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Integrating Brain Science into Health Studies: An Interdisciplinary Course in Contemplative Neuroscience and Yoga

Uta Wolfe[1] & Amy Moran[2]

[1]Department of Psychology, Program for Neuroscience, University of St. Thomas, St. Paul, MN, 55105, USA; [2]Counseling Center, University of Maine, Orono, ME, 04469, USA.

As neuroscience knowledge grows in its scope of societal applications so does the need to educate a wider audience on how to critically evaluate its research findings. Efforts at finding teaching approaches that are interdisciplinary, accessible and highly applicable to student experience are thus ongoing.

The article describes an interdisciplinary undergraduate health course that combines the academic study of contemplative neuroscience with contemplative practice, specifically yoga. The class aims to reach a diverse mix of students by teaching applicable, health-relevant neuroscience material while directly connecting it to first-hand experience. Outcomes indicate success on these goals: The course attracted a wide range of students, including nearly 50% non-science majors. On a pre/post test, students showed large increases in their knowledge of neuroscience. Students' ratings of the course overall, of increases in positive feelings about its field, and of their progress on specific course objectives were highly positive. Finally, students in their written work applied neuroscience course content to their personal and professional lives. Such results indicate that this approach could serve as a model for the interdisciplinary, accessible and applied integration of relevant neuroscience material into the undergraduate health curriculum.

Key words: neuroscience education, contemplative neuroscience, contemplation, yoga, mindfulness, mental health, health studies, interdisciplinary, non-science majors, pedagogy

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A novel blueprint for the future of undergraduate neuroscience education, called "Neuroscience Studies", intentionally stresses the integral connection of the discipline to other liberal arts and the need to "open the dialogue regarding the core mission of undergraduate neuroscience instruction to a larger intellectual space" (Wiertelak and Ramirez, 2008). Accordingly, recent years have seen numerous initiatives to reach a wider undergraduate population by making neuroscience more interdisciplinary, integrative, accessible and applicable to students' lives; by helping non-majors gain "brain literacy" and overcome (neuro)science anxiety; and by connecting neuroscience to students' intrinsic interests outside of the sciences (e.g., Solomon et al., 2015; Birkett and Shelton, 2011; McFarlane and Richeimer, 2015; Roesch and Frenzel, 2016).

One approach recently shown to engage a wide range of students in neuroscientific material was to make it health-related, and thus practical and intrinsically interesting, even to non-majors (Been et al., 2016). Given the natural connections between neuroscience and health studies, recently formalized by the outline of a new field called Health Neuroscience (Erickson et al., 2014), integrating neuroscience topics into health courses might be a fruitful approach for reaching a diverse mix of students. One emerging health-related subfield in the discipline is contemplative neuroscience which examines changes in the nervous system with practices such as meditation and yoga. A sizable body of research supports the idea that such contemplative practices are beneficial for stress reduction, mental health and cognitive functioning (for a review, see Greeson, 2009). Similarly, many studies show changes in neural functioning and structure that appear to underlie these benefits, such as changes in prefrontal cortex activity and thickness, limbic system functioning and structure, and GABA release (e.g., Davidson et al., 2003; Streeter et al., 2010; Hölzel et al., 2011, Tang et al., 2015).

College students in particular might be inherently interested in these findings of contemplation's benefits for mental health: A combination of factors such as developmental stage, life transitions, and conflicting social, academic and financial pressures uniquely predispose students to stress and mental health problems. Contemplation can benefit this population in terms of stress, sleep, depression, mindfulness, self-compassion and quality of life (e.g., Gard et al., 2012; Eastman-Mueller et al., 2013; Greeson et al., 2014). An additional appeal of contemplative practices might be that they are relatively socially accepted and unstigmatized, so that some students reluctant to seek counseling might be willing to use them for managing stress and mental health symptoms. Perhaps partly for these reasons, participation in practices such as yoga has seen strong increases overall, but especially on college campuses (Adams and Puig, 2008). There is thus a potentially large and diverse audience of students interested in contemplation and the neuroscientific mechanisms for its benefits.

