

**“Navigating the Disciplinary Fault Lines”<sup>1</sup> in  
Science and in the Classroom:  
Undergraduate Neuroscience Classroom in Mind,  
Brain, and Behavior at Harvard**

by  
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**Abstract:** This paper explores the key elements of success in the interdisciplinary teaching of neuroscience, using the example of two undergraduate seminars offered by the Mind, Brain, and Behavior (MBB) program at Harvard University. These elements include students’ and faculties’ disposition for boundary-crossing, their intellectual breadth and ability to cope with unanswered questions in science, and the particular organization of the curriculum which was designed to keep the students at the crossroads of many competing theories and to stimulate a search for synthesis. An institutional commitment to developing interdisciplinary curricula in neuroscience in the form of the MBB Interfaculty Initiative also serves as an important foundation for interdisciplinary teaching and learning. The two MBB seminars provide models of integrative curriculum in neuroscience, as instructors in the classroom reenact the actual interdisciplinary debate that defines the field of neuroscience itself. Founded on a belief in the inherent unity of the mind and the brain, neuroscience tries to find the connecting tissue between psychological and biological theories of the mind/brain. Keeping the search for a unified theory central to the discussion in the classroom, asking students to test the explanatory limits of each contributing discipline, and discussing the shortfalls of current integrative mind/brain thinking, instructors in both seminars are able to spark an interdisciplinary dialogue of the most compelling nature.

### **Introduction**

NEUROSCIENCE LENDS A SPECIAL OPPORTUNITY to study interdisciplinarity. Not only are the disciplines that it tries to bring together (psychology and biology, neurochemistry and behavior, “harder” and “softer” sciences) epistemologically more distant from each other than history and English or chemistry and biology, for example, but connecting them is central to the science itself, which is born out of a belief in the inherent unity of

the mind and the brain. Therefore, the pedagogical experiment of teaching a neuroscience course reenacts the experimentation which created this dynamic field, with all the excitement and uncertainty that it had originally. On top of widening a barely trodden path in their *neu* science, neuroscience instructors are basically on their own in terms of pedagogy, designing strategies for interdisciplinary teaching as they go. The untrodden path in pedagogy, the lack of systematic theory about the nature of the connection between physical and mental phenomena in science, and the vast epistemological divide between the human and natural sciences make the interdisciplinary teaching of neuroscience courses an adventurous and risky journey bound to produce new strategies and creative solutions.

The Mind, Brain, and Behavior Interfaculty Initiative (MBB), which offers both of the undergraduate seminars that I will describe, is one way in which Harvard University participates in the neuroscience revolution and in the experiment of integrative teaching that accompanies it. Created in 1993, MBB's goal is to bring faculties of different schools together "to probe critically the depths and implications of the neuroscientific revolution, and to develop multi-level frames of reference . . . that emphasize the interplay of biology and culture in the making of human life and experience" (About MBB 2000). What makes an interdisciplinary classroom in neuroscience work as an integrative experience? How does this classroom address and reenact interdisciplinary dialogue in science itself? These are guiding questions for this study.

The article lays out key elements of an interdisciplinary classroom in neuroscience in succession. First, it describes the qualities of the students and instructors that contribute to their particular capacity for boundary crossing. Then, it analyzes the curricular organization and the pedagogy that is used to stimulate integrative thinking in students. The conclusion summarizes challenges and impacts of interdisciplinary learning in neuroscience. Although more data are needed to substantiate claims about the benefit of integrative seminars on students, preliminary observations in that regard may prove useful to stimulate further inquiry.

### **Courses and Data Collection**

Participants in this research were students and instructors in two interdisciplinary courses taught at Harvard University as part of the MBB Junior Seminar curriculum in spring 2000. The names of students are confidential, while all instructors are identified with their permission. The courses were selected on the basis of their stated interdisciplinary goal—to bring into dialogue the

perspectives of the hard sciences (neuroscience, biological science) and the social/behavioral sciences or arts/humanities.

