

ARTICLE

The Use of Case Studies in Teaching Undergraduate Neuroscience

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Case studies have been the cornerstone of many discoveries in neurology and continue to be an indispensable source of knowledge. Attaching a name, face, and story to the study of neurological disorders makes them more “real” and memorable. This article describes the value of the case study methodology and its advantages as a pedagogical approach. It also illustrates how the seminal case of H.M. can be used to highlight the advantages and disadvantages of the case study methodology. Three exercises are described for incorporating case studies into neuroscience courses. The first exercise requires students to conduct a literature review regarding their assigned case and then design an experiment to address a lingering question regarding that neurological disorder. Survey results of 90 students provide quantitative and qualitative support for this

approach. The vast majority of students indicated this exercise was a valuable learning experience; sparked interest in the topic and in biopsychology; increased their knowledge and stimulated critical thinking. The second exercise discusses how students might conduct their own case studies. The third exercise emphasizes the use of case studies as a platform to examine competing hypotheses regarding neurological conditions and their treatment. A table listing case studies appropriate for undergraduate neuroscience courses is included. Cases are categorized by the type of neurological disorder and notes regarding the nature of and content of each case are provided.

Key words: case studies; teaching methods; neuroscience education; classroom exercises; H.M.

Asking a new crop of neuroscience students the functions associated with the hippocampus or frontal lobes usually produces a classroom of diverted gazes. Asking who is H.M. or Phineas Gage elicits glimmers of recognition and raised hands. Many seminal discoveries and lasting dogma within neuroscience and neurology stem from the results of case studies. For example, case studies such as H.M., Phineas Gage, and “Tan” have significantly enhanced our knowledge and facilitated further research in the areas of memory, behavior control, and language, respectively (Pinel, 2006). The case study methodology is often criticized for its lack of generalizability. However, noted neurologist V.S. Ramachandran (2004) maintains this “...is nonsense. Most of the syndromes in neurology have stood the test of time -...(they) were initially discovered by a careful study of a single case, and I don’t know of even one that was discovered by averaging the results of a large sample” (p. xi). Ramachandran continues noting the most advantageous approach for studying neurological conditions begins with the study of individual cases and subsequently verifying that these observations are reliably seen in other patients. Additional authors also argue for the interrelated and complementary role case studies can have with other research methods (Kazdin, 1998) despite the fact that they have previously been designated as being “exploratory” and merely the source of ideas and hypotheses to be assessed by more empirical approaches (Bolgar, 1965). Today, case studies continue to be an important tool for gaining insight into neurological conditions and serve as a valuable method of pedagogy in clinical neuroscience.

Case studies are a form of non-experimental research methodology and are considered a type of single-subject

research design (Ray, 2000). A case study is often simply defined as an in-depth investigation of an individual subject (Weiten, 2001). Traditionally, case studies were distinguished by their focus on characteristics surrounding a particular individual. However, this distinction has faded over the years (Ray, 2000). Today, features that distinguish the case study design are less clear. In fact, McBurney (2001) notes “...one of the few generalizations possible about case studies is that it is difficult to generalize about them” (p. 224). Various authors have seized on different features of case studies that they believe set apart this method. Yin (1989) believes it is the use of multiple sources of evidence that distinguishes case studies; whereas, McBurney (2001) maintains that it is the individuality of the case or situation that characterize case studies. This emphasis on the nature of an individual incident can be seen in many case studies which describe the shared experience of small groups of individuals. For example, Smith et al. (1978) describe cases of psychogenic illness among industrial workers. Occasionally, case studies will address the application and results of a particular treatment. However, treatment variables are rarely systematically manipulated in order to control for extraneous variables; and therefore, they differ from single case experimental designs (Shaughnessy et al., 2000).

Case studies most often describe individuals with rare, unique, and abnormal conditions. Indeed this approach has been the mainstay in clinical medicine, clinical psychology and neuroscience (Ray, 2000). However, many personality and developmental theories validate their positions using information gained from case studies (Vadum and Rankin, 1998; Shaughnessy et al., 2000).

The form and content of case studies vary greatly depending on the audience and context. For example, neurologist Oliver Sacks has written a series of popular books that include brief case descriptions for a largely lay audience of individuals with peculiar and fascinating neurological conditions, emphasizing the impact of these conditions on the person's life and relationships (Sacks, 1985; Sacks, 1995). In contrast, numerous texts are available for medical students and practicing neurologists which describe both common and rare neurological disorders with meticulous jargon laden details of the case's clinical presentation, examination results, diagnostic results, and history of treatment (Schapira and Rowland, 2001). Similarly, journals such as the *Journal of Clinical Neuroscience* and the *Journal of Clinical Neurology and Neurosurgery* contain a subsection in each volume with highly technical case study reports. Case studies may include information gathered from a single source or from a variety of sources including naturalistic observations, archival records, psychological test batteries, results of neural imaging, and interviews with the case subject and those who regularly interact with them.

