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Focal points: affecting undergraduates' scientific literacy through a three-skill intervention

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BOSTON UNIVERSITY
SCHOOL OF MEDICINE

Thesis

**FOCAL POINTS:
AFFECTING UNDERGRADUATES' SCIENTIFIC LITERACY
THROUGH A THREE-SKILL INTERVENTION**

by

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B.S., Webster University, St. Louis, 2008

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DEDICATION

I would like to dedicate this work to the students from the fall 2015 semester of Introduction to Neuroscience – NE 101. Their engagement made this project possible, and any conclusions that have the potential of improving undergraduate STEM education are a direct result of their participation. It was a privilege to witness their personal and academic development throughout the semester, and I am grateful for being able to have contributed to their education.

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ABSTRACT

Undergraduate science, technology, engineering, and mathematics (STEM) education has been receiving a great deal of attention. Stakeholders in government as well as academic institutions recognize the significance of educational reform in STEM fields to improve student engagement, retention and proficiency. Boston University, through partnership with the Center for the Integration of Research, Teaching and Learning (CIRTL), offers graduate students the opportunity to perform an educational research project in a STEM course in the Teaching-as-Research (TAR) Fellowship. The main goal of a TAR project is to identify educational interventions that improve student outcomes. This study, being a TAR project, examines how scientific literacy of undergraduates enrolled in Introduction to Neuroscience (NE 101) at Boston University changes over the course of a semester in response to a three-skill intervention.

Scientific literacy, broadly defined as the ability to leverage evidence and data to interpret scientific research and evaluate the significance of conclusions, has been promoted by academic institutions by some time. Be that as it may, best practices for teaching scientific literacy and standardized methods of measurement have yet to be explicitly

outlined. There are, however, validated paradigms that are gaining momentum: The integrated STEM education model and the Test of Scientific Literacy Skills (TOSLS). Integrated STEM education incorporates multiple academic disciplines (within and outside STEM fields) and promotes application of knowledge to solving real-world problems. The TOSLS is an assessment tool in sync with this educational model; its purpose is to gauge students' proficiency in nine key skills of scientific literacy by posing questions that require students to implement these skills in meaningful scenarios.

In this study, I used a subset of the scientific literacy skills outlined in the TOSLS to design curriculum for the discussion component of NE 101. I also used pre- and post-intervention adaptations of the TOSLS for measuring students' achievement of scientific literacy in addition to weekly quiz questions. However, another focus of this study was to highlight changes in students' motivation and attitudes toward scientific inquiry pre- to post-intervention. Research conducted by Carberry et al. suggests that employing a variety of quantitative and qualitative measurements provides a more holistic picture of students' learning. To this end, two focus groups were held and a post-course discussion survey was deployed at the end of the course.

The quantitative and qualitative data collected from these instruments indicate vital points for STEM educators to consider when designing and implementing course curriculum, especially those courses oriented toward promoting scientific literacy in their student population. Major considerations include:

1. Design problem-based activities that integrate multiple scientific literacy skills

2. Incorporate scientific literature from non-primary sources and that is representative of students' interests
3. Develop students' competency in reading primary scientific literature by gradually increasing the difficulty of material
4. Provide students with an intuitive and explicit framework for deciphering primary scientific literature
5. Use formative assessment to identify students' strengths and challenges; leverage strengths to improve upon areas of difficulty

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LIST OF ABBREVIATIONS

AAAS.....	American Association for the Advancement of Science
BU.....	Boston University
CIRTL.....	Center for Integration, Research, Teaching and Learning
NE 101	Introduction to Neuroscience
NRC	National Research Council
PISA.....	Program for International Student Assessment
STEM.....	Science, Technology, Engineering and Mathematics
TAR.....	Teaching-as-Research
TOSLS	Test of Scientific Literacy Skills

INTRODUCTION

Undergraduate STEM Education

Undergraduate education in the fields of science, technology, engineering and mathematics (STEM) has been receiving a great deal of attention. This is evident in recent governmental policy focused on improving the quality of STEM education by recruiting highly talented educators in a STEM Master Teacher Corps (“President Obama Announces,” 2012). Another strategy emanating from this policy is educational reform, development and standardization of “best teaching practices.” This concept of increasing the quality of STEM education has a potentially broad impact, specifically when considering the student population within a general education undergraduate STEM course. These courses typically contain a student body coming from diverse backgrounds that must be taken into account when establishing “best teaching practices.”

Another vital outcome in STEM education is improving students’ scientific literacy. By providing students with skills necessary for understanding basic principles of science and interpreting scientific research, STEM courses can have important, practical and long-term relevance in students’ lives. A recent publication from the Smithsonian Institute promoting the urgent need of promoting scientific literacy in academic institutions shares findings from the Programme for International Student Assessment that reemphasize the point:

“The United States placed 17th on the 2006 Programme for International Student Assessment test given to 15-year-olds in the

world's 30th wealthiest nations to measure their ability to apply math and science knowledge in real-life contexts" ("Increasing Scientific Literacy," n.d.).

While it is imperative to address this need at all educational levels, this study will demonstrate interventions for affecting scientific literacy of undergraduates.

Introduction to Neuroscience

Another development gaining momentum in academia is the establishment of courses that integrate multiple academic disciplines. Neuroscience is a highly integrative subject, contributing to and informed by a variety of academic areas and practical applications. Reflecting this level of integration, neuroscience courses in undergraduate institutions are becoming increasingly more accessible to students from a dynamic range of majors (Salomon, 2015). Some course offerings are designed to reflect the broad range of interests of their student by examining topics in neuroscience from unique perspectives, including philosophy and history.

Introduction to Neuroscience (NE 101) at Boston University represents this momentum. Although a majority of the students in NE 101 are incoming freshman majoring in neuroscience, a notable proportion of its students are enrolled in a variety of STEM and non-STEM majors. Students examined topics varying from basic neural transmission to brain-machine interfaces used to assist patients with special mobility needs. Notable historical developments in neuroscience were emphasized in lectures at the beginning of the course, in addition to ethical implications of more recent advancements in the field in both lecture and discussion components.

Integrated STEM Education Model

With these points of leveraging a multidisciplinary approach and establishing best teaching practices in mind, a promising instructional model has emerged that centers on creating authentic, real-world scenarios in which students apply multidisciplinary strategies. The integrated STEM education model is an instructional framework for incorporating knowledge and skills from various fields into STEM course curriculum (Johnson, 2013). An important concept of this model is having students employ methods of scientific inquiry, technological and engineering design, and mathematical reasoning in meaningful ways. However, this model also allows for incorporating various subjects (such as social studies, psychology, and philosophy) into a STEM course, a method currently employed by multiple institutions across the United States.

In order to increase the likelihood of engaging students from a diversity of academic backgrounds, I employed this instructional framework for developing curriculum. Depending on the goals of a particular discussion, teaching methodologies were varied to include inquiry-based, problem-based, and cooperative learning models. Additionally, I used a heterogeneity of source materials when designing lesson plans, spanning from primary research articles to novels written by scientists.

Teaching-as-Research Fellowship

Boston University is a member of the Center for Integration, Research, Teaching and Learning (CIRTL) network in collaboration with nearly 25 other institutions to provide

professional development opportunities for future educators (BU CIRTLL, 2015). By enhancing training of graduate and post-doctoral students in educational practice, the mission of Boston University as an affiliate of CIRTLL is to prepare future faculty members to be effective undergraduate STEM educators. Specific projects as part of network activities include hands-on teaching experiences for graduate and post-doc students, including the Teaching-as-Research Fellowship (Teaching-as-Research Fellowship, 2015). Teaching-as-Research (TAR) fellows undertake a Teaching-as-Research project in order to provide evidence-based conclusions on teaching methodology. Graduate and post-doctoral students typically conduct a project spanning 1-2 semester through a course offered at Boston University.

The TAR program represents the growing number of initiatives within academic institutions focusing on improving undergraduate STEM education. Expectations for a high-quality TAR project are in sync with standards of scientific research, such that researchers are instructed to design their project to generate data that may be used in developing educational strategies beyond the individual course. Specific requirements include the development of a research question that is based on observations in the classroom and/or evidence from educational research literature pointing to a specific teaching and/or learning challenge. Additionally, TAR projects must build upon the existing literature and contain objectives that will contribute to the scholarship of teaching and learning. Data collection is performed through quantitative and qualitative assessments. These assessments, in turn, must be aligned with the learning goals of the

course the project occurs in. After the project is completed, findings are then utilized to inform classroom interventions that can improve learning outcomes.

Scientific Literacy

The definition of scientific literacy according to the National Research Council (NRC) is the ability to “use evidence and data to evaluate the quality of science information and arguments put forth by scientists and in the media” (NRC, 1996). An alternative definition is provided by Project 2061 (AAAS, 1993) and PISA:

“The capacity to use scientific knowledge to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity” (Organisation for Economic Co-operation and Development, 2003).

These definitions collectively outline the relevance of scientific literacy in our everyday lives. By demonstrating to students the importance of developing scientific literacy skills, they may be more motivated to practice them. For this reason, I selected these definitions to guide the focus of this study, definitions that also provide the framework for a key piece of literature used throughout the study: Test of Scientific Literacy Skills (TOSLS).

The TOSLS is a newly validated instrument for assessing students’ scientific literacy in nine key skills (Gormally et al., 2012). Researchers first identified these skills by examining the literature on current instruments used to assess scientific literacy. Thereafter, expert STEM educators working in state colleges, public research universities, and private research universities were surveyed for what they believed to be necessary in students’ attainment of scientific literacy. This approach was used as a

method of validation for the skills identified through literature review. After constructing questions that assess each of these skills, analytical techniques were used to validate the TOSLS and to demonstrate its utility in various academic settings. Specifically, this instrument was developed with students enrolled in general education-level STEM courses in mind. Therefore, the TOSLS serves as a valid framework for this study. I utilized the TOSLS itself as an instrument for determining students' scientific literacy pre- and post-teaching intervention, as well as the scientific literacy skills as a schema for curriculum development.

Assessment of Students' Learning

While a major goal of this study is identifying whether a three-skill intervention is an effective measure for increasing scientific literacy overall, it is also of importance to determine how students' attitudes and perceptions of scientific literature change pre- to post-intervention. This is pertinent when we consider a vital outcome for promoting scientific literacy: the likelihood of students reading scientific literature and using scientific principles in their daily lives. Leveraging a combination of quantitative measurements for assessing the cognitive domain (increase in scientific literacy) and qualitative measurement for the affective domain (changes in attitudes and/or perceptions) provides a more holistic picture of students' learning (Carberry, 2012).

To this end, I employed the following methods for evaluating student outcomes:

1. Pre- and post-intervention adaptations of the Test of Scientific Literacy Skills

2. Weekly quiz questions assessing students' proficiency in a particular skill
3. Two focus groups convened after the final discussion
4. Post-course survey eliciting feedback from students on the quality of the discussions, their opinions of the discussion curriculum, and their attitudes toward scientific literature

Specific Aims and Objectives

A major goal of this study centers on increasing students' scientific literacy. Furthermore, it is of interest to determine how students' attitudes and perceptions of scientific literature change over the course of the semester. Lastly, this study aims to identify literature selections, teaching methodologies and assessments that may be translated for use in other undergraduate STEM courses at Boston University and beyond. These goals are explicitly stated below, and are categorized by their theoretical level of impact.

Local Objectives - NE 101

1. To identify whether a three-skill intervention is capable of increasing students' scientific literacy in all nine skills of scientific literacy as defined by Gormally et al. (2012)
2. To determine students' perceptions of scientific literature and the likelihood of their engaging with scientific literature after the course has ended

Global Objectives - Boston University and Beyond

1. To specify scientific literature, teaching methodologies, and assessments well suited for teaching and evaluating students' scientific literacy
2. To identify literature, methodologies, and assessments which may be translated for use in other undergraduate STEM courses at Boston University and beyond

METHODS

Scientific Literacy Skills

The Test of Scientific Literacy Skills (TOSLS), developed by Gormally, Brickman, and Lutz (2012), provided much of the framework for this study. Through their work in developing a tool for measuring scientific literacy and by the subsequent process of validating this tool, a total of nine key skills were identified as being necessary for students' development of scientific literacy. These skills were established by conducting an extensive literature search, surveying faculty for expert opinion, and pinpointing common challenges for students in becoming scientifically literate (amongst other measures taken to ensure relevance and validity). Additionally, the researchers established two major categories in which the skills fall: 1) skills related to recognizing and analyzing the use of methods of inquiry that lead to scientific knowledge, and 2) skills related to organizing, analyzing, and interpreting quantitative data and scientific information.

It was necessary to drill down the original nine skills to a subset that could serve as the focus of a study conducted over the course of a single semester. I therefore selected three skills, one for each block of discussions and that represent both major categories mentioned above. These skills can be found in the table below, along with the major category into which they fall (Table 1). Information contained under the headings of 'Explanation of skill' and 'Examples of Common Student Challenges and

Misconceptions’, as well as the skills themselves, is taken from the Test of Scientific Literacy Skills (Gormally et al., 2012).

Table 1 – Selected Skills of Scientific Literacy

Scientific Literacy Skill	Major Category of Skill	Explanation of Skill	Examples of Common Student Challenges and Misconceptions
Identify a valid scientific argument	Skills related to recognizing and analyzing the use of methods of inquiry that lead to scientific knowledge	Recognize what qualifies as scientific evidence and when scientific evidence supports a hypothesis	-Inability to link claims correctly with evidence and lack of scrutiny about evidence -“Facts” or even unrelated evidence considered to be supportive for scientific arguments
Understand elements of research design and how they impact scientific findings / conclusions	Skills related to recognizing and analyzing the use of methods of inquiry that lead to scientific knowledge	Identify strengths and weaknesses in research design related to bias, sample size, randomization, and experimental control	-Misunderstanding randomization contextualized in a particular study design -General lack of understanding of elements of good research design
Read and interpret graphical representations of data	Skills related to organizing, analyzing, and interpreting quantitative data and scientific information	Interpret data presented graphically to make a conclusion about study findings	-Difficulty in interpreting graphs -Inability to match patterns of growth (i.e. linear or exponential with graph shape)

Curriculum

Prior to and during the fall 2015 semester, I developed a curriculum for the discussion component of NE 101 with some key considerations in mind. First, I based my rationale for selecting readings and developing lesson plans on how these materials could help students develop a particular scientific literacy skill. Second, I selected a variety of source material. Students in STEM fields commonly experience burnout (Inside Higher Ed, 2013), and I wanted to mitigate the risk of students in NE 101 losing interest in neuroscience from being over-exposed to primary scientific literature in discussions. While helping them develop scientific literacy was held in high regard, so was the desire for students to be more likely to read scientific literature after leaving the classroom and into the future. I considered how a greater breadth of source material might aid in accomplishing both goals simultaneously, and selected readings spanning primary research articles to secondary sources to novels written by scientists.

One final consideration I made when designing curriculum was the goal of guiding students through the process of telling a story as part of communicating scientific information. This process of ‘scientific storytelling’ uses the different components of research literature (i.e. introduction, methods, results, and discussion) as the key facets of a story (i.e. protagonist, antagonist, conflict, resolution) (Luna, 2015). The need for some specific research might be conceptualized as the conflict, the method as the protagonist, or the results as the resolution. Accordingly, I designed specific activities that might help students to identify these necessary components for retelling the story that the research is

communicating, such as recognizing the significance of a study and determining whether the need had been met based on the data presented. However, it should be noted that this goal is distinct from developing students' scientific literacy in two ways. First of all, communicating research findings via narrative is a framework for engaging students in scientific literature, but its use does not ensure increasing their scientific literacy (nor does it intend to). Secondly, the data or 'product' of this effort was not measured quantitatively. Rather, it was observed in the quality of students' participation during the discussions.

Within the first block of discussions (Discussions #1-3), I assigned readings from a total of two primary sources and three secondary sources. Leveraging secondary sources can help students to navigate primary literature by identifying the most important components of a research article, as well as help them pinpoint the characters and plot of the story embedded in the research. Activities within this first block were oriented toward helping students become familiar with the major elements of scientific literature and navigating a primary research article.

During the second block of discussions (Discussions #5-8), I again employed two primary research articles. Students were also assigned readings from two novels, one written by Ramon y Cajal (2004) and the other by Dr. Oliver Sacks (1998). Referring to the earlier point of engaging students in scientific literature by exposing them to a diversity of materials, I selected these readings with the hope of eliciting students' enthusiasm in reading scientific literature. Doing so also exposed them to two notably

different narrative styles, both exemplary of scientific storytelling. Cajal (2004) presents a historical perspective of scientific development and industrialization, personal perspectives of what makes for high-quality research, and a survey of personal characteristics of the successful scientist. I chose this author in particular because of his insight into the nature of scientific research and blunt mode of communication, figuring it might spur students into identifying their own views and philosophies of science. Dr. Sacks, on the other hand, provides clinical cases recounted with a certain romantic tone (1998). He presents his patient encounters as opportunities for patient and clinician, as equals, to arrive at incredible insights into disease and treatment. In these ‘clinical tales’, as he calls them, the physician and patient are both readily identifiable as the protagonists of the story, while the ailment the patient reports is the antagonist. I selected readings from his book The Man Who Mistook His Wife for a Hat with the hopes of cultivating students’ interest in clinical research and applications in medicine.

Within the final block (Discussions #10-12), all of the assigned reading came from primary sources. The purpose in doing so was to bring previously developed skills to bear on interpreting primary literature. Activities centered on having students analyze and discuss plausible interpretations of figures extracted from the articles, relating to the skill of interpreting graphical representations of data. The final discussion (Discussion #12) built on this skill, and presented an overarching view of past discussions with regards to their related skills of scientific literacy and specific goals of each lesson.

An overview of the discussions and their assigned readings is provided in Table 2. The lesson plans for the semester's discussions are included in Appendix A-1, along with a collection of worksheets in Appendix A-2. Citation for all source material utilized during the process of curriculum development and implementation can be found in Appendix B.

Table 2 – Discussions and Assigned Readings

Discussion Number and Title	Assigned Reading	Source Type
1. Controversial Science	a. “How to Critically Appraise an Article” b. “Feeling the Future” c. Journal’s Article on ESP Expected to Prompt Outrage	a. primary scientific literature b. primary scientific literature c. secondary scientific literature
2. Power of the Brain(s), Part 1	a. Secrets of the Brain b. Scientists Demonstrate Animal Mind-Melds	a. secondary scientific literature b. secondary scientific literature
3. Power of the Brain(s), Part 2	a. Secrets of the Brain b. Scientists Demonstrate Animal Mind-Melds	a. secondary scientific literature b. secondary scientific literature
4. Exam Review	Not applicable	Not applicable
5. Mistreatment of Medical Treatment	a. Randomized Trial of Modafinil as a Treatment of Excessive Daytime Somnolence of Narcolepsy b. Modafinil-Induced Psychosis	a. primary scientific literature b. secondary scientific literature
6. Wise Words	a. <i>Advice for a Young Investigator</i>	a. Novel
7. Lost in Transmission	a. <i>The Man Who Mistook His Wife for a Hat</i>	a. Novel
8. Proprioception via Misdirection	a. <i>The Man Who Mistook His Wife for a Hat</i>	a. Novel
9. Exam Review	Not applicable	Not applicable
10. Vice or Virtue	a. Low-Dose Nicotine Facilitates Spatial Memory in Apo-E Knockout Mice in the Radial Arm Maze	a. primary scientific literature
11. Alzheimer’s and Lifestyle Interventions	a. Exercise is More Effective than Diet Control in Preventing High Fat Diet-induced Beta-amyloid Deposition and Memory Deficit in Amyloid Precursor Protein Transgenic Mice	a. primary scientific literature
12. Conclusions and Brain-Machine Interfaces	a. Selecting the Signals for a Brain-Machine Interface b. Controlling Robots with the Mind	a. primary scientific literature b. secondary scientific literature

Test of Scientific Literacy Skills

The Test of Scientific Literacy Skills (TOSLS), developed by Gormally, Brickman, and Lutz (2012), was utilized not only in enumerating the skills of scientific literacy for this

study, but also for baseline and post-intervention quantitative measurement of students' scientific literacy in these three skills. The pre-intervention adaptation of the TOSLS consisted of 10 questions assessing students' abilities in the following: 1) identify a valid scientific argument; 2) understand the elements of research design and how they impact scientific findings/conclusions; and 3) read and interpret graphical representations of data. The post-intervention adaptation of the TOSLS consisted of 15 questions assessing students' scientific literacy for all nine skills identified by Gormally et al. These skills can be found in Table 3 below, along with the major category into which they fall. Information contained under the headings of 'Explanation of skill' and 'Examples of Common Student Challenges and Misconceptions', as well as the skills themselves, is taken from the Test of Scientific Literacy Skills (Gormally et al., 2012).

Table 3 – Categories of Scientific Literacy Skills

Scientific Literacy Skill	Major Category of Skill	Explanation of Skill	Examples of Common Student Challenges and Misconceptions
1. Identify a valid scientific argument	Skills related to recognizing and analyzing the use of methods of inquiry that lead to scientific knowledge	Recognize what qualifies as scientific evidence and when scientific evidence supports a hypothesis	Inability to link claims correctly with evidence and lack of scrutiny about evidence “Facts” or even unrelated evidence considered to be supportive for scientific arguments
2. Evaluate the validity of sources	Skills related to recognizing and analyzing the use of methods of inquiry that lead to scientific knowledge	Distinguish between types of sources; identify bias, authority, and reliability	Inability to identify accuracy and credibility issues
3. Evaluate the use and misuse of scientific information	Skills related to recognizing and analyzing the use of methods of inquiry that lead to scientific knowledge	Recognize a valid and ethical scientific course of action and identify appropriate use of science by government, industry, and media that is free of bias and economic and political pressure to make societal decisions	Prevailing political beliefs can dictate how scientific findings are used All sides of a controversy should be given equal weight regardless of their validity
4. Understand elements of research design and how they impact scientific findings / conclusions	Skills related to recognizing and analyzing the use of methods of inquiry that lead to scientific knowledge	Identify strengths and weaknesses in research design related to bias, sample size, randomization, and experimental control	Misunderstanding randomization contextualized in a particular study design General lack of understanding of elements of good research design
5. Create graphical representations of data	Skills related to organizing, analyzing, and interpreting quantitative data and scientific information	Identify the appropriate format for the graphical representations of data given particular type of data	Scatter plots show differences between groups Scatter plots are best for representing means, because the graph shows the entire range of data

Scientific Literacy Skill	Major Category of Skill	Explanation of Skill	Examples of Common Student Challenges and Misconceptions
6. Read and interpret graphical representations of data	Skills related to organizing, analyzing, and interpreting quantitative data and scientific information	Interpret data presented graphically to make a conclusion about study findings	Difficulty in interpreting graphs Inability to match patterns of growth (i.e. linear or exponential with graph shape)
7. Solve problems using quantitative skills, including probability and statistics	Skills related to organizing, analyzing, and interpreting quantitative data and scientific information	Calculate probabilities, percentages, and frequencies to draw a conclusion	Guessing the correct answer without being able to explain basic math calculations Statements indicative of low self-efficacy: “I’m not good at math.”
8. Understand and interpret basic statistics	Skills related to organizing, analyzing, and interpreting quantitative data and scientific information	Understand the need for statistics to quantify uncertainty in data	Lack of familiarity with functions of statistics and with scientific uncertainty Statistics prove data is correct or true
9. Justify inferences, predictions, and conclusions based on quantitative data	Skills related to organizing, analyzing, and interpreting quantitative data and scientific information	Interpret data and critique experimental designs to evaluate hypotheses and recognize flaws in arguments	Tendency to misinterpret or ignore graphical data when developing a hypothesis or evaluating an argument

The pre- and post-intervention adaptations of the TOSLS are included in Appendices C-1 and C-2, respectively. Both assessments were administered with a 30-minute time limit and were completed voluntarily by students in the NE 101 course with the knowledge that their score on the assessment would have no impact on their overall grade in the course. Students were encouraged to complete both assessments, as doing so would be

beneficial not only for helping them realize changes in their scientific literacy but also in informing future curriculum development for the course.