The course Psychology 987b: Music, Mind, and Brain (further referred to as *Music*) was taught by Professor Mark Tramo, an Assistant Professor of Neurology at Harvard Medical School, whose research interests include auditory physiology, neurology of music, speech and voice perception, and a broad spectrum of hearing disorders. He is also a prolific songwriter, composer, and performer. The course goal, as presented in the syllabus, is to explore the “underlying mental operations and brain mechanisms” involved in music perception. Thus, *Music* brings together scholarship from the areas of psychoacoustics, neurophysiology, neuroanatomy, neurology, cognitive psychology, and music theory. Seven students of different academic affiliations (out of about twenty enrolled in the course) volunteered for an interview. There was a balanced mix of male and female students of different racial and national origins (Caucasian, African American, Latino, Asian), with a striking diversity of intellectual passions. At least three students in the group had backgrounds in music (playing in bands, composing, solid instrumental training). The rest had an interest in, and appreciation for, music while majoring in biology, neurobiology, or cognitive science.

Psychology 987f: The Biology of Conscious States—Waking, Sleeping, and Dreaming (further referred to as *Sleep*) was co-taught by instructors Robert Stickgold and Matthew Walker. Both instructors conduct their investigations into the biology of sleep at the Massachusetts Mental Health Center (MMHC) research lab affiliated with the Harvard Medical School. Both have MD/PhD training in neuroscience. Matthew Walker is fairly new to the field, while Robert Stickgold has been a significant contributor to sleep research for many years. Their teaching styles are very similar in that both display humility regarding their knowledge and are ready to expose their ignorance or weakness in argument.<sup>2</sup> *Sleep* is an undergraduate seminar course, the goal of which, as stated in the syllabus, is “to discuss various approaches to understanding the functions of sleep and wake (consciousness)” including those of “neurology, physiology, psychology, and cognitive neurosciences.” The course tackles the issue of consciousness and sleep from the perspectives of anatomy, psychophysiology, cognitive neuroscience, and psychological, psychoanalytical theories. The course runs in two sections with about twenty people enrolled in each. A total of fourteen students from both sections volunteered for the interviews. While there was a balanced mix of male and female students, and a good diversity of racial and national backgrounds in the sample, students’ disciplinary range in the two sections was somewhat

different. One section had a student body with a fairly uniform educational background, primarily in cognitive psychology. The other section had a wider representation of fields ranging from philosophy to chemistry and biology. This difference set a unique tone in each classroom.

The main sources of data in this research are participant interviews and my course observations. Most participants were interviewed twice (at the beginning and the end of the course) in a 1–2 hour session per person. The core questions concerned participants' disciplinary backgrounds and the integrative efforts that took place inside and outside the classroom. Several samples of student work (papers written for *Music*, *Sleep*, or other MBB courses) became part of the analysis courtesy of their authors.

### **Method and Theoretical Background**

Embarking on this research, I felt like an anthropologist immersing myself in a different culture with the goal not so much to estimate and measure, as to observe and share my sense of discovery. As Field, Lee, and Field (1994), I felt strongly that “a great deal of what is important in . . . interdisciplinary programs, is difficult or impossible to measure quantitatively, and it certainly cannot be measured by a single test” (p. 77). So, rather than holding the two selected courses against some standardized measure, I focused on capturing the complex dynamics of the interdisciplinary process.

I felt encouraged to engage in this analysis because I was both a researcher and a full-fledged participant in the courses. Along with students, I did the readings, prepared presentations (*Music*), and was generally part of the discussion. My own training in the Mind, Brain, and Education Program at the Harvard Graduate School of Education afforded some insight into the subject matter of neuroscience. My training and interest in the relationship between physical and mental phenomena and in the complexity of interdisciplinary learning made me “a vulnerable observer” (Behar 1996) in both classrooms. My presence in the classroom for the duration of the course, and familiarity with the course material, facilitated in-depth conversations with the participants during the interviews.