While case studies have always had substantial pedagogical impact, there appears to be an emerging incorporation of case studies within neuroscience curriculum and validation of their pedagogical value. For example, when the University of Missouri-Columbia Medical School employed a problem-based neuroscience and endocrinology curriculum emphasizing the use of clinical cases, scores on relevant sections of the United States Medical License Examination significantly increased (Cunningham et al., 2001). In addition, most undergraduate biological psychology and neuroscience textbooks now feature case studies in chapter introductions, in special text boxes, or have them integrated within the text (Kolb and Whishaw, 2006; Carlson, 2007; Bear et al., 2007). Also, a new biological psychology text has made case studies a prominent feature with multiple case vignettes within each chapter and repeated references to these vignettes within the chapter text (Pinel, 2007).

Grupe and Jay (2000) highlighted several advantages of case studies as pedagogical tools. Case studies help students see real applications of class work. How do various neurological diseases impact people's lives? To what extent are pharmacological or surgical treatments effective for neurological disorders? Moreover, compared to instructor-centered lectures, the onus is often placed on the student to analyze and synthesize information gleaned from case studies. The complex nature of case studies often necessitates students to go beyond simplified illustrations portrayed in texts. This may result in material being covered in greater depth. The ambiguity surrounding cases often requires analysis and value judgments that foster class discussion and search for better decision models. Case studies also encourage information to be considered from multiple positions, often beyond the obvious. Because case studies often contain data from multiple sources, they highlight the complex nature of and the interactions between the forces that influence behavior.

Also, the inclusion of case studies as an instructional tool adds variety to course materials as too much of any one pedagogical approach may result in student indifference and boredom. Finally, the fact that case studies allow students to appreciate the effects of neurological deficits on peoples' lives makes them more "real" and often leads to a greater emotional investment in the material, making it more memorable. Who could not imagine the profound effects of memory loss like H.M.'s on their lives and the lives of those around them?

The focus of this paper is to consider the use of case studies as a pedagogical tool in undergraduate neuroscience. The use of the seminal case of H.M. to highlight the advantages and disadvantages of the case study methodology is described. Several suggestions are made for incorporating case studies into neuroscience courses and data is presented regarding the value of one of these approaches. Finally, a partial list of case studies and potential case studies and case study sources will be provided.

H.M. AND THE ADVANTAGES AND DISADVANTAGES OF CASE STUDIES

The case of H.M is probably the most famous case in neurological history (Corkin, 2002). Using the story of H.M. can facilitate students' understanding of the advantages and disadvantages of the case study method. Rather than an instructor or student generated list, it may be beneficial to use this seminal case to illustrate the relative value of case study methodology by providing particular examples of how this method has spurred and at times impaired our understanding of brain science. As highlighted below, students may benefit from an initial discussion of the case emphasizing its legacy and impact followed by coverage of how caution is warranted in over-generalizing from this case due to the limits of the case study methodology. There are several excellent descriptions of this case (Milner et al., 1968; Ogden, 2005; Corkin, 2002).

Advantages of Case Studies

Shaughnessy et al. (2000) cited several advantages and disadvantages of the case study method. Among the advantages of case studies is their ability to serve as a source for new ideas and hypotheses. In 1953 H.M. had surgery to remove parts of his medial temporal lobes in an attempt reduce the epileptic seizures from which he suffered daily. This surgery successfully decreased H.M.'s seizures but left him with pervasive anterograde amnesia and variable retrograde amnesia for the 11 years prior to surgery. At the time of his surgery the role of these structures in memory was unrealized (Ogden, 2005). It may be informative to ask students why this was the case and whether such a surgery was ethical. However, H.M.'s tragedy represents a major impetus in the field of memory research. Corkin (2002) notes the publication of Scoville and Milner's first paper on H.M. in 1957 is among the most highly cited and influential in neuroscience. Furthermore, H.M. continues to be a reference point for theories of human memory and his contributions to the study of the neural basis of memory are immense (Corkin, 2002). Most

biological psychology textbooks feature H.M. prominently in their coverage of memory (Pinel, 2007, Carlson, 2007). Students may be asked to imagine how the field of memory might have progressed without H.M.'s story.

Similarly, while case studies most often highlight the atypical, they possess the ability to teach us about what is typical (Shaughnessy et al., 2000). The impact of H.M.'s case on our understanding of memory mechanisms cannot be over emphasized. As noted, above H.M.'s case has been a major impetus and point of reference for most research investigating the neural basis of memory (Corkin, 2002).

