Center for Behavioral Neuroscience. Local organizations were also recruited by local organizing committees and were termed "regional partners." For example, at the Expositions in Atlanta, several local academic institutions, local chapters of national patient advocacy organizations, and the children's science museum and local zoo comprised the regional partnership.

Neuroscience professionals (termed "presenters") and local Exposition organizers worked together with the Brains Rule! team to develop fun, engaging, age- and culturally appropriate exercises through orientation sessions, a handbook, sample exhibits, and basic training about communicating science to children. The Brains Rule! team reviewed activities for accuracy and compliance with Institutional Review Board and Institutional Animal Care and Use Committee regulations or recommendations. At its maximum, this development process encompassed all these components and occurred in person with the Brains Rule! team members months or weeks before the program. At its minimum, the process took place through the Internet, electronic mail, and telephone, with on-site planning just before the program. Partnerships were established and maintained in each location by on-site visits by the principal investigator and/or project coordinator several months in advance of the program, developing a professional rapport, explaining the program thoroughly, answering questions about the Exposition and its goals, and facilitating planning processes. For the regional partnerships in Atlanta and Corpus Christi, regional organizers communicated well with the Brains Rule! team as well as local partners and thereby succeeded in terms of effective Exposition administration, organization, and sustainability.

The concepts for the activities presented by the neuroscience professionals varied depending on the expertise and career level of the neuroscience and health professions recruited. This was quite different in Atlanta compared with Corpus Christi because of the demographics of the participating neuroscience professionals, who ranged from graduate students to faculty in Atlanta, and undergraduate students to practicing community health professionals in Corpus Christi. The regional community partners themselves oversaw the event planning and execution with guidance the first year from the Brains Rule! team. The chosen venues to host an Exposition included a science museum, a zoo, and institutional partner facilities. Local organizing committees recruited school partners from which middle school fifth- through eighth-grade students were invited to participate in the Expositions. (Although data were collected from middle school participants, student outcomes are not the focus of the present analysis and will not be described.)

Quantitative Assessment

A survey instrument was developed by the project team to examine the presenters' perceptions about their ability in successfully communicating neuroscience knowledge to children, as well as their predictions and ratings on children's interest level in neuroscience and specific exhibits. Evaluation of several pilot surveys early in the project resulted in the version of the questionnaire used in this study, consisting of five questions and a 5-point Likert response scale.

An inferential statistical test was used to examine whether a significant difference existed between responses given by the presenters to the five questions before (presurvey) and immediately after participating in an Exposition (postsurvey). In particular, because of the small sample size of the participants, a nonparametric Wilcoxon signed ranks test (Siegel and Castellan, 1988) was used to examine the differences between the pre- and postsurvey responses. This inferential statistical test was performed in two stages. First, the test was performed on each of the five Likert Scale questions. Second, the test was conducted on the summed scores of presenters' presentation skills (three questions) and children's interest in neuroscience (two questions). The significance level was set at 0.05.

Qualitative Assessment

Qualitative data were collected through participant observation, semi-structured interviews, and tape-recorded focus group discussions at the Exposition sites. The analysis scheme was synthesized

Table 1. Demographic information of Atlanta Neuroscience Exposition participants

Demographic information	Exposition I[a]	Exposition II[a]	Exposition III
Gender			
Male	5	26	8
Female	15	11	16
Highest education level			
High school	2	8	5
Bachelor	7	17	2
Master	0	3	4
PhD	8	8	2
Total no. of presenters	20	37	24
Total no. of children	99	155	72
Age range of children	11–14	11–14	12–14
Grade distribution of children	6th–8th	6th–8th	6th and 7th

[a] Indicates that this demographic information is not complete due to some presenters not answering this on their form.

across several strategies (Bogdan and Biklen, 1992; Morse and Field, 1995; Denzin and Lincoln, 1998). A research assistant transcribed recordings of interviews and group discussions.