Theoretical frameworks that informed this study come from educational research literature on the nature of interdisciplinary learning and teaching. The definition of interdisciplinarity that I subscribe to here is based on a view voiced by Klein (1990) and Newell (1994); it expects deep interactivity and synergy between different disciplinary perspectives. As White (1981), another theorist of interdisciplinary education, points out in *Interdisciplinary Teaching*, it is not “the proximity of two or more disciplines in a course” that

makes it interdisciplinary, but “the effort to overcome the isolation of the subject” (p. 6). Understanding interdisciplinarity as an effort to create synergy affords the view that clustering different disciplinary facts around a topic falls short of interdisciplinarity, and could be described, at best, as a multi-disciplinary or theme-based approach. For example, neuroscience education, which stays within the realm of biology and does not challenge it with philosophical or behavioral data, is not an integrative or interdisciplinary effort by this definition. I share Howard Gardner’s position, expressed in his book *The Disciplined Mind* (1999), that there is no discontinuity between disciplinary and interdisciplinary efforts, and recognize that solid mastery of “more than one discipline” is the pre-requisite of good interdisciplinary work (p. 219). Boix Mansilla, Miller, and Gardner, in their paper “On Disciplinary Lenses and Interdisciplinary Work” (2000), likewise define interdisciplinary education as “geared towards deep forms of understanding” that can “make use of both [disciplinary and interdisciplinary] perspectives” (p. 17) in order to “illuminate issues that cannot be adequately tested through one discipline” (p. 18).

### **Teachers and Students as Boundary-Crossers**

Teaching an interdisciplinary course places many demands on teachers. According to William Newell, the role of faculty in an interdisciplinary setting changes from that of an “expert” to “guide or coach” (1994, p. 48). This role seems to fit all three instructors well. They are all learners inside and outside the classroom who recognize the existence of serious gaps in our knowledge about mind/brain functions. Most of the students also fit a similar profile of avid learners, marked by intellectual breadth and tolerance for ambiguity. These cognitive qualities of the participants proved to be important in making the integrative curriculum work.

### **Intellectual Breadth**

The educational background of most students in both classes reveals them as intellectual omnivores with a broad palette of interests. *Sleep* and *Music* students included in their ranks music majors interested in biology, pre-med concentrators with a passion for creative writing, and chemistry lovers with a penchant for asking philosophical questions. Course material and course instructors in both classrooms relied on this breadth. Where intellectual diversity among and within students was most prominent, the integrative spirit was more evident than in the classrooms where students’ backgrounds were more uniform (as in one of the sections of the *Sleep* course dominated by

psychology majors).

Much as students in my sample have a diverse social, racial, and family background, the spread of their intellectual interests is wider still. “I won prizes in the same year for being a top student in math, history, physics, and English,” said one student when I asked him whether he gravitated towards humanities or towards the sciences. “In my senior year, I thought of applying to MIT, and then, no, what if I want to major in English! So, physics, English—who can say! I kept ping-ponging between the humanities and sciences.” While it may sound like youthful maximalism or dilettantism, similar comments were made by a lot of students and were marked by a sense of the compelling necessity for such breadth. “As soon as you bring them [psychology and biology] together then you bring in social analysis, you bring the literature, history, so many other fields than just the two. Just by necessity,” a student said.

Some students defended their choice not to specialize against pressure from academe, parents, and sometimes themselves. “I definitely was scared because I’ve heard horror stories about people not being focused, not having the advisors and the help they need. . . . So, it’s definitely harder.” But through fear and hardship, a few students arrived at the realization that their non-specializer tendency might be something to hold out for. “When I got to the end of my junior year . . . I thought that I am getting a better education. Whereas others are just getting straight facts out of books, I am learning a lot about myself.” Another student had the courage to question the external boundaries: “Is it me, or is it external divisions that are false?” “Why do we have to choose?” several students asked indignantly, summoning for support examples of eminent discipline-defying people or even the course instructors. “I think the best thinkers are the ones who can go across different domains of knowledge. Like Bob!” said one student excitedly about Robert Stickgold.

Robert Stickgold and Mark Tramo are, indeed, seasoned boundary-crossers who display intellectual voraciousness no less than the students. Robert Stickgold does cutting-edge research on sleep and memory at Massachusetts Mental Health Center. He is also a published writer of science fiction (Stickgold & Noble 1978) who seriously thinks about the philosophical and social implications of science. His unpublished book *We Know Jack About Consciousness* (2000) is a unique mix of solid neuroscience and the author’s subjective “trying on” of its findings. Robert Stickgold’s teaching assistant, Matthew Walker, who teaches in both sections of the *Sleep* course, also shows an inclination to combine scientific and humanistic interests, as he informs his neuroscience research with patient psychology and concern about patient

welfare.

