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ARTICLE
Neural Networks: Making Connections about the Brain and about College while Monitoring Student Engagement in Second Graders

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This article describes a neuroscience outreach program developed by college undergraduates and aimed at second graders. Over a period of four weeks, twenty-five Denison students enrolled in a non-majors course on gender and the brain visited twenty-four second grade classrooms to engage a total of 464 students. We had a mission to both promote college awareness and to specifically bring some brain science into the classroom. The desire to engage students with the brain was in part a wish to celebrate brain awareness week and in part a wish to follow a feminist tenet of bridging theory and practice via activism. The college students chose six activities: a brain puzzle, a sock content guessing game, a jelly bean olfaction and taste test, mystery noises, a message transmission game, and a version of tag. During our outreach with the second graders, my students monitored student engagement and compared engagement between male and female second graders. Engagement was high for nearly all activities but girls were more engaged than boys during the brain puzzle and jelly bean activities. Effect sizes measured as Cohen's "d" statistics were small to large (0.2 to 0.93). The other four activities (mystery socks, mystery noises, message transmission and neuron chain tag) showed no difference in engagement between male and female second graders. Our program benefited the Denison students as well, introducing many to community involvement and awakening in them an interest in teaching or working with kids.

Key words: brain awareness, brain puzzle, college awareness, gender and play, student engagement

For the past few years, I have taught a non-majors undergraduate neuroscience class called "Sex, Gender, and the Brain." This class is cross-listed between Biology and Women's Studies and addresses topics such as how different or similar human males and females are biologically, the male and female brain, the neural origin of sex differences in the brain, and how social status affects sex hormones which then affect the brain. We also discuss complex non-human mating systems that include other genders, the role of hermaphrodites, parthenogenesis, and asexual reproduction. This course has an associated lab that, this year, had two components. The first eight weeks consisted of wet lab observations and experiments based on the brain, physiology, and gender (see Mead (2009) for some examples). The last six weeks of lab were based on developing, practicing and performing lab activities as part of an outreach to seven elementary buildings in the Newark (OH) City School District. This outreach was done in part to celebrate Brain Awareness Week and in part because it is an important feminist tenet to put theory into practice via activism and outreach. The initial relationship with the Newark City Schools, and the eventual logistics, were coordinated by Denison's Alford Center for Service Learning and "A Call to College", a non-profit college access organization that partners with the school system.

"A Call to College," founded in 1991, provides financial aid advising and college scholarship assistance to qualified Newark graduates. Newark exhibits a very low graduation rate (68%), exacerbated in the past decade by deep cuts in school funding and a significant increase in low-income students. To address these concerns, a new program called PEAK (Providing Early Awareness and Knowledge), was begun by "A Call to College." The program seeks to increase college awareness and readiness by intervening in classrooms as early as the second grade. Among other activities, PEAK provides local college students mentoring opportunities with elementary and middle schools students in the district.

Because of PEAK's emphasis on the importance of post-secondary education, the Denison contingent was asked to spend some time talking and answering questions about college. Typically the Denison students shared where they were from, their year in college, their major, how they prepared for college, the types of courses they took, and what it was like to live with their friends.

To meet the goals of our class, and to keep the focus on both brain and gender, we designed a program in which college students designed six brain-related activities that could be used independently and in any order so as to be flexible given the different needs and abilities of each second grade classroom. The activities, which will be described in greater detail later, were: a brain puzzle, a mechanosensory activity in which students had to guess the contents of a sock by using their sense of touch, a "mystery noise" activity, a jellybean smell/taste activity, an activity that simulated message transmission along neurons, and a version of tag called "neuron chain tag." We kept an awareness of gender central to our course content by monitoring student engagement in all of the activities and comparing engagement among boys and girls. Students worked in teams of four per Newark second grade classroom. We visited six second grade classrooms per week, eventually going to all of the second graders in Newark.