Quiz Questions

During the semester, I developed questions assessing students' proficiency for a specific skill that were included in a weekly quiz. The graduate teaching assistants administered these quizzes at the beginning of the discussion, and students were given five minutes to complete. Of the five questions on each quiz, four of the questions were written to assess students' basic understanding of that week's assigned reading and were recorded for a grade. The question assessing scientific literacy, however, did not count toward the quiz grade. These quiz questions can be found in Appendix A-1; they are included as the measurement component of the lesson plans used throughout the semester.

These ungraded quiz questions served two main purposes. First, they comprised a formative assessment of students' scientific literacy within each block of discussions. By identifying trends in the average scores, I hoped to identify whether curriculum and instruction were successful at increasing students' ability in a particular skill. Secondly, by using the common student challenges and misconceptions put forth by Gormally et al. (2012) (listed in Table 3) as a guide, I wrote incorrect answers in order to determine whether these challenges and misconceptions applied to the student population in NE 101 and to what extent.

It is significant to note that these questions did not undergo any standardized process of validation; they were included in the weekly quizzes based simply on the collective acknowledgment of their relevance to a particular scientific literacy skill by the graduate teaching assistants, undergraduate learning assistants, and/or course director for NE 101. Any conclusions that may be reached by interpreting the data these questions generated is highly tentative, but may also be grounds for further research.

Focus Groups

Students in NE 101 were recruited by the graduate teaching assistants to voluntarily participate in focus groups that occurred after the final discussion of the course. Two focus groups were held, each consisting of 5 student representatives from both the Thursday and Friday discussion meetings. Students were encouraged to provide candid feedback with regards to their experience with the discussion curriculum and how it related to developing skills of scientific literacy, as well as how certain readings and activities impacted their motivation and attitudes toward scientific literature. Elizabeth Tingley, program administrator for the Undergraduate Neuroscience Program at Boston University, served as the moderator for both of these focus groups. Ms. Tingley was selected based on the fact that she was not directly involved with the NE 101 course or with the research being conducted in it, as well as the fact that she holds good rapport with the students in the course. Thus, it could be assumed that she would receive honest opinions from them. The script utilized in both focus groups is included as Appendix D.

These focus groups, along with the post-course discussion survey, comprised the qualitative assessment for this study.

Post-Course Discussion Survey

Following the final discussion of the course, I designed and deployed a survey to assess students' opinion on the following:

- a. Utility of an assigned reading in developing a skill of scientific literacy
- b. Level of enjoyment (possible predictor of future desire to read scientific literature)
- c. Augmentation of current curriculum (retain or remove specific readings)

This survey is included as Appendix E.

RESULTS

Given the scope of this project and the multiple methods of data collection, I collected a robust body of qualitative and quantitative data. Pertinent findings are discussed within the context of the qualitative and quantitative measurements I utilized for assessing the affective and cognitive domain of students' learning.

Pre- and Post-Intervention Adaptations of the TOSLS

A total of 150 students in the NE 101 course completed the pre-intervention adaptation of the Test of Scientific Literacy Skills. Data generated can be found in Table 4.

Item discrimination scores indicate how well a question differentiates between students achieving high versus low overall scores; a score of less than 0.20 indicates poor differentiation. All of the item discrimination scores for questions contained on the pre-intervention assessment were greater than 0.20, and the overall average was 0.55.

Item difficulty scores range from 0 to 1, with larger scores indicating easier questions. For purposes of interpretation, categories of difficulty are as follows: questions with item difficulty scores greater than 0.80 are easy questions, between 0.30 and 0.80 are medium, and scores less than 0.30 are hard. Item difficulty scores ranged from 0.35 to 0.85. I also collected data on standard deviation for each question, which ranged from 3.62 to 4.78 on a ten-point scale.

It should be noted that students received the lowest average score, item discrimination score, and item difficulty score for Question #9. The highest standard deviation also

occurs for this question. Additionally, of the skills listed, students received the lowest overall average in understanding elements of research design and how they impact scientific findings/conclusion.

Table 4 - Results of Pre-intervention Adaptation of TOSLS

Scientific Literacy Skill	Questions	Item Discrimination	Item Difficulty	Average Score	Standard Deviation
Identify a valid scientific argument	1	0.56	0.85	8.47	3.62
	6	0.63	0.74	7.41	4.41
	7	0.59	0.79	7.87	4.12
Understand elements of research design and how they impact scientific findings / conclusions	3	0.53	0.75	7.47	4.37
	8	0.53	0.75	7.47	4.37
	9	0.47	0.35	3.47	4.78
Read and interpret graphical representations of data	2	0.47	0.81	8.07	3.97
	4	0.65	0.84	8.4	3.68
	5	0.55	0.84	8.4	3.68
	10	0.52	0.77	7.67	4.25

In order to assess whether students' scientific literacy improved in the skills selected for the study, I chose to include those questions classified as medium difficulty (#3, #6, #7, #8, #9, and #10) on the post-intervention adaptation of the TOSLS while excluding easy

questions (#1, #2, #4, and #5). A total of 26 students in the NE 101 course completed the post-intervention adaptation of the TOSLS. Data generated can be found in Table 5.

Table 5 - Results of Post-intervention Adaptation of TOSLS

Scientific Literacy Skill	Question	Item Discrimination	Item Difficulty	Average Score	Standard Deviation
Identify a valid scientific argument	2	0.48	0.81	8.08	4.02
	5	0.55	0.77	7.70	4.30
Evaluate the validity of sources	4	0.38	0.81	8.08	4.02
	10	0.53	0.73	7.31	4.53
Evaluate the use and misuse of scientific information	3	0.41	0.85	8.47	3.68
Understand elements of research design and how they impact scientific findings / conclusions	6	0.31	0.73	7.31	4.53
	7	0.38	0.54	5.39	5.09
Create graphical representations of data	8	0.52	0.62	6.16	4.97
Read and interpret graphical representations of data	1	0.49	0.77	7.70	4.30
	11	0.10	0.81	8.08	4.02
Solve problems using quantitative skills, including probability and statistics	9	0.54	0.88	8.85	3.26
	12	0.51	0.69	6.93	4.71
Understand and interpret basic statistics	14	0.43	0.54	5.39	5.09
Justify inferences, predictions, and conclusions based on quantitative data	13	0.41	0.85	8.47	3.68
	15	0.59	0.73	7.31	4.53

Again, I collected item discrimination, item difficulty and average scores, as well as standard deviation for each question. Item discrimination scores for all questions were greater than 0.20, the overall average being 0.44. Six questions fell under the classification of easy according to their difficulty scores (#2, #3, #4, #9, #11, and #13); two of these questions assessed a scientific literacy skill selected for the study (#2 and #11), while four questions in this category evaluated skills of scientific literacy outside of the curriculum (#3, #4, #9, and #13). Nine questions registered as medium difficulty (#1, #5, #6, #7, #8, #10, #12, #14, and #15). Four of these questions assessed a selected skill of scientific literacy (#1, #5, #6, and #7), while five of these questions related to other skills of scientific literacy (#8, #10, and #12).

After administering the post-intervention assessment, I analyzed average scores and standard deviations for questions occurring on both pre- and post-evaluations. Data generated from questions contained in pre- and post-assessments is included in Table 6; questions within the same row were presented to students on both evaluations identically, i.e. question #6 (pre-assessment) and question #2 (post-assessment).

**Table 6 – Comparison of Scientific Literacy Skills
Pre-intervention to Post-intervention**

Scientific Literacy Skill	Pre-Intervention Adaptation of TOSLS			Post-Intervention Adaptation of TOSLS		
	Question	Avg. Score	Std. Dev.	Question	Avg. Score	Std. Dev.
1. Identify a valid scientific argument	6	7.41	4.41	2	8.08	4.02
	7	7.87	4.12	5	7.70	4.30
2. Understand elements of research design and how they impact scientific findings / conclusions	8	7.47	4.37	6	7.31	4.53
	9	3.47	4.78	7	5.39	5.09
3. Read and interpret graphical representations of data	2	8.07	3.97	1	7.70	4.30
	10	7.67	4.25	11	8.08	4.02

In order to determine any significant increase in average scores for these questions, I performed a lower-tailed t-test with a 95% confidence interval ($\alpha = 0.05$) and degrees of freedom equal to 174. Doing so revealed a statistically significant increase in the average score for a question assessing students' understanding of the elements of research design and how they impact scientific findings/conclusions, the scientific literacy skill on which they scored the lowest for the pre-intervention adaptation of the TOSLS.

However, no significant gains occurred for any other questions. Average scores and standard deviations for these questions are provided in Figure 1.

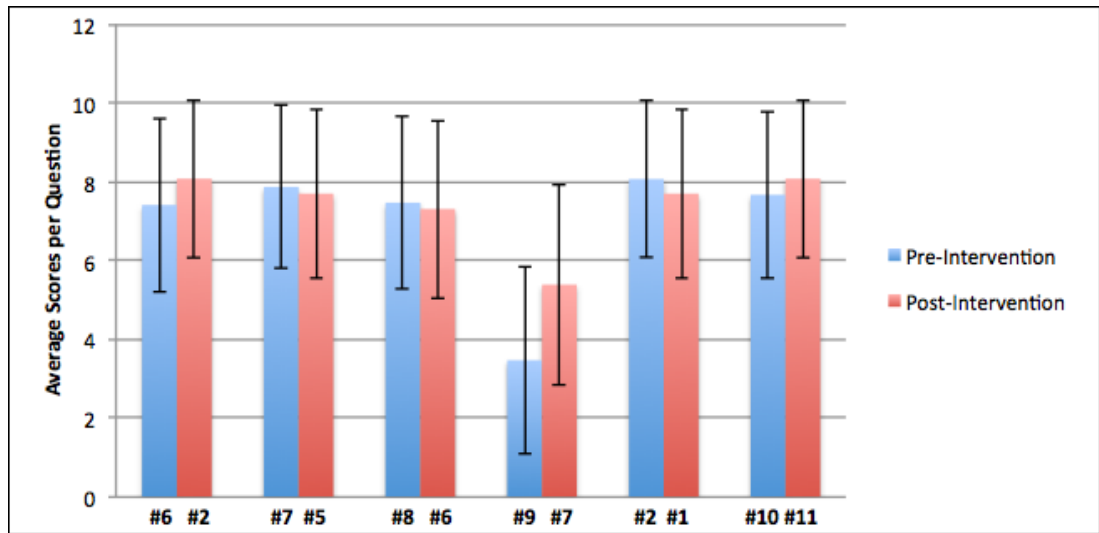


Figure 1 - Average Scores and Standard Deviations for Questions Contained on Pre- and Post-intervention Adaptations of TOSLS

I also examined item discrimination scores for questions occurring on both assessments. Figure 2 provides a comparison of pre- and post-assessment item discrimination indexes, noted by the scientific literacy skill they pertain to. For the purposes of interpretation, these skills are as follows: 1. Identify a valid scientific argument, 2. Understand elements of research design and how they impact scientific findings/conclusions, and 3. Read and interpret graphical representations of data. It is notable that a question about the skill of reading and interpreting graphical representations of data received an acceptable item discrimination score on the pre-intervention assessment (0.52) but failed to do so on the post-assessment (0.10).

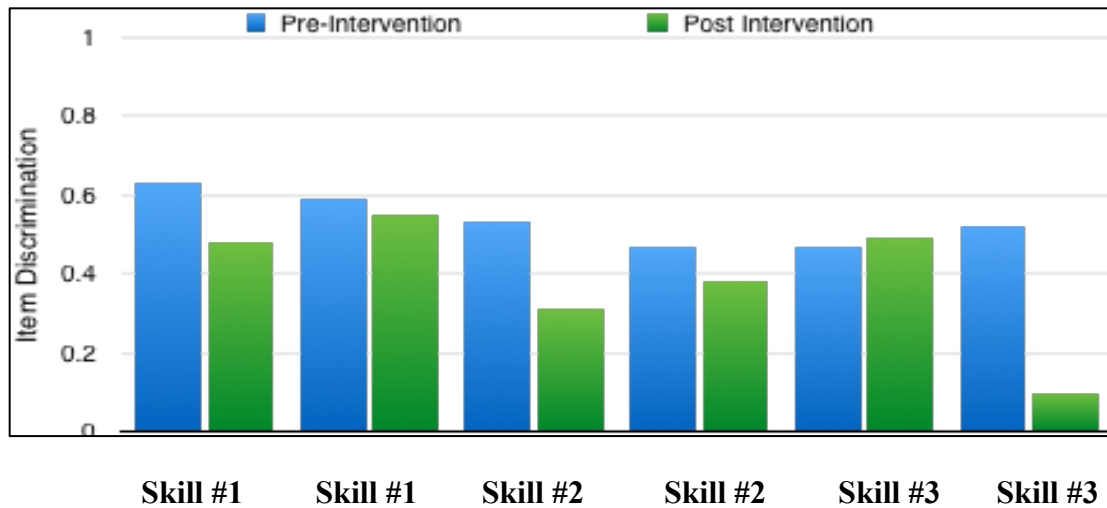


Figure 2 - Item Discrimination for Questions Contained on Pre- and Post-intervention Adaptations of TOSLS

Lastly, Table 7 provides contextual information for the pre- and post-intervention adaptations of the TOSLS. Specific attention will be given to the average time spent by students when completing assessments as well as their overall average in the discussion.

**Table 7 – Contextual Information for
Pre- and Post-intervention Adaptations of TOSLS**

Measurement	Pre-test	Post-test
Number of Questions	10	15
Average Time Spent (overall)	8 minutes	3 minutes
Average Time Spent (per question)	48 seconds	12 seconds
Scientific Literacy Skill #1 Number of Questions	3	2
Scientific Literacy Skill #1 Average Score	79.13%	78.85%
Skill #2 Number of Questions	3	2
Skill #2 Average	61.34%	63.47%
Skill #3 Number of Questions	4	2
Skill #3 Average	81.34%%	78.85%
Overall Average	74.67%	74.11%

Quiz Questions

Discussions were grouped in three blocks, each focusing on a specific scientific literacy skill. Table 8 and Figure 3 provide average scores for quiz questions in the first block of discussions, followed by details of potentially significant findings.

Table 8 – Average Scores of Quiz Questions for Discussions #1-3

Skill of Scientific Literacy	Discussion	Thursday Average	Friday Average	Question: Same or Different
Identify a valid scientific argument	Controversial Science	57.45%	47.67%	Different
	Power of the Brain(s), Part 1	67.03%	84.42%	Same
	Power of the Brain(s), Part 2	70.00%	69.62%	Same
		64.83%	67.24%	

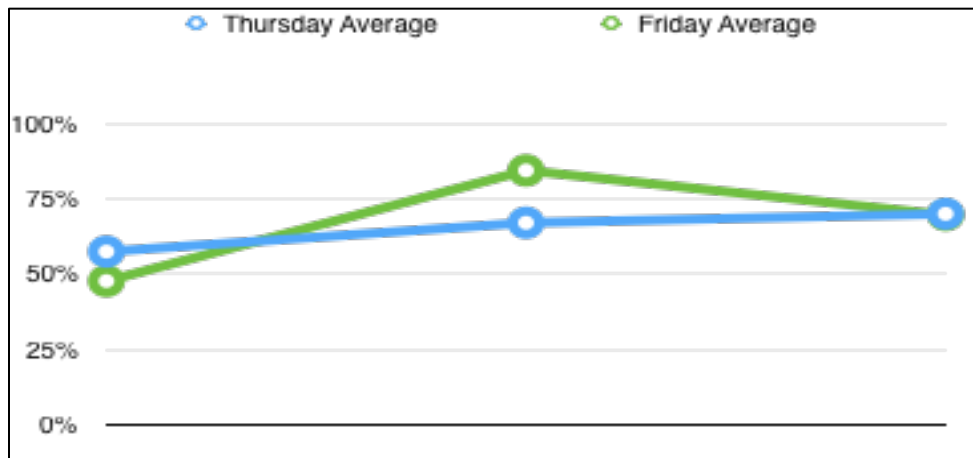


Figure 3 - Average Scores of Quiz Questions for Discussions #1-3

a. Controversial Science

-Thursday: Collectively, 42.55% of students chose incorrect answers for establishing validity of a scientific argument relating to the following: researcher's reputation, sample, and the potential of novel findings emerging from the study.

-Friday: 31.40% of students chose answer D (Do the data justify the conclusions?) as being directly related to the validity of a scientific argument, whereas 47.67% chose answer A (Does the study test a stated hypothesis?). While both are technically correct, students were later instructed that in order for relevant data to be collected from which conclusions can be made, a study must first test a stated hypothesis.

b. Power of the Brain(s), Part 1

-Thursday: 28.57% chose answer C, which was designed to be a distractor. This answer puts forth a seemingly factual statement, but does not answer the question as adequately as answer B, which 67.03% of students chose.

-Friday: While both discussions received identical questions, only 9.09% of students chose answer C in this discussion. 84.42% of students chose the correct answer.

c. Power of the Brain(s), Part 2

-Thursday: 27 out of 90 students (30.00%) chose incorrect answers giving seemingly "factual" support for a scientific argument.

-Friday: 24 out of 79 students (30.38%) chose incorrect answers giving seemingly “factual” support for a scientific argument.

Table 9 and Figure 4 provide an overview for quiz questions administered in the second block of discussions, again followed by details for individual discussions.

Table 9 – Average Scores of Quiz Questions for Discussions #5-8

Skill of Scientific Literacy	Discussion	Thursday Average	Friday Average	Question: Same or Different
Understand the elements of research design and how they impact scientific findings / conclusions	Mistreatment of Medical Treatment	42.35%	98.77%	Different
	Wise Words	60.00%	61.04%	Different
	Lost in Transmission	85.39%	88.61%	Same
	Proprioception via Misdirection	42.35%	87.65%	Different
		57.52%	84.02%	

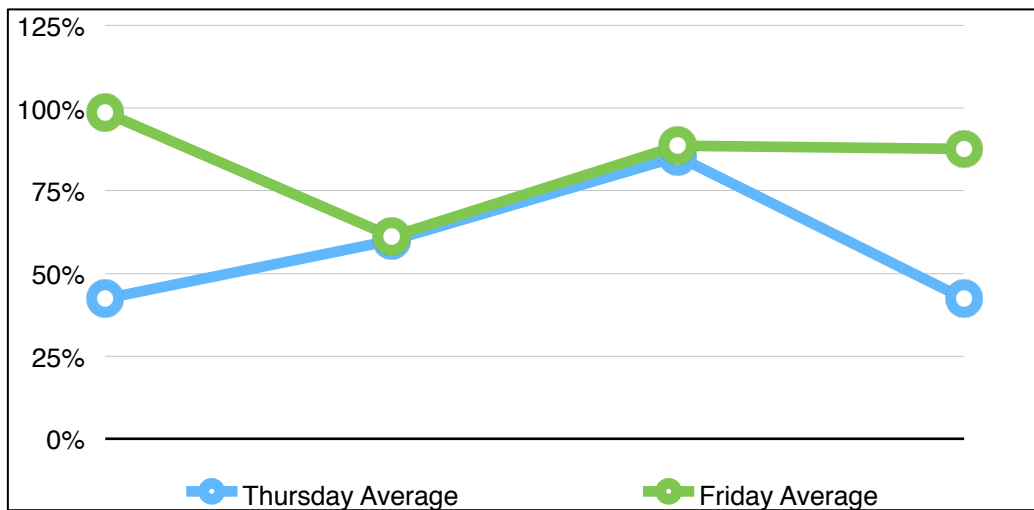


Figure 4 - Average Scores of Quiz Question for Discussions #5-8

a. Mistreatment of Medical Treatment

-Thursday: 54.12% of students chose an incorrect answer (answer D) that relates to a common student misunderstanding: the difference between causation and correlation.

-Friday: 98.77% chose the correct answer in response to a question assessing their understanding of randomization techniques, prior to having received any explicit instruction in discussion on the topic

b. Wise Words

-Thursday: 11.76% of students chose an incorrect answer relating to how economic bias can compromise scientific research. A total of 23.53% of students chose an answer that states that randomization *eliminates* the possibility of confounding variables influencing

the outcome of a study, whereas randomization simply *minimizes* this possibility.

-Friday: 29.87% of students chose an incorrect answer (confirmation bias) that is closely related to the correct answer (attentional bias).

c. Lost in Transmission

-Thursday: 85.39% of students chose the correct answer. The number of incorrect answers was negligible.

-Friday: 88.61% of students chose the correct answer, thereby achieving the highest average score amongst all quiz questions. The number of incorrect answer choices was negligible.

d. Proprioception via Misdirection

-A significant discrepancy in average scores occurred during this week's discussion. It may be significant to note that both of the questions used in Thursday and Friday's discussion groups were negatively phrased, i.e. 'Which of the following is not ...'

-Thursday: 57.65% of students chose an incorrect answer that hits on the relation between generating differential diagnoses and alternative hypotheses, a concept discussed in Discussion #7 – Lost in Transmission.