Mark Jude Tramo is an audiologist/neurologist who heads the Institute for Music and Brain Science. Unlike Robert Stickgold, however, Mark Tramo uses music as a general inspiration and background rather than a backbone for his research. He describes composing as time away from science, with the musician in him maintaining some independence from the scientist and the doctor.

The hybrid knowledge of several fields allowed all three instructors to teach integrative seminars solo, rather than team teach with experts from another field. Single teaching, as opposed to team teaching, provides powerful opportunities for modeling interdisciplinary learning. Team teaching (if explicit effort is not made to integrate) can be a façade for expert exchange rather than a venue for a risky integrative discussion. Teaching integrative neuroscience seminars solo adds an edge of boundary-crossing and was possible because instructors had multiple databases of knowledge on which to draw.

Part of the mentality of a boundary-crosser is the belief that you can be the scientist and the philosopher, the musician and the biologist at the same time. “You can be both!” claims Mark Tramo from his own experience. “I do take issue with . . . the statement that you can only do one thing. I heard that during my own education—saying, you couldn’t be both a researcher and a clinician. I just find it distasteful and to some extent territorial.” His own example demonstrates to students that “doing both” while “doing them well” is not impossible.

## Wisdom of Fools

Another important element of the intellectual make-up of a boundary-crosser and a determinant of the success or failure of an interdisciplinary classroom is the participant’s ability to embrace the unknown. In Klein’s list of the qualities of the interdisciplinary mind, the capacities for “patience,” “risk-taking,” “thick skin,” and “a tolerance for ambiguity” feature quite prominently (1990, p. 183).

Awareness of the limits of a single, expert view makes all teachers in the two seminars assume the stance of learners. The quality of mind that is essential for accepting the unknown is *sophomore* (meaning “wisdom of the fool”) thinking, according to Robert Stickgold. Instead of being on the receiving end of an established body of facts, the students in the interdisciplinary classrooms are expected to be critical challengers of their knowledge, never quite settled in their positions but always encouraged to push through

the obscurity. Instructors hope that they will come out of a class, in the words of Robert Stickgold, as “confident ignorants” or “wise fools,” i.e., true sophomores, who know in specific terms what they don’t know about the topic and where the light is brightest or darkest in the current state of neuroscience.

The sophomore stance towards learning does not imply a dilettantish attitude towards mastery of the scientific tools and knowledge. Nor is it a mark of disenchantment with the possibility of progress in the complex areas of science. Confident ignorance actually means more work in the trenches because, as one student put it, “you can’t get to how much we don’t know until you realize how much we do know.” Stickgold’s teaching goal, for example, is “to produce a cadre of young people in the sciences and other fields who just think from the perspective of mind and brain being a unity, which we don’t have any idea how to describe as a unity.” For him, the ideal statement from a student at the end of the course would be: “At the beginning I thought I had an idea of what consciousness was, and after the first week I realized that I really didn’t know what consciousness was, and now I think I sort of have a handle on what it is I don’t know about it. And I have a way to think about not knowing.”

This sophomore disposition towards learning is particularly important in neuroscience where theoretical bridges frequently seem imaginary or shaky or in constant construction mode. A neuroscientist currently operates in the absence of any grand theory, yet under the assumption that connections between mental and biological phenomena are inherently there. Neuroscience research generally treads a thin line between reductionist and complexity modes as it inquires about the workings of such a complicated system as the brain. Therefore, an instructor in the neuroscience classroom, according to Robert Stickgold, has to shed all “trappings of authority” and practice utmost intellectual humility in front of students. Any presumption of superior knowledge or authority that might come from seniority or title is antithetical to the kind of learning and teaching that takes place in his classroom. “Reductionism largely results from a failure to acknowledge ignorance,” Stickgold believes, and hopes that his students will develop the ability to acknowledge ignorance and to locate “holes in science.”