Many campuses offer for-credit yoga and meditation classes through health studies or related programs. Most, including those on our campus as well as those outlined in the publications above, focus appropriately on providing students with the opportunity and skill to practice contemplation as self-care. They do not offer formal

instruction on the neuroscientific principles that underlie contemplative health benefits so that students could gain the scientific knowledge to critically evaluate health claims, an important skill for all students, especially those with health-related majors. Conversely, few neuroscience classes incorporate first-person experiences of contemplative principles, although one recent study convincingly shows the beneficial learning effects of doing so (Levit Binnun and Tarrasch, 2014).

Here, we describe an undergraduate health class that combines an academic component in contemplative neuroscience with yoga practice. The class aims to reach a diverse range of students by engaging them in an accessible, non-intimidating way with health-relevant neuroscience material that they directly apply to their first-hand experience. While aimed at all students, the class might particularly benefit those in (mental) health fields not usually exposed to neuroscience so that they gain skills to critically examine the (neuro)-scientific merit of various health claims.

MATERIALS AND METHODS

All research followed ethical guidelines and was approved by the St. Thomas IRB.

The course "Yoga for Therapy" is offered as a two-credit, semester-long elective class without prerequisites in the department of Health and Human Performance, College of Arts and Sciences at the University of St. Thomas (UST), St. Paul, MN. Taught since 2012, the class is advertised as examining the application of yoga and other contemplative practices to the treatment of psychological conditions (such as stress, depression and anxiety), the neural mechanisms and clinical evidence of these practices' benefits, and the personal experience of their effects in students' own lives. It is taught by the first author, a faculty member of psychology and neuroscience and a certified yoga teacher. In spring semester 2015, the class was assisted by the co-author, a certified yoga teacher, who at the time was a doctoral-level practicum student at UST's counseling center. The current paper focuses on seven sections taught between Fall 2012 and Spring 2015. Class meets for 1 hour 45 minutes once a week in a regular classroom of about 500 square feet with wall-to-wall carpet and moveable chairs with desk arms. The chairs are used for the lecture/discussion portion of the class and moved to the periphery of the room for the yoga practice. The first 50-55 minutes consist of lecture/discussion, usually of a topic in neuroscience, psychology, or physiology. The rest of the time is dedicated to yoga practice in which, whenever possible, the content previously discussed is emphasized. For example: Following discussion of the effects of slowed breathing on parasympathetic activity, heart rate variability and relaxation (Lehrer and Gevirtz, 2014), yoga practice will focus more strongly on attention to the breath and its effects. Following discussion of emotional embodiment, practice will focus on paying attention to bodily markers of emotions. See the Supplementary Material for more examples of connections between yoga concepts and neuroscience content.

Required readings consist of the book "The Mindful Way through Depression" (Williams et al., 2007) and 2-3 popular science articles on contemplation and neuroscience (most recently used articles: Van der Kolk, 2009; Konnikova, 2012). The readings, written for a lay audience, provide the basic background on contemplative practices and scientific mechanisms of their benefits for the more in-depth discussion in class.

The following are examples of neuroscience-related lecture/discussion topics for the semester. The scientific articles cited in the list are not read by students, but presented by the instructor and discussed in class. Each of the topics below takes up between 20-45 minutes of class time.

- Neural bases for learning: Neuroplasticity and long-term-potentiation/depression (Kalat, 2008). Discussion of how mental (just like physical) habits and practice can lead to synaptic and brain changes and thus to strengthening/ weakening of mental patterns. For example, maladaptive thought patterns characteristic of depression can lead to relapse into depression, while practicing adaptive patterns (through mindfulness or cognitive therapy) can break this cycle (Teasdale et al., 2000).
- Embodiment: psychological and physiological evidence of how posture and facial expressions influence cognition, emotion and physiology. (e.g., Hennenlotter et al., 2008; Carney et al., 2010). Possible relationship to taking yoga postures is discussed.
- Neural mechanisms of emotions and stress: role of the limbic system, prefrontal cortex (PFC), autonomic nervous system, HPA (hypothalamus-pituitary-adrenal) axis, cortisol, GABA, etc. (Kalat, 2008).
- Effects of slow, regular breathing on parasympathetic/vagal activity and heart rate variability (HRV). Evidence that HRV is related to both mental and physical health (Lehrer and Gevirtz, 2014).
- Effects of stress and meditation on telomere length, telomerase activity and presumably cellular longevity (Conklin et al., 2015).
- Research evidence that meditation and yoga can cause beneficial changes in neural functioning and structure, e.g. changes in prefrontal cortex activity and thickness, limbic system functioning and structure, and GABA release (e.g., Davidson et al., 2003; Streeter et al., 2010; Hoelzel et al., 2011).