-Friday: 71 out 81 students (87.65%) identified the correct answer that relates to the concept of undue admiration of authority, a point that Cajal discusses in Advice for a Young Investigator and that was focused on in Discussion #6 - Wise Words.

Table 10 and Figure 5 provide an overview for quiz questions administered in the third and final block, followed by details for individual discussions. A quiz question was not administered for Discussion #10 - Vice or Virtue due to a lack of consensus regarding the relevancy of the question I proposed for that week. As such, an average score value was not recorded for this discussion.

Table 10 – Average Scores of Quiz Questions for Discussions #10-12

Skill of Scientific Literacy	Discussion	Thursday Average	Friday Average	Question: Same or Different
Read and interpret graphical representations of data	Vice or Virtue	63.64%	N/A	N/A
	Alzheimer's and Lifestyle Interventions	96.25%	84.42%	Different
	Conclusions and Brain-Machine Interfaces	72.29%	68.75%	Same
		77.39%	76.59%	

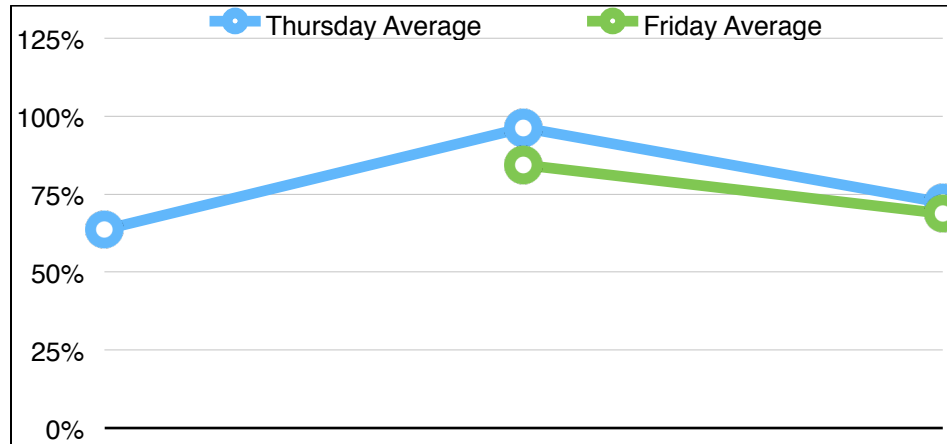


Figure 5 - Average Scores of Quiz Questions for Discussions #10-12

a. Vice or Virtue

-Thursday: 27.27% of students identified an incorrect answer which included the phrase “much more significant decrease”. Varying interpretations of this phrase will be explored further in the discussion section.

-Friday: Value not recorded.

b. Alzheimer’s and Lifestyle Interventions

-Thursday: 96.25% of students identified the correct answer, thereby achieving the highest average score amongst all quiz questions.

-Friday: 14.29% of students identified an incorrect answer that included the phrase

“markedly different relative ratios.” Similar to Thursday’s discussions of Vice or Virtue, different possible conceptions of this phrase will also be considered in the discussion.

c. Conclusions and Brain-Machine Interfaces

-For this question, students were asked to interpret two graphs to determine what percentage of neurons is required to achieve a 67.50% success rate for a study protocol.

-Thursday: The largest proportion (20.48%) of incorrect answers occurred for answer C, stating 75% of neurons were required. Interestingly, this percentage is the closest in value to the success rate in the question stem compared to all other answer choices.

-Friday: Again, the largest proportion (20.00%) of incorrect answers occurred for answer C.

Focus Groups

After the final discussion of the semester, students responded to questions pertaining to the three blocks of discussions, the scientific literacy skills promoted in each block, and the readings used to help students acquire these skills. Excerpts from both focus groups are organized under major categories of scientific literacy skills and subcategories of specific readings used in teaching these skills.

a. Skill #1 - Identify a valid scientific argument

“How to Critically Appraise an Article”

Students found this article to be fairly boring, but also considered it to be necessary for

“setting the tone for the semester” for goals for the discussions, as well as being useful for students lacking a solid scientific background or experience with scientific literature.

“Feeling the Future” and “Journal’s Article on ESP Expected to Prompt Outrage”

Students enjoyed discussing this article, as it was a good example of how a respected scientist is capable of having questionable research published.

“Secrets of the Brain”

Some students identified this as being their favorite reading for this block of discussions.

“Scientists Demonstrate Animal Mind-Melds”

No comments were made by either group regarding this article.

General Comments for Block #1

Students commented on the fact that lecture material synced up with discussions occasionally during this block, but inconsistently so.

b. Skill #2 - Understand elements of research design and how these impact scientific findings/conclusions

“Randomized Trial of Modafinil as Treatment of Excessive Daytime Somnolence of Narcolepsy” and “Modafinil-induced Psychosis”

Students said that they found the discussions focusing on medicine stimulating and enjoyable. They also found these articles to be the most helpful in understanding

elements of research design, and beneficial in learning how to interpret graphs.

Advice for a Young Investigator

While some individuals identified this as their favorite reading, overall students expressed both very positive and very negative responses to this reading. Furthermore, speaking on behalf of their peers, most students in NE 101 either loved or hated this reading. Many students did not think of it as relevant, but others thought it provided a good context for thinking about research and practical issues of performing research.

“The President’s Speech” and “On the Level”

Students said that they enjoyed reading this and other stories from The Man Who Mistook His Wife for a Hat, saying they were “not difficult to read or overly detailed.”

General Comments for Block #2

Aligning lecture and discussion material again emerged during the discussion as being something students wanted more of. However, they commented that the synchronization between the two course components was better for this block than the previous.

c. Skill #3 - Read and interpret graphical representations of data

“Low-dose Nicotine Facilitates Spatial Memory in ApoE-knockout Mice in the Radial Arm Maze”

Students commented on this article (as well as “Exercise is More Effective...”) being one of the best in this block.

“Exercise is More Effective than Diet Control in Preventing High Fat Diet-induced beta-Amyloid Deposition and Memory Deficit in Amyloid Precursor Protein Transgenic Mice”

Students commented on this article (as well as “Low-dose Nicotine...”) being one of the best in this block.

“Selecting the Signals for a Brain-Machine Interface”

Neither students in the first focus group nor the second focus group expressed any comments specific to this reading.

General Comments for Block #3

Students found the articles in this section to be more difficult than any of the other readings. They also commented on the fact that becoming familiar with scientific jargon requires a certain level of background knowledge in multiple scientific disciplines, but that they did not find it to impede them from interpreting data.

d. General Comments for Discussions Overall

Structure of Discussions: Students appreciated the autonomy granted them during discussions, and reported feeling that discussions were very student-centered and “novel compared to other past learning experiences.” They reported that the graduate teaching assistants allowed students to think about the readings and approach problems on their own terms, but then also gave feedback and guidance on their thinking.

Attitudes and Perceptions: Students expressed feeling less intimidated by the prospect of reading a research article, and that doing so has become more enjoyable. Students also commented on their enjoyment in being able to sit and work with students they would be collaborating with on group exams. Additionally, they viewed group work in general as being helpful to their learning.

Post-course Discussion Survey

Students (n=24) completed a post-course discussion survey comprised of questions relating to how effective certain readings were in helping them acquire scientific literacy skills and how much they enjoyed reading them. Answers choices were provided on a Likert scale (the least value indicating the most negative response, the greatest value indicating the most positive response). Each reading was then “graded” by summing Likert scores of utility in acquiring a scientific literacy skill and degree of enjoyment expressed by students. The denominator of these scores was calculated by multiplying the number of students who responded to the survey by the greatest point value attainable on the Likert scale for that particular question.

Students were also asked to select which readings they would choose to be retained in the discussion curriculum for NE 101, and which should be removed. The “Net Votes” were calculated by subtracting the number of votes for removal from the number of votes for retention. Lastly, students responded to questions about their sense of confidence and personal interest in reading scientific literature, as well as how effective they found the

discussions to be in helping them understand scientific research in general. Students were also encouraged to write in general comments at the end of the survey, which are included following Tables 11-13.

Table 11 - Post-course Assessment of Readings for Scientific Literacy Skill #1: Identify a valid scientific argument

Reading	Utility in Acquiring Scientific Literacy Skill	Level of Enjoyment	Votes for Keeping in Curriculum *	Votes for Removal from Curriculum *	Net Votes
How to Critically Appraise an Article	71/120 59.17%	55/120 45.83%	2	7	-5
Feeling the future	75/120 62.50%	64/120 53.33%	2	8	-6
Journal's Article on ESP Expected to Prompt Outrage	75/120 62.50%	83/120 69.17%	3	4	-1
Secrets of the Brain	82/120 68.33%	100/120 83.33%	14	0	14
Scientists Demonstrate Animal Mind-Melds	74/120 61.67%	85/120 70.83%	1	4	-3

*Votes for keeping in curriculum

-one survey respondent was excluded as it was unclear which readings they indicated

-one survey respondent was excluded for indicating all readings for retention

*Votes for removal from curriculum

-one survey respondent was excluded for not identifying any readings for removal

**Table 12 - Post-course Assessment of Readings for
Scientific Literacy Skill #2: Understand elements of research design
and how they impact scientific findings/conclusions**

Reading	Utility in Acquiring Scientific Literacy Skill	Level of Enjoyment	Votes for Keeping in Curriculum *	Votes for Removal from Curriculum *	Net Votes
Randomized Trial of Modafinil as Treatment of Excessive Daytime Somnolence of Narcolepsy	86/120 71.67%	74/120 61.67%	1	6	-5
Modafinil-induced Psychosis	87/120 72.50%	67/120 55.83%	6	4	2
Selections from Advice for a Young Investigator	69/120 57.50%	71/120 59.17%	3	10	-7
The President's Speech	73/120 60.83%	92/120 76.67%	12	2	10
On the Level	74/120 61.67%	87/120 72.50%	1	1	0

*Votes for keeping in curriculum

-one survey respondent was excluded for indicating multiple readings for retention

*Votes for removal from curriculum

-one survey respondent was excluded for indicating multiple readings for removal

**Table 13 - Post-course Assessment of Readings for
Scientific Literacy Skill #3: Read and interpret graphical representations of data**

Reading	Utility in Acquiring Scientific Literacy Skill	Level of Enjoyment	Votes for Keeping in Curriculum*	Votes for Removal from Curriculum*	Net Votes
Low-dose Nicotine Facilitates Spatial Memory in ApoE-knockout Mice in the Radial Arm Maze	49/69 71.01%	48/66 72.73%	9	3	6
Exercise is More Effective than Diet Control in Preventing High Fat Diet-induced beta-Amyloid Deposition and Memory Deficit in Amyloid Precursor Protein Transgenic Mice	52/69 75.36%	46/66 69.70%	8	7	1
Selecting the Signals for a Brain-Machine Interface	40/69 57.97%	37/66 56.06%	5	13	-8

*Votes for keeping in curriculum

-one survey respondent was excluded as it was unclear which readings they indicated

-one survey respondent was excluded for indicating multiple readings for retention

*Votes for removal from curriculum

-one survey respondent was excluded as it was unclear which readings they indicated

Following this analysis of discussions block-by-block, students were asked to provide their overall opinion of the discussions and the readings used in them. Of the twenty-four survey respondents, ten students wrote in additional comments that are found below.

General Comments

“It would have been helpful if the discussions connected to the material we were covering in class. In many cases the articles we were given included terminology and concepts we hadn’t been taught, or assumed that the reader had a background in neuroscience. For an introductory class many of the articles were very dense, and that made it difficult to get any useful information out of them.”

“It was cool to read about current neuro research articles, but I feel like I didn’t learn much new stuff about reading scientific articles that I hadn’t previously learned in high school.”

“Some of the graph-heavy readings were harder to get through / remember.”

“I feel that the discussion readings could at times be quite interesting. However, I saw the articles more as a learning exercise than leisure reading. This could be due to the fact that I am not a science major and do not have interest in this type of scientific reading. Yet the ideas presented were extremely interesting holistically. I simply did not care for the style of reading. Overall though, the discussion reading DID help me better understand scientific literature.”

“I think the readings should be more related to what is being learned during lecture. That was not the case towards the beginning of the semester.”

“I think there were a few that were overpacked with information which made remembering important info more difficult. Some were incredibly dry, which lowered (at least my) motivation to read carefully. Others were really interesting and really liked the ones toward the end of the semester.”

“The discussion section could be a bit more helpful if instead of asking questions regarding lecture, they instead briefly review the lecture from

that week and allow questions to come that way.”

“Discussion wasn’t my favorite to be honest, only until the later parts of the semester did the articles connect to class. I would prefer if the discussions were more focused on what we did in lecture. Other than that, I don’t really have an opinion on discussion.”

“They were all very interesting. I just sometimes wished there was a more evident overlap from what we were learning in lecture. I understand discussion was meant to foster our scientific literacy skills, but why not kill two birds with one stone or however you say it. But either way, I enjoyed it. :)”

“As the course went on, I started to understand the article choice more (they seemed more relevant to the course) and the instruction was better. At first, I found the articles to be hard to understand and I didn’t see a connection the course, but the final few were much more helpful.”

The response rate with regards to students electing to take the pre-intervention adaptation of the TOSLS, participating in focus groups, and completing the post-course discussion survey was outstanding. Information gathered from focus groups and the candid feedback found above provides a meaningful context for interpreting quantitative data generated from adaptations of the TOSLS and weekly quiz questions.

DISCUSSION

I undertook this study as a member of the Teaching-as-Research Fellowship offered through Boston University as an affiliate of CIRTLL. Therefore, the purpose of this work is to produce evidence-based recommendations for improving STEM instruction. This applies not only to NE 101, but other courses at Boston University and beyond.

Therefore, I analyzed data generated from the pre- and post-intervention adaptations of the TOSLS, quiz questions, focus groups, and post-course discussion survey to identify important factors for promoting scientific literacy in an undergraduate STEM course.

Pre-TOSLS versus Post-TOSLS

The goal of selecting scientific literacy skills specific to this study was to identify whether teaching these skills could foster development of other skills. I reasoned that identifying skills generalizable to and supportive of other scientific literacy skills might benefit STEM instructors who promote scientific literacy in their courses. I also considered the fact that many courses occur within a single semester, and how discerning skills that have high-yield potential for increasing scientific literacy could help focus the learning goals of a course when time is an issue.

First, it is notable that average scores (and item difficulty indexes) increased from 3.47 (0.35) for Question #9 on the pre-TOSLS to 5.39 (0.54) for Question #7 on the post-TOSLS. The terminology contained in the answer choices for this question is specific to the subject of statistics, and it is less likely that students in an entry-level undergraduate

science course had previously been exposed to such terminology. Discussion #5 – Mistreatment of Medical Treatment included activities for helping students understand randomization, random sampling, and experimental versus control groups. This discussion may have influenced students' performance, suggesting the need for instruction centered on statistical terminology and understanding how statistical techniques are used in research design.

Secondly, I would like to consider the potential impact of teaching students how to interpret graphical representations of data. Item discrimination scores went from 0.52 for Question #10 (pre-TOSLS) to 0.10 for Question #11 (post-TOSLS). Although not statistically significant, the average scores for this question increased from 7.67 to 8.08 and item difficulty indexes increased from 0.77 to 0.81. Based on the decrease in item discrimination and increases in average scores and item difficulty indexes, instruction focusing on interpreting graphical representations of data may have high-yield potential. However, students may have simply remembered this question from the pre-TOSLS.

Related to this point is students having achieved the second highest average score on Question #13 for the post-TOSLS (the highest average occurred for Question #9). In order to choose the correct answer, students had to examine a graph and decide which answer was supported by the data. This question is designed to assess the skill of justifying inferences, predictions, and conclusions based on quantitative data. Although this skill was not included in the subset of skills designated for this study, it does align with two of the three skills selected: identifying a valid scientific argument, and reading

and interpreting graphical representations of data. Therefore, a consequence of teaching these skills may impact students' ability to justify inferences, predictions, and conclusions based on quantitative data.

Teaching students how to interpret graphs and figures may also impact their proficiency in solving problems using quantitative skills, another component of scientific literacy in the category of organizing, analyzing, and interpreting quantitative data and scientific information (Gormally et al., 2012). Students achieved an average score of 8.85 for Question #9 versus 6.93 for Question #12. Both questions evaluate students' ability to solve problems using quantitative skills, but differ in one notable way: Question #9 includes a graph, whereas Question #12 does not. Students had no prior experience to either of these questions on the pre-TOSLS, and the curriculum did not highlight this skill. Thus, the presence of a graph and students' ability to interpret it correctly may have aided them in identifying the correct answer for Question #9.

When comparing the relative ratios of questions classified as easy versus medium according to item difficulty scores, we find that it is exactly 2:3 for both assessments. That is, on the pre-intervention adaptation of the TOSLS, four questions were categorized as 'easy' and six as 'medium'; six questions were categorized as 'easy' and nine as 'medium' for the post-TOSLS. Furthermore, questions about skills focused on during the semester (and that appeared on the pre-intervention adaptation of the TOSLS) shifted from a 'medium' to 'easy' categorization as well as an 'easy' to 'medium' categorization. Although the teaching interventions listed may not guarantee that students become more

capable in these skills, it is perplexing to make sense of why students found the questions to be more difficult than before.

Comparison of the student response rate and average time spent per question between assessments hints toward an important component of education in general: student motivation. Far fewer students elected to complete the post-intervention adaptation of the TOSLS and, of those students who completed it, took a fraction of the time compared to the pre-TOSLS. Regarding the difficulty rating on the post-TOSLS, we cannot dismiss how little time students spent answering questions. Further research may focus on how to nurture students' interest and intrinsic motivation to become scientifically literate. Doing so may not only improve course grades, but also the quality of learning and application of these skills after students leave the classroom. Further consideration of the affective domain of students' learning will be given in the sections 'Focus Groups' and 'Post-course Discussion Survey'.

Quiz Questions

The quiz questions I developed were included in weekly quizzes assessing students' preparedness for the discussion. The graded questions were written by other course leaders to assess general characteristics of the assigned readings, and for the purpose of incentivizing students coming to discussion prepared and ready to participate. The ungraded quiz questions were dissimilar to others in that the answer choices were written to assess a students' scientific literacy for a particular skill, as opposed to their familiarity

with the reading. However, these ungraded quiz questions were still rooted in the assigned reading, thus students needed to have at least some degree of familiarity with the material.

Within the first block of discussions, we saw a notable difference in average scores that occurred for the same quiz question administered to both discussion groups. This difference may be an artifact of differences in students' preparedness. Since Friday's discussion group scored notably higher on an identical quiz question, one interpretation is that these students achieved a higher score because they had more time to review the material. It is important to remember that a vast majority of the students in the NE 101 course were freshman, facing new challenges of managing competing priorities and proper time management. With this in mind, it is important to consider the demands any one educator places on their students as well as possible effects on student interest and motivation. While students are likely to be disinterested in an overly easy and unchallenging course, it is just as likely for them to disengage from a course they consider too taxing.

In the second block of discussions, notable differences in average scores occurred in Discussions #5 and #8. A plausible mechanism for interpreting the difference in scores for Discussion #5 emerges upon examination of the answer choices provided to students in Thursday's discussion; these students received a much lower average score versus those in Friday's discussion. Not only were students asked to correctly identify three correct answers (out of four answers total), but also the only incorrect answer to a

common student misunderstanding of the differences between correlation and causation. While this misconception had been previously recognized amongst those leading the NE 101 course, this question helped to quantify the extent of students' misinterpretation. However, all of the interpretations listed must be considered in light of the fact that different quiz questions were administered to Thursday's and Friday's discussion groups.

In Discussion #8, students received non-identical yet qualitatively similar questions. Students in Thursday's group were asked to identify key considerations for diagnosing a patient with Parkinson's disease, whereas Friday's group was asked to pinpoint important factors for treatment. However, students in Friday's discussion achieved an average score more than two times that of Thursday's discussion. The language of this question was taken from Discussion #7, in which students examined correlates of the scientific method and the practice of medicine. The correct answer for Friday's question was developed from points raised in Discussion #6 - Wise Words, while the correct answer for Thursday's question did not directly relate to prior discussion material. Through this lens, it might be reasoned that students' newly acquired knowledge about research design had a positive impact on their ability to correctly identify the answer.

Finally, within the third block of discussions, the two lowest scores for either group occurred when a common theme was present: ambiguous phrasing with statistical terminology occurring in an answer choice. For Discussion #10, the greatest proportion of incorrect answers selected by students in Thursday's discussion group occurred when that answer included the phrase "much more significant decrease." Similarly, students in

Friday's group showed a greater propensity for selecting an incorrect answer that included the phrase "markedly different relative ratios" than any other with regards to the quiz question administered for Discussion #11. This development coincides with the previously mentioned point of providing education in statistical terminology and helping students understand the precise meaning of words such as "significant" and "markedly" in the context of scientific research.

Focus Groups

Student responses to assigned readings and related discussions raise important points educators should consider when designing curriculum for STEM courses, specifically those that have a lecture and discussion component.

a. Providing students with a framework for deciphering scientific literature

Students in both focus groups did not find the article 'How to Critically Appraise an Article' interesting, but they did recognize the utility of it. Instructors who plan on utilizing scientific literature within their curriculum should recognize that many incoming undergraduate students have not received instruction on how to interpret and critique scientific literature. In order for them to develop this skill set, they must first be given the tools to do so.

b. Incorporating scientific literature from non-primary sources

Students that did comment on the article 'Secrets of the Brain' regarded it highly. This article from National Geographic Magazine provides an interesting overview of research

being conducted in multiple neuroscience labs around the country and, while containing some scientific terminology, can be understood by the layman. Also, student responses to readings taken from The Man Who Mistook His Wife for a Hat by the late Dr. Oliver Sacks were overwhelmingly positive. These ‘clinical tales’, as Sacks puts it, were selected in order to provide a novel context for material covered in lecture dealing with agnosia, aphasia, and Parkinson’s disease. Students’ enjoyment of and engagement in the discussions for these tales substantiate the concepts of using literature outside of scientific journals. By selecting literature from alternative sources, it may be possible for STEM educators to increase students’ interest and confidence in reading scientific literature. This point is especially important when considering how apt students might be to apply their skills of scientific literacy beyond the classroom and in their daily lives.

c. Leveraging content from lecture to problem-based learning in discussion

Many of the general comments for the first block of discussions related to the degree of overlap between lecture and discussion. Students found it frustrating that, at times, these two components of the course were disjointed. With this in mind, discussions might be well purposed toward problem-based learning. In this model, students apply both pre-existing knowledge about a topic as well as the information they have acquired (e.g. lecture content) to solving a particular problem in discussion (Llewellyn, 2007). I designed curriculum in later discussions using this framework more so than in the first, which is indicated by students commenting on better alignment with lecture and discussion content over time.