Transcriptions and observational field notes were then analyzed independently by two investigators of the project using the following procedure. First, the entire transcript was reviewed for the general tenor of discussions. By choosing one transcript at random and analyzing it for repeated words ("key words"), phases, and patterns, the initial coding categories were identified. With this list of coding categories, investigators examined the next transcript to group the text into different categories. Appropriate modifications were made to the initial categories, based on the examined data; categories were added and/or existing categories were clustered or combined. Thus, the initial coding categories were constantly contrasted, expanded, clustered, condensed, or refined to generate sufficient, accurate, and representative categories to reflect the content of collected data. This approach is known as the "constant comparison method" (Bogdan and Biklen, 1992). Finally, relationships among different categories such as antecedents, consequences, and concurrences were explored and examined to generate final themes (Morse and Field, 1995; Denzin and Lincoln, 1998). The two investigators then met to share and compare results. When discrepancies were detected, data were reexamined and interpretations modified until a consensus was reached.

In addition to this triangulation of data, a group member checked to ensure the trustworthiness of data analysis. First, coding categories (with attached quotes or examples) were sent to selected participants of the focus group for feedback on accurate reflection of perceptions. Comments were examined and incorporated accordingly. Second, reports generated from the study were sent to selected participants for review on whether the interpretation of data adequately reflected their experience and perceptions. Further clarification from participants was examined and incorporated accordingly.

RESULTS

Atlanta

A total of 81 presenters participated in the three Expositions held in Atlanta in March 2003, 2004, and 2005. Demographic information on the presenters is displayed in Table 1, along with number of children attending. Table 2 lists participating regional partners.

The results of the Wilcoxon signed ranks test are presented in Table 3. Table 3 displays the Z value and the significance level of the tests, i.e., the exact p value. A superscript "a" is placed next to the p value if the difference is significant. As illustrated in Table 3, the results between pre- and postsurvey tests were mixed because some differences reached significance ($p < 0.05$) and others did not. It is noted that the difference between the pre- and postsurvey tests regarding the ability to explain neuroscience concepts to children was significant for the 2003 Exposition, but not for the 2004 and 2005 Expositions.

Corpus Christi

A total of 81 presenters participated at the two Expositions in Corpus Christi in February and November 2004. Demo-

Table 2. Atlanta Brains Rule! partners

Atlanta I	Creighton University, SciTrek Museum, the Center for Behavioral Neuroscience, Emory University, Georgia State University, Morehouse College, Georgia Tech University, Atlanta Chapter of the Society for Neuroscience, Institute for Biomedical Philosophy, Epilepsy Foundation of Georgia, the Center for Education Integrating Science and Mathematics and Computing
Atlanta II	University of Nebraska at Omaha, SciTrek Museum, Emory University, Center for Behavioral Neuroscience, Institute for Biomedical Philosophy, Georgia State College, Spelman College, Georgia Institute of Technology, Morehouse College, Morehouse School of Medicine, Atlanta Chapter of the Society for Neuroscience
Atlanta III	University of Nebraska at Omaha, Center for Behavioral Neuroscience, Zoo Atlanta, Institute for Biomedical Philosophy, Atlanta Chapter of the Society for Neuroscience, Epilepsy Foundation of Georgia, Atlanta Center for Cognitive Therapy, Alzheimer's Association Atlanta Center for Medical Research, Attention Deficit Hyperactivity Disorder Association of Atlanta, Center for Healthy Aging, Dana Alliance for Brain Initiatives, National Association for Mental Disorders, Parkinson's Disease Association, Spelman College, Morehouse College Tourette's Syndrome Association of Georgia

Table 3. Results of the nonparametric Wilcoxon ranks test between presenter pre- and postsurveys in Atlanta Neuroscience Expositions