Case studies also represent an opportunity to study rare conditions. Some phenomena are so rare and infrequent that it is not possible to gather a sufficient number of subjects at any one time and so they must be studied through intensive examination of single cases (Shaughnessy et al., 2000). Indeed, with the tragic results of H.M.'s surgery his neurosurgeon actively campaigned against its subsequent use (Scoville, 1968). Though other similarly afflicted individuals have been reported (Penfield and Milner, 1958) large numbers of people have not been recipients of this procedure especially given subsequent advances in the pharmacotherapy of epilepsy (Hoppe, 2006). Moreover, while other more widespread diseases, such as Korsakoff's disease and herpes simplex encephalitis, result in global amnesia, their symptomology and neural pathology can be dissociated from those observed in H.M. (Ogden, 2005). Therefore, insight can certainly be gained through comparison of these conditions, but lumping H.M. in with them is not warranted.

Case studies can also be beneficial for evaluating existing hypotheses, especially in the wake of procedures that would be unethical to perform as experiments (Shaughnessy et al., 2000). H.M.'s case challenged the then-prevalent ideas of Karl Lashley (1950) that memory functions are diffusely and equivalently distributed across the forebrain and renewed efforts to localize memory processes particularly to the hippocampus and medial temporal lobes (Pinel, 2007). In addition, it was initially thought that the hippocampus represented an all purpose memory machine and that all long-term memories were similarly processed. However, subsequent research with H.M. has led to the distinction between declarative (memory which is verbally expressed, events in one's past) and nondeclarative memory (a collective term for perceptual, stimulus-response, and motor memory). The former of which was found to be impaired in H.M. (Corkin, 2002).

Case studies also represent an opportunity for clinical innovation and to try out new therapeutic techniques or unique application of existing techniques (Shaughnessy et al., 2000). Indeed, between 1942 and 1953 H.M.'s absence seizures (about 10 weekly) and weekly generalized seizures did not respond to large doses of antiepileptic medication. With little precedent and appreciation for the role of the medial temporal lobes in memory, these structures were removed. As a result of the operation, his absence seizures were reduced to about five a month and his generalized seizures were reduced to less

than one a year (Ogden, 2005). While the tragic effects of the surgery on H.M.'s memory were not foreseen they illustrate the effectiveness of psychosurgery in some cases of epilepsy, a tradition that continues today (Hoppe, 2006).

It has also been argued that case studies are advantageous in that they help us appreciate the complexity of factors that contribute to behavior. As noted above, the case of H.M. has been instrumental in illustrating that long-term memory is not a singular entity, but instead has multiple subtypes with specific neural substrates (Ogden, 2005; Corkin, 2002). Moreover, the fact that H.M.'s language, IQ, and memory abilities are dissociable has significant implications for the dependence of each of these entities on one another (Corkin, 2002). This issue also lends itself to a discussion of whether one's identity or sense of self is dependent upon memory (Corkin, 2002).

The qualitative data obtained by researchers during their often extended interactions with case subjects may enrich our understanding of their level of neuropsychological function. Students might be asked to imagine what their own interactions with H.M. might be like and what they might be able to learn beyond what can be revealed in standardized assessment of memory. In fact, Ogden (2005) is devoted to emphasizing how qualitative data and quantitative data can add to our understanding of H.M. by providing various anecdotes and interview passages to illustrate significant aspects of the case. For example, Ogden reports that H.M. spends much of his day watching television and reading newspapers. Following several weeks of massive media coverage of the space shuttle "Challenger" explosion, H.M. was able to show crude though incomplete and fragmented knowledge of the space shuttle disaster. It is unlikely that standardized testing of anterograde memory would reveal that the extensive repetition of significant events is able to leave an impression upon H.M.

Disadvantages of Case Studies

Despite the overwhelming impact of H.M.'s story on the study of the neural basis of memory, this case can also be used to illustrate the drawbacks of case studies. One marked disadvantage of case study research is the inability to draw cause-effect conclusions due to lack of control of extraneous variables (Shaughnessy et al., 2000). Histologically verified lesions of specific brain structures in laboratory animals run through pre- and post-surgical assessments on standardized behavioral tests clearly carry more causal weight than examining the effects of brain damage in humans which typically spans multiple brain regions and whose evaluation often occurs post hoc. H.M. experienced bilateral removal of the amygdala, entorhinal cortex, anterior portion of the dentate gyrus, hippocampus, and subicular complex and his memory was not explicitly assessed prior to his surgery (Ogden, 2005). In addition, H.M. was plagued with memory loss for the 11 years prior to his surgery but because of a lack of experimental control it is unclear whether this deficit resulted from the surgery, his seizures, the high doses of antiepileptic medications he received, or a combination of these factors. It remains

unclear whether H.M.'s placid nature results from a genetic tendency, removal of the amygdala, or years of antiepileptic medication (Ogden, 2005). Students might be asked what variables they perceive as limiting the causal inferences that can be drawn from H.M.'s case and how they might control for those variables to clarify the role of medial temporal lobe in memory.