For possible additional topics, the recent review by Tang and colleagues (2015) provides a range of studies applicable to the course. Furthermore, the book used in the class (Williams et al., 2007) will provide additional ideas to the interested reader.

Course Objectives: The student course rating system at UST asks instructors to select two to four class objectives (from a standard list of 12) and to explain to students what these mean in the context of the class. For this course, the three objectives are:

1. "Learning fundamental principles, generalizations, or theories," i.e., principles of yoga and mindfulness and relevant neuroscience and psychology concepts.

2. "Learning to apply course material (to improve thinking, problem solving, and decisions)," i.e., how the principles of contemplation and neuroscience could be applied to improving health and well-being.

3. "Developing a clearer understanding of, and commitment to, personal values," i.e., using course material to become aware of personal habits such as those of posture, breath, thought, speech and action; to explore how these habits originate and whether or not they are beneficial.

Grading and Assignments: Grading is based on three components:

- Weekly Journal (30% of final grade): In each of 14 weekly entries (minimum: 400 words/week), students summarize one or two of the principles covered in class and the readings (related to Objective 1 above), personalize them by connecting them to their own personal, professional or academic experience (Objectives 2 and 3), and reflect on how they might be applied in a beneficial way (Objectives 2 and 3). Due to the personalized nature of the journal, students receive full credit for a full entry that has accurate information, is a true personal reflection of at least the required length, and that contains all three required parts.

- Final exam (30%): The two-hour final exam of 40 questions covers topics from neuroscience, psychology, mindfulness and yoga philosophy. Seventy percent of it consists in multiple-choice and short answer questions on factual information (Objective 1). The rest consists in essay questions that ask students to reflect on how they personally apply some of the information from the class (Objectives 2, 3).

- Attendance and participation (40%). Because of the highly experiential nature of this course, attendance and participation make up the largest portion of the grade. It is determined by the attendance record and the frequency and quality of contributions to discussion. For the yoga practice portion of the class, it is made clear to students that they are not graded on how 'well' they perform the asanas/postures, but that they receive full credit for participating to the best of their ability.

Course Ratings: In the anonymous end-of-semester course ratings, students are asked to assess their progress on the three main course objectives on a five-point scale (1 = No apparent progress to 5 = Exceptional progress). They are also asked to indicate their agreement with the statements: "As a result of taking this course, I have more positive feelings toward this field of study," "Overall, I rate this instructor an excellent teacher" and "Overall, I rate this course as excellent" on a five-point scale (1 = Definitely False to 5 = Definitely True).

Neuroscience Knowledge Test: In one recent section of the course (n=12), students took a 10-item, multiple-choice (four answer choices), ungraded knowledge pre-test on neuroscience materials early in the semester without receiving feedback. Subjects included neuroplasticity, neural changes associated with meditation, roles of the prefrontal cortex, amygdala, hippocampus, HPA axis, cortisol and GABA. The same test was given again as a post-test at the end of the semester to gauge student progress. Rather than being forced to guess the correct answer, students had the additional option of indicating that they had no prior knowledge of a topic, by checking, e.g., "I have never heard of GABA."

RESULTS

Student Distribution: A total of 80 students (26 or 32.5% male) took the course between Fall 2012 and Spring 2015, with section size ranging from 10 to 16 students. The course successfully attracted a wide range of students: Nearly half (39 or 47.5%) were from non-science majors, (including business, communication/ journalism, arts, and humanities). Psychology majors made up 25%, Social Work 10%, Neuroscience 6%, and Health and Human Performance 4%. The remaining majors were in Biology, Computer Science or Engineering. Also notable is the over-representation of (mental) health-related fields: 16% of students in the class were Social Work or Health and Human Performance majors who make up a total of only 5% in the general UST population (according to a 2015 census).