Problem-based learning is also a valid approach for emphasizing the practicality of scientific research to students. In the articles ‘Randomized Trial of Modafinil as a Treatment of Excessive Daytime Somnolence of Narcolepsy’ and ‘Modafinil-induced Psychosis’, students examined how elements of research design (e.g. exclusion criteria) for a drug trial had a significant impact on a handful of patients. By guiding students to recognize the significance of how research design impacts a study’s findings and the consequences of such findings, instructors can leverage students’ interest to increase their overall understanding of scientific research.

d. Selecting literature that is capable of eliciting an emotional response

Advice for a Young Investigator was likely the most controversial reading assigned to students throughout the semester, which is indicated by the comments made by both focus groups as well as individual student reports to course leadership during the semester. In the reading, Ramon y Cajal gives his candid opinions of the nature of science, what characteristics make for a good scientist, how research is performed, and how research should be performed. I selected this reading for helping students identify which opinions resonated with their own beliefs and which ones did not, so that they may begin constructing their own framework for criticizing other scientists’ research. The highly divisive reactions to this reading indicate that the selection may have been successful in this goal. However, it is critical to provide context for readings such as these. Some students may have reacted negatively to this reading because of a difference in opinion with Cajal; many students reported not fully understanding the purpose of the

reading.

e. Developing students' competence by gradually increasing the difficulty of material

Students found the readings in the final block of discussions to be the most difficult overall. However, they did not necessarily report this in a negative context. It is vital for instructors to be aware of their students' limitations, strengths, and weaknesses when they first begin in a course. For example, many of the students in NE 101 did not initially have a scientific background strong enough to be able to effectively and confidently navigate the articles used in the final block. By employing less difficult readings from non-primary sources, students were better able to develop the skills necessary for evaluating these primary articles.

Finally, students' comments of the discussions overall reveal several key principles for leveraging students' interest through intrinsic motivators.

f. Providing a sense of community in the classroom

NE 101 employed a relatively novel assessment technique: group exams. Students in the course completed an exam assessing their understanding of lecture material, and immediately thereafter worked within a small group (typically 3-4 students) to take the same test. In the discussions, students were encouraged to work with these same team members during various class activities. Some students in the focus groups reported enjoying this aspect of discussion, as working with others enhanced their learning. When educators facilitate a classroom environment in which students have a sense of

community, students are more likely to increase their level of engagement (Kay et al., 2011). This engagement, as well students' sense of belonging, can be leveraged to delve into higher-level material.

g. Promoting students' autonomy to solve problems independently

Developing a sense of community in the classroom is important. It is also crucial for educators to create an environment that encourages students to take chances in their learning. Students in focus groups commented on the graduate teaching assistants allowing them to navigate problems on their own terms, an important allowance for instructors to make. However, in order to safeguard against students veering down an inaccurate path, educators should also provide opportunities for students to receive feedback (Gibbs et al., 2012). Doing so minimizes the chance of students developing an inaccurate understanding of a topic, and can be a process for validating students when they have mastered the material.

h. Helping students identify purpose of course components

Students from both focus groups repeatedly commented that there should be greater concurrence between content from lecture and discussion. Consequently, students did not always fully understand the purpose of a selected reading and/or activity in terms of their development of scientific literacy. Educators should consider the likelihood of whether students are readily able to identify the end goal of a certain classroom activity, assigned reading, or assessment. It is common for instructors to outline broad learning goals at the beginning of a course. However it may also be practical to break down these course-level

learning goals into concise, topic-level learning objectives for a single lecture or discussion meeting. Aligning multiple course components with similar learning objectives can aid students in identifying the purpose of activities and assessments, which in turn develops their intrinsic motivation to engage in them.

Post-course Discussion Survey

Students' assessment of discussion readings supports the notion of leveraging multiple sources of scientific literature to bolster scientific literacy and students' enjoyment of reading scientific literature. When considering summative scores of the two survey categories 'Utility in acquiring scientific literacy skill' and 'Enjoyability', three different types of sources are identified as scoring the highest in each block: 'Secrets of the Brain' (secondary source), President's Speech (short story), and 'Low-dose Nicotine Facilitates Spatial Memory in ApoE-knockout Mice in the Radial Arm Maze' (primary source). Students again commented on desiring a greater degree of overlap between lecture and discussion content, but also that this aspect of the course improved as the semester went on.

Interestingly, an essential point for STEM educators to be mindful of emerged from student comments at the end of the survey. Especially in general science education courses, there may exist a great deal of variation in students' scientific knowledge. For the NE 101 course, a majority of students were incoming freshman majoring in neuroscience. However, there were also a considerable number of students who had

enrolled in the course in order to fulfill a general science education requirement for a non-science major. It is especially problematic when designing curriculum for these types of courses, as one must be considerate of those students who do not have a prominent scientific background while also paying mind to those individuals with greater scientific proficiency. However, students engaged in a course that is outside of their usual field of study can be invaluable resources for providing a diversity of problem-solving strategies. It is therefore vital for educators to engage students across academic fields in order to leverage the utility of having non-science majors in a STEM course.

APPENDICES

Appendix A1 - Lesson Plans

Discussion #1 - Controversial Science

Dates: September 10 & 11th, 2015

1. Objective(s)

-Begin developing students' ability to constructively critique scientific research and how it is performed

2. Skill of Scientific Literacy

-Identify a valid scientific argument

3. Readings & Method

-Utilize the article 'How to Critically Appraise an Article' as a framework for evaluating a research experiment and its results

-Use the primary article 'Feeling the Future' and secondary article 'Journal's Article on ESP Expected to Prompt Outrage' for a context in which to apply questions from 'How to Critically Appraise an Article'

4. Activities

"How to Critically Appraise an Article" (Source: Nature)

- a. Discuss first skill of scientific literacy: identifying a valid scientific argument
- b. Ask students to form groups and discuss one question from Box 1 on pg. 2 that directly relates to this skill, and provide rationale for their decision

"Feeling the Future" (Source: Journal of Personality & Social Psychology)

- a. Relate questions chosen by students from Box 1 on pg. 2 to how Dr. Bem's article fails/succeeds in identifying a valid scientific argument

b. Poll students on general opinion of the article

“Journal’s Article on ESP Expected to Prompt Outrage” (Source: New York Times)

a. Discuss difference between conflict of interest vs. bias

b. Poll students on whether they thought this article was biased: pro-Bem or anti-Bem?

5. Measurement

Thursday: B1 through B4

Question #5: According to the New York Times article, which of the following may be an appropriate basis for validating the scientific argument posed in Dr. Bem’s research?

A. Dr. Bem is a respected leader in the field of social psychology.

B. The study included over 1,000 participants.

C. Dr. Bem’s article underwent a peer review process by four trusted social psychologists.

D. The research could potentially contribute new information to the field of social psychology and science in general.

Answer: D

Friday: B5 through B8

Question #2: One important skill of understanding scientific publications is identifying whether research contains a valid scientific argument. Which of the following questions posed in Box 1 of the article “How to Critically Appraise an Article” directly relates to this skill?

A. Does the study test a stated hypothesis?

B. Does the study add anything new?

C. Did the study methods address the most important potential sources of bias?

D. Do the data justify the conclusions?

Answer: A

Discussion #2 - Power of the Brain(s), Part 1

Dates: September 17th & 18th, 2015

1. Objective(s)

-Identify the qualities of a valid hypothesis: a testable explanation of a phenomenon, typically given in an if-then statement

2. Skill of Scientific Literacy

-Identify a valid scientific argument

3. Readings & Method

-Enable students in identifying testable hypotheses presented by the various labs discussed in the National Geographic article ‘Secrets of the Brain’

-Utilize the article ‘Scientists Demonstrate Animal Mind-Melds’ for eliciting testable hypotheses from students

4. Activities

Assessing Students’ Knowledge

a. Discussion of components of a good hypothesis: testable, proposes an explanation for something, if-then statements (5 minute group discussion, 5 minute class discussion)

“Secrets of the Brain”

a. Ask groups to correctly match a testable hypothesis to one of the following brain imaging researchers describe in the article (table is written on the board by instructor, leaving entries in the field ‘Hypothesis’ blank to be filled in via class discussion)

Researcher	Laboratory	Hypothesis
Wedeen	Martinos Center for Biomedical Imaging	Brain tumors alter neuronal organization by compressing the neuronal tracts
Lichtman	Lichtman Lab at Harvard University	The number of synapses on an individual neuron is reduced with age
Descoteaux	Allen Brain Institute	Expression of the Prt1 gene is increased in the temporal lobe of patients with depression
Deisseroth	Deisseroth Lab at Stanford University	The neurons in the prefrontal cortex are more disorganized in patients with autism

“Scientists Demonstrate Animal Mind-Melds”

- a. Ask students to discuss why they think, in the experiment involving three monkeys that were tasked with manipulating a virtual arm in three-dimensional space, that they were more effective than any one monkey performing the same task independently
- b. Recommend students watch a TED Talk given by Dr. Nicolelis on brain-to-brain interfaces (www.ted.com/talks/miguel_nicolelis_brain_to_brain_communication_has_arrived_how_we_did_it?language=en)

5. Measurement

Thursday: B1 through B4

Question #4: In the article from National Geographic Magazine entitled “Secrets of the Brain”, Dr. Wedeen notes that nerve bundles are arranged in a specific orientation within the human brain. Which of the following is the most valid scientific observation?

- A. The human brain is like a computer, in that both the human brain and computer process information.
- B. Structural similarities exist in other animals, including lower life forms like the Cambrian worm, and thus this organization has been retained by evolution.

C. Due to the average length of an axon, it would be impossible for these processes to extend in one direction within the human brain, and thus they are oriented at a 90o angle.

Answer: B

Friday: B5 through B8

Question #4: In the article from National Geographic Magazine entitled “Secrets of the Brain”, Dr. Wedeen notes that nerve bundles are arranged in a specific orientation within the human brain. Which of the following is the most valid scientific observation?

A. The human brain is like a computer, in that both the human brain and computer process information.

B. Structural similarities exist in other animals, including lower life forms like the Cambrian worm, and thus this organization has been retained by evolution.

C. Due to the average length of an axon, it would be impossible for these processes to extend in one direction within the human brain, and thus they are oriented at a 90o angle.

Answer: B

Discussion #3 - Power of the Brain(s), Part 2

Dates: September 24th & 25th, 2015

1. Objective(s)

-Identify the qualities of a valid conclusion: statement that agrees with data collected in research and gives insight into the meaning of that data

2. Skill of Scientific Literacy

-Identify a valid scientific argument

3. Readings & Method

-Direct students to identify the kind of data that researchers mentioned in the article ‘Secrets of the Brain’ are collecting, and what kind of conclusions could be drawn from that data

-Direct students to create alternative uses for the data being collected by researchers mentioned in ‘Secrets of the Brain’ and conclusions they may be able to draw from it

-Direct students to identify the conclusions made by fellow scientists about their peers’ research and their potential validity by examining the article ‘Scientists Demonstrate Animal Mind-Melds’

4. Activities

“Secrets of the Brain” and “Scientists Demonstrate Animal Mind-Melds”

a. What is the research being performed by Reid, Donoghue, and Nicolelis?

-Reid: neural excitability in the visual regions of the brain

-Donoghue: brain-computer interfaces (BCI), brain-machine interfaces (BMI)

-Nicolelis (from NYT article): neural synchrony (rats); neural networks (monkeys)

b. What is the research question for each of these individuals?

-Reid: How does the neuronal activity create a representative image in the brain?

-Donoghue: How can the output of neurons in the motor cortex be translated into movement of a computer cursor or robotic arm?

-Nicolelis (from NYT article): Are more brains more efficient than a single brain in executing a motor task?

c. What is the common theme for the research being conducted by these three scientists? All of these scientists are examining individual neurons and gathering data from these neurons' action potentials. They are then using that data to understand how networks of neurons work together to execute a specific task: vision (Reid), helping paralyzed patients (Donoghue), and motor movement coordinated by a neural network (Nicolelis).

d. How can Reid's technique be utilized in Donoghue and/or Nicolelis' research? Students are encouraged to think creatively; a variety of answers are acceptable.

e. In the series of experiments called MindScope that Reid and his colleagues are undertaking at the Allen Institute for Brain Science:

-What kind of data are they collecting?

-How can this data be used?

-Ask students to discuss possible applications of constructing a mathematical model of vision; how could it further neuroscience research, or possible medical applications

f. In Donoghue's and Nicolelis' research utilizing the motor cortex of patients with paralysis to manipulate a computer cursor, robotic arm, and exoskeleton:

-What data did these researchers need in order to develop these technologies?

-How can these technologies be improved?

g. In the New York Times article Scientists Demonstrate Animal Mind-Melds:

-What was one conclusion, ethical or scientific, that Dr. Rommelfanger came to based on the data from Dr. Nicolelis' research? Do you believe this was a valid conclusion?

5. Measurement

Thursday: B1 through B4

Question #4: In the article from the New York Times entitled "Scientists Demonstrate

Animal Mind-Melds”, Dr. Miguel Nicolelis speculates that our minds may exhibit a natural synchrony when we share the same experiences. Which of the following is the most valid scientific explanation for this argument?

A. Human beings are of the same species, so it makes sense that our brains exhibit similar responses to the same stimuli.

B. Human beings are inherently empathetic creatures, so it makes sense that our minds share similar responses when we share similar experiences.

C. Human beings are inherently cooperative creatures, so it makes sense that our minds are naturally capable of working together.

Answer: A

Friday: B5 through B8

Question #4: In the article from the New York Times entitled “Scientists Demonstrate Animal Mind-Melds”, Dr. Miguel Nicolelis speculates that our minds may exhibit a natural synchrony when we share the same experiences. Which of the following is the most valid scientific explanation for this argument?

A. Human beings are of the same species, so it makes sense that our brains exhibit similar responses to the same stimuli.

B. Human beings are inherently empathetic creatures, so it makes sense that our minds share similar responses when we share similar experiences.

C. Human beings are inherently cooperative creatures, so it makes sense that our minds are naturally capable of working together.

Answer: A

Discussion #5 - Mistreatment of Medical Treatment

Dates: October 8th & 9th, 2015

1. Objective(s)

- Identify correlations between the scientific method and components of a research article
- Define specific strategies used in the methodology of experimental research

2. Skill of Scientific Literacy

- Understand elements of research design and how they impact scientific findings / conclusions

3. Readings & Method

- Elicit components of a research article from students (i.e. abstract, introduction, etc.) and use a worksheet to aid in correlating these components to steps of the scientific method
- Define strategies used in methods section of the article ‘ Randomized Trial of Modafinil as a Treatment of Excessive Daytime Somnolence of Narcolepsy’ and identify potential strengths and / or weaknesses; strategies for consideration include placebo-controlled, double-blind, randomization, discontinuation phase, exclusion criteria
- Consider the real-world implications of exclusion criteria referenced above for the patient cases presented in the article ‘Modafinil-induced Psychosis’

4. Activities

Correlates of the Anatomy of a Research Article and the Steps of the Scientific Method*

*Included in a collection of worksheets in Appendix A2

- Elicit the components of a research article from students and write on board; students should fill in the bottom portion of the worksheet from discussion
- Briefly discuss what is contained in each part of a research article
- Ask students to finish the table in the bottom portion of the worksheet; discuss answers

“Clinical Trial of Modafinil”

- Discuss definitions/examples of the following terminology

-placebo-controlled - describes a clinical research study in which a placebo is used to

compare two groups: one group receiving new drug or Tx and another receiving the placebo (no drug or Tx); define 'placebo' and give some examples

-double-blind - describes a study in which neither the participants nor the researcher(s) know the Tx (or placebo) that the participants are receiving

-randomization - two main definitions include the process of generating a random sample from a population, and the process of randomly assigning patients to different Tx

*Ask students to identify which type of randomization is used in a clinical trial

b. Assign each small group with the task of identifying at least one potential strength or weakness of these three techniques; have groups share answers in class discussion

c. Ask students what they believe was the purpose of the discontinuation phase, as well as possible advantages/disadvantages of using this technique; can be done either in small groups or class discussion

“Modafinil-induced Psychosis”

a. As a class, briefly summarize the important information in the patient case reports discussed in this article:

-61 yr. old woman w/ undifferentiated schizophrenia exhibiting clozapine-induced sedation; developed psychotic symptoms when treated w/ 800 mg Modafinil per day

-17 yr. old man w/ narcolepsy experienced a manic episode with delusions and hallucination when treated with 400 mg Modafinil per day

-38 yr. old woman w/ no prior psychiatric history developed psychotic symptoms in response to sleep disruption/deprivation and 400 mg Modafinil per day

-31 yr. old man w/ neurological history (right parietal meningioma) developed 'low mood' post-operatively and was treated w/ citalopram intermittently; self-report of 1 yr. history of EDS, Tx w/ 30-35 mg dexamphetamine, Rx withdrawn after abuse was evident, began Tx w/ Modafinil 400 mg per day; developed psychiatric symptoms after ingesting >500 mg Modafinil and >300 mg caffeine at once that morning

b. As a class, briefly discuss the exclusion criteria referenced in the introduction of the clinical trial article:

-prior adverse reaction to CNS stimulants

-any other active, uncontrolled medical disorder

-any medication with stimulating or sedating effects within 3 weeks of study onset

-any other psychoactive agents with stimulating or sedating effects within 3 weeks of study onset

c. In small groups, ask students to discuss how these exclusion criteria made it difficult to predict how these four patients would respond to Tx with Modafinil

5. Measurement

Thursday: B1 through B4

Question #1: Which of the following is/are important concept(s) to consider when designing a research study? Circle all that apply.

- A. Clearly identifying a research question and justifying why it is important
- B. Creating a specific hypothesis that answers the research question
- C. Describing the data necessary for testing the hypothesis and how that data will be obtained
- D. Identifying a cause-effect relationship from the data obtained

Answers: A, B, and C

Friday: B5 through B8

2. Friday - B5 through B8

Question #5: Which of the following is an advantage of randomization in a research study?

- A. It produces a sample size necessary for statistical analysis
- B. It increases the chance that the researcher's desired outcome is achieved
- C. It decreases the chance that variables unrelated to the focus of the study will affect the outcome of the study
- D. It ensures that patients requiring a particular medical treatment will receive that treatment

Answer: C

Discussion #6 - Wise Words

Dates: October 15th & 16th, 2015

1. Objective(s)

-Cultivate students' critical thinking and ability to criticize scientific literature

2. Skill of Scientific Literacy

-Understand elements of research design and how they impact scientific findings / conclusions

3. Readings & Method

-Review excerpts from Advice for a Young Investigator by Ramon y Cajal and use them as a framework for developing students' awareness of how science *is* done and their own personal beliefs in how science *should be* done

-Pose open-ended questions for students to share those beliefs, i.e. questions about hypothetical scenarios, articles previously read in past discussions, and current paradigms in scientific research

4. Activities

Research Scenarios #1 & #2 with Discussion Questions*

*Included in a collection of worksheets in Appendix A2

a. Ask students to read a hypothetical scenario involving a newcomer to scientific research and an issue Cajal discusses in Chapter 2: undue admiration of authority

b. Ask students to complete the accompanying questions in their small groups, then discuss answers as a class; review conflicting answers/ideas as necessary

c. Ask students to read individually the scenario of Alexander Fleming inadvertently discovering penicillin, and how the principles Cajal discusses of having a solid general education/knowledge and finding inspiration in nature in Chapter 4 apply

d. Ask students to complete the accompanying questions in their small groups, then discuss answers as a class; review conflicting answers/ideas as necessary

Research Funding and Major vs. Minor Findings

*Research grants are typically given to those individuals with a solid reputation in research and who have presented important data/conclusions; in order to get funding, you need a reputation and significant data, but to get a reputation and significant data you need funding (present idea orally, write simple diagram of concept on black board)

- a. What would Cajal say about our process of funding research? (class discussion)
- b. Should we change this system to be more favorable to new scientists? if so, what are some changes that could be made? (small group discussion, then class discussion)
- c. If we consider awarding funding to those scientists who are most likely to produce major scientific findings, how can we define what is a 'major' vs. 'minor' scientific finding? (class discussion)
- d. Use point of determining what is 'major' vs. 'minor' as important factor for determining a focus for research, leading into next discussion topic

Experimental Process

- a. Elicit initial 3 steps of the scientific process necessary for generating a focus for research with class discussion focusing on principles in chapter 4 relating to these steps:
 - formulate a research question
 - perform background research
 - state a hypothesis

*principles from chapter 4: general education; the need for specialization; foreign languages; how monographs should be read; the absolute necessity of seeking inspiration in nature; mastery of technique; in search of original data

- b. What differences can we see in how these steps were performed in the article by Dr. Bem vs. the Modafinil clinical trial article? (class discussion)
- c. Consider the case of Alexander Fleming accidentally discovering penicillin, or Roentgen's haphazard discovery of x-rays; how do these initial steps of the scientific process (or Cajal's principles) apply to these scenarios, if at all? (class discussion)

5. Measurement

Thursday: B1 through B4

Question #5: Which of the following best describes Cajal's attitude towards factors that may influence research design?

- A. An important factor of research design is the immediate applicability of the information acquired, thereby allowing economic factors to influence scientific research
- B. An important factor of research design is the sample size used, as the magnitude of the study population directly relates to the importance of the study and its conclusions
- C. An important factor of research design is the use of randomization techniques because these techniques eliminate the possibility of small and insignificant variables influencing the outcome
- D. An important factor of research design is the use of an experimental control, a necessary component of the scientific process that translates scientific theory into scientific application

Answer: D

Friday: B5 through B8

Question #5: In chapter 4, Cajal proposes that a researcher's intellectual interest is driven primarily by their emotional response to that area of study. Which of the following types of research bias does this idea relate to?