Survey questions	Expositions		
	Atlanta I	Atlanta II	Atlanta III
1. Your skills in presenting neuroscience knowledge to these children	$Z = -1.85$ $p = 0.065$	$Z = -2.44$ $p = 0.015$[a]	$Z = -0.96$ $p = 0.338$
2. The interest level of these children in neuroscience	$Z = -1.73$ $p = 0.083$	$Z = -0.526$ $p = 0.599$	$Z = -0.42$ $p = 0.674$
3. The interest level of these children in your presentation	$Z = -0.50$ $p = 0.617$	$Z = -1.20$ $p = 0.231$	$Z = -0.65$ $p = 0.518$
4. How difficult was it for you to present your project to these children?	$Z = -1.60$ $p = 0.109$	$Z = -0.45$ $p = 0.309$	$Z = -1.10$ $p = 0.273$
5. How successful do you think your project was?	$Z = -2.32$ $p = 0.02$[a]	$Z = -1.84$ $p = 0.655$	$Z = -0.28$ $p = 0.782$
Summed scores of presenters' presentation skills	$Z = -2.67$ $p = 0.008$[a]	$Z = -1.84$ $p = 0.066$	$Z = -0.573$ $p = 0.567$
Summed scores of children's interest in neuroscience	$Z = -1.66$ $p = 0.096$	$Z = -0.664$ $p = 0.507$	$Z = -0.70$ $p = 0.482$

The exact Z value and p value of the Wilcoxon ranks test are displayed.
[a] Indicates that the difference reached a significant level ($p < 0.05$).

graphic information on the presenters is displayed in Table 4, along with the number of children attending. Table 5 lists participating regional partners.

The results of the nonparametric inferential statistical test are presented in Table 6. Similarly, both the Z values and the exact p values are displayed in Table 6. Differences between pre- and postsurvey responses reached statistical significance in the majority of categories. Exceptions included the ability to explain neuroscience concepts to children and the level of success of their exhibits in the second Exposition (Corpus Christi II).

Qualitative Analysis of Postevent Interviews and Focus Group Discussions

For all the Expositions in Atlanta and Corpus Christi, the results of qualitative data analysis demonstrated that presenters were consistently surprised by the level of neuroscience knowledge shown by participating children. Many presenters reported that children knew more about neuroscience than they themselves knew at the same age, surpassing presenter expectations. The presenters also reported that children asked unexpectedly good questions and were more engaged than anticipated.

Table 4. Demographic information of Corpus Christi Neuroscience Exposition participants

Demographic information	Exposition I	Exposition II
Gender		
Male	15	4
Female	36	26
Highest education level		
High school	34	14
Bachelor	10	12
Master	3	2
PhD	0	0
Professional degree	4	2
Total no. of presenters	51	30
Total no. of children	49	152
Age range of children	10–13	11–12
Grade distribution of children	5th	5th

Presenters adjusted their communication strategies throughout the day in order to convey concepts to the children. Three major themes pertaining to changes in communication were noted: goodness of fit, age appropriateness, and linkage to past experience.

- Goodness of fit: As the day progressed, presenters began to strive for the best fit between the approaches they took and the audience they were facing related to the size of the group and ages of the children. Presenters used informal assessment and immediate feedback to gauge what children already knew or what they had learned in other activities and then adjusted their presentations to reach a "goodness of fit."
- Age appropriateness: Presenters commented that, over the course of their presentations, they came to understand that different age groups required different verbiage to communicate concepts in an understandable manner. They also reported that they provided visual materials and hands-on activities to engage children in their exhibits, but their use of aids evolved over the course of several presentations to optimize their presentation.
- Linkage to past experience: Presenters attempted to link their exhibit explanations to children's past experiences, both recent (at the Exposition) and distant (early childhood or family experiences), to help children relate to the content.

Exemplars of presenters' comments for each of these three themes taken from comments throughout the five Expo-

Table 5. Corpus Christi Brains Rule! partners

Corpus Christi I	University of Nebraska at Omaha, Texas A&M University Corpus Christi, Warm Spring Rehabilitation, Shea Physical Therapy, DC Chiropractic, Occupational and Rehabilitation Services, Acoustic Imaging Center
Corpus Christi II	University of Nebraska at Omaha, Texas A&M University Corpus Christi, Don Vaughn Chiropractic

sitions (both Atlanta and Corpus Christi) are presented below.