Observer biases in data collection and or data interpretation are also limitations of case studies (Shaughnessy et al., 2000). Some sources of bias arise from theoretical perspectives dominant at the time in which the case is being interpreted. For example, Corkin (2002) argues that recent evidence of hippocampal neurogenesis has further informed the controversy regarding the contributions of H.M.'s damaged versus preserved medial temporal lobe structures in his deficits. Other biases may stem from technological limitations at the time of review. This has been illustrated in the case of H.M. A magnetic resonance imaging (MRI) scan when he was 66 suggests the amount of medial temporal lobe tissue removed was initially overestimated by his neurosurgeon (Ogden, 2005). For this issue it may be particularly informative to discuss the fluid nature of information and its dependence upon theoretical orientation and technology. H.M.'s case is particularly significant in that he has now been studied across five decades and we have continued to learn from him as knowledge and technology have progressed (Corkin, 2002). This case is relatively atypical for this reason and students might be asked to consider whether we would still be talking about H.M. if he had not lived as long as he has particularly given that his retention of nondeclarative memory was not realized until 12 years after his surgery.

The problem of generalizing results from a single individual is an additional liability of case study research (Shaughnessy et al., 2000). This limitation is widely recognized among scientists, case studies may be accepted by nonscientists with little regard for their limitations. As noted earlier the symptomology and neural pathology observed in H.M. varies from other conditions that produce amnesia (Ogden, 2005). The tendency to overgeneralize case results can potentially stunt and over simplify our understanding of the neural underpinnings of behavior and diseases of the brain. This has been illustrated by the fact that soon after H.M.'s amnesia was reported, researchers attempted to create amnesia in laboratory animals via lesions to the hippocampus but these attempts met little success. Students might be asked to speculate why H.M.'s case appeared to lack the generalizability so many had hoped for. Though the initial desire to overgeneralize H.M.'s case likely resulted in frustration for many researchers, the desire to extend H.M.'s case across species has led to a greater understanding and refinement of our understanding of the neural mechanisms of memory (LeDoux, 2002).

PEDAGOGICAL APPROACHES WITH CASE STUDIES

This section will provide several suggestions for using case studies as teaching tools in neuroscience courses and

provide the results of a student survey suggesting students respond positively to their use. The pedagogical approach one chooses when employing case methods to an undergraduate neuroscience or biological psychology course vary depending on class size, available time, students' knowledge of experimental design, students' knowledge of neuroscience, and one's teaching goals.

Case Study Exercise: Literature Review and Experimental Design

This assignment requires students to write a three-part paper and do an in-class presentation. Cases are assigned to or chosen by students early in the semester to allow adequate time for them to accumulate relevant literature. Students are provided general guidelines as to the length of each paper section, but told these vary because the details of each case and amount of relevant background literature also vary (Part I: 3-5 pages, Part II: 5-15 pages, Part III: 3-5 pages). Part I asks the students to describe the most salient aspects of the case. Who was the person? What happened to them? How did their condition influence their life and the lives of those around them? In Part II, students are asked to conduct a literature review for the condition described in the case. Among the questions students are asked to address are: What causes the condition? What is the neurobiological basis of the condition? What are typical symptoms that characterize the condition? How is the condition treated and what is the treatment prognosis? In addition, students are asked to relate what they discover in their literature review to their case study and to discuss what their case suggests about normal brain function. In Part III students are given the opportunity to be creative and think critically about their topic. In this section students are asked to design an experiment to address an unanswered question regarding the condition described in their case. Here students present rationale, hypotheses, participants, materials and apparatus, procedures, and statistical analyses sections.

This assignment was designed to foster a variety of skills among students. Students are asked to summarize the case in order to encourage them to identify the essential features of the case. Part II of this assignment is designed to emphasize information literacy by having students conduct a review of relevant literature and demonstrate their ability to correctly reference these sources. In addition, the students' understanding of the neural basis of behavior should be strengthened through their work on this section. This section should also provide the opportunity for students to integrate previous course material to the understanding of the case and synthesize the results of various studies. Students in my Physiological Psychology course are required to have a minimum of two classes in research design and analysis. My course is one of several lecture/ lab courses in which students are expected to apply their knowledge from these earlier courses. This latter expectation is the goal of the third part of the paper.