To foster a sophomore attitude, Stickgold and Walker chose to be “brutally honest” with students, in stating that they “won’t know what consciousness is at the end of the course.” Similarly, Mark Tramo finished *Music* with the discussion of unsatisfying theories of creativity and the statement of the missing biological foundation for them. “Just at the point when

you start to get enough knowledge that you think you know it all,” Stickgold says, “I am trying to get them to the opposite side, where they know so much that they know almost nothing.” Cultivating the state of mind which is in between “the crystal clear and fluid, reductionist and non-reductionist, associative vs. episodic” means to him maintaining “both the sense of wonder and the sense of possibility” in which students would treat the subject of consciousness as “scientifically approachable” even though “not immediately solvable.” “It means,” Stickgold adds, “that a part of their mind is going to have a new way of thinking about it.” As if in response, one student commented on her experience in *Sleep* this way: “At the beginning I could say, ‘Oh, sleep is this, or consciousness is this!’ I didn’t even know what questions to ask. And so I feel one of the things this course is definitely giving me is an idea what questions to even begin to ask, and what are the issues that are even on the table in such a discussion. And looking at different levels that we can approach it at.”

While limited data in this research does not allow profiling of successful participants in an integrative classroom, the importance of intellectual breadth and the suspension of certainty were evident in both classrooms. But while the internal pre-dispositions of students and instructors for integrative work are extremely important for the success of the courses, the kind of interdisciplinary dialogue that took place in the classroom also relied heavily on the pedagogical moves or steps that the instructors took.

### **Integrative Moves in the Classroom**

Instructors in *Music* and *Sleep* used varied strategies to give the discussion a strong integrative turn in their classroom. They focused the curriculum on broad, ill-defined issues (memory, nature of dreams, music perception) that could be approached from multiple disciplinary perspectives, made sure there was always a competing view—a different story (told by music theory or Freud, for example) that did not allow current scientific knowledge (e.g., of the biology of the auditory nerve) to be complete, and kept asking unanswerable questions. (What is music? What is consciousness? How can we understand an issue both psychologically and neurochemically?) While there was no set order to the integrative strategies in either of the classes in which such steps were taken, they were important, present in various forms and degrees, and should be described in greater detail.

#### **1) Learn the Discipline(s)**

The first strategy for promoting integrative thinking in the classroom is to

gain some grasp of the disciplines from which theories, methods, examples, and information will be drawn. Klein (1990), Newell (1998), and Gardner (1999) have all pointed out that “interdisciplinarity is defined in terms of disciplines” (Newell 1998, p. 541) and is based upon a solid mastery of the fields to be integrated. Both courses devoted substantial time to laying the disciplinary foundations for the issues they explored before an attempt at convergence was made. Instructors’ commitment to integration does not come at the expense of rigorous or critical consideration of the disciplinary knowledge. Scientific articles are discussed with penetrating detail, which includes questioning the method, results, and theoretical assumptions. “What are they not telling us?” “How else could this experiment be flawed?” “How would you go about testing this yourself?” These are everyday questions in *Sleep* and *Music*.

Students frequently report that they come out of the course more “skeptical” and experimentally minded than they were before. Stickgold, Walker, and Tramo spend time in their seminars giving in-depth presentations on brain anatomy, neurochemicals, and the physiology of the brain. Stickgold and Walker typically take five to fifteen minutes of each class to go over the basic theories and findings. Tramo, on the other hand, does “front-loading” of disciplinary material at the beginning of the term, presenting core theories and the basics of brain anatomy in a series of two to three lectures. Of course, extensive and intensive mastery of neuroscience or the other disciplines is beyond the scope of both undergraduate courses, but focus on a specific problem (broad as it is) has the potential to provide an adequate foundation for future comparison and integration.

## **2) Identify Points of Connection and Disconnection**

A second strategy for building an integrative classroom is to identify important points of connection and disconnection among theories. *Sleep* makes this an explicit and necessary part of the discussion. Stickgold’s ultimate goal is to have students realize the incompleteness of any one perspective and understand the limitations of our knowledge of the biology of consciousness. The goal is getting students to recognize the “crudeness” of available tools and scientific theories in terms of explaining subtle changes in behavior and states of consciousness. Pointing to the “gap” between our intuitive understanding of conscious behavior and our ability to explain it chemically creates a productive tension that drives the discussion. As a result, many conversations take the form of open debate about the areas of disjuncture and then lead to formulation of an action plan to bridge the glaring gaps in re-

search.