Goodness of Fit

I changed from the beginning what did not quite work. By the last group it was much smoother. The presentation was much smoother, and I could also realize how much information they knew. For the first group I think I gave them more background, and then for the last groups I realized that they already knew quite a bit of information.

You could ask a similar question or a question on the same topic but make it at the appropriate level for the students to bring them along—like Ligosky's educational theory where you are at the appropriate level. I forget what the exact terminology is, but anyway. For example with the ions, we would ask one group, "What are ions for?" or "What is an ion?" And if the group didn't know at all, it was a little frustrating to see them struggling by not having any clue, so I would say, "Ions are charged particles; which charges can they have?" And then of course they are going to say, "Positive and negative," because that is certainly something they will know. So then you can follow it right up with a success for them with the answer that they can get easily. I found that to work.

If something worked, we would incorporate that more, and if something didn't work, we would leave it out because, since it was a neuroscience symposium or exhibition and it was all concentrated on the brain, we just kind of eliminated that part of ours, doing the anatomy because I just figured the other groups would cover that in detail because our presentation was on brain disorders, so we wanted to get more of an interaction.

. . . [I]f they can remember a couple of things, you are probably doing really well, because they start to get this glazed look if you try to pack it in too much, so I think that you should probably concentrate on something really attention getting and just stick with that and not do so much information overload.

Whatever their interest level was at the moment and whatever their capability of grasping information, I would try to apply it at that level. And sometimes I didn't reach the kids. Sometimes we would be done, and I didn't reach them, and other times we would be three minutes into it, and they would have mastered the concept.

. . . [I]t was the attitudes that were different in each group. So we have to adjust how we engage the kids, and then when we would respond to them, they would respond differently to each one of us—which I thought was good; I did discover that about the kids. You can't just do the same thing with each group. You have to adjust your plan of action and your attack on each group.

Age Appropriateness

We talked to them; we know what they understand now and what words to use, what they don't understand. We can explain to them better what they don't understand and get them more interested in it. So, we kind of adjusted ourselves. We're not used to dealing

Table 6. Results of the nonparametric Wilcoxon ranks test between presenter pre- and postsurveys in Corpus Christi Neuroscience Expositions

	Expositions	
Survey questions	Corpus Christi I	Corpus Christi II
1. Your skills in presenting neuroscience knowledge to these children	$Z = -2.26$ $p = 0.024^a$	$Z = -2.30$ $p = 0.022^a$
2. The interest level of these children in neuroscience	$Z = -2.11$ $p = 0.035^a$	$Z = -2.90$ $p = 0.004^a$
3. The interest level of these children in your presentation	$Z = -2.30$ $p = 0.003^a$	$Z = -3.18$ $p = 0.001^a$
4. How difficult was it for you to present your project to these children?	$Z = -2.95$ $p = 0.003^a$	$Z = -1.15$ $p = 0.249$
5. How successful do you think your project was?	$Z = -2.65$ $p = 0.008^a$	$Z = -1.73$ $p = 0.083$
Summed scores of presenters' presentation skills	$Z = -3.42$ $p = 0.001^a$	$Z = -2.33$ $p = 0.020^a$
Summed scores of children's interest in neuroscience	$Z = -2.76$ $p = 0.006^a$	$Z = -3.40$ $p = 0.001^a$

The exact Z value and p value of the Wilcoxon Ranks test are displayed.
[a] Indicates the difference reached a significant level ($p < 0.05$).