Communication skills are also emphasized as students are also asked to conduct a twenty-minute class

presentation summarizing each section of their case study assignment. It is emphasized that the presentation is an opportunity to communicate what he or she has learned to others. Students are also told that if they ask each other questions after each presentation there will be less time for me to ask questions.

In order to assess student reaction to this case study assignment, surveys were distributed to 90 students who attended class on the last day of student case study presentations. This represented 81% of the 111 students enrolled in the course between the Fall 2004 and Fall 2006 semesters. All of the students who attended class that day responded to the survey after being assured that their responses would remain anonymous. The survey asked students to rate their agreement (strongly agree, agree, no opinion, disagree, strongly disagree) with ten statements regarding the case study assignment. The survey also included two open-ended questions asking students what they did and did not like about the case study assignment.

This case study assignment appears to be highly successful at achieving its pedagogical goals from a student perspective. All students indicated the case study assignment was a valuable learning experience. The vast majority of students (<90%) indicated the assignment sparked their interest in the topic, increased their knowledge in the topic, increased their knowledge in biopsychology, stimulated critical thinking, successfully integrated information from the course, and that they enjoyed the assignment. The majority of students (<75%) also reported that the assignment further sparked their interest in biopsychology and that the assignment involved integrating information from other courses (e.g. Research Design and Analysis and Abnormal Psychology). More than 90% of the students indicated that the class presentations increased their knowledge in biopsychology. In addition, more than 75% of students reported that the case study assignment helped them recognize the advantages and disadvantages of case study research.

Question	Strongly agree	agree	No opinion	disagree	Strongly disagree
Valuable learning experience	41.4	49.5	0	0	0
Sparked interest in the topic	37.4	44.4	4	4	1
Incr. topic knowledge	65.7	24.2	1	0	0
Incr. biopsychology knowledge	34.3	52.5	3	1	0
Sparked biopsychology interest	24.2	49.5	13.1	4	0
Stimulated critical thinking	42.4	45.5	2	1	0
Integrated course information	41.4	41.4	6.1	1	0
Integrated other courses	20.2	48.5	12.1	10.1	0
Presentations incr. knowledge	21.2	60.6	5.1	4	0
Recognize adv/disadv. of cases	24.2	52.5	9.1	5.1	0
Enjoyed assignment	32.3	49.5	4	5.1	0

Table 1. The table shows the percentage of respondent answers to 10 closed-ended questions regarding agreement with statements about a case study assignment by 90 students enrolled in a course in Biological Psychology.

The results of an open-ended question asking what

students liked about the case study assignment further illustrates the value of case study assignments as pedagogical tools in neuroscience. Overall, students supplied more reasons for liking the assignment (130) than for not liking the assignment (61). The most common reasons students supplied for liking the case study assignment were: the depth of knowledge they acquired, learning about their case study, learning from other student presentations, and the interesting nature of the case study topics. Difficulty in obtaining and finding research resources, the time-consuming nature and length of the assignment, difficulty designing experiments, and conducting the class presentation were reasons given by students for not liking the case study assignment. Interestingly, approximately equal numbers of students supplied the answers of designing their own experiment and conducting class presentations as reasons for both liking and not liking the assignment.

<i>Open-ended responses: What students liked about the case study assignment</i>	
Depth of knowledge acquired	34
Enjoyed learning about their case study	21
Learning from others presentations	13
Interesting nature of topics	12
Conducting presentations	8
Application of course material	8
Designing experiment	7
Critical thinking	6
<i>Open-ended responses: What students did not like about the case study assignment</i>	
Difficulty finding and obtaining resources/literature	12
Time-consuming nature and length of assignment	11
Difficulty designing experiment	10
Conducting presentations	9

Table 2. This table includes the frequency of answers to open-ended questions asking what students liked and did not like about the case study assignment from 90 students enrolled in a course in Biological Psychology. Answers provided by five or more students are listed.

Case Study Exercise: Conducting a Case Study

There are several other ways in which the case study method can be applied as a pedagogical tool in neuroscience courses. The value of case studies in neuroscience can be realized by having students conduct their own case study. While this approach may involve significant challenges for both the instructor and student, it is also likely to be the most rewarding. Direct interaction with individuals suffering from brain disorders is likely to produce the greatest investment among students, engender empathy for those afflicted and their families, and provide an opportunity for personal growth.

There are several important considerations when supervising this type of project. Instructors should consider whether such a project would require Institutional Review Board (IRB) approval at their institution. While IRB approval may appear to be a roadblock to this type of

project, this process can also provide an important lesson to students conducting research as well as ethics. Patient consent will also be necessary if medical records and test results are to be obtained. This approach should only be considered if the instructor is able to invest the time to teach students appropriate interviewing techniques, professional behavior, and sensitivity towards their case subjects.