A typical *Sleep* class consists of two main parts. First, students present readings describing scientific experiments and psychological/psychoanalytical theories pertaining to dreams or states of consciousness. They are then asked to talk about the disconnection between them, for example, about how Freud’s views on the function of dreams differs from those of Hobson (Hobson 1988). In the perception of one student, instructors strategically stack different disciplinary perspectives against each other: “I think that they pick a really interesting mix, you get a lot of different viewpoints,” says one student in *Sleep*. “One guy thinks that dreams are spandrels of sleep, that they are nothing, and you get Freud who thinks that they are telling you about your inner self. I like that variety. It allows me to read them all and make my own decision.” The instructors’ own positions as scientists are totally open for debate and critical consideration by students, and they actively help the students to see vulnerable points in their own published papers.

After this discussion, in the second half of the *Sleep* class, a debate over a chapter from Antonio Damasio’s book *The Feeling of What Happens* (1999) takes place. While acknowledging that his theory of multi-layered consciousness does not do away with the fundamental “gap” between biological and mental phenomena, students try to tease out its potential for correlating the chemical/biological structures and the levels of subjective awareness. Students are provoked to challenge Damasio’s synthesis and perhaps offer their own schema.

Damasio’s “solution” does not prove to be satisfying to most students scientifically. But from the instructors’ point of view, it helps to hold the students on the crossroads of major theories contributing to the scientific conversation about the complex phenomena of consciousness. Damasio’s writings, thus, serve as an example of interdisciplinary thinking and inspire integrative juices to flow as the students examine the beauty and pitfalls of his attempt.

*Music* emphasizes differences in the acoustical, biological, and psychological theories of music perception in a much more implicit way, placing the job of comparison and synthesis largely on the students. Mark Tramo sets the stage for this masterfully. He organizes the readings for the classes in much the same way as the Stickgold-Walker team, having different disciplinary perspectives on topics such as pitch, harmony, and rhythm collide in students’ thinking. Some students get to present neurobiological, some acoustical, and some cognitive psychology papers on pitch in the same class. The emphasis here is on describing the parameters of the individual experiments

rather than on generating a synthetic understanding. Also, the “softer” psychological or musical theories are typically not part of the general mix of contributing disciplines, and only the final two classes are devoted to psychological writings on the nature of musical creativity and intelligence. Still, by asking methodological questions about the theoretical assumptions of each experiment, Tramo is able to stimulate dialogue among and across contributing scientific disciplines.

Students, as it appears from the interviews, are equipped in different ways to explore connections and to deal with disconnections. Some fear that putting music and science side by side is not productive at all because music “will lose its magic once you know what happened chemically.” Others are interested in exploring where the difficulty of connecting the biological and psychological theories is rooted. Still others take this difficulty as inspiration and try (following Damasio) to imagine their own “big theory” of connection. History gives them faith that “the holes will be slowly filled in” and that “a unifying bridge,” in the words of one student, will be found eventually.

Instructors expertly build upon the discrepancies in students’ educational backgrounds and bring those into dialogue with each other. Tramo, for example, assigns papers with an eye to students’ particular grounding in cognitive psychology or neurobiology. In *Sleep*, instructors keep an ear out for disagreement among students based on their particular disciplinary reading of the same paper. When a philosophy student in one section of the *Sleep* course challenges the scientific hypotheses of Damasio from a philosophical standpoint, Stickgold, aided by biology students in the class, launches into a heated discussion of the explanatory limits of the philosophical paradigm followed by a similar questioning of the explanatory powers of the biological framework.

Discussion and dialogue serve as the main vehicle of integration and acquire greater significance in an interdisciplinary classroom compared perhaps to any other. In the true Bakhtinian sense, dialogue in both interdisciplinary classrooms goes beyond the exterior exchange of ideas among students and instructors to constitute the interior complexity of their thinking, bringing out “a multitude of bounded verbal-ideological and social belief systems” (Bakhtin 1981, p. 288).