Gender and play in children. A variety of studies indicate that male and female children have different preferences during play. For instance, boys and girls are supposed to prefer different types of toys, with boys gravitating to balls, blocks, bikes, trucks, cars, weapons, and male figurines, and girls gravitating towards board games, puzzles, crayons, and dolls (Berenbaum and Hines, 1992; Hines, 2004; Berenbaum et al., 2008). Boys spend more time on rough and tumble games (Fabes et al., 2003; Hines 2004). Although these differences appear early on in life (12 months; Snow et al., 1983), they are reinforced by parents and peers (Fagot and Patterson, 1969; Fagot, 1978) and grow stronger and encompass more types of activities as children reach adolescence (McHale et al., 2004; Ruble et al., 2006). However, about one third of girls and one quarter of boys engage in play behaviors more typical of the other sex, at least occasionally (Sandberg et al., 1993). The amount of cross-play can be influenced by the gender-roles demonstrated by the parents, the presence, number and age of opposite sex siblings, culture, exposure to gonadal hormones, and other factors (Hines, 2004; McHale et al., 2005)

Given these studies, our hypotheses were as follows: 1) girls would be more engaged than boys with the brain puzzle, 2) the sensory activities (Mystery socks, Jelly beans, Mystery noises) would be gender neutral, and 3) the running around and competitive activities (Message transmission, neuron chain tag) would be more engaging for boys than for girls.

MATERIALS AND METHODS

Basic plan. The undergraduate students worked in teams of four or five. All but one Denison student led the activities with the second graders. The last student monitored student engagement using criteria described below. Our visits were part of our lab time, which unfortunately meant that we were interacting with the second graders at the end of their day.

Activities. All activities chosen except for the brain puzzle were adapted from brain-related activities found on Dr. Eric Chudler's excellent "neuroscience for kids" website (http://faculty.washington.edu/chudler/neurok.html). We chose activities using the following criteria: they needed to be time-flexible, fun, and cheap. Activities needed to be able to be included in a modular fashion, depending on how much time we had in the classroom and on the abilities of the students on that particular day. Since we knew that we would be reaching almost 500 students, any "disposables" needed to be inexpensive, as the outreach budget was $150 total.

Our biggest expense was the brain puzzle, because we wanted to make enough so that each student could have one and take it home. We constructed 500 brain puzzles using recycled manila folders, brain images, simple text about basic functions of the brain, plastic ziplock bags, tape and glue. We found a colorful labeled brain image on the web (many exist; we used one from http://www.sharpbrains.com/blog/2008/06/05/your-brain-on-trading-101/) and saved costs by printing them out four to a page. We cut each brain into 7-10 pieces and placed the pieces into a ziplock bag which was then taped into the inside of the folder. We glued simple descriptions of brain lobe function onto the inside of the folder. Altogether, the brain puzzles cost us about 0.15 each. We typically did the brain puzzle as the first activity, after introductions and the discussion about college. Once the second graders had assembled the puzzle, the Denison students briefly described and answered questions about the parts of the brain (Fig. 1). Depending on the time available and the focus of the second graders, this activity took between 10 and 20 minutes. Afterwards, when the second graders did different activities relating to their senses or to movement, we related these experiences to the relevant parts of the brain.

Figure 1. Newark second graders engaging in a discussion of what the brain does. Their brain puzzle folders are in front of them.

The goal of the mystery sock activity was to have students identify common objects using their sense of touch, which we then related back to the parietal lobe. Our mystery socks consisted of plain white sports socks filled with items that would present some interesting tactile contrasts and that were objects that I had around the house: markers, glue sticks, whiffle balls, playdough, pennies, legos, small metal trucks and cars, and tissues. Each Denison team had the same assortment of eight socks. During the activity, each child tried to guess the contents of each sock by using their sense of touch alone. The hardest part of this activity was keeping the second graders from shouting out what they thought was in the sock. But by asking them to keep it a secret, we were able to keep the experience novel for everyone. Students really enjoyed guessing once everyone had felt all of the socks. A good strategy for keeping track of which students had felt each sock was to have the students form lines in front of the Denison students, who were holding the socks (Fig. 2). By varying the number of socks in circulation, this activity's duration could be varied from 5 to 15 minutes.

The goal of the jelly bean activity was for students to recognize the extent to which taste is affected by smell, and thus also the general concept of how the senses can work together. For our jellybean experiments, we used Lifesaver jellybeans because they are inexpensive and have strong flavors and fragrances that most people enjoyed. Typically, Denison students ran this exercise by sorting the jellybeans by color and giving all of the second graders the same color jellybean. During the first round, the second graders were allowed to use all their senses to identify the flavor. During the second round they were asked to close their eyes, to avoid the color cue, and for the third round, they were asked to pinch their nose to minimize the flavor-amplifying effect of odor.