Neuroscience Knowledge Test: As illustrated in Figure 1a, scores on the knowledge post-test were significantly higher than those on the pre-test ($t=4.07$, $df=11$, $p<0.001$, paired t-test) with an average increase of 33% (from 44% to 77% Correct; Cohen's $d=1.17$) indicating the course's large effect on this measure of neuroscience knowledge. On the pre-test, half the students (6 out of 12) indicated for at least one item and for a total of 20 instances (1-6 per student) that they had no prior knowledge of a given topic by selecting "I never heard of X" (see Figure 1b for details). On the post-test, none of the students selected this option. Together, these data show that students who were completely unfamiliar with certain neuroscience content improved their understanding substantially through this course.

Student Course Ratings: In their anonymous ratings, students indicated that they had made strong progress on the three course objectives, that they had "more positive feelings toward this field of study" due to the course, and that they rated the course and instruction overall as highly positive. Figure 2 shows overall mean ratings for these six items across all seven sections. Means for Objectives 1 (Learning fundamentals), 2 (Applying material) and 3 (Understanding personal values) were 4.6, 4.8 and 4.7, respectively. (Individual course section means ranged from 4.3 to 4.8; standard deviations: 0.4-1.1). Similarly, students strongly agreed that they had more positive feelings about the field as a result of this course: The overall mean rating was 4.7 (individual section means: 4.3-4.9; standard deviations: 0.3-0.9). Finally, they strongly agreed with a rating of "excellent" for both the course and instruction, with overall means of 4.8 and 4.9, respectively (individual section means: 4.6-5.0; standard deviations: 0-

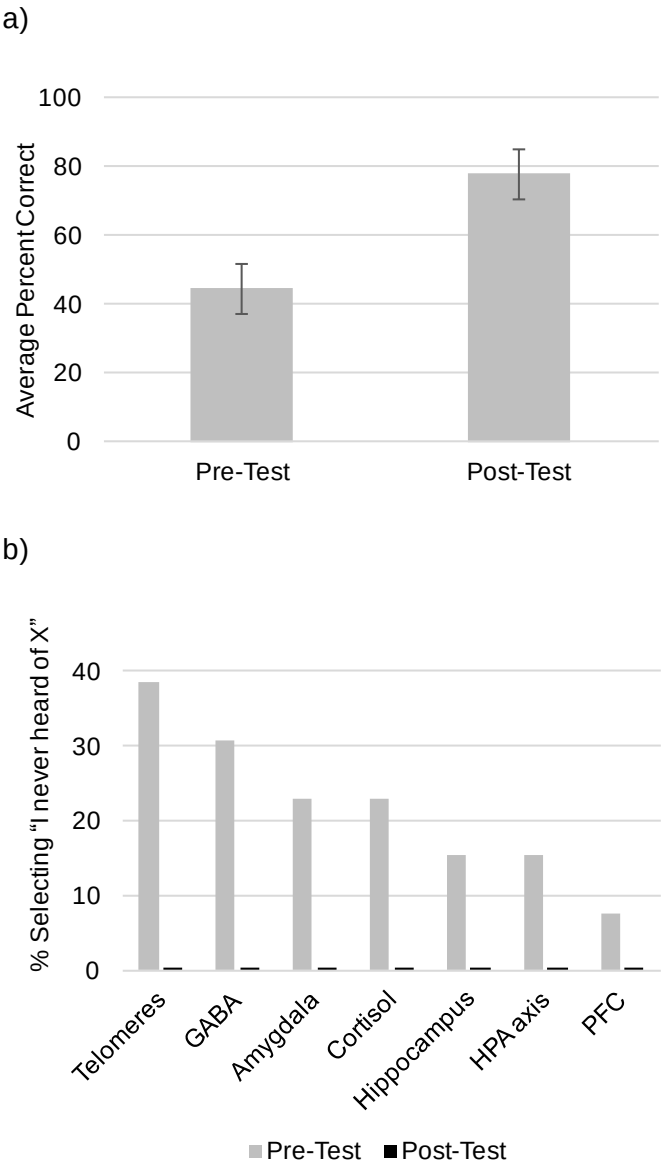

Figure 1. a) Pre-post comparison of results from neuroscience knowledge test (n=12). Columns show mean percentage correct; error bars denote standard error. *b)* Percentage of students selecting "I have never heard of X" for each topic shown, at the start and end of the most recent course. (All post-test percentages are zero).