Instructors must also carefully supervise the type of information collected for each case. This will increase the likelihood that only appropriate information is collected. For example, it is certainly not appropriate for students to administer any standardized tests for which they have not been trained. Instructor supervision will also maximize the use of the students and participants time together. It may be helpful to ask students to research the condition of their case participant so that they can best focus on their data collection and choose hypotheses. This approach may also afford students the ability to interview family members or caregivers to provide additional perspectives on the case. This may be particularly insightful given that many neurological patients remain fully or partially unaware of their condition.

Finding appropriate case subjects may represent another challenge. Having students work in groups may decrease the need for obtaining large numbers of participants. It is likely that your students may have a family member or friend who suffers from a relevant condition; however, forging a relationship with a local neurologist, psychiatrist, or public advocacy groups such as the National Alliance on Mental Illness (NAMI) may also aid in obtaining participants. The internet may also represent a source for case subjects. Many individuals now chronicle their battle with neurological disorders through BLOGS or websites. Video cases also represent a source of alternative case material.

Case Study Exercise: Taking Apart Then Reassembling the Pieces

Case study methodology can also be applied to neuroscience education by using it as a platform to compare competing explanations of issues surrounding a condition. This approach may be particularly advantageous for larger classes because multiple students can be assigned the same case. Often the etiology or the extent to which certain variables influence the development, characteristics, or course of a given disorder are unknown or controversial. According to this approach after reading a given case, students or groups of students may be asked or assigned to evaluate the plausibility of a given explanation for a certain aspect of the case. For example, the case "An Anthropologist on Mars" (Sacks, 1995) which chronicles Temple Grandin who suffers from Aspergers Syndrome, an autism spectrum disorder, can provide a platform for students to investigate the multiple causes and influences on autism. In this case students may be asked to investigate the relative influences of genetics, underlying medical conditions (phenylketonuria, toxoplasmosis, etc.), mercury containing vaccines, bad parenting, food allergies, and immune deficiencies among

others. The case of Temple Grandin also illustrates a range of autistic symptoms and can provide the basis for different students to investigate variables surrounding the spectrum nature of autism.

Similarly, the neural basis and course of treatment of many disorders remains controversial and lend themselves to this type of approach. The case description of the depression and psychotic behavior experienced by musical artist Brian Wilson (Levine, 2005) can serve as a platform for students to assess the relative role of genetics, different neurotransmitters and hormones, different brain regions, lateralization, borna virus, other medical conditions, and neurogenesis, etc. in depression and psychosis. Alternately, students may research the efficacy of different approaches to treating these conditions: various psychotherapies, pharmacotherapies, electroconvulsive therapy, deep brain stimulation, vagus nerve stimulation, etc. Overall, this approach carries several benefits: this exercise lends itself readily to classroom debates, requires student to synthesize and evaluate various studies in order to reach a conclusion regarding their topic, and will add to students' appreciation of the multiple influences on behavior and their interactions.

CASE STUDIES FOR UNDERGRADUATE NEUROSCIENCE COURSES

As noted earlier, case studies vary greatly in depth and content. The results of neural imaging, psychological test batteries, and other medical tests found in neurology journals and medical texts may be beyond the scope of many undergraduate neuroscience students. The case studies listed in Appendix I were chosen because they are at a level appropriate for most undergraduate students. This table includes the title, type of disorder, source of the case, and comments regarding the contents and nature of the case description. Many of these cases are brief or are several years old; nonetheless, they are valuable as a starting point for understanding neurological conditions and for the case study exercises described in the previous section. These case studies have been categorized by the general type of neurological condition they describe: motor disorders, perceptual disorders, language disorders, memory disorders, and miscellaneous disorders. However, cases can be used to illustrate multiple conditions. When this is the case these other conditions are also listed.

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APPENDIX I

Appendix I includes a listing of case studies appropriate for use in most undergraduate neuroscience courses. The title, type of disorder, source of the case, and comments regarding the contents and nature of the case description are presented for each case.