### **3) Describe Limits of the Discipline**

A third strategy for developing integrative thinking is to test the limits of each considered disciplinary perspective. To do that, according to Stickgold,

“we need to maintain bi-directional movement of working in parallel on bottom-up and top-down questions.” His hope with such design is that “at the end of the class you can always go back and sit at the side of the room where you feel the most comfortable, but don’t forget that you had the trip to the other side of the room, and you’ve seen the problem from the other side of the fence.” Much as the introductory undergraduate seminars may be limited in how far they can go to truly test the limits of scientific disciplines, both courses make concerted efforts to identify such limits.

The act of “translating” the results of one experiment through the methods and assumptions of another discipline in Stickgold-Walker classes helps reveal to students the incompleteness or the unaccounted facets of each experiment or theory. Here is how Robert Stickgold stimulates this translation by the question he posts to the class on the Web site: “In talking about the absence of smell in dreams (Hobson 1988, p. 246), Hobson asks, ‘Does this mean there is something deficient with my wish-fulfillment mechanism? Or is my brain’s internal-stimulus generator just incapable of finding the right combination to the padlock of my olfactory and gustatory memory bank?’ How would you translate this last sentence into something that makes neurophysiological or cognitive neuroscience sense” (Anonymous personal communication, May 21, 2000)?

Throughout the term, instructors make requests of students to put their personal intuitions next to science. “How does it [acoustical data] feel to you?” “Do you personally buy this?” “Did you not find it [Damasio’s theory] particularly interesting? Why?” These were not only motivational but also substantive questions that pushed the explanatory capacities of the sciences to the limit. “I’d like to see if my subjective level of alertness matches up with some hardcore data,” one student finds herself thinking after the *Sleep* class.

#### **4) Attempt a Synthesis**

A fourth strategy for promoting integration is to *try* it. Despite the unlikely prospect of finding the perfect fit between a theory of music and the laws of acoustics or auditory nerve functions, neither course has a mood of despair hovering over it. Quite the opposite, the classrooms are often filled with excitement and feverish discussion of what the next experiment or the unifying theory might be. Even the presentation of the most technical neurobiological paper opens up to a discussion of what the findings might mean for the whole mind/matter debate. The difficulty of reconciliation, the misfit in ideas, is often seen as a provocation to find a better theory that could account

for different sets of data.

But attempting any kind of synthesis, especially at the junior undergraduate level, is no small task. The two seminars venture on this path modestly and in different fashions. In the *Music* course, the search for a synthesis is more implicit than explicit, with students left to put the music as a physical-psychological phenomenon together on their own. Creative personal writings on the subject, or visions of an emergence of “a common language,” or “a translation theory” are some of the outcomes of synthetic thinking that students describe in the interviews. In *Sleep*, the discussion of strengths and weaknesses of Damasio’s attempt at synthesis gives explicit impetus for students to think of what a more satisfying try might look like. Professor Stickgold’s unpublished book *We Know Jack about Consciousness* (2000) (which he shared with the class) provides another model of synthetic thinking.

The shape that synthesis might take in students’ papers in the *Sleep* course is the construction of maps that correlates the physiological and psychological markers of various conscious states. One student, for example, plots in her paper the “psychophysiological parameters” of the state of lucid dreaming. “Considering such physiological variables as metabolic rate, heart rate, EEG activity, and muscular movement increase” during lucid dream mentation, she observes general coherence between psychological and physiological indicators. She then explores the implication of this for the holistic view of consciousness and the current theories of dream function. She is also aware that her synthesis is limited because “it assumes that all parts of the cerebral cortex function at the same level of activity at the same time” and that “the psychological and physiological continua are linear.” Her effort also makes her review critically other integrative models of consciousness and sleep such as proposed by Hobson and Damasio. In other words, she does not end with a conclusive and all-inclusive account of the phenomenon but is well on her way to formulating steps for further syntheses.

Students in both courses are left with the desire to find a better fit between the disciplinary perspectives, and they would like instructors to engage them more explicitly in this thinking through points of disconnection and connection. To some students, the discrepancies in biological and psychological theories are frustrating, while to others, these discrepancies are more acceptable or even invigorating. Many students view the lack of a more satisfying link between different disciplinary frameworks not as a failure to integrate, but rather as a tribute to the instructors’ honesty about the state of the art. Robert Stickgold admits openly in front of students that “Damasio is

probably wrong. We don’t know where or how, but no one gets it right the first time!” Mark Tramo also leaves his class at the end of the term with the sense that theories of musical creativity are a far cry from the science of music perception, and with a big question regarding how the gap might be bridged in the future.