Figure 2. Denison students helping second graders try to discover what's in the socks using their sense of touch.

The mystery noises activity involved producing noises which the second graders had to identify. In some cases, Denison students were able to play electronic noises of ice cream trucks, cows mooing, popcorn popping, etc. on their laptops. These sounds were all found on www.youtube.com. When the internet was not available in the classrooms, Denison students created sounds by ripping paper, clapping erasers, dropping a penny, closing a door, etc. This activity had the double virtue of being both free and time-flexible.

We divided the class into groups to do the message transmission activity. The goal of this exercise was to show how signals can be passed from one neuron to another. Students formed two or three lines with equal numbers of students and were instructed to tap the next person in line once they felt a tap themselves. We varied the distance between students to show how this affects message transmission.

Our final activity was neuron chain tag. In this version of tag, one player is "it." This player is the first neuron and tries to tag another player. A tagged player must hold the hand of the first player and together they have to chase the other players. As more and more players are tagged, they are added to the chain of neurons. The game ends when all of the players are part of the chain.

Student engagement. Over the course of each activity, the Denison student assigned to monitor second grader engagement observed each student in the classroom. They visually scanned each student multiple times per activity. This was facilitated by the fact that for activities 1-5 students were typically grouped at desk clusters or in rows. They noted each student's gender and decided if he/she was engaged or unengaged and recorded this in a data sheet with a + or a - mark. Students were considered engaged when they watched the Denison students leading the activity, followed directions, interacted with peers when instructed (as in the tag and message games), and worked independently as assigned (as in the brain puzzle), etc. Students were considered unengaged when they were not looking at the students leading the activities or were talking out of turn, had their head down on their desk, or were otherwise not following directions.

These + and – ratings were converted into numerical scores as follows. Students who received mostly – for an activity were given a 1 for that activity, students who received an approximately equal mix of – and + were given a 2, and students who received mostly + were considered to have an engagement of 3 for that activity. Since these scores are ordinal, we compared student engagement between boys and girls using the Mann-Whitney test with the improved normal approximation (Zar, 1999). This test was calculated busing JMP 8 software (SAS Institute Inc., 2008). Effect sizes were calculated using Cohen's "d" statistics, in which the difference between the means is divided by the mean standard deviation (Cohen, 1988). The results of these calculations are given in Figure 3 and in Table 1.

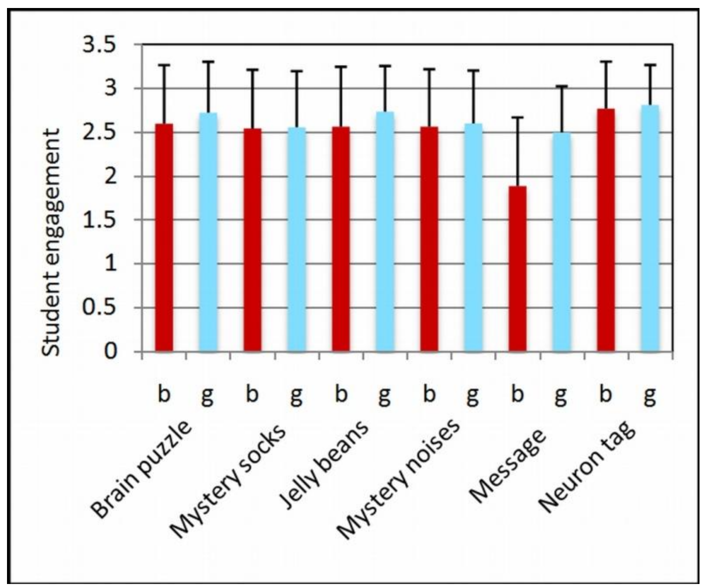

Figure 3. Means (bars) and standard deviations (error bars) of student engagement data for the six activities listed across the x axis. Data are separated by gender; boy engagement data are in red and girl engagement data are in blue. Sample sizes are indicated in Table 1.

Denison students also filled out a weekly individual form reporting on how the activities went and what they learned. They also filled out an anonymous survey commenting on the service learning experience as a whole.

