ARTICLE

Can You Change a Student's Mind in a Course about the Brain? Belief Change Following an Introductory Course in Biological Psychology

Ian A. Harrington

Department of Psychology & Program in Neuroscience, Augustana College, Rock Island, IL 61201.

Undergraduate courses in the neurosciences, including biological psychology, often appeal to students because they offer perspectives on human behavior and experience that are so different from those students arrive with or are exposed to elsewhere on campus. Consider, for example, this passage from Crick's, *Astonishing Hypothesis*: "You, your joys and your sorrows, your memories and your ambitions, your sense of personal identity and free will, are in fact no more than the behaviour of a vast assembly of nerve cells and their associated molecules." Unfortunately, because this perspective is at such odds with those many students arrive with, the very thing that makes these classes so interesting is also likely to engender resistance. With Crick's hypothesis serving as the theme of my introductory course in biological psychology, we explore the ways in which complex experiences and behaviors can be explained by lower-level, biological phenomena. Historically, and for a host of valid reasons, class assessment tends to focus on whether students *understand* the course material (e.g., Can you explain the role of Ca^{2+} in synaptic transmission?), rather than whether students *believe* what they have been introduced to (e.g., Do you believe that the mind exists as something separate from the body?). For a number of years, however, I have also been collecting pre- and post-test data from students enrolled in three formats of the class in an effort to measure changes in beliefs. One format was a conventional standalone class, whereas the other two were more intensive and involved parallel coursework in the Philosophy of Mind with a second instructor. The full assessment, identical at both test intervals, was comprised of 56 items and included 16 items from a Theoretical Orientation Scale (TOS; Coan, 1979), several of which addressed whether human behavior was predictable; 14 items that addressed dualism, the veracity of our perceptions, personal responsibility, and other topics; and 26 items from the Organicism-Mechanism Paradigm Inventory (OMPI; Germer et al., 1982). Unlike most of the other test items, which addressed class topics specifically, the OMPI addressed general worldviews between two poles of mechanism and organicism. Mechanistic explanations, common in Neuroscience, tend to be highly reductive and treat organisms as more passive and reactive, whereas organismic explanations treat organisms as more active and the systems that give rise to their behaviors as non-reductive. Overall, analyses revealed statistically significant changes on a wide range of items that were generally, though not always, consistent with course objectives. The results of the OMPI indicated that the average student began the term closer to the organismic end of the scale, and became slightly more organismic by the end of the term. And yet, on a number of items related more specifically to the relationship between brain and behavior, students became more willing to endorse reductive and mechanistic positions. Although student beliefs can be very resistant to persuasion, change can occur.

Key words: biological psychology; beliefs; mechanistic; organismic; teaching of neuroscience; student learning; assessment; theoretical orientation.

Former US Secretary of State Henry Kissinger once said, "To be absolutely certain about something, one must know everything or nothing about it." Although he made this comment about the political interactions that might occur in the boardroom, it seems to capture nicely what we often face in the classroom. Despite the actual novelty of much of what is taught in an introductory course in biological psychology or in the neurosciences more broadly, for example, it has been my experience that students are often willing to reject many of the ideas they encounter even when they are empirically supported (Ahluwalia, 2000; Briñol et al., 2004). The tendency of people to be resistant to persuasive arguments in general is well known in the psychological literature (e.g., Lord et al., 1979; Briñol et al., 2004; for a review see Wood, 2000), and the cognitive conflict that occurs when a student's prior knowledge meets a persuasive argument in the classroom has attracted the interest of educators (e.g., Limón, 2001; Nersessian, 1989). Although I appreciate that we shouldn't want our students' beliefs to change too easily, an education should do more than simply confirm a student's existing beliefs. A number of topics within our discipline and related ones (e.g., evolution; Sinatra et al., 2008) have the potential to challenge our students' beliefs on significant issues including the freedom of the will (e.g., Morse, 2008), the veracity of perceptual experiences, and the relationship between mind and brain (Demertzi et al., 2009). In addition to the traditional content assessments used in my class, therefore, I have also been assessing students' beliefs about these issues at the beginning and end of the term.