- A. confirmation bias - the tendency of a researcher to hold preference for information that confirms one's beliefs or hypotheses, while giving less information attention to information that contradicts it.
- B. experimenter bias - the effect exhibited when the expectations of a researcher unintentionally influences the subject(s) under study, thereby affecting the outcome of the experiment
- C. selection bias - the bias which results from a non-randomized sample taken from the population under study, thereby misrepresenting the occurrence of a particular outcome in that population
- D. attentional bias - the tendency of an individual's perception to be affected by the recurrence or prominence of their thoughts, causing the individual to focus on a relatively limited set of information and explanations

Answer: D

Discussion #7 - Lost in Transmission

Dates: October 22nd & 23rd, 2015

1. Objective(s)

-Identify correlations between the scientific method and the practice of medicine

2. Skill of Scientific Literacy

-Understand the elements of research design and how they impact scientific findings / conclusions

3. Readings & Method

-Consider specific examples within the story 'On the Level' that relate the practice of medicine to the steps of the scientific method

-Use students' preexisting knowledge on alternative explanatory models of illness as a framework for generating differential diagnoses and possible treatment options

4. Activities

Correlates of the Practice of Medicine and the Steps of the Scientific Method*

*Included in a collection of worksheets in Appendix A2

a. Activate students' existing knowledge by eliciting information on symptoms and brain areas affected with regards to global aphasia and tonal agnosia via class discussion

b. Ask students to work in their small groups to identify examples from 'The President's Speech' that relate to the correlates listed; pool together info via class discussion

c. Write steps for diagnosing and treating on the board for students to reference later

Case Study

a. Pose a hypothetical clinical case to students to work on in small groups:

-Clinical Case: You are a neurologist at Boston Children's Hospital. You take on a medical case of a 4-year-old boy who has not begun speaking yet. While he does utter sounds and is able to communicate his needs in other ways (i.e. pointing at objects, showing emotional responses to stimuli or lack of stimuli, etc.), his parents are deeply concerned that he may never talk.

b. Testing, Diagnoses, and Treatment:

- Provide medical testing options that may be used in order to differentiate possible diagnoses of global aphasia vs. tonal agnosia.
- Provide 2-3 differential diagnoses that may also explain the symptoms the patient is presenting with (autism, learning disability, deafness, etc.)
- Provide a possible treatment for all of the diagnoses you suggest

5. Measurement

Thursday: B1 through B4

Question #1: Which of the following is not an important component of diagnosing tonal agnosia?

- A. using an MRI to detect damage to a patient's right temporal lobe
- B. having a knowledge of areas of the temporal lobe involved in language processing
- C. testing your diagnosis by immediately treating the patient with speech therapy
- D. considering other differential diagnoses that may explain a patient's symptoms

Answer: C

Friday: B5 through B8

Question #5: Which of the following is **not** an important component of diagnosing global aphasia?

- A. using an MRI to detect damage to a patient's left temporal lobe
- B. having a knowledge of areas of the temporal lobe involved in language processing
- C. testing your diagnosis by immediately treating the patient with speech therapy
- D. considering other differential diagnoses that may explain a patient's symptoms

Answer: C

Discussion #8 – Proprioception via Misdirection

Dates: October 29th & 30th, 2015

1. Objective(s)

-Identify correlations between the scientific method and the practice of medicine

2. Skill of Scientific Literacy

-Understand the elements of research design and how they impact scientific findings / conclusions

3. Readings & Method

-Consider specific examples within the story ‘On the Level’ that relate the practice of medicine to the steps of the scientific method

-Use students’ preexisting knowledge on alternative explanatory models of illness as a framework for generating differential diagnoses and possible treatment options

4. Activities

Clinical Case - On the Level*

*Included in a collection of worksheets in Appendix A2

a. Activate students’ existing knowledge by eliciting information on symptoms and brain areas affected in Parkinson’s disease and other movement disorders

b. Ask students to work in their small groups to identify solutions for the questions presented; pool small group information through class discussion

5. Measurement

Thursday: B1 through B4

Question #5: Which of the following is not an important aspect of treating a patient with Parkinson’s disease?

- A. monitoring a patient to see if their symptoms worsen, stay the same, or improve
- B. knowing what to expect when you initially begin treating the patient, i.e. knowing if their symptoms should worsen, stay the same, or improve
- C. considering alternative diagnoses when drugs typically used for Parkinson's Disease patients do not help the patient you are treating
- D. considering how the patient's personal characteristics, i.e. physical, mental, emotional traits, may impact the effectiveness of treatment

Answer: B

Friday: B5 through B8

Question #3: Which of the following is not an important aspect of diagnosing a patient with Parkinson's Disease?

- A. asking a doctor that has been practicing medicine for a long time for their opinion about a patient
- B. understanding how the disease causes specific symptoms, a.k.a. disease pathology
- C. considering how other illnesses that are similar to Parkinson's can cause the same kinds of symptoms
- D. using diagnostic testing (i.e. CT, fMRI, etc.) that can either confirm or disprove your diagnosis

Answer: A

Discussion #10 - Vice or Virtue

Dates: November 12th & 13th, 2015

1. Objective(s)

-Enable students to be able to analyze schematic diagrams representing research findings

2. Skill of Scientific Literacy

-Read and interpret graphical representations of data

3. Readings & Method

-Explore the article “Low-dose nicotine facilitates spatial memory in ApoE-knockout mice in the Radial Arm Maze” with regards to the following: synopsis of research into the psychoactive effects of nicotine and its role in learning and memory, animal models used to study these effects, and diagrams that display relevant findings

-Provide students with learning opportunities for recapitulating information within the article, specifically the diagrams, in their own words

4. Activities

Radial Arm Maze Protocol

a. Activate students’ knowledge by eliciting information on reference memory and working memory; what are they, and how do they differ?

b. Ask students to work in their small groups to organize information for the following aspects of the radial arm maze mentioned in the article “Low-dose nicotine facilitates spatial memory in ApoE-knockout mice in the Radial Arm Maze”

-overall design: shape, number of arms, presence of food, etc.

-how it assesses reference memory

-how it assesses working memory

“Low-dose nicotine facilitates spatial memory in ApoE-knockout mice in the Radial Arm Maze”

a. Ask students to review and discuss Figure 1 in their small groups; pool small group information through class discussion

-identify the control

-identify the subject of analysis

-what conclusions can be drawn based on the data presented?

b. Ask students to review and discuss Figure 2 in their small groups; pool small group information through class discussion

-identify the control

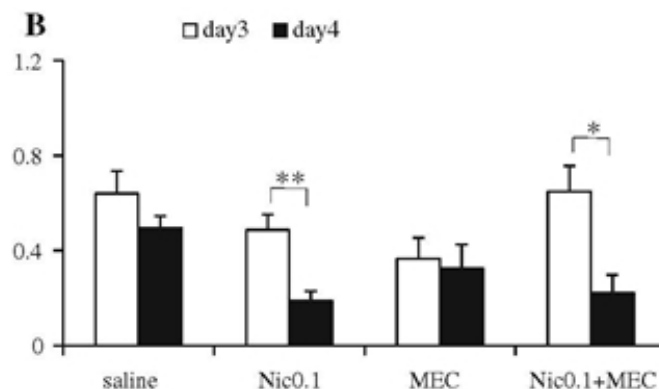
-identify the subject of analysis

-what conclusions can be drawn based on the data presented?

5. Measurement

Thursday: B1 through B4

Question #5: In the graph shown, performance ratios on days 3 and 4 of the experiment are displayed on the y-axis, while saline, nicotine, and mecamylamine (MEC) administered to ApoE-knockout mice on are displayed on the x-axis. Which of the following is the best interpretation of the graph?



A. Mice that received neither nicotine nor MEC showed an increase in performance ratios.

B. Mice that received MEC only showed a significant decrease in their performance ratios.

C. All of the mice, regardless of the drug administered to them, displayed a decrease in their performance ratios.

D. Mice administered 0.1 mg/kg of nicotine + MEC exhibited a much more significant decrease in their performance ratios than mice who received 0.1 mg/kg of nicotine only.

Answer: C

Friday - B5 through B8

*No question included

Discussion #11 - Alzheimer's and Lifestyle Interventions

Dates: November 19th & 20th, 2015

1. Objective(s)

-Enable students to be able to analyze schematic diagrams representing research findings

2. Skill of Scientific Literacy

-Read and interpret graphical representations of data

3. Readings & Method

-Explore the article "Exercise is More Effective than Diet Control..." with regards to the following: synopsis of research into Alzheimer's disease as it pertains to lifestyle choices in diet and exercise, animal models used to study correlates of Alzheimer's, diet, and exercise, and diagrams that display relevant findings

-Provide students with learning opportunities for recapitulating information within the article, specifically the diagrams, in their own words

-Provide students with learning opportunities for discussing potential future research based off of the information presented in the article

4. Activities

"Exercise is More Effective than Diet Control in Preventing High Fat Diet-induced Beta-amyloid Deposition and Memory Deficit in Amyloid Precursor Protein Transgenic Mice"

a. Ask students to work in their small groups to review and discuss Figure 1 in their small groups; pool small group information through class discussion

-what is the experimental design?

-what are the quantitative domains of measurement?

-what is the significance of serum glucose and serum insulin levels?

b. Ask Students to work in their small groups to review and discuss Figures 3 and 4 in their small groups; pool small group information through class discussion

-identify the control

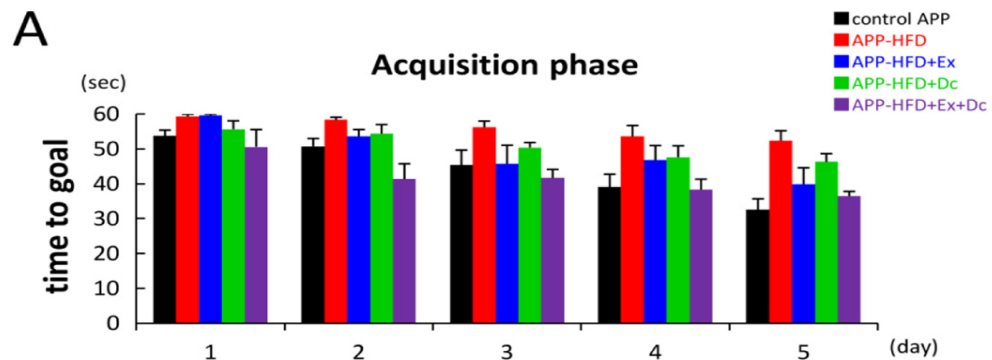
-identify the subject of analysis

-what conclusions can be drawn based on the data presented?

5. Measurement

Thursday: B1 through B4

Question #5: In the graph shown, the time to goal (in seconds) is displayed on the y-axis while the various experimental groups and the days upon which data was collected are displayed on the x-axis. Which of the following is the most accurate description of how the time to goal changes for the APP-HFD+Ex experimental group over the course of 5 days?

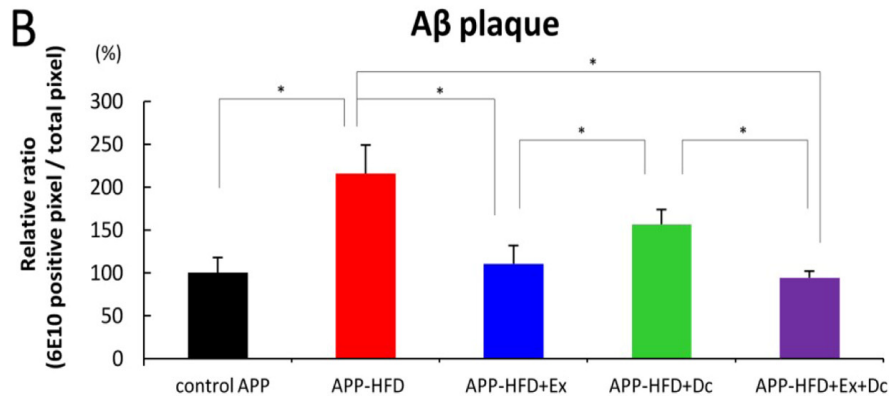


- A. The time to goal for the APP-HFD+Ex decreases on a daily basis.
- B. The time to goal for the APP-HFD+Ex is less than the time to goal for the APP-HFD+Dc group on a daily basis.
- C. The time to goal for the APP-HFD+Ex shows an overall decrease over the course of 5 days.
- D. The time to goal changes for the APP-HFD+Ex group and the time to goal changes for the APP-HFD+Ex+Dc group show the same general trends (both increase or decrease) going from one day to the next.

Answer: C

Friday: B5 through B8

Question #5: In the graph shown, the relative ratio (calculated as a percentage) is plotted on the y-axis while the various experimental groups are displayed along the x-axis. Choose one of the following statements that is the best interpretation of the data displayed above.



- A. A. Diet control (+DC) in experimental APP mice exhibited a significant decrease in relative ratio compared to control APP mice.
- B. Mice who performed exercise (+Ex) exhibit relative ratios that are more similar to that of the control APP mice than mice who did not perform exercise.
- C. Mice fed a high fat diet (-HFD) exhibit markedly different relative ratios than that of the control APP mice.
- D. No experimental group exhibited a similar relative ratio compared with the relative ratio of the control APP group.

Answer: B

Discussion #12 - Conclusions and Brain-Machine Interfaces

Dates: December 3rd & 4th, 2015

1. Objective(s)

- Enable students to be able to analyze schematic diagrams representing research findings
- Enable students in generating an abstract for a primary research article

2. Skill of Scientific Literacy

- Read and interpret graphical representations of data

3. Readings & Method

- Explore the articles “Selecting the signals for a brain-machine interface” (and supplemental reading assignment “Controlling Robots with the Mind”) with regards to the following: synopsis of research into brain-machine interfaces and how the basic research presented in these article set the stage for the work presented later in “Scientists Demonstrate Animal Mind-Melds”
- Provide students with learning opportunities for recapitulating information within the article, specifically the diagrams, in their own words
- Provide students with learning opportunities for discussing potential future research based off of the information presented in the article

4. Activities

Conclusions

a. Through class discussion, review key points of past discussion meetings:

- scientific literacy, and the three skills focused on during discussions
- primary goals of each discussion (identified as objectives within lesson plans)

“Selecting the signals for a brain-machine interface”

a. Distribute the article “Selecting the signals for a brain-machine interface” to students while removing all identifying information; ask students to review independently

b. Ask Students to work in their small groups to review and discuss Figures 1-3 in their small groups; pool small group information through class discussion

- identify the control

-identify the subject of analysis

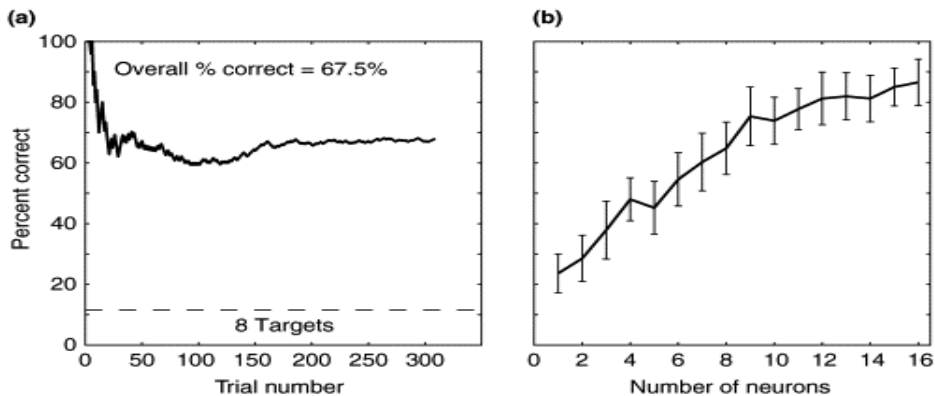
-what conclusions can be drawn based on the data presented?

c. Ask students to work in small groups to generate an abstract for the article, recalling the main components of a research article: introduction, methods, results, discussion

5. Measurement

Thursday: B1 through B4

Question #1: In the graph shown, the success rate (percent correct) of monkeys reaching toward 8 target locations in space was recorded; the mean success rate (overall % correct) was 67.5% over the course of approximately 300 - 350 trials. Using the graph above on the right, select the approximate percentage of recorded neurons out of the total number of 16 neurons that were required to achieve a success rate of 67.5%.



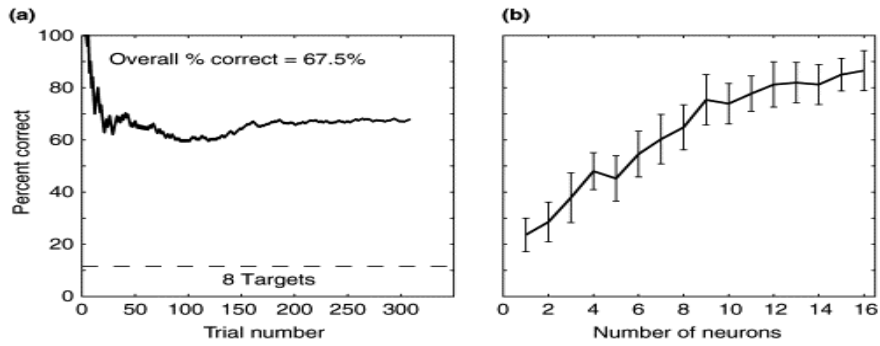
- A. 25%
- B. 50%
- C. 75%
- D. 100%

Answer: B

Friday: B5 through B8

Question #5: In the graph shown, the success rate (percent correct) of monkeys reaching toward 8 target locations in space was recorded; the mean success rate (overall % correct) was 67.5% over the course of approximately 300 - 350 trials. Using the graph above on

the right, select the approximate percentage of recorded neurons out of the total number of 16 neurons that were required to achieve a success rate of 67.5%.



- A. 25%
- B. 50%
- C. 75%
- D. 100%

Answer: B

Appendix A2 - Worksheets

Discussion #5 - Mistreatment of Medical Treatment

Correlates of the Anatomy of a Research Article and the Steps of the Scientific

Method (Student Version)

Anatomy of a Research Article

a.

b.

c.

d.

e.

f.

Directions: Use the following table to correlate the steps of the scientific method with the components of a research article.

Steps of Scientific Method	Explanation of Step of Scientific Method	Component(s) of Research Article
1. Formulate a research question*	Develop a question based on observation that can be solved through experimentation and measured.	
2. Perform background research*	Search existing literature on your topic to gain a better understanding and focus your research question.	
3. State a hypothesis	Give an educated guess or prediction that answers the research question and that is measurable.	
4. Test the hypothesis with an experiment	Develop and follow a procedure for testing your hypothesis.	
5. Analyze data collected from experiment	Use <u>appropriate</u> statistical and/or logical applications to understand the data collected.	
6. Draw conclusions based on data analysis	Decide whether to accept or reject the hypothesis based on the data analysis.	
7. Communicate findings	Present conclusions of research and provide suggestions for how the research could be improved upon and/or ideas for further investigation	

*Note: formulation of a research question and performing background research may occur in separate stages, but these steps often occur simultaneously. Performing background research typically helps to focus the research question on something specific and measurable.

Discussion #5 - Mistreatment of Medical Treatment

Correlates of the Anatomy of a Research Article and the Steps of the Scientific

Method (Instructor Version)

Anatomy of a Research Article

a. abstract - summary of article

b. introduction - identification of research topic, review of related literature, purpose of research study, and expected outcomes

c. methods - provides information on subjects involved in study, instruments used, and procedures; should include enough detail to allow for replication

d. results - procedures used to organize and analyze data; specific procedures depend on the type of research being undertaken and what research question(s) is (are) being asked

e. conclusions / discussion - provides explanation of whether the results answered the research question, if the hypothesis is accepted or rejected, and considerations for further research (or changing standard practice)

f. references / bibliography - citation of all literature relevant to the study

Directions: Use the following table to correlate the steps of the scientific method with the components of a research article.

Steps of Scientific Method	Explanation of Step of Scientific Method	Component(s) of Research Article
1. Formulate a research question*	Develop a question based on observation that can be solved through experimentation and measured.	a. abstract b. introduction
2. Perform background research*	Search existing literature on your topic to gain a better understanding and focus your research question.	a. abstract b. introduction
3. State a hypothesis	Give an educated guess or prediction that answers the research question and that is measurable.	a. abstract b. introduction
4. Test the hypothesis with an experiment	Develop and follow a procedure for testing your hypothesis.	a. abstract c. methods
5. Analyze data collected from experiment	Use <u>appropriate</u> statistical and/or logical applications to understand the data collected.	a. abstract d. results
6. Draw conclusions based on data analysis	Decide whether to accept or reject the hypothesis based on the data analysis.	a. abstract e. conclusions / discussion
7. Communicate findings	Present conclusions of research and provide suggestions for how the research could be improved upon and/or ideas for further investigation	a. abstract e. conclusions / discussion

*Note: formulation of a research question and performing background research may occur in separate stages, but these steps often occur simultaneously. Performing background research typically helps to focus the research question on something specific and measurable.

Discussion #6 - Wise Words

Research Scenario #1 with Discussion Questions (Student Version)

Research Scenario #1 - Beginner's Traps (Chapter 2)

Tom H. recently graduated from Boston University with a masters degree in neuroscience. During his last year at school, he reads a paper by a well-known neuroscientist at UCSD named Dr. Coffman. Coffman's paper exquisitely explains the function of the brain as being synonymous to the function of a computer, a theory which resonates with Tom's ideas of the nature of the brain as well as his personal interest in computer science. Dr. Coffman's research is unchallenged, as he is a highly respected and experienced research scientist. Tom decides that it would be an incredible opportunity to perform research with such an eminent figure in neuroscience, and so he applies to work in Dr. Coffman's lab.

After arriving in San Diego and beginning work in Dr. Coffman's lab, Tom begins to delve deeper into the questions raised by Dr. Coffman's research. One of his first experiments is a replication of the research he had originally read so that he may better understand the technique used by Dr. Coffman and how he came to the conclusions he did. However, after many attempts Tom finds that he is unable to consistently replicate the results from the protocol Dr. Coffman gives in his scientific report. Specifically, Tom finds that Dr. Coffman's theory applies to healthy brain tissue but not diseased brain tissue. However, the focus of Dr. Coffman's article was how his theory has immediate medical applications for treating brains with neuropsychiatric diagnoses. After meticulously repeating the research protocol and coming up with inconsistent results, Tom decides to bring his findings to Dr. Coffman. When he does so, Dr. Coffman lashes out and insults Tom's ability to effectively replicate his experiment. He berates Tom, telling him that he lacks the patience necessary to carry out the research protocol. Just as Dr. Coffman is about to fire Tom, their conversation is interrupted by an official from the NIH who has come to the lab to discuss the status of Dr. Coffman's research. It is then that Tom discovers that Dr. Coffman's grant is nearing its deadline and he is under considerable pressure to produce valuable scientific data in order for his funding to continue.

Questions for Research Scenario #1

1. Which of the following biases did Tom not exhibit when he chose to do research with Dr. Coffman?

- a. confirmation bias
- b. selection bias
- c. attentional bias

2. Which of the following points raised in chapter 2 of Advice for a Young Investigator was an important but misleading factor influencing Tom's decision to do research with Dr. Coffman?