<i>Perceptual disorders</i>			
Case	Condition	Source	Comments
The man who mistook his wife for a hat	Prosopagnosia, visual agnosia	Sacks (1985)	Classic case, lacking recent background information
The disembodied Lady	Disorder of proprioception	Sacks (1985)	Lacking recent background information
The man who fell out of bed	Hemiplegia, anosognosia	Sacks (1985)	Very short, lacking recent background information
My mother's best friend	Hemiplegia, anosognosia	Klawans (1990)	Also touches on strokes and aphasia
The case of the colorblind painter	Achromatopsia	Sacks (1995)	Tracks influence on case's life and art
To see and not see	Restoration of vision	Sacks (1995)	Addresses complexity and origins of visual perception
Prodigies	Autism, savant abilities	Sacks (1995)	Chronicles an artistic savant
An anthropologist on mars	Autism, Asperger's syndrome	Sacks (1995)	Extremely insightful look at autism from within
A trip to paradise	Complex partial seizures (orgasm seizures)	Klawans (1990)	Dostoyevski as a similar case, seizures and stigma
Making the playoffs	Cluster headaches	Klawans (1990)	Case on pain
The phantom within and Chasing the phantom	Phantom limb	Ramachandran and Blakeslee (1998)	Tale tracing phantom limbs to neural plasticity

<i>Perceptual disorders</i>			
Case	Condition	Source	Comments
The secret life of James Thurber	Charles Bonnet Syndrome	Ramachandran and Blakeslee (1998)	Visual hallucinations in the blind
Through the looking glass	Hemineglect	Ramachandran and Blakeslee (1998)	Disorder of perception and attention
The sound of one hand clapping	Anosognia	Ramachandran and Blakeslee (1998)	Denial syndrome
The unbearable likeness of being	Capgrass syndrome	Ramachandran and Blakeslee (1998)	Provides insight into the link between visual recognition and emotion
God and the limbic system	Complex partial seizures and religious experiences	Ramachandran and Blakeslee (1998)	Raises interesting questions regarding the nature of god
Out of control: the consequences and treatment of epilepsy	Complex partial seizures (fear seizures)	Ogden (2005)	Follows case through surgery, extensive background information
A body in the mind: a case of autotopagnosia	Autotopagnosia, Gerstmann's syndrome, Apraxia	Ogden (2005)	Covers a variety of often related perceptual deficits
Out of mind, out of sight: a case of hemineglect	Hemineglect	Ogden (2005)	Covers topic in great depth
Vision without knowledge: visual object agnosia and prosopagnosia	Visual agnosia, prosopagnosia	Ogden (2005)	Covers topic in great depth, extensive background information on topic provided
Inside the mind of a savant	Autism, savant abilities	Treffert and Christensen (2006)	Case of Kim Peek, the inspiration for the movie "Rain Man"
The man who tasted shapes	Synesthesia	Cytowic (2003)	This book contains many case studies on synesthesia

<i>Motor disorders</i>			
Case	Condition	Source	Comments
Witty ticcy ray	Tourettes syndrome	Sacks (1985)	Lacking recent background information
A surgeon's life	Tourettes syndrome	Sacks (1995)	Great success in the face of adversity
Maganese miners	Manganese-induced parkinsonism	Klawans (2000)	Parkinsonism and neurotoxicity
Anticipation	Huntington's disease	Klawans (2000)	Lacking most recent information
The hermit of Thief River Falls	Refsum's disease	Klawans (2000)	Rare genetic disease of white matter
Still smiling	Wilson's disease, dystonia	Klawans (1990)	Genetic disorder - copper metabolism
The lizard	Parkinson 's disease	Klawans (1990)	Covers treatment with L-dopa and adrenal transplants
The flying scalpels	Myoclonic epilepsy	Klawans (1990)	Short case, importance of correct diagnosis
The bobbsy twins take neurology	Multiple sclerosis	(Klawans (1990)	Covers its motor and perceptual nature
Just right: Mahmoud Abdul-Rauf	Tourettes syndrome	Klawans (1996)	Describes case of professional basketball player with disorder
First-half Jameson	Myasthenia gravis	Klawans (1996)	Describes case of professional football player with disorder
Awakenings	Encephalitis lethargica, Parkinson's disease	Sacks (1973)	This book chronicles many cases of those who suffered from this illness, L-dopa
Wapniarka	Lathyrism, Lower limb paralysis	Klawans (1988)	Spasticity resulting from a diet of Lathyrus sativus "chickling peas", neurotoxins
Spontaneous generation	Huntington's disease	Klawans (1988)	Genetics and Huntington's disease, lacking most recent information
Tomorrow is another day: living with multiple sclerosis	Multiple sclerosis	Ogden (2005)	Describes case of a woman and illustrates the variable nature of this disorder
Mind over matter: coping with Parkinson's disease	Parkinson's disease	Ogden (2005)	Describes case of a medical doctor with Parkinson's disease, pallidotomy, extensive background information

<i>Motor disorders</i>			
Case	Condition	Source	Comments
Huntington's disease: a family challenged	Huntington's disease	Ogden (2005)	Chronicles the struggle of a family with Huntington's disease, extensive background information