> with real small kids so it helped us out as they came along, and we got to know them better, you know, what they needed more help with and what they didn't.
>
> Yeah, I changed strategies on how I was approaching certain concepts. One of the concepts I wanted to get across was cephalization. . . . I mean, it was like having them get to the point that the senses are concentrated in the head and that the head is where the brain is, and the brain is what controls everything. You know, just kind of lead them through it instead of lecturing at them.
>
> We go down our list, and one of the things is appendages; so before we do the little game with them, we go down the list, and we start seeing which words they get stuck with and which words they know. Everybody knows what the habitat is, but appendages, it's not a hard word, but they just haven't really thought of it in that context. I mean, its just defining the language in terms that they can get.
>
> At times we had trouble simplifying, but not really simplifying to the point where we were just giving it to them. It was a little hard picking a level; you didn't want to use too many technical terms, but you wanted to go easy. It wasn't as if they were stupid; you had to find a balance. That was a little bit hard.
>
> That's why as it moved throughout the day, I started to say, instead of using the word neurotransmitter, "the chemical that talks to muscle." I just don't think that they care or need to know that sort of terminology . . . Yeah, the terminology is difficult. It intimidates them. And once you start getting to that point with them, you may as well be talking to the wall. It really worked better when you took it down.

Relating to Experiences

> Bringing it down to their level makes them understand it better and relate it to things that they do like, for example, when you're talking about the gag reflex. Instead of saying, "when you are sick," we say, "when you go to the doctor, and they put the tongue depressor on your tongue"—things like that so they can understand.
>
> I started out doing a more in depth explanation like the different senses and how your body picks up stuff from the environment, and then your brain processes it, and you have a response. And I was also talking about voluntary and involuntary responses, but I was taking way too long, and I was kind of losing the kids. So I just started talking about hand–eye coordination and relating it to video games, because they all picked up on that. Because when I started talking about the sense and input and stuff, they were kind of like, "So what." But as soon as you say video games they are like, "Oh, we play video games. . . ," so I would say, "That's hand–eye coordination. You see some things, the brain processes them, and then it goes to your thumb and you push the buttons"; . . . they were like, "Oh yeah."
>
> I think when I explained things, I tried to take my time and think about it before I spoke because I didn't want to use words that were too big for them, that they wouldn't understand, and I wanted to say it in a way that would stick with them and make more sense. So, for example, we had a true/false question about whether when you communicate with each other, it is always excitatory or positive, and so I explain inhibition as being something like silencing your neighbor, like telling them to shut up, something like that, and so, it's not always the most accurate in terms of neuroscience, but it's a way that is going to stick with them more permanently.
>
> . . . [W]e had a lot of people ask us too, they were like, "Yeah, my friends did ecstasy" or "Yeah, I know a girl that did that," and then they were like "Yeah, you know it is like bad," and I was like "Well, that's why I'm here to teach you." And then they say, "Well, then, why do they take it?"
>
> You just have to relate it to like things they know how they work so they understand how it works. . . . [W]e talked about airplanes and NASCAR. Yeah, they understood that it has to go down the axon fast, like NASCAR.

Two additional themes emerged related to the professional development of neuroscience professionals: strengthening of personal knowledge of neuroscience, and appreciating the value of participating in an Exposition as a service to the community.

- Strengthening personal knowledge: Presenters experienced Joseph Joubert's axiom "To teach is to learn twice." In particular, presenters who were undergraduate or graduate students, drawing from their own prior experience as consumers of knowledge, understood that good teaching is about substance. To communicate the content effectively, they themselves had to understand it well enough to be able to demonstrate it concretely (e.g., teaching a hands-on activity). For several presenters this involved review of content they previously studied, thus enhancing their own knowledge levels.
- Appreciating the value of participation: Children's immediate responses to the activities and to the presenters themselves affirmed the sense that the neuroscience professionals were contributing to their local community in a unique and valuable way ("giving back") as well as influencing attitudes toward science. First-time presenters consistently commented on their willingness to participate again in the future.

Again, exemplars of presenters' comments for each of these two themes taken from comments throughout the five Expositions (both Atlanta and Corpus Christi) are presented below.