- a. undue admiration of authority
- b. preoccupation with applied science
- c. perceived lack of ability

3. Which of the following points raised in chapter 2 of Advice for a Young Investigator was a key factor influencing Dr. Coffman's research and plausibly erroneous presentation of scientific findings?

- a. most important problems are already solved
- b. preoccupation with applied science
- c. perceived lack of ability

4. During the heated discussion between Tom and Dr. Coffman, Tom begins to doubt his ability to be effective as a research scientist. List up to 3 personal characteristics Cajal identifies as being sufficient to compensate for Tom's perceived lack of ability.

Discussion #6 - Wise Words

Research Scenario #1 with Discussion Questions (Instructor Version)

Research Scenario #1 - Beginner's Traps (Chapter 2)

Tom H. recently graduated from Boston University with a masters degree in neuroscience. During his last year at school, he reads a paper by a well-known neuroscientist at UCSD named Dr. Coffman. Coffman's paper exquisitely explains the function of the brain as being synonymous to the function of a computer, a theory which resonates with Tom's ideas of the nature of the brain as well as his personal interest in computer science. Dr. Coffman's research is unchallenged, as he is a highly respected and experienced research scientist. Tom decides that it would be an incredible opportunity to perform research with such an eminent figure in neuroscience, and so he applies to work in Dr. Coffman's lab.

After arriving in San Diego and beginning work in Dr. Coffman's lab, Tom begins to delve deeper into the questions raised by Dr. Coffman's research. One of his first experiments is a replication of the research he had originally read so that he may better understand the technique used by Dr. Coffman and how he came to the conclusions he did. However, after many attempts Tom finds that he is unable to consistently replicate the results from the protocol Dr. Coffman gives in his scientific report. Specifically, Tom finds that Dr. Coffman's theory applies to healthy brain tissue but not diseased brain tissue. However, the focus of Dr. Coffman's article was how his theory has immediate medical applications for treating brains with neuropsychiatric diagnoses. After meticulously repeating the research protocol and coming up with inconsistent results, Tom decides to bring his findings to Dr. Coffman. When he does so, Dr. Coffman lashes out and insults Tom's ability to effectively replicate his experiment. He berates Tom, telling him that he lacks the patience necessary to carry out the research protocol. Just as Dr. Coffman is about to fire Tom, their conversation is interrupted by an official from the NIH who has come to the lab to discuss the status of Dr. Coffman's research. It is then that Tom discovers that Dr. Coffman's grant is nearing its deadline and he is under considerable pressure to produce valuable scientific data in order for his funding to continue.

Questions for Research Scenario #1

1. Which of the following biases did Tom not exhibit when he chose to do research with Dr. Coffman?

a. confirmation bias (Tom endorsed Dr. Coffman's theory of the brain functioning like a computer because it confirmed his own beliefs/hypotheses about the brain)

b. selection bias (this relates to the generation of an unrepresentative sample taken from a study population due to lack of randomization techniques)

c. attentional bias (Tom's personal interest in computer science influenced his decision to agree with Dr. Coffman's conclusions and to work with him)

2. Which of the following points raised in chapter 2 of Advice for a Young Investigator was an important but misleading factor influencing Tom's decision to do research with Dr. Coffman?

a. undue admiration of authority (Dr. Coffman is described as well-known, highly respected, experienced, and eminent; his research is seemingly unchallenged)

b. preoccupation with applied science (Tom focuses first on replicating the experiment he read about, not on how to apply the data and conclusions)

c. perceived lack of ability (while Tom may have questioned his abilities after beginning work with Dr. Coffman, it did not influence his decision to begin working with him)

3. Which of the following points raised in chapter 2 of Advice for a Young Investigator was a key factor influencing Dr. Coffman's research and plausibly erroneous presentation of scientific findings?

a. most important problems are already solved (neuroscience is still a relatively young field of study, and there remains a great deal of unknown information)

b. preoccupation with applied science (Dr. Coffman's judgment and objectivity have been compromised by the need to maintain his grant funding, which include making scientific discoveries that have immediate medical applications)

c. perceived lack of ability (while this may be true, Dr. Coffman seems to be riding on his

reputation and perceived abilities in research)

4. During the heated discussion between Tom and Dr. Coffman, Tom begins to doubt his ability to be effective as a research scientist. List up to 3 personal characteristics Cajal identifies as being sufficient to compensate for Tom's perceived lack of ability.

Answers: determination, hard work, perseverance, patience, concentration

Discussion #6 - Wise Words

Research Scenario #2 with Discussion Questions (Student Version)

Research Scenario #2 - What Newcomers to Biological Research Should Know

Alexander Fleming returned to his research laboratory at St. Mary's Hospital in London after World War I. He wanted to find a chemical that could stop bacterial infection. He discovered lysozyme, an enzyme occurring in many body fluids, such as tears. It had a natural antibacterial effect, but not against the strongest infectious agents. He kept looking. Fleming had so much going on in his lab that it was often in a jumble. This disorder proved very fortunate.

In 1928, he was straightening up a pile of Petri dishes where he had been growing bacteria, but which had been piled in the sink. He opened each one and examined it before tossing it into the cleaning solution. One made him stop and say, "That's funny." Some mold was growing on one of the dishes... not too unusual, but all around the mold, the staph bacteria had been killed... very unusual. He took a sample of the mold. He found that it was from the penicillium family, later specified as *Penicillium notatum*. Fleming presented his findings in 1929, but his lack of understanding regarding his discovery (i.e. the mold's medical benefits) resulted in little public interest being raised. He published the report on penicillin and its potential uses in the *British Journal of Experimental Pathology*, giving little attention to its therapeutic properties and instead commenting at length about its applications in laboratory research.

Fleming worked with the mold for some time, focusing mainly on its application for isolating penicillin-insensitive bacteria from penicillin-sensitive bacteria in a mixed culture. However, refining and growing it was a difficult process better suited to a chemist. The work was taken over by a team of chemists and mold specialists, but was cut short when several of them died or relocated. In 1935, Australian Howard Florey was appointed professor of pathology at Oxford University where he headed up a laboratory. One researcher he hired soon after his arrival was Ernst Chain. Chain was paid to do cancer research, and work that spilled over into Florey's own interest and work on lysozyme. Chain became quite enthusiastic about the search for antibacterial chemicals. In looking back at old articles written about lysozyme, including those by Fleming in the 1920s, he happened across Fleming's paper on penicillin.

The Oxford team, as Florey's researchers have become known, began experimenting with the penicillin mold. They took it one step further than Fleming did: they did not just try it topically or in a petri dish, but injected it in live mice. With controlled experimentation, they found it cured mice with bacterial infections. They went on to try it on a few human subjects and saw amazing results. By now it was 1941, and England was at war. As Fleming first foresaw, the wartime need for an antibacterial was great, but resources were tight and penicillin still very experimental. Florey had connections at the Rockefeller Foundation in the United States, however, and it funded further research.

Source: <http://www.pbs.org/wgbh/aso/databank/entries/dm28pe.html>

Questions for Research Scenario #2

1. Which of the following principles discussed in chapter 4 of Advice for a Young Investigator was the most influential in Alexander Fleming's discovery of penicillin?

- a. mastery of technique
- b. general education
- c. search for original data

2. After discovering penicillin and working with it for some time, Fleming decided to turn it over to a team of chemists and mold specialists for refining and growing the mold. Which of the principles discussed in chapter 4 best correlates with Fleming's decision?

- a. search for original data
- b. mastery of technique
- c. need for specialization

3. Which of the following factors related to research design was likely the most problematic in attempting to replicate the accidental discovery made by Fleming?

- a. randomization

b. sample size

c. experimental control

4. In chapter 4 of Advice for a Young Investigator, Cajal suggests two considerations to be made when reading a scientific monograph or report: analysis of the research methods used by the author and problems that remain unsolved within the specific field of inquiry.

Describe the importance of each of these points to Ernst Chain reading Fleming's report on penicillin nearly nine years after its initial publication.

Discussion #6 - Wise Words

Research Scenario #2 with Discussion Questions (Instructor Version)

Research Scenario #2 - What Newcomers to Biological Research Should Know

Alexander Fleming returned to his research laboratory at St. Mary's Hospital in London after World War I. He wanted to find a chemical that could stop bacterial infection. He discovered lysozyme, an enzyme occurring in many body fluids, such as tears. It had a natural antibacterial effect, but not against the strongest infectious agents. He kept looking. Fleming had so much going on in his lab that it was often in a jumble. This disorder proved very fortunate.

In 1928, he was straightening up a pile of Petri dishes where he had been growing bacteria, but which had been piled in the sink. He opened each one and examined it before tossing it into the cleaning solution. One made him stop and say, "That's funny." Some mold was growing on one of the dishes... not too unusual, but all around the mold, the staph bacteria had been killed... very unusual. He took a sample of the mold. He found that it was from the penicillium family, later specified as *Penicillium notatum*. Fleming presented his findings in 1929, but his lack of understanding regarding his discovery (i.e. the mold's medical benefits) resulted in little public interest being raised. He published the report on penicillin and its potential uses in the *British Journal of Experimental Pathology*, giving little attention to its therapeutic properties and instead commenting at length about its applications in laboratory research.

Fleming worked with the mold for some time, focusing mainly on its application for

isolating penicillin-insensitive bacteria from penicillin-sensitive bacteria in a mixed culture. However, refining and growing it was a difficult process better suited to a chemist. The work was taken over by a team of chemists and mold specialists, but was cut short when several of them died or relocated. In 1935, Australian Howard Florey was appointed professor of pathology at Oxford University where he headed up a laboratory. One researcher he hired soon after his arrival was Ernst Chain. Chain was paid to do cancer research, and work that spilled over into Florey's own interest and work on lysozyme. Chain became quite enthusiastic about the search for antibacterial chemicals. In looking back at old articles written about lysozyme, including those by Fleming in the 1920s, he happened across Fleming's paper on penicillin.

The Oxford team, as Florey's researchers have become known, began experimenting with the penicillin mold. They took it one step further than Fleming did: they did not just try it topically or in a petri dish, but injected it in live mice. With controlled experimentation, they found it cured mice with bacterial infections. They went on to try it on a few human subjects and saw amazing results. By now it was 1941, and England was at war. As Fleming first foresaw, the wartime need for an antibacterial was great, but resources were tight and penicillin still very experimental. Florey had connections at the Rockefeller Foundation in the United States, however, and it funded further research.

Source: <http://www.pbs.org/wgbh/aso/databank/entries/dm28pe.html>

Questions for Research Scenario #2

1. Which of the following principles discussed in chapter 4 of Advice for a Young Investigator was the most influential in Alexander Fleming's discovery of penicillin?

- a. mastery of technique (Fleming was notorious for keeping a disorderly lab which indicates his laboratory techniques were not outstanding either)
- b. general education** (fortunately Fleming had some background in fungi, otherwise he may not have recognized its presence in the petri dish as significant)
- c. search for original data (while this was the stated purpose of Fleming's research, he had previously been performing experiments using lysozyme as an antibacterial agent with limited success)

2. After discovering penicillin and working with it for some time, Fleming decided to turn it over to a team of chemists and mold specialists for refining and growing the mold. Which of the principles discussed in chapter 4 best correlates with Fleming's decision?

a. search for original data (the opposite is likely true, as Fleming handed over this novel mold which had just recently been discovered)

b. mastery of technique (this principle correlates with the chemists' and mold specialists' ability to more effectively research the newly discovered penicillin instead of Fleming)

c. need for specialization (Fleming maintained focus on his original research endeavor and allowed specialists to pursue purification and cultivation of the mold he had discovered)

3. Which of the following factors related to research design was likely the most problematic in attempting to replicate the accidental discovery made by Fleming?

a. randomization (this refers to specific techniques for assigning research subjects to different experimental procedures, i.e. creating treatment and control groups)

b. sample size (cultivating penicillin and bacteria in a petri dish would be relatively inexpensive; this would likely not be a serious hindrance in replicating Fleming's work)

c. experimental control (Fleming's discovery occurred completely by chance, and he was also notorious for poor laboratory upkeep and maintaining written records; the entire event was serendipitous and lacked the structure of scientific procedure, including experimental control)

4. In chapter 4 of Advice for a Young Investigator, Cajal suggests two considerations to be made when reading a scientific monograph or report: analysis of the research methods used by the author and problems that remain unsolved within the specific field of inquiry.

Describe the importance of each of these points to Ernst Chain reading Fleming's report on penicillin nearly nine years after its initial publication.

Answers: Analysis of the research methods could enable Chain and his colleagues to cultivate penicillin, and the problems that remain unsolved within Chain's field included a large demand for antibacterial agents during World War I.

Discussion #7 - Lost in Transmission

Correlates of the Practice of Medicine and the Steps of the Scientific Method

(Student Version)

1. Formulate a research question

a. medical corollary

-What is/are the specific symptom(s) being considered for medical treatment?

-Alternatively, this can be generalized into the following questions: what is the patient's chief complaint? why have they come in for medical treatment?

b. notes

2. Perform background research

a. medical corollary

-What information is necessary for understanding the pathology and how to treat it?

-What information can the patient give that aids in understanding the pathology?

b. notes

3. State a hypothesis

a. medical corollary

-Decide on the best treatment for the patient, based on the patient's symptoms and disease pathology

-Alternatively, this step of the scientific process could also correlate to stating the best-fitting diagnosis based on the symptom(s) being considered

b. notes

4. Test the hypothesis with an experiment

a. medical corollary

-Application of selected medical treatment

b. notes

5. Analyze data collected from experiment

a. medical corollary

-Patient and clinician observe the patient's response to treatment with regards to whether the severity of symptom(s) increase, decrease, or remain the same

b. notes

6. Draw conclusions based on data analysis

a. medical corollary

-If symptom(s) improve, continue with the first course of treatment; make minor adjustments when necessary

-If symptom(s) do not improve or worsen, reconsider initial explanation of the cause of the symptom(s) and the appropriate treatment, i.e. differential diagnosis

b. notes

7. Communicate findings

a. medical corollary

-Can the information supporting the decision for treatment and the treatment itself be applied to other similar clinical cases?

b. notes

Discussion #7 - Lost in Transmission

Correlates of the Practice of Medicine and the Steps of the Scientific Method

(Instructor Version)

1. Formulate a research question

a. medical corollary

-What is/are the specific symptom(s) being considered for medical treatment?

-Alternatively, this can be generalized into the following questions: what is the patient's chief complaint? why have they come in for medical treatment?

b. notes

-For patients with global aphasia, the primary symptom is that they are unable to comprehend the meaning of words in speech. However, the patient may still be

capable of interpreting the meaning of speech by focusing on extra-verbal cues from the speaker.

-For patients with tonal agnosia, the situation is essentially the opposite. These patients retain their ability to understand the meaning of words, but exhibit a marked loss of ability to interpret 'the expressive qualities of voices' (as Dr. Sacks puts it).

2. Perform background research

a. medical corollary

-What information is necessary for understanding the pathology and how to treat it?

-What information can the patient give that aids in understanding the pathology?

b. notes

-For patients with global aphasia, it is important to consider key regions of the brain contributing to receptive and expressive speech (Broca's and Wernicke's area). These are both located in the left temporal lobe, which is damaged in patients with global aphasia. In order to gather information from the patient that supports this diagnosis, the clinician might speak in a manner that is devoid of the expressive tone found in natural speech and assess whether the patient is able to understand them.

-For patients with tonal agnosia that do not exhibit any deficit in their ability to understand and use words, the right temporal lobe is implicated. To assess for the presence of tonal agnosia, a clinician might say a sentence with an obvious emotional tone but that consists of a nonsensical series of words. Afterward, the patient would be asked to identify the general 'feeling' of the sentence, i.e. happy, sad, angry, etc.

3. State a hypothesis

a. medical corollary

-Decide on the best treatment for the patient, based on the patient's symptoms and disease pathology

-Alternatively, this step of the scientific process could also correlate to stating the best-fitting diagnosis based on the symptom(s) being considered

b. notes

-For patients with either global aphasia or tonal agnosia, speech therapy and utilizing alternative modes of communication (i.e. writing, sign language, etc.) would be helpful treatments. Also, because these disorders are associated with specific brain regions diagnostic testing should be conducted to assess the extent of the damage to either the right or left temporal lobe. Afterward, surgical intervention may also be of benefit.

-Both disorders bear similarities with other neurological disorders. Therefore, in order to

state the best-fitting diagnosis for both illnesses, differential diagnoses must be considered and ultimately ruled out.

4. Test the hypothesis with an experiment

a. medical corollary

-Application of selected medical treatment

b. notes

-Refer to above examples of speech therapy, utilizing alternative modes of communication, diagnostic testing for viewing images of the brain, and surgical intervention. Encourage students to suggest other treatment options they believe would be helpful for either or both diagnoses.

5. Analyze data collected from experiment

a. medical corollary

-Patient and clinician observe the patient's response to treatment with regards to whether the severity of symptom(s) increase, decrease, or remain the same

b. notes

-For patients with either of these diagnoses, how the severity of symptoms change may be deduced by neuropsychologic testing, subjective report from the patient, and/or observation by the clinician. Encourage students to suggest other means by which a patient's progress might be observed, and how a clinician might measure the severity of symptoms.

6. Draw conclusions based on data analysis

a. medical corollary

-If symptom(s) improve, continue with the first course of treatment; make minor adjustments when necessary

-If symptom(s) do not improve or worsen, reconsider initial explanation of the cause of the symptom(s) and the appropriate treatment, i.e. differential diagnosis

b. notes

-Discuss with students an important distinction to make when assessing the effectiveness of treatment: Is there an expectation from the clinician and/or the patient for symptoms to abate completely, or for symptoms to decrease in their severity?

-Referring to #3 (Stating a hypothesis), differential diagnoses should be considered early

on during the diagnostic process and prior to treatment. However, if the most common alternative diagnoses were already ruled out, the clinician then must reassess the patient's symptoms and begin considering less common and/or more complex explanatory models of illness.

7. Communicate findings

a. medical corollary

-Can the information supporting the decision for treatment and the treatment itself be applied to other similar clinical cases?

b. notes

-Depending on the complexity of the medical case, the findings made by a clinician while treating a patient with either global aphasia or tonal agnosia may be of great use to other patients and clinicians in comparable situations. The written report may be published as a case study providing recommendations for diagnosis and treatment of similar patients.

Discussion #8 - Proprioception via Misdirection

Clinical Case - On the Level (Student Version)

Imagine you are Dr. Oliver Sacks. In this hypothetical situation in which you are a brilliant, famous neurologist you meet Mr. MacGregor, a 93 year old patient with Parkinson's disease that tells you other people observe him leaning dangerously over to the side as he walks.

Every detail of Mr. MacGregor's and your interaction is identical to that described in 'On the Level', aside from one important detail: When Mr. MacGregor attempts to correct his balance by using his 'spirit level glasses', he is unable to do so. The treatment you two have decided upon is, unfortunately, unsuccessful. You realize that it is therefore necessary to reevaluate your initial hypothesis of what is causing his gait abnormality and how you might be able to treat it.

1. In the clinical tale 'On the Level', Dr. Sacks refers to the writing of Purdon Martin and his research on the integration of three important internal senses that is affected in

patients with Parkinson's disease. What are these three senses, and what are their primary functions in relation to regulating an individual's gait and movement?

a.

b.

c.

2. What diagnostic testing might you conduct in order to assess the overall function of these individual internal senses?

a.

b.

c.

3. Provide as many possible alternative explanations for what may be causing Mr. MacGregor's gait abnormality. Consider any differential diagnoses for Parkinson's disease you may know of, as well as co-existing conditions i.e. dual diagnoses of Parkinson's disease and some other illness.

4. What are some plausible treatments for the alternative diagnoses you suggested? If you deduced that some other aspect of Mr. MacGregor's ability to regulate his gait has been affected, how might you go about treating this patient? Think outside the box!

Discussion #8 - Proprioception via Misdirection

Clinical Case - On the Level (Instructor Version)

Imagine you are Dr. Oliver Sacks. In this hypothetical situation in which you are a brilliant, famous neurologist you meet Mr. MacGregor, a 93 year old patient with Parkinson's disease that tells you other people observe him leaning dangerously over to the side as he walks.

Every detail of Mr. MacGregor's and your interaction is identical to that described in 'On the Level', aside from one important detail: When Mr. MacGregor attempts to correct his balance by using his 'spirit level glasses', he is unable to do so. The treatment you two have decided upon is, unfortunately, unsuccessful. You realize that it is therefore necessary to reevaluate your initial hypothesis of what is causing his gait abnormality and how you might be able to treat it.

1. In the clinical tale 'On the Level', Dr. Sacks refers to the writing of Purdon Martin and his research on the integration of three important internal senses that is affected in patients with Parkinson's disease. What are these three senses, and what are their primary functions in relation to regulating an individual's gait and movement?

a. vision – provides information of the location of objects in the environment as well as an information about an individual's motion through that environment

b. proprioception – provides information about the position of body parts relative to one another in space and the amount of force being generated by those parts for movement

c. vestibular sense – primarily contributes to an individual's sense of balance and spatial orientation in order to coordinate balance with movement

2. What diagnostic testing might you conduct in order to assess the overall function of

these individual internal senses?

***The following examples are provided to guide students' discussion**

a. vision – simple vision test to assess central and peripheral vision

b. proprioception – Romberg's Test for assessing proprioceptive function (many students are familiar with this test, as it is used in neurology clinics as well as by law officials for testing a drunk driver); individual is asked to close their eyes while standing and if they lose balance this indicates that proprioception is impaired

c. vestibular sense – simple hearing test to assess the hearing organs of the inner ear; while the results of this test would not necessarily allow one to rule out the possibility of an abnormality of gait arising from dysfunctional vestibular sense, it is a very simple, safe, and cost-effective diagnostic test that could provide valuable information

3. Provide as many possible alternative explanations for what may be causing Mr. MacGregor's gait abnormality. Consider any differential diagnoses for Parkinson's Disease you may know of, as well as co-existing conditions i.e. dual diagnoses of Parkinson's Disease and some other illness.

***The following examples are provided to guide students' discussion**

Differential diagnoses: related movement disorders (cortical basal ganglionic degeneration, multiple system atrophy, progressive supranuclear palsy, etc.)

Co-existing conditions: cataracts and glaucoma (vision), diabetic neuropathy and arthritis (proprioception), ear infection (vestibular sense)

4. What are some plausible treatments for the alternative diagnoses you suggested? If you deduced that some other aspect of Mr. MacGregor's ability to regulate his gait has been affected, how might you go about treating this patient? Think outside the box!