<i>Language disorders</i>			
Case	Condition	Source	Comments
Defending the cavewoman	Early abuse and aphasia	Klawans (2000)	Language acquisition with an eye on evolution
A Lucy of my very own	Language and lateralization	Klawans (2000)	Addresses many topics: epilepsy, handedness, evolution, brain surgery
The gift of speech	Landau-Kleffner syndrome	Klawans (2000)	Epilepsy, brain surgery, language lost and recover, neuroplasticity
The music goes round and round	Global aphasia	Klawans (2000)	Also lends insight into music and the brain
The breakdown of language: case studies of aphasia	Broca's and Wernicke's aphasia	Ogden (2005)	Two cases illustrate Broca's and Wernicke's aphasia, extensive background information

<i>Memory disorders</i>			
Case	Condition	Source	Comments
The lost mariner	Korsakoff's syndrome, Amnesia	Sacks (1985)	Lacking recent background information
The last hippie	Amnesia	Sacks (1995)	Addresses several other issues: pituitary tumors, religion, anosognosia. May interest fans of '60's rock music
The landscape of his dreams	Exceptional memory, seizures	Sacks (1995)	Examines fluid nature of memory, time, and emotion
Morbid obesity	Korsakoff's syndrome, Amnesia	Klawans (1990)	Case of Korsakoff's syndrome after gastric bypass surgery
Marooned in the moment: H.M. a case of global amnesia	Amnesia	Ogden (2005)	Case of H.M. with a qualitative twist
Dementia: a family tragedy	Dementia	Ogden (2005)	Follows case of dementia of the Alzheimer's type in great depth

<i>Miscellaneous disorders</i>			
Case	Condition	Source	Comments
Mad cows and mad markets	Prion diseases	Klawans (2000)	Touches on: CJD, BSE, Kuru, Visna, Scrapie
Newton's madness	Mercury poisoning	Klawans (1990)	Links mood disturbances of Sir Isaac Newton to mercury
The man about town	Epilepsy, prolonged postictal automatism	Klawans (1990)	Short case of man driving to other states with amnesia of events
Little Mo	Prion diseases	Klawans (1990)	Touches on: CJD, BSE, Kuru, Visna, Scrapie
The great American opera	Syphilis, general paresis	Klawans (1990)	Case of Ragtime composer Scott Joplin- jive
Primo Carnera: the bigger they are	Acromegaly	Klawans (1996)	Story of a boxer with excessive release of growth hormone
The woman who died laughing	Pathological laughter	Ramachandran and Blakeslee (1998)	Three very short cases, neural basis of laughter and humor, evolutionary biology
You forgot to deliver the twin	Pseudocyesis (phantom pregnancy)	Ramachandran and Blakeslee (1998)	Brief case leading to discussion of mind-body relationship
The impaired executive: a case of frontal-lobe dysfunction	Frontal lobe syndrome	Ogden (2005)	Case illustrates the constellation of frontal lobe syndrome deficits
Beating the odds: severe head injury and the importance of ongoing rehabilitation	Severe head injuries	Ogden (2005)	Two cases illustrate the consequences of head trauma, Extensive background information

<i>Miscellaneous disorders</i>			
Case	Condition	Source	Comments
Explosions in the mind: a case of subarachnoid hemorrhage	Subarachnoid hemorrhage	Ogden (2005)	Case follows patient with a stroke through rehabilitation
Twenty years too late: organic-solvent neurotoxicity	Occupational organic solvent neurotoxicity	Ogden (2005)	Highlights neurological and psychological impact of toxin exposure
Split brain, split mind: case L.B.	Split brain surgery	Ogden (2005)	Extensive detail on the testing of a split brain patient
A whole with half a brain: Kate's story	Hemispherectomy	Ogden (2005)	Rasmussen's syndrome, lateralization, plasticity
Brian Wilson: a cork in the ocean	Executive dysfunction and schizoaffective disorder	Levine (2005)	Chronicles musician Brian Wilson and his battle with schizoaffective disorder
The return of Phineas Gage: clues about the brain from the skull of a famous patient	Frontal lobe syndrome	Damasio (1994)	A modern take on this classic case via neuroimaging
Legacy	Progressive multifocal leukoencephalitis	Klawans (1988)	White matter diseases, viral diseases, diagnostic process
Giants among men	Acromegaly	Klawans (1988)	Parallels Roman emperor and basketball player with excessive growth hormone release
The hounds of hell	Trigeminal neuralgia (tic douloureux)	Klawans (1988)	Describes intense facial pain due to trigeminal nerve neuropathology
Broca's Amusica	Loss of musical abilities following a stroke	Klawans (1988)	Describes a woman who selectively loses her ability to play the oboe

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