> If there was another event like this in the future, I would definitely come, and I would come so I could keep teaching some more—reach out to the community and help those kids.
>
> I have learned a lot too today, helping the kids, and I like communicating with them. And hopefully I can make a difference and maybe they will, you know, want to stay in school and want to pursue their education. That's what would be important to me.
>
> I think for me, it was also learning and reunderstanding. I mean, I've learned axons, you know, back in Bio and just trying to reintegrate into my mind and then trying to explain it to someone else. I guess when you teach something is when you really learn something.

> Once I started to understand it, I could teach it a little bit better I think.

> I actually came today to just get volunteer hours, but next year I think I would come because I had a lot of fun working here, and I learned a lot. I didn't think I would, I just thought we were going to talk to the kids; I didn't think we were actually going to teach the kids.

> Well, even though I am extremely busy and this took a lot of my time, I enjoy giving back to the community, and I feel it is very important that we get children interested in science, because I think that a lot of kids are taught that science is very hard and a lot of them are scared of science.

> I just really like working with kids because I feel that's where science is missing out. We are not bringing in our younger kids because they are not interested in science—they see basketball players on TV, and that's what they want to be. They don't see scientists on TV so it's very important that as a scientist we get our younger generation interested in it and doing stuff like this is what works. Some of these kids might come away from this today and going, "Wow, that brain was really cool—I think I want to be a neurobiologist."

> I think it's pretty important for us as professionals to reach out to the communities that we live in and help them understand what we do. I think it is important for building communication with society, so that there aren't such sharp divides, and I think children are the place to start that, because their early experiences are going to influence the fact that some of these kids are going to consider going to college for the first time in two or three years because they have this experience. Some of them wouldn't even consider it if they didn't have activities like this.

> I actually went down to the . . . building and gave Brain Injury 101 to the congressmen and their delegates. . . and it was much harder than it looks. It was frustrating. To go through what a neuron is, and what a synapse is, they already had their blinders on. The interest level was way up here, but once the jargon started coming, they just tuned out. A fourth grader can say "What's that—I don't know what you are talking about," whereas an adult can't. . . they (the congressional representative) don't understand any better than the fourth graders. . . . Clearly you need to approach something like neuroscience on a fourth-grade level with many adults. And it's hard to do that until you deal with fourth graders or fifth graders.

DISCUSSION

The results of this study demonstrate that participating in a Brains Rule! Exposition substantially impacts neuroscience professionals' skills in conveying neuroscience to fifth- through eighth-grade school children. The quantitative analysis conducted on the presenter pre- and postsurvey responses confirms the directional nature of the hypothesis that, as a group the presenters' perceptions about their own capabilities to teach neuroscience to children would improve significantly, which it did in three of the five Expositions studied. This is represented by the summed score of presenters' presentation skills, representing a comparison of the three questions related to presentation skill as a single subset. In Corpus Christi, before an Exposition, the presenters (many of whom were undergraduate students who had not previously participated in a science education outreach activity) had predicted that the children would not show much interest in neuroscience (summed score of children's interest in neuroscience, representing a single subset of two questions related to interest). After the Exposition, during which time they both observed and interacted with the children as the activities occurred, the presenters rated the interest level of the children in neuroscience higher than they had originally predicted.

These results are in agreement with those of our previous study earlier in the project indicating that participating neuroscience professionals perceived their overall abilities to present neuroscience to young children improved in a statistically significant way (Zardetto-Smith *et al.*, 2000). However, in this present study, the additional statistical comparison of differences in responses of the presenters before and after the event to each of the five specific questions was made for each of the five Expositions held. The comparisons across the two Exposition partnership sites yield interesting insights as to why the differences across pre- and postsurvey responses to individual questions may occur.

Differences between pre- and postsurvey responses on nearly all questions for Corpus Christi I and II reached a significant level, but not for any of the questions in Atlanta by year 3 (Atlanta III). Several complex, interacting factors may explain this discrepancy. These include differences in the educational level of the presenters, a predominance of community health professionals as presenters in Corpus Christi; the extent or mode of pre-Exposition orientation and training, the level of interaction with school programs on a recurring basis, and repeating the program with a majority of second- or third-time–returning presenters in Atlanta.

As described previously, the majority of the presenters at the Corpus Christi Expositions were undergraduate students from science or allied health fields, such as nursing. Several of the degreed presenters were from community-based rehabilitation and medical practices. In contrast, the Atlanta presenters largely comprised faculty, graduate students, and postdocs involved in basic neuroscience research with the remainder from community-based advocacy groups (for example, the National Alliance for the Mentally Ill). Although training and orientation materials were available for all Expositions on brainsrule.com, two to six orientation and training meetings were held by local organizers in Atlanta beginning 3 mo before the program. Scheduling challenges for the students and community partners in Corpus Christi prevented a similar advance preparation; instead, orientation and training materials were reviewed in an early morning training session the day of the Exposition itself. In Corpus Christi, a recurring outreach involving the undergraduate students to local schools was in its infancy, compared with the larger and better established outreach programs involving several of the Atlanta partners.

Finally, more than 80% of the presenters at the third Exposition in Atlanta had participated in the previous two Expositions. Therefore, the lack of a significant effect in the Atlanta III pre- and postsurvey questions may be due to a ceiling effect of the questionnaire. If perceptions of abilities to teach children effectively were elevated before the Exposition because of prior experience or intense training, then no further elevation may have been possible after the Exposition. Although such sustained involvement of neuroscience professionals may extinguish significant effects on pre- versus post-Exposition surveys, the high level of participation underscores the long-term sustainability and success of this local partnership. The lack of significance by Atlanta III on questions regarding the children's interest in neuroscience, as well as presenters' perceptions of their own skills in conveying neuroscience concepts to children, may be considered a benchmark of success in helping the neuroscience professionals develop the confidence and skills required for presenting neuroscience information with each successive Exposition. Both Atlanta and Corpus Christi have sustained the Brains Rule! model beyond the initial, funded Expositions; Corpus Christi's third program was originally scheduled for fall 2005 (but was postponed because of a hurricane) and is being rescheduled for 2006.

The exemplars of Presenter comments derived from interviews and focus group discussions in Boxes 1 and 2, respectively, also reflect experiences among presenters. Involvement in a Brains Rule! Exposition has a positive impact on neuroscience professionals; they demonstrate a consistent pattern of change in their communication during the course of repeating their exhibit for different groups. The challenge therefore, in terms of continued professional development, is to ensure that the lessons learned about communication during the Exposition are repeated and strengthened. Over the long term, the present data suggest that neuroscience professionals can tailor their lessons to a variety of educational settings to convey information at a level understandable to varied audiences, especially the lay public. A strong and well-established local partnership sustaining the event on an annual basis provides opportunities to develop such skills, while also encouraging future active participation in neuroscience education, and builds emphasis on "giving back to the community."

Assessment of the children's reaction to the Exposition experience demonstrate that they perceive the learning activities are fun and interesting, and that they believe they have learned something about the brain and nervous system (Zardetto-Smith *et al.*, 2002). Together, the quantitative and qualitative data suggest that the self-perceived increase in the presenter's abilities to easily and effectively present neuroscience to children derives in part from the realization during the event that the level of children's interest both in neuroscience and their own activity is much higher than they thought before the event. The change in the presenters' perceptions, as particularly evidenced by their statements, reflects a process of experiential learning that occurs as the presenters repeat several cycles of their activity, finding out "what works" to best convey their particular concepts.

Overall, the Brains Rule! Neuroscience Expositions program makes strides toward increasing neuroscience education literacy among neuroscience professionals through increasing their communication and presentation skills and can be an effective model of professional stewardship. Using this model can substantively assist the formation of a cadre of neuroscience professionals who value informal science education both as a community service and a uniquely important contribution to the future of neuroscience.

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