Appendix B - Bibliography of Curriculum Source Material

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Appendix C1 - Pre-intervention Adaptation of the Test of Scientific Literacy Skills

Description

The following exam is being used to assess your baseline understanding of the following skills of scientific literacy:

1. Identify a valid scientific argument
2. Understand the elements of research design
3. Read and interpret graphical representations of data

While the outcome of this test will not affect your grade in the course, it will be extremely helpful in helping you understand some of the type of questions that will be asked on future quizzes in discussion, as well as assist those leading the course to design curriculum focused on concepts identified as being more difficult.

Instructions

1. For each of the following questions, choose from one of the four multiple choice answers provided that you believe to be the correct answer.
2. Some of the questions refer to supplementary data, i.e. a graph or some background information. Please carefully review this information when considering your answer.
3. Lastly, this exam is timed for 30 minutes. Answer as many questions possible to the best of your ability in that time.

Question 1: Which of the following is a valid scientific argument?

- a. Measurements of sea level on the Gulf Coast taken this year are lower than normal; the average monthly measurements were almost 0.5 cm lower than normal in some areas. These facts prove that sea level rise is not a problem.

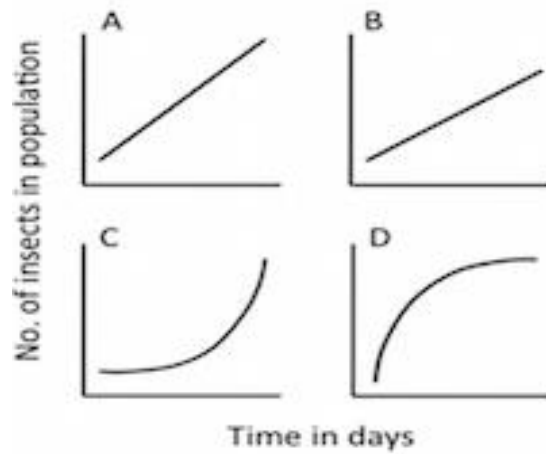
b. A strain of mice was genetically engineered to lack a certain gene, and the mice were unable to reproduce. Introduction of the gene back into the mutant mice restored their ability to reproduce. These facts indicate that the gene is essential for mouse reproduction.

c. A poll revealed that 34% of Americans believe that dinosaurs and early humans co-existed because fossil footprints of each species were found in the same location. This widespread belief is appropriate evidence to support the claim that humans did not evolve from ape ancestors.

d. This winter, the northeastern U.S. received record amounts of snowfall, and the average monthly temperatures were more than 20 F lower than normal in some areas. These facts indicate that climate change is occurring.

Question 2: While growing vegetables in your backyard, you noticed a particular kind of insect eating your plants. You took a rough count (see data below) of the insect population over time. Which graph shows the best representation of your data?

Time (days)	Insect Population (number)
2	7
4	16
8	60
10	123



- a. Graph A
- b. Graph B
- c. Graph C
- d. Graph D

Question 3: Which of the following research studies is least likely to contain a confounding factor (variable that provides an alternative explanation for results) in its design?

- a. Researchers randomly assign participants to experimental and control groups. Females make up 35% of the experimental group and 75% of the control group.
- b. To explore trends in the spiritual/religious beliefs of students attending U.S. universities, researchers survey a random selection of 500 freshmen at a small private university in the South.
- c. To evaluate the effect of a new diet program, researchers compare weight loss between

participants randomly assigned to treatment (diet) and control (no diet) groups, while controlling for average daily exercise and pre-diet weight.

d. Researchers tested the effectiveness of a new tree fertilizer on 10,000 saplings. Saplings in the control group (no fertilizer) were tested in the fall, whereas the treatment group (fertilizer) were tested the following spring.

Background for Question 4: The following graph appeared in a scientific article¹ about the effects of pesticides on tadpoles in their natural environment.

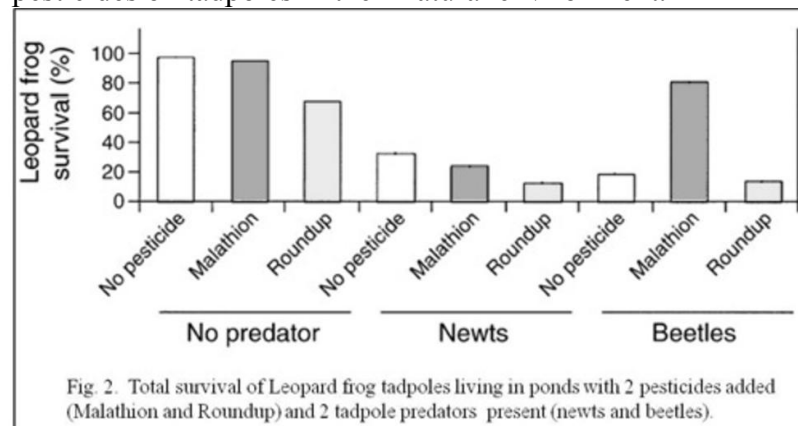


Fig. 2. Total survival of Leopard frog tadpoles living in ponds with 2 pesticides added (Malathion and Roundup) and 2 tadpole predators present (newts and beetles).

¹Modified from Relyea, R.A., N.M. Schoeppner, J.T. Hoverman. 2005. Pesticides and amphibians: the importance of community context. *Ecological Applications* 15: 1125-1134.

Question 4: When beetles were introduced as predators to the Leopard frog tadpoles, and the pesticide Malathion was added, the results were unusual. Which of the following is a plausible hypothesis to explain these results?

a. The Malathion killed the tadpoles, causing the beetles to be hungrier and eat more tadpoles.

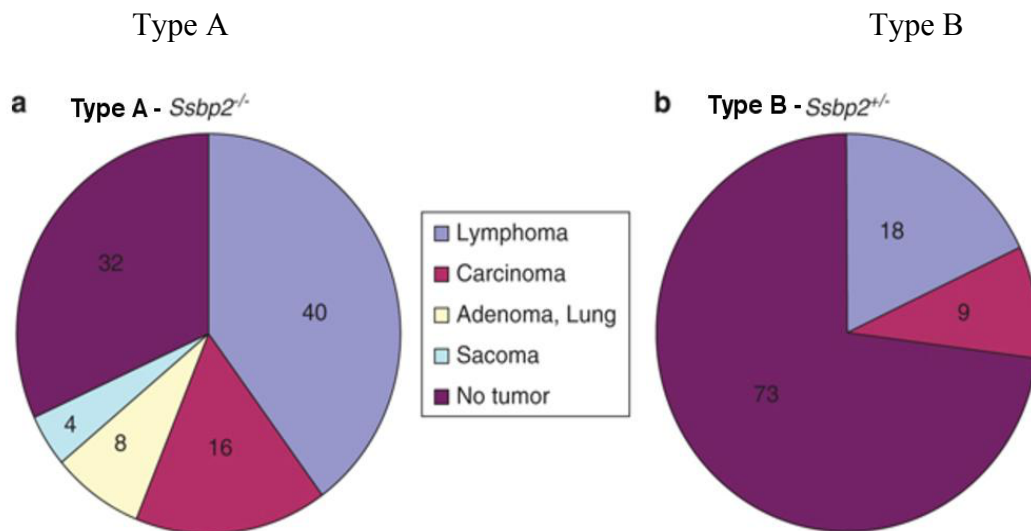
b. The Malathion killed the tadpoles, so the beetles had more food and their population

increased.

c. The Malathion killed the beetles, causing fewer tadpoles to be eaten.

d. The Malathion killed the beetles, causing the tadpole population to prey on each other.

Background for Question 5: Tumors found in type A and type B mice. Pie chart² depicts relative incidence of tumors. Numbers inside each slice denote the percentage of specific tumor type.



²Modified from Want, Y., S. Klumpp, H.M. Amin, H. Liang, J. Li, Z. Estrov, P. Zweidler-McKay, S.J. Brandt, A. Agulnick, L. Nagarajan. 2010. SSBP2 is an in vivo tumor suppressor and regulator of LDBI stability. *Oncogene* 29: 3044-3053.

Question 5: Which of the following is the best interpretation of the graph above?

a. Type “A” mice with Lymphoma were more common than type “A” mice with no tumors.

b. Type “B” mice were more likely to have tumors than type “A” mice.

- c. Lymphoma was equally common among type “A” and type “B” mice.
- d. Carcinoma was less common than Lymphoma only in type “B” mice.

Question 6: Creators of the Shake Weight, a moving dumbbell, claim that their product can produce "incredible strength!" Which of the additional information below would provide the **strongest evidence** supporting the effectiveness of the Shake Weight for increasing muscle strength?

- a. Survey data indicates that on average, users of the Shake Weight report working out with the product 6 days per week, whereas users of standard dumbbells report working out 3 days per week.
- b. Compared to a resting state, users of the Shake Weight had a 300% increase in blood flow to their muscles when using the product.
- c. Survey data indicates that users of the Shake Weight reported significantly greater muscle tone compared to users of standard dumbbells.
- d. Compared to users of standard dumbbells, users of the Shake Weight were able to lift weights that were significantly heavier at the end of an 8-week trial.

Background for Questions 7-9: *“A recent study, following more than 2,500 New Yorkers for 9+ years, found that people who drank diet soda every day had a 61% higher risk of vascular events, including stroke and heart attack, compared to those who avoided diet drinks. For this study, Hannah Gardener's research team randomly surveyed 2,564 New Yorkers about their eating behaviors, exercise habits, as well as cigarette and alcohol consumption. Participants were also given physical check-ups, including blood pressure measurements and blood tests for cholesterol and other factors that might affect the risk for heart attack and stroke. The increased likelihood of vascular events remained*

even after Gardener and her colleagues accounted for risk factors, such as smoking, high blood pressure and high cholesterol levels. The researchers found no increased risk among people who drank regular soda.”

Question 7: The findings of this study suggest that consuming diet soda might lead to increased risk for heart attacks and strokes. From the statements below, identify additional evidence that supports this claim:

- a. Findings from an epidemiological study suggest that NYC residents are 6.8 times more likely to die of vascular-related diseases compared to people living in other U.S. cities.
- b. Results from an experimental study demonstrated that individuals randomly assigned to consume one diet soda each day were twice as likely to have a stroke compared to those assigned to drink one regular soda each day.
- c. Animal studies suggest a link between vascular disease and consumption of caramel-containing products (ingredient that gives sodas their dark color).
- d. Survey results indicate that people who drink one or more diet soda each day smoke more frequently than people who drink no diet soda, leading to increases in vascular events.

Question 8: The lead researcher was quoted as saying, "I think diet soda drinkers need to stay tuned, but I don't think that anyone should change their behaviors quite yet." Why didn't she warn people to stop drinking diet soda right away?

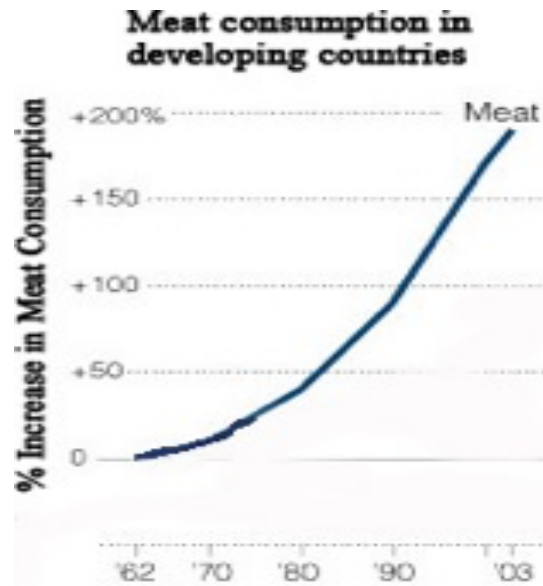
- a. The results should be replicated with a sample more representative of the U.S. population.
- b. There may be significant confounds present (alternative explanations for the relationship between diet sodas and vascular disease).

- c. Subjects were not randomly assigned to treatment and control groups.
- d. All of the above

Question 9: Which of the following attributes is **not** a strength of the study's research design?

- a. Collecting data from a large sample size.
- b. Randomly sampling NYC residents.
- c. Randomly assigning participants to control and experimental groups.
- d. All of the above

Question 10: Which of the following is the most accurate conclusion you can make from the data in this graph³?



³Modified from Rosenthal, Elizabeth. 2008. As More Eat Meat, a Bid to Cut Emissions. New York Times, December 3, 2008. Accessed June 9, 2011. <http://www.nytimes.com/2008/12/04/science/earth/04meat.html>

- a. The largest increase in meat consumption has occurred in the past 20 years.
- b. Meat consumption has increased at a constant rate over the past 40 years.
- c. Meat consumption doubles in developing countries every 20 years.
- d. Meat consumption increases by 50% every 10 years.

Assessment Key

Scientific Literacy Skill	Major Category of Skill	Questions	Correct Answers
Identify a valid scientific argument	Understand methods of inquiry that lead to scientific knowledge	1	B
		6	D
		7	B
Understand elements of research design and how they impact scientific findings / conclusions	Understand methods of inquiry that lead to scientific knowledge	3	C
		8	D
		9	C
Read and interpret graphical representations of data	Organize, analyze, and interpret quantitative data and scientific information	2	C
		4	C
		5	A
		10	C

Appendix C2 - Post-intervention Adaptation of the Test of Scientific Literacy Skills

Description

During this past semester, we focused on three skills of scientific literacy in the discussion component of this course:

1. Identify a valid scientific argument
2. Understand elements of research design and how they impact scientific findings / conclusions
3. Read and interpret graphical representations of data

This test is meant to help you and the educators of this course assess your success in acquiring those skills, as well as other related skills. Please answer all of the questions to the best of your ability, as the outcome of this exam will be used to inform future decisions about the discussions and curriculum used in them.

Instructions

1. For each of the following questions, choose from one of the four multiple choice

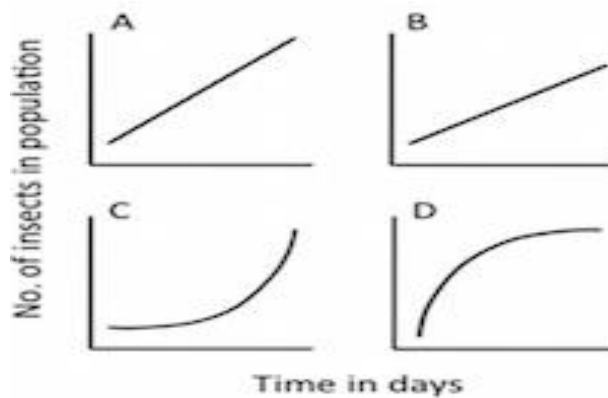
answers provided that you believe to be the correct answer.

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3. Lastly, this exam is timed for 30 minutes. Answer as many questions possible to the best of your ability in that time.

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- a. Graph A
- b. Graph B
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- d. Graph D

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- a. Survey data indicates that on average, users of the Shake Weight report working out with the product 6 days per week, whereas users of standard dumbbells report working out 3 days per week.
- b. Compared to a resting state, users of the Shake Weight had a 300% increase in blood flow to their muscles when using the product.
- c. Survey data in indicates that users of the Shake Weight reported significantly greater muscle tone compared to users of standard dumbbells.
- d. Compared to users of standard dumbbells, users of the Shake Weight were able to lift weights that were significantly heavier at the end of an 8-week trial.

Question 3: Which of the following is **not** an example of an appropriate use of science?

- a. A group of scientists who were asked to review grant proposals based their funding recommendations on the researcher's experience, project plans, and preliminary data from the research proposals submitted.
- b. Scientists are selected to help conduct a government-sponsored research study on global climate change based on their political beliefs.
- c. The Fish & Wildlife Service reviews its list of protected and endangered species in response to new research findings.
- d. The Senate stops funding a widely used sex-education program after studies show limited effectiveness of the program.

Background for Question 4: Your interest is piqued by a story about human pheromones on the news. A Google search leads you to the following website.

Question 4: For this website (Eros Foundation), which of the following characteristics is most important in your confidence that the resource is accurate or not?

- The resource may not be accurate, because appropriate references are not provided.
- The resource may not be accurate, because the purpose of the site is to advertise a product.
- The resource is likely accurate, because appropriate references are provided.
- The resource is likely accurate, because the website's author is reputable.

Background for Questions 5-7: *“A recent study, following more than 2,500 New Yorkers for 9+ years, found that people who drank diet soda every day had a 61% higher risk of vascular events, including stroke and heart attack, compared to those who avoided diet drinks. For this study, Hannah Gardner’s research team randomly surveyed 2,564 New Yorkers about their eating behaviors, exercise habits, as well as cigarette and alcohol consumption. Participants were also given physical check-ups, including blood*

pressure measurements and blood tests for cholesterol and other factors that might affect the risk for heart attack and stroke. The increased likelihood of vascular events remained even after Gardener and her colleagues accounted for risk factors, such as smoking, high blood pressure and high cholesterol levels. The researchers found no increased risk among people who drank regular soda.”

Question 5: The findings of this study suggest that consuming diet soda might lead to increased risk for heart attacks and strokes. From the statements below, identify additional evidence that supports this claim:

- a. Findings from an epidemiological study suggest that NYC residents are 6.8 times more likely to die of vascular-related diseases compared to people living in other U.S. cities.
- b. Results from an experimental study demonstrated that individuals randomly assigned to consume one diet soda each day were twice as likely to have a stroke compared to those assigned to drink one regular soda each day.
- c. Animal studies suggest a link between vascular disease and consumption of caramel-containing products (ingredient that gives sodas their dark color).
- d. Survey results indicate that people who drink one or more diet soda each day smoke more frequently than people who drink no diet soda, leading to increases in vascular events.

Question 6: The lead researcher was quoted as saying, "I think diet soda drinkers need to stay tuned, but I don't think that anyone should change their behaviors quite yet." Why didn't she warn people to stop drinking diet soda right away?

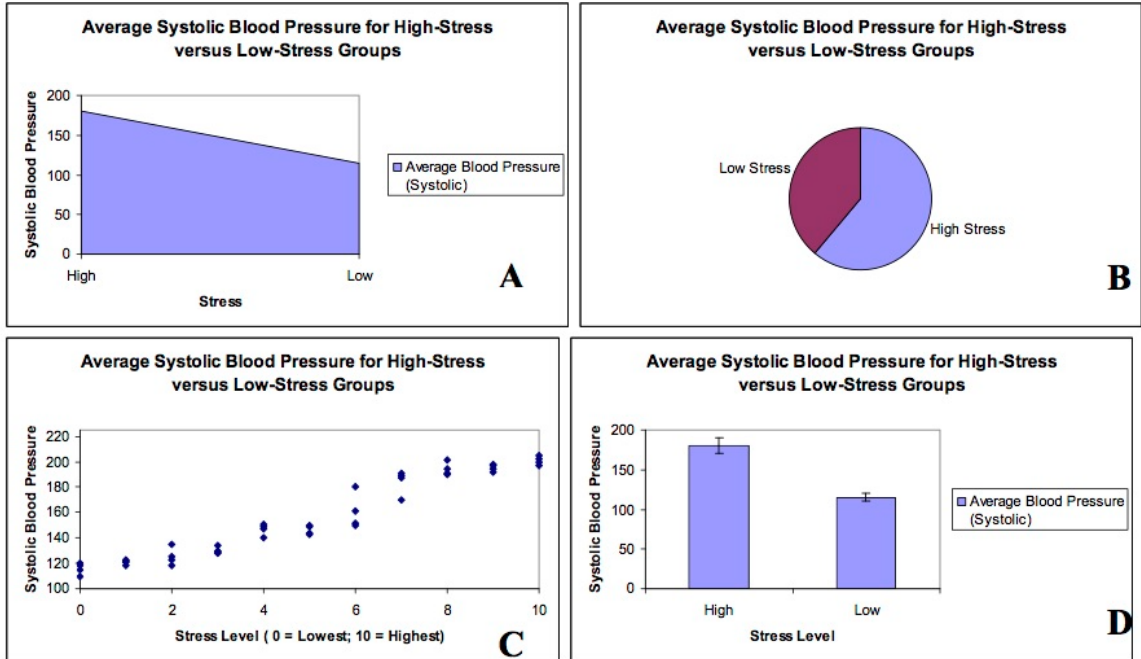
- a. The results should be replicated with a sample more representative of the U.S. population.

- b. There may be significant confounds present (alternative explanations for the relationship between diet sodas and vascular disease).
- c. Subjects were not randomly assigned to treatment and control groups.
- d. All of the above

Question 7: Which of the following attributes is **not** a strength of the study's research design?

- a. Collecting data from a large sample size.
- b. Randomly sampling NYC residents.
- c. Randomly assigning participants to control and experimental groups.
- d. All of the above

Question 8: Researchers found that chronically stressed individuals have significantly higher blood pressure compared to individuals with little stress. Which graph would be more appropriate for displaying the mean (average) blood pressure scores for high-stress and low-stress groups of people?



a. Graph A

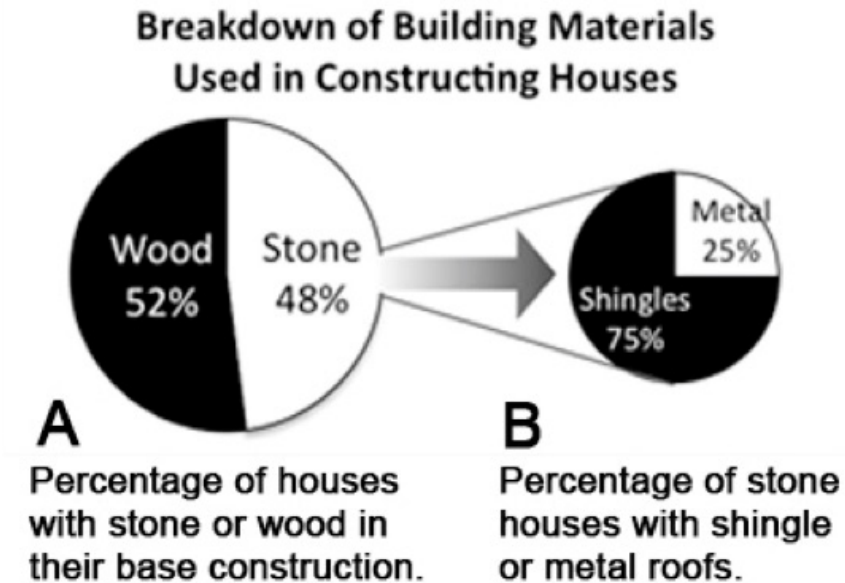
b. Graph B

c. Graph C

d. Graph D

Background for Question 9: Energy efficiency of houses depends on the construction materials used and how they are suited to different climates. Data was collected about the types of building materials used in house construction (results shown below). Stone houses are more energy efficient, but to determine if that efficiency depends on roof

style, data was also collected on the percentage of stone houses that had either shingles or a metal roof.