My biological psychology course, Brain & Behavior (PSYC 248), has been offered in three formats since I started teaching at Augustana College in 2005. Augustana is a four-year residential college of 2,500 students with a Lutheran Church affiliation. The first format of the class, and the one I have taught most often, was a conventional class and has served three primary groups of students: all

Neuroscience majors; many Psychology majors; and some students seeking distribution credits outside of their primary major, often including Biology majors. The class was lecture based, supported by James Kalat's textbook, *Biological Psychology* (Wadsworth), along with a number of other readings, and ran for 10 weeks with just under four hours of instruction weekly. The range of topics covered was fairly standard for such a course (if slightly abbreviated) and included functional neuroanatomy, the basics of intra- and inter-neuronal signaling, development, motor systems, sensation and perception, learning and memory, emotions, and thinking and consciousness. The second and third formats of the class, referred to as the Learning Community (LC) and Immersion Term (IT), differed from the conventional class in that they involved parallel coursework in the Philosophy of Mind, and differed from each other in their depth and breadth. In the LC the class was simply taken in tandem with a class in the Philosophy of Mind, whereas in the IT a smaller student cohort participated in a team-taught, 4-course-equivalent program in neurophilosophy (see Harrington et al., 2013). Both of these class formats involved considerably more discussion of historical and contemporary accounts of the relationship between mind and brain, generally beginning with Cartesian dualism and ending with eliminative materialism.

Regardless of its format, there has been a single organizing theme for my class since it was first offered. On the second day of class we discuss the opening chapter of Crick's book, *The Astonishing Hypothesis: The Scientific Search for the Soul* (1995). In that chapter, for example, Crick writes: "You, your joys and your sorrows, your memories and your ambitions, your sense of personal identity and free will, are in fact no more than the behavior of a vast assembly of nerve cells and their associated molecules." This reading has proven to be an effective and provocative way to introduce students to the ideas of materialism and physicalism (i.e., there is nothing but matter and energy) and reductionism (i.e., that phenomena at one level can be explained in terms of phenomena at a lower level), particularly as they relate to brain and behavior. In this chapter Crick also introduces the idea of "emergent properties." Many of my students report that it is difficult to understand how the full range of human behavior and experience could be explained in terms of brain activity. Emergence allows complexity (e.g., consciousness) to be produced by interconnected systems even when the behaviors of the elements that comprise those systems are limited (e.g., as with the spiking behavior of neurons). My students are often willing to accept the reductive explanations I offer for such things as motor behavior and sensation during the first half of the term, but come to balk at such explanations when we discuss what they consider to be higher-level phenomena like feelings, decision making, and consciousness in the second half of the term. I find Crick's writing about the neural basis of consciousness in this chapter particularly valuable because parsimony would suggest that if we are to accept his hypothesis about the bases of *any* behaviors and experiences, we should be willing to accept it as the basis for *all* behaviors and experiences. Nevertheless, although my class takes a reductive approach to the explanation of human behavior and experience, with the introduction of ideas like emergent properties I am also willing to entertain the possibility with my students that, in practice, a reduction to physical science might never be fully realized.

This project had two related aims. The first was to characterize the way students thought about certain aspects of the world in general, and about the relationship between brain and behavior in particular. The second was to determine whether (and, if so, how) these beliefs and worldviews might change after completing an introductory course in Biological Psychology. The questions administered at the beginning and end of the term were drawn from several sources. A number were taken from a theoretical orientation scale published in the late 1970s that had been used to characterize the differences between the practitioners of various schools of Psychology (Coan, 1979). In addition to a number of items that had been developed by and with my LC and IT teaching partner, I have also administered a scale that situates its users between the two poles of mechanism and organicism, because this seems so relevant to contemporary discussions of the relationship between brain and behavior (Germer, Efran, and Overton, 1982, as cited in Johnson et al., 1988). Proponents of a mechanistic worldview, particularly historically, have maintained that organisms are more passive and reactive, and, in contrast to the gestalt mantra that characterizes the organismic approach, can be considered as the sum of their parts (Reese and Overton, 1970; Johnson et al., 1988; Gilbert and Sarkar, 2001; Allen, 2005). Proponents of an organismic worldview, on the other hand, maintain that organisms are more proactive and autonomous and that complex systems can only be understood at the level of the whole system (Reese and Overton, 1970; Johnson et al., 1988; Gilbert and Sarkar, 2001; Allen, 2005). When measures like the OMPI were administered to a fairly diverse sample of psychologists, for example, Johnson and colleagues (1988) demonstrated differences with behaviorists being the most mechanistic and developmental psychologists being the most organismic.

Mechanistic explanations offered in the days of behaviorism were quite different from those offered in the age of the brain. I can think of very few neuroscientists today, if any, who espouse a "brain as clockwork" metaphor, and it is illustrative how much more "mainstream" research in areas like the neural bases of consciousness or attention has become in just the last few decades. In practice, contemporary mechanistic thinking seems to incorporate many aspects of organicism