The progression of integrative strategies from learning the disciplines, tracing connection and disconnection among them, to pointing out the limitations of any single view and attempting a synthesis is not to be viewed linearly. These strategies are present in the two MBB courses to a differing degree. The *Sleep* course holds the students in intense dialogue about the nature of consciousness through the lens of science and philosophy throughout the entire semester. The disconnect between our subjective awareness and scientific proof propels the discussion in every session. The *Music* course takes a more rigorously disciplinary tack, aspects of subjective perception in modest doses, using the musical sensibilities of students more for illustration and amplification rather than verification of the results obtained through scientific means. The debate about the possible synthesis of ideas occurs, but implicitly, outside of the classroom, in students’ own thinking about different dimensions of music.

## Conclusions

The combination of the internal dispositions of learners and the pedagogical strategies of the instructors is essential for the success of integrative work. What are the potential benefits of such an interdisciplinary process for students? I take some risk by sketching some of them out here, given that my sample (21 students, 3 sections, 3 professors) is too small to make any sweeping statements about the impacts of the courses on students. A controlled or longitudinal study needs to be conducted to isolate a natural stage of intellectual maturation from the impact of a certain way of teaching, no matter how radical or experimental. With full awareness of the limits of my ability to draw conclusions from the data in this study, I would like to make a few observations based just on student interviews and classroom observations regarding the potential value of an interdisciplinary program.

First of all, the study of several disciplines or disciplinary theories seems generally to deepen students’ understanding of each of the contributing disciplines. Secondly, some students comment on the change in their thinking towards a higher level of analysis, critical thinking, and ability to synthesize information. Interdisciplinary efforts support their multi-level thinking about complex questions, they allow students to analytically isolate

central elements of each theory, compare and contrast them, and even generate a synthetic view of the phenomenon under study.

Stretching the boundaries of music or biology, students also stretch their vision of what it might mean to be a doctor, a concert pianist, or a scientist in the future. Some of them go as far as to challenge traditional views of what the practice of this profession might be—using new insight into the interdisciplinary nature of the field. Some students who envision a musical career, for example, claim that scientific training makes them more complex and interesting thinkers who (similar to “the Chomskys and the Yo-Yo Mas of the world”) will be able to overcome the intensely singular focus of conservatory training and open themselves to alternative ways of self-expression. So, even though the influence of science on their musical performance is not direct or obvious, these students see it as enriching their expressive palettes.

Science-minded students challenge traditional views of what it means to be a scientist, too. A *neu* scientist, while charged with the primary goal of “mastering the disciplinary floor” as a true expert, is also, according to those students, called upon to be an integration specialist. A scientist of their vision should be aware of what cannot be seen from the slender disciplinary branch on which he or she is perched, and be prepared to inhabit other branches of science and human thought. Putting philosophical or even artistic perspectives next to science helps students realize the social responsibility of science. “The real goal of science—even though we are talking about physiology, anatomy, lesion effects—is involved in the philosophy of mind and brain,” Tramo says. Even under pressure to focus narrowly, a scientist should try to stay “relevant to society,” as one student explains. Again, only data from a longitudinal study could provide validity for those observations and identify the scope and shape of the influence of an interdisciplinary curriculum on students.

Key elements of the interdisciplinary predispositions of participants (such as breadth of interests and tolerance for ambiguity described here) will benefit from further elaboration. Klein points out that accounts of “the complex actuality of doing interdisciplinary work” are underrepresented in literature on interdisciplinarity (1990, p. 184). Thick descriptions of the mental processes that an integrative effort entails are crucial for developing strategies to support such an effort in the classroom.

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## Notes

1. Quoted from the Mind, Brain, and Behavior program homepage (About MBB 2000).
2. Because the *Sleep* instructors worked as a teaching team, I refer to the two courses (*Sleep* and *Music*) as representing two, rather than three pedagogical approaches.

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