Question 9: What proportion of houses was constructed of a stone base with a shingle roof?

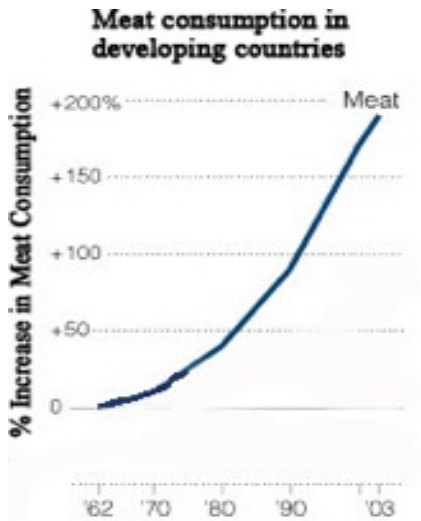
- a. 25%
- b. 36%
- c. 48%
- d. Cannot be determined without knowing the original number of survey participants.

Question 10: The most important factor influencing you to categorize a research article as trustworthy science is:

- a. The presence of data or graphs.
- b. The article was evaluated by unbiased third-party experts.
- c. The reputation of the researchers.

d. The publisher of the article.

Question 11: Which of the following is the most accurate conclusion you can make from the data in this graph³?



Modified from Rosenthal, Elizabeth. 2008. As More Eat Meat, A Bid to Cut Emissions. New York Times, December 3, 2008. <http://www.nytimes.com/2008/12/04/science/earth/04meat.html>

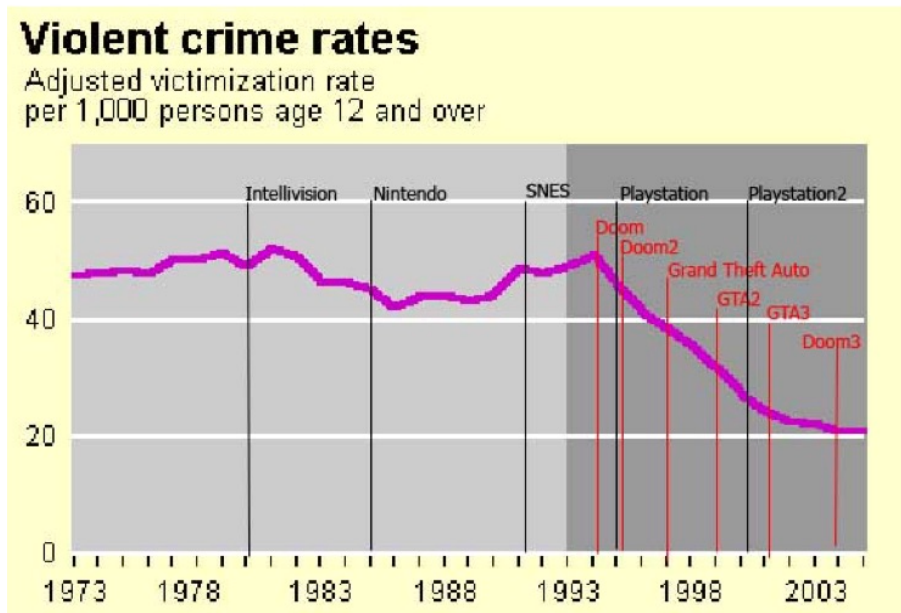
- a. The largest increase in meat consumption has occurred in the past 20 years.
- b. Meat consumption has increased at a constant rate over the past 40 years.
- c. Meat consumption doubles in developing countries every 20 years.
- d. Meat consumption increases by 50% every 10 years.

Question 12: A hurricane wiped out 40% of the wild rats in a coastal city. Then, a disease spread through stagnant water killing 20% of the rats that survived the hurricane. What percentage of the original population of rats is left after these 2 events?

- a. 40%
- b. 48%
- c. 60%

d. Cannot be calculated without knowing the original number of rats.

Background for Question 13: A video game enthusiast argued that playing violent video games (e.g. Doom, Grand Theft Auto, etc.) does not cause increases in violent crimes as critics often claim. To support his argument, he presents the graph below. He points out that the rate of violent crimes has decreased dramatically, beginning around the time the first "moderately violent" video game, Doom, was introduced.



Question

13: Considering the information presented in this graph, what is the most critical flaw in the blogger's argument?

- a. Violent crime rates appear to increase slightly after the introduction of the Intellivision and SNES game systems.
- b. The graph does not show violent crime rates for children under the age of 12, so results are biased.
- c. The decreasing trend in violent crime rates may be caused by something other than

violent video games.

d. The graph only shows data up to 2003. More current data are needed.

Question 14: Why do researchers use statistics to draw conclusions about their data?

a. Researchers usually collect data about everyone / everything in the population.

b. The public is easily persuaded by numbers and statistics.

c. The true answers to researchers' questions can only be revealed through statistical analysis.

d. Researchers are making inferences about a population using estimates from a smaller sample.

Background for Question 15: Researchers interested in the relation between River Shrimp (*Macrobrachium*) abundance and pool site elevation presented the data in the graph below. Interestingly, the researchers also noted that water pools tended to be shallower at higher elevations.

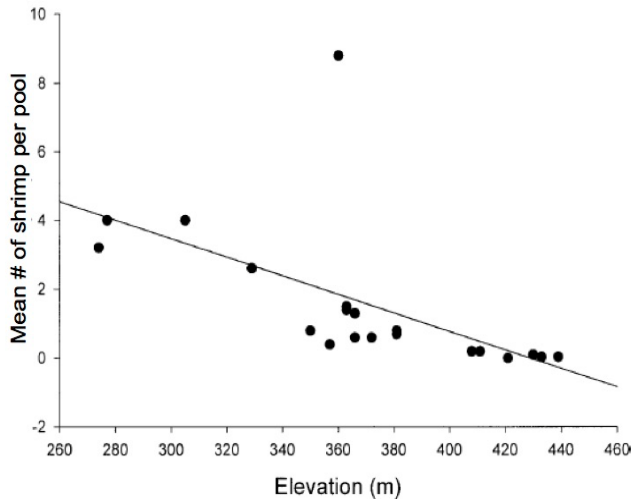


FIG. 3. Relationship between total abundance of *Macrobrachium* (1988–2002) and elevation in Quebrada Prieta.

Question 15: Which of the following is a plausible hypothesis to explain the results presented in the graph?

- a. There are more water pools at elevations above 340 meters because it rains more frequently in higher elevations.
- b. River shrimp are more abundant in lower elevations because pools at these sites tend to be deeper.
- c. This graph cannot be interpreted due to an outlying data point.
- d. As elevation increases, shrimp abundance increases because they have fewer predators at higher elevations.

Assessment Key

Scientific Literacy Skill	Major Category of Skill	Questions	Correct Answers
Identify a valid scientific argument	Understand methods of inquiry that lead to scientific knowledge	2 5	D B
Evaluate the validity of sources	Understand methods of inquiry that lead to scientific knowledge	4 10	B B
Evaluate the use and misuse of scientific information	Understand methods of inquiry that lead to scientific knowledge	3	B
Understand elements of research design and how they impact scientific findings / conclusions	Understand methods of inquiry that lead to scientific knowledge	6 7	D C
Create graphical representations of data	Organize, analyze, and interpret quantitative data and scientific information	8	D
Read and interpret graphical representations of data	Organize, analyze, and interpret quantitative data and scientific information	1 11	C A
Solve problems using quantitative skills, including probability and statistics	Organize, analyze, and interpret quantitative data and scientific information	9 12	B B
Understand and interpret basic statistics	Organize, analyze, and interpret quantitative data and scientific information	14	D
Justify inferences, predictions, and conclusions based on quantitative data	Organize, analyze, and interpret quantitative data and scientific information	13 15	C B

Appendix D - Focus Group Script
Introduction to Neuroscience (NE 101)
December 11th, 2015

A. Introduction

Firstly, thank you very much for volunteering to participate in this focus group. Your willingness to take part is very much appreciated, and will be extremely helpful to not only the educators involved in the course but also to future students.

The purpose of these focus groups is get honest, straight-forward feedback on the curriculum which was used in the discussion component of this course. Please feel free to share your candid opinion of these materials, as doing so will help us to improve upon the quality of this course in the future.

During the focus group we will be discussing questions and ideas in three main domains, each domain pertaining to one of the skills of scientific literacy covered in the discussions this past semester:

1. Identify a valid scientific argument
2. Understand elements of research design and how they impact scientific findings / conclusions
3. Read and interpret graphical representations of data

In addition to these specific categories, we will also consider more general questions that pertain to any or all of the discussions and the skills of scientific literacy mentioned above.

B. Identify a valid scientific argument

*Recall the following readings from Discussions 1 - 3:

- How to Critically Appraise an Article (in *Nature Reviews*)
- Feeling the Future (in *Personality and Social Psychology* by Dr. Daryl Bem)
- Journal's Article on ESP Expected to Prompt Outrage (in *The New York Times*)
- Secrets of the Brain (in *National Geographic Magazine*)
- Scientists Demonstrate Animal Mind-Melds in (in *The New York Times*)

1. Did any of these readings stand out to you as particularly interesting, boring, difficult, easy, etc.?

2. Which discussions and / or readings were more helpful for identifying a valid scientific argument?

C. Understand elements of research design and how they impact scientific findings / conclusions

*Recall the readings from Discussions 5 - 8:

- Randomized Trial of Modafinil as a Treatment of Excessive Daytime Somnolence of Narcolepsy (the clinical trial in the scientific journal named *Neurology*)
- Modafinil-induced Psychosis (a case study in the *Internal Medicine Journal*)
- Advice for a Young Investigator (by Ramon y Cajal)
- The President's Speech (by Dr. Oliver Sacks)
- On the Level (by Dr. Oliver Sacks)

1. Did any of these readings stand out to you as particularly interesting, boring, difficult, easy, etc.?

2. Which discussions and / or readings were more helpful for understanding elements of research design and how they impact scientific findings / conclusions?

D. Read and interpret graphical representations of data

*Recall the readings from Discussions 10 - 12:

- Low-dose Nicotine Facilitates Spatial Memory in ApoE-knockout Mice in the Radial Arm Maze (in the journal entitled Neurological Sciences)
- Exercise Is More Effective than Diet Control in Preventing High Fat Diet-induced beta-Amyloid Deposition and Memory Deficit in Amyloid Precursor Protein Transgenic Mice (in the Journal of Biological Chemistry)
- Selecting the Signals for a Brain-Machine Interface (Current Opinion in Neurobiology)

1. Did any of these readings stand out to you as particularly interesting, boring, difficult, easy, etc.?
2. Which discussions and / or readings were more helpful for reading and interpreting graphical representations of data?

E. General Questions

1. How has your motivation for reading scientific literature changed since the beginning of the semester: increased, decreased, or stayed the same? Why?
2. How has your enjoyment for reading scientific literature changed since the beginning of the semester:
increased, decreased, or stayed the same? Why?
3. What were some strengths of the discussions and / or readings? What do you think needs improvement?

Appendix E - Post-course Discussion Survey

Skill #1 - Identify a valid scientific argument

1. Rank the following articles in order of how helpful they were in helping you to acquire the skills of **identifying a valid scientific argument**; 1 is the least helpful, 5 is the most helpful.

Article	Source and / or Author	Rank
How to Critically Appraise an Article	Nature Reviews	
Feeling the Future	Personality and Social Psychology; article by Dr. Daryl Bem	
Journal's Article on ESP Expected to Prompt Outrage	New York Times	
Secrets of the Brain	National Geographic Magazine	
Scientists Demonstrate Animal Mind-Melds	New York Times	

2. Rank the following articles in order of **how enjoyable** they were to read; 1 is the least enjoyable, 5 is the most enjoyable.

Article	Source and / or Author	Rank
How to Critically Appraise an Article	Nature Reviews	
Feeling the Future	Personality and Social Psychology; article by Dr. Daryl Bem	
Journal's Article on ESP Expected to Prompt Outrage	New York Times	
Secrets of the Brain	National Geographic Magazine	
Scientists Demonstrate Animal Mind-Melds	New York Times	

3. Choose **one** of the readings that you believe **should be kept** on the list of readings for next year's discussions by placing an X next to that reading.

Article	Source and / or Author	Should be kept
How to Critically Appraise an Article	Nature Reviews	
Feeling the Future	Personality and Social Psychology; article by Dr. Daryl Bem	
Journal's Article on ESP Expected to Prompt Outrage	New York Times	
Secrets of the Brain	National Geographic Magazine	
Scientists Demonstrate Animal Mind-Melds	New York Times	

4. Choose **one** of the readings that you believe **should be removed** from the list of readings for next year's discussions by placing an X next to that reading.

Article	Source and / or Author	Should be removed
How to Critically Appraise an Article	Nature Reviews	
Feeling the Future	Personality and Social Psychology; article by Dr. Daryl Bem	
Journal's Article on ESP Expected to Prompt Outrage	New York Times	
Secrets of the Brain	National Geographic Magazine	
Scientists Demonstrate Animal Mind-Melds	New York Times	

Skill #2 - Understand elements of research design and how these impact scientific findings / conclusions

5. Rank the following readings in order of how helpful they were in helping you to acquire the skill of **understanding elements of research design and how these impact scientific findings / conclusions**; 1 is the least helpful, 5 is the most helpful.

Article	Source and / or Author	Rank
Randomized Trial of Modafinil as a Treatment of Excessive Daytime Somnolence of Narcolepsy	Neurology (clinical trial)	
Modafinil-induced Psychosis	Internal Medicine Journal (case study)	
Selections from <u>Advice for a Young Investigator</u>	Ramon y Cajal	
The President's Speech	<u>The Man Who Mistook His Wife for a Hat</u> by Dr. Oliver Sacks	
On the Level	<u>The Man Who Mistook His Wife for a Hat</u> by Dr. Oliver Sacks	

6. Rank the following articles in order of **how enjoyable** they were to read; 1 is the most enjoyable, 5 is the least enjoyable.

Article	Source and / or Author	Rank
Randomized Trial of Modafinil as a Treatment of Excessive Daytime Somnolence of Narcolepsy	Neurology (clinical trial)	
Modafinil-induced Psychosis	Internal Medicine Journal (case study)	
Selections from <u>Advice for a Young Investigator</u>	Ramon y Cajal	
The President's Speech	<u>The Man Who Mistook His Wife for a Hat</u> by Dr. Oliver Sacks	
On the Level	<u>The Man Who Mistook His Wife for a Hat</u> by Dr. Oliver Sacks	

7. Choose **one** of the readings that you believe **should be kept** from the list of readings for next year's discussions by placing an X next to that reading.

Article	Source and / or Author	Should be kept
Randomized Trial of Modafinil as a Treatment of Excessive Daytime Somnolence of Narcolepsy	Neurology (clinical trial)	
Modafinil-induced Psychosis	Internal Medicine Journal (case study)	
Selections from <u>Advice for a Young Investigator</u>	Ramon y Cajal	
The President's Speech	<u>The Man Who Mistook His Wife for a Hat</u> by Dr. Oliver Sacks	
On the Level	<u>The Man Who Mistook His Wife for a Hat</u> by Dr. Oliver Sacks	

8. Choose **one** of the readings that you believe **should be removed** from the list of readings for next year's discussions by placing an X next to that reading.

Article	Source and / or Author	Should be removed
Randomized Trial of Modafinil as a Treatment of Excessive Daytime Somnolence of Narcolepsy	Neurology (clinical trial)	
Modafinil-induced Psychosis	Internal Medicine Journal (case study)	
Selections from <u>Advice for a Young Investigator</u>	Ramon y Cajal	
The President's Speech	<u>The Man Who Mistook His Wife for a Hat</u> by Dr. Oliver Sacks	
On the Level	<u>The Man Who Mistook His Wife for a Hat</u> by Dr. Oliver Sacks	

Skill #3 - Read and interpret graphical representations of data

9. Rank the following readings in order of how helpful they were in helping you to acquire the skill of **reading and interpreting graphical representations of data**; 1 is the least helpful, 3 is the most helpful.

Article	Source and / or Author	Rank
Low-dose Nicotine Facilitates Spatial Memory in ApoE-knockout Mice in the Radial Arm Maze	Neurological Sciences	
Exercise is More Effective than Diet Control in Preventing High Fat Diet-induced beta-Amyloid Deposition and Memory Deficit in Amyloid Precursor Protein Transgenic Mice	Journal of Biological Chemistry	
Selecting the Signals for a Brain-Machine Interface	Current Opinion in Neurobiology	

10. Rank the following articles in order of **how enjoyable** they were to read; 1 is the least enjoyable, 3 is the most enjoyable.

Article	Source and / or Author	Rank
Low-dose Nicotine Facilitates Spatial Memory in ApoE-knockout Mice in the Radial Arm Maze	Neurological Sciences	
Exercise is More Effective than Diet Control in Preventing High Fat Diet-induced beta-Amyloid Deposition and Memory Deficit in Amyloid Precursor Protein Transgenic Mice	Journal of Biological Chemistry	
Selecting the Signals for a Brain-Machine Interface	Current Opinion in Neurobiology	

11. Choose **one** of the readings that you believe **should be kept** on the list of readings for next year's discussions by placing an X next to that reading.

Article	Source and / or Author	Should be kept
Low-dose Nicotine Facilitates Spatial Memory in ApoE-knockout Mice in the Radial Arm Maze	Neurological Sciences	
Exercise is More Effective than Diet Control in Preventing High Fat Diet-induced beta-Amyloid Deposition and Memory Deficit in Amyloid Precursor Protein Transgenic Mice	Journal of Biological Chemistry	
Selecting the Signals for a Brain-Machine Interface	Current Opinion in Neurobiology	

12. Choose **one** of the readings that you believe **should be removed** from the list of readings for next year's discussions by placing an X next to that reading.

Article	Source and / or Author	Should be removed
Low-dose Nicotine Facilitates Spatial Memory in ApoE-knockout Mice in the Radial Arm Maze	Neurological Sciences	
Exercise is More Effective than Diet Control in Preventing High Fat Diet-induced beta-Amyloid Deposition and Memory Deficit in Amyloid Precursor Protein Transgenic Mice	Journal of Biological Chemistry	
Selecting the Signals for a Brain-Machine Interface	Current Opinion in Neurobiology	

General Questions & Comments

Directions: For questions #13 - 17, please indicate your response to the following statements by placing an X in the box under your level of agreement.

13. The discussion component of this course has helped me be more confident in my ability to read and analyze primary scientific literature.

1	2	3	4	5
strongly disagree	disagree	neutral	agree	strongly agree

14. The discussion component of this course has helped me gain a better understanding of the scientific process and how it applies to scientific research.

1	2	3	4	5
strongly disagree	disagree	neutral	agree	strongly agree

15. Before enrolling in this course, I was interested in reading scientific literature and/or understanding scientific research.

1	2	3	4	5
strongly disagree	disagree	neutral	agree	strongly agree

16. After taking this course, I have become more interested in reading scientific literature and/or understanding scientific research.

1	2	3	4	5
strongly disagree	disagree	neutral	agree	strongly agree

17. Overall, I enjoyed the discussions and readings.

1	2	3	4	5
strongly disagree	disagree	neutral	agree	strongly agree

18. Please share any general comments about the discussions and/or readings used in the discussions.

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VITA

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Education

Webster University — St. Louis, MO

August 2006 – May 2008

Bachelor of Science in Biology

- *Emphasis of major in health science*
- *Focus of senior thesis in neuroscience research*

Boston University School of Medicine — Boston, MA

August 2013 - Present

Master of Science in Medical Sciences

- *Concentration in mental health counseling & behavioral medicine*
- *Focus of masters thesis in neuroscience education*
- *Expected graduation date in May 2016*

Professional Skills

Healthcare

- *Support nursing staff and child life specialists within the Department of Neurology at Boston Children's Hospital by delivering non-medical care to patients and their families.*
- *Aid instructors teaching first aid and CPR for infants, children, and adults to healthcare professionals at educational and healthcare institutions within the metro St. Louis area.*

- *Collaborate with educational and healthcare professionals to help students with a broad array of neurological diagnoses develop the social and academic skills necessary to realize their personal goals.*
- *Educate staff working at Shelter Children’s Home in Ngong, Kenya on utilizing first aid and over-the-counter medications to be used for children under their care.*
- *Provide basic care for children living at Shelter Children’s Home including first aid, patient transport, and collaboration with healthcare professionals at local clinics and hospitals.*

Education

- *Develop and administer evidence-based educational resources for undergraduate neuroscience students in partnership with the Boston University Undergraduate Neuroscience Program and the Center for Integration of Research, Teaching, and Learning (CIRTL) Network.*
- *Advance knowledge base of practical educational resources and teaching methodologies utilized for undergraduate education in the fields of science, technology, engineering, and mathematics.*
- *Create culturally relevant educational materials as a guest educator to instruct international and domestic teachers at teachers’ workshops in South Korea.*
- *Deliver educational services to middle and high school students in collaboration with their caregivers as well as other educational specialists including occupational, physical, and speech therapists.*
- *Write and implement curriculum for elementary, middle, and high school students as well as adult learners at private and public educational institutions in America, Africa, and Asia.*

Work History

Boston Children’s Hospital — Research Assistant

February 2015 - Present

WyzAnt Tutoring Network — Tutor

March 2014 - February 2015

New England School of English — Teacher January 2014 - August 2014
St. Louis Public School District — Substitute Teacher February 2013 – August 2013
English Program in Korea — Teacher/Guest Educator February 2011 – February 2013
CPR Plus — Assistant Instructor July 2009 - February 2011
Touchpoint Autism Services — Educational Therapist Assistant August 2009-May 2010
Metropolitan School - Teacher August 2008 – January 2009

Volunteer Service & Activities

Mensa International — Member January 2016 - Member
Boston Children’s Hospital — Volunteer October 2014 - Present
Teaching-as-Research Fellowship — Fellow & Researcher April 2015 - Present
*Volunteer International Community Development Africa — Volunteer Intern
April 2009 - June 2009*
*Webster University Student Literacy Corps — Literacy Tutor August 2006 – May 2008
August 2006 - May 2008*