0.7). As this is the only class either of the instructors teach in the Health and Human Performance, comparison data are not available.

Student Comments: Comments on the anonymous rating forms showed that students perceived the course material as relevant to their lives and benefitting them personally. They thus seemed to apply materials as consistent with Objectives 2 and 3. The following are representative comments:

"I am so thrilled to have learned these outcomes [of neural changes] as it pushes me to continue my yogic meditation practice throughout the rest of my life instead of just quitting once the semester was over as I had initially planned."

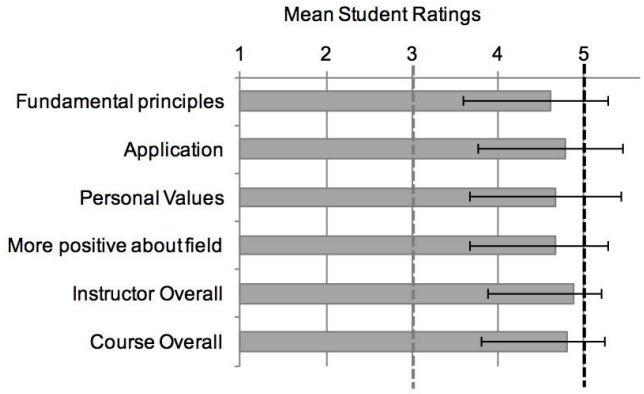

Figure 2. Mean ratings for six evaluation items (80 students, seven sections; see text for details). Error bars denote standard deviations. Black dashed line marks most positive rating possible (5), grey dashed line marks neutral rating (3).

"I loved this class. It has changed my life in a positive way and made me dedicated to my yoga practice and appreciate the benefits from it."

"This course more than any other at UST taught me things I can use outside of class to really improve/enhance my life."

"The class was wonderful and really brought together aspects of my psychology major and my interest in yoga."

As part of the personalization requirement of the weekly journal assignment, several students specifically wrote about the neuroscience material covered and how it related to their own lives. Examples include:

- Neuroplasticity: learning that the brain is plastic even late in life made students feel more hopeful about correcting habits and learning new mental skills.
- Cortisol, HPA axis: Learning about the detrimental effects of long-term cortisol release highlighted the importance of regulating emotional responses to daily stress.
- Parasympathetic/ Vagus activation: Learning how deep breathing can increase parasympathetic activation emphasized the benefits of mindful breathing throughout the day to regulate stress.
- Changes of hippocampus and PFC with meditation: Students applied these specific changes with meditation to their own struggles with depression and emotional regulation.
- Effects of stress and meditation on telomeres and telomerase levels: Learning about the possible ways in which stress and meditation might affect cellular aging highlighted the importance of practicing beneficial health habits.

In sum, students tended to express appreciation, even excitement, about the neuroscientific findings because, as one student put it, they offer strong "concrete evidence to support the positive effects of the practice" of contemplation.

Moreover, several students who worked as interns in mental health fields chose to write about how neuroscience material applied to their work. Examples include:

- Role of GABA in reducing anxiety: noting how patients whose anxiety medications are no longer effective

might benefit from yoga's effect of increasing GABA function (Streeter et al., 2010).

- Emotional embodiment: teaching patients how holding expression of emotions might amplify psychological and physiological aspects of their emotions and to thus become aware of their posture and facial expressions. Teaching clients with a history of violence or a history of drug abuse to identify bodily markers of anger or cravings; relating embodiment and body mindfulness to psycho-education on recognizing and coping with feelings of HALT (hungry, angry, lonely, tired) in relapse prevention.
- Cost effectiveness and lack of side effects of stress-reduction techniques: Noting how patients might need less medication (such as SSRIs) and/or counseling when they learn exercises such as the body scan, breathing techniques and meditation.
- Possibility of positive interactions between drugs and contemplative techniques: Noting that drugs in combination with meditation might drastically help a subset of patients.