RESULTS AND DISCUSSION

We successfully visited all 24 second grades in Newark, OH, and interacted with about 560 second graders. The activities presented in each classroom varied depending on teacher preparedness, time available and other constraints (such as achievement testing occurring elsewhere in the building). Every visit included the brain puzzle and the jelly bean taste test, and most groups did the mystery socks, but fewer groups did the other activities. All activities except for message transmission had a score of at least 2.5 out of 3, with the mean engagement for all activities being 2.63. The most engaging activity, for both boys and girls, was the neuron chain tag (2.77 and 2.81 for boys and girls). A summary of the mean engagement scores of the six activities, analyzed by gender, is shown in Figure 3.

When student engagement was analyzed as a function of gender, girls were more engaged than boys during the brain puzzle and jelly bean activities. Effect sizes measured as Cohen's "d" statistics for these activities were small to moderate (0.203 and 0.285). The other four activities (mystery socks, mystery noises, message, and neuron chain tag) showed no difference in engagement between male and female second graders, although the message activity might well show a difference with a larger sample size.

The first hypothesis, that girls would be more engaged in the brain puzzle than boys was supported ($p < 0.0226$, $d = 0.203$; Figure 3, Table 1). The second hypothesis, that the sensory activities would be gender neutral, was supported by two out of the three sensory activities (mystery socks and mystery noises), but not by jelly beans ($p < 0.0074$, $d = 0.285$). The third hypothesis, that the more active games would engage boys more than girls, was not supported. Message transmission and neuron chain tag -the favorite of both boys and girls- was gender neutral.

Activity	Sample size	Mean ± SD	Z	Prob > Z	Effect size
Brain puzzle	225	B: 2.60 ± 0.67	-2.28	**0.0226**	0.203
	234	G: 2.73 ± 0.58			
Mystery socks	183	B: 2.55 ± 0.67	-0.051	0.956	0.022
	189	G: 2.56 ± 0.64			
Jelly beans	228	B: 2.57 ± 0.68	-2.68	**0.0074**	0.285
	236	G: 2.74 ± 0.52			
Mystery noises	78	B: 2.56 ± 0.66	-0.237	0.8124	0.061
	83	G: 2.60 ± 0.60			
Message	9	B: 1.89 ± 0.78	-1.735	0.083	0.934
	10	G: 2.50 ± 0.53			
Neuron tag	74	B: 2.77 ± 0.54	-.316	0.752	0.087
	75	G: 2.81 ± 0.46			

Table 1. Sample size, means ± standard errors, Z values, p-values from Mann-Whitney tests, and effect sizes (comparing engagement between boys and girls for each activity) are reported for each of the activities. Significant p-values are in bold.

It is worth considering the biases that could have crept in to the observations of the effect of gender on student engagement. Although our class did not explicitly discuss the theoretical gender bias of our chosen activities, saying only that we wanted to have a variety of types of activities to accommodate different learning styles, these students may have formed predictions and this may have affected their scoring. I tried to minimize the likelihood of bias by creating a rubric for scoring student engagement that relied on simple, clear observations.

I was initially surprised that girls were equally or more engaged than boys for all six activities. However, this could be due to the fact that "engagement" has to do with following instructions and looking at whoever is giving instructions. Perhaps, if engagement had been structured to be about enthusiasm, jumping out of one's seat, asking questions, and interrupting out of eagerness, boys might have received higher scores. This experiment could be the subject of an outreach in another offering of this course.

Figure 4. Denison students sitting at desk clusters and interacting with Newark second graders.

Eighteen out of 23 students (78%) thought that the experience of teaching about college and about the brain enhanced their understanding of the content material, saying that they "learned more about the brain and [its] functions by teaching 2nd graders." Typical responses from the 22% who did not feel that this experience helped them directly with course content included that the experience "didn't enhance class subject matter but [they] did learn more about kids and learning styles." Twenty-one out of 23 students (91%) felt that the experience gave them a window into solving community problems, saying that this outreach "exemplifies and supports Denison's mission" and that they felt proud to have "taken action." The two who did not respond affirmatively felt that the college awareness part was certainly important, but didn't think that greater brain awareness could solve this community's problems. Twenty out of 23 students (87%) felt that they had developed a greater sense of themselves as agents of change as a result of the experience. The three who did not respond affirmatively felt that earlier volunteering experiences had transformed them already. Some responses included "I feel like I may have left a lasting impression on students who may otherwise get little attention," and "I became passionate again about volunteering." Some students reflected that the experience "made me realize that people in the surrounding community don't have the great opportunities and constant encouragement that I do."