Such unsolicited comments in journals demonstrate that (consistent with Objectives 2, 3) students applied class materials in contemplative neuroscience to (mental) health, both personally and professionally.

DISCUSSION AND CONCLUSIONS:

Efforts to increase the reach and relevance of neuroscience to the general undergraduate population are ongoing. Previous work has shown that emphasizing the health connections of neuroscientific material can successfully engage a wide range of students, including non-science majors (Been et al., 2016). Neuroscience's obvious health applications offer numerous opportunities for applied instruction as well as for the interdisciplinary teaching of neuroscience and health studies in general. Contemplative neuroscience, specifically, has important applications for mental health and stress management, issues that can pose significant challenges for college students. Taken together with the rising popularity of contemplative practices, especially yoga, on campuses, this suggests that an interdisciplinary class in health studies that applies neuroscience to the health effects of yoga would be of great interest and relevance to college students. It could also offer a non-threatening environment for introducing neuroscience material to a diverse range of students while connecting it to the direct experience of contemplation in the same class and in students' lives. Such first-person exploration and direct life application has previously been shown to improve learning of neuroscience concepts (Binnun and Tarrasch, 2014).

Most yoga and other contemplative classes offered through college health departments and centers focus appropriately on providing stress relief and self-care, without examining the scientific bases for these benefits. The class outlined here additionally aims to educate students formally on the neuroscientific evidence and mechanisms of contemplation's health effects. Whereas we consider this scientific exposure important for all students, it might be especially crucial to those in (mental) health fields that normally do not require strong course work in neuroscience as they will need to critically evaluate various health claims in their future profession.

As outlined above, the class was successful in attracting a wide range of students, increasing basic neuroscience knowledge, motivating students to apply it to their personal and professional lives, and eliciting positive ratings and comments: Nearly half of the students in the class were from non-science majors, and a disproportionate number came from (mental) health-related fields. As shown by the pre/post-test, these diverse students greatly improved their knowledge of neuroscience through the class. Positive course ratings, of progress on the course objectives, quality of course and instructor, and increases in "positive feelings towards this field of study" indicate the success of the class. Students' written comments (on rating forms and in their journals) indicate that they found the class highly relevant and beneficial, and that they thoughtfully applied neuroscientific findings to their lives and their work (particularly those in health-related areas).

One obvious limitation is that a two-credit class that meets for only 105 minutes/week, half of which spent on yoga practice, can cover only a narrow range of core neuroscience principles. We are exploring future options of offering an expanded version of the course, with four credits and a stronger neuroscience component, that might count as elective credit towards neuroscience and psychology degrees. However, even in its present form the course seems to spark interest in neuroscience, improve literacy of non-majors in the subject, and provide a direct application of its principles to students' lives.

The course's logistics make it an accessible template for integrating neuroscience into activity-based health classes on a wide range of campuses: It meets for only slightly longer than a practice-only yoga class, requiring little extra time commitment from students. The readings (a paperback popular science book and several online articles) are inexpensive and accessible to students regardless of background. The course meets in a regular class room, obviating the need for special yoga or exercise space. Most undergraduate institutions have access to both yoga instructors and faculty in neuroscience or biopsychology opening the possibility of guest-lecture or co-teaching arrangements to provide a similar course.

Moreover, the class might serve as a more general model for integrating neuroscience material into health studies courses. At UST and similar institutions, several health classes would thoroughly lend themselves to this interdisciplinary and applied approach, among them those on Personal Health and Wellness, Stress Management, and Alcohol and Drugs. Integrating neuroscience into the undergraduate health curriculum might thus open a new way to reach a diverse student body by making the subject directly relevant and applicable to their lives.

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Address correspondence to: Dr. Uta Wolfe, Psychology Department/ Program for Neuroscience, University of St. Thomas, JRC LL56, 2115 Summit Avenue, St. Paul, MN 55105. Email: uta.wolfe@stthomas.edu