Unanimously, the students validated the importance of engaging in the community. They noted that simple things, like sitting at the table with the second graders, and giving them a lot of attention and encouragement, made a big difference. Some comments included: this "definitely enhanced my Denison experience," the "PEAK program [was] extremely beneficial to both volunteers and participants," they "wanted to stay longer to have more impact", and that the outreach "made me examine myself as a teacher and as a student at the same time."

As a faculty member, I was highly pleased with the experience. I think that my students, as well as the second graders, were highly engaged. I think that the Denison students benefitted from seeing male-female differences in learning styles and from analyzing and discussing the data. I think that they also benefitted personally- either finding a drive to volunteer, or perhaps realizing how fortunate they were. However, these activities took a lot of time to prepare and then lead. Altogether, we devoted six out of our fourteen lab times to this outreach (one planning, one preparing and practice, four weeks in the classrooms). Part of this extensive time commitment was due to the mission of PEAK and the program's desire to have every student in the targeted grade level uniformly involved in the outreach. Since this class was a non-majors class, I felt that the benefits of this experience outweighed the costs (losing time for additional wetlabs or independent projects). I am not sure that I could rationalize using the same amount of time doing outreach for my upper level neurophysiology course. After this experience, however, I will be looking for ways that we can reach out to the community in a different way for a shorter period of time.

REFERENCES

Berenbaum SA, Hines M (1992) Early androgens are related to childhood sex-typed toy preferences. Psychol Sci 3:203-206.

Berenbaum SA, Martin CL, Hanish LD, Briggs PT, and Fabes RA (2008) Sex differences in children's play. In: Sex differences in the brain: from genes to behavior (Becker JB, Berkley KJ, Geary N, Hampson E, Herman JP, Young EA, eds) pp 275-290. New York: Oxford University Press.

Chudler E "neuroscience for kids" website (http://faculty.washington.edu/chudler/neurok.html).

Cohen J (1988) Statistical power analysis for the behavioral sciences (2nd ed). Hillsdale, NJ: Lawrence Erlbaum Associates.

Fabes RA, Martin CL, Hanish, LD (2003) Young children's play qualities same-, other-, and mixed-sex peer groups. Child Dev 74:921-932.

Fagot BI (1978) The influence of sex of child on parental reactions to toddler children. Child Dev 49:459-465.

Fagot BI, Patterson GR (1969) An in vivo analysis of reinforcing contingencies for sex-role behaviors in the preschool child. Dev Psychol 5:563-568.

Hines M (2004) Brain gender. New York: Oxford University Press.

McHale SM, Shanahan L, Updegraff KA, Crouter AC, Booth A (2004) Developmental and individual differences in girls' sex-typed activities in middle childhood and adolescence. Child Dev 75:1575-1593.

McHale SM, Updegraff KA, Shanahan L, Crouter AC, Killoren SE (2005) Siblings' differential treatment in Mexican American families. J Marriage Fam 67:1259-1274.

Mead, KS (2009) Sex, gender, and the brain: a non-majors course linking neuroscience and women's studies. J Undergrad Neurosci Educ 8:A5-A9.

Ruble DN, Martin CL, Berenbaum SA (2006) Gender development. In: Handbook of child psychology. Volume 3. Social, emotional, and personality development. (6th ed) (Eisenburg N, ed), pp 858-932. New York: Wiley.

Sandberg DE, Meyer-Bahlburg HF, Ehrhardt AA, Yager TJ (1993) The prevalence of gender-atypical behavior in elementary school children. J Am Acad Child Adolesc Psychiatry 32:306-314.

Snow ME, Jacklin CN, Maccoby EE (1983) Sex of child differences in father-child interaction at one year of age. Child Dev 54:227-232.

Zar, JH (1999) Biostatistical analysis, 4th edition. Upper Saddle River, NJ: Prentice Hall.

Supplementary material: script with lesson plans for each activity (1), student engagement forms (2), and lab supply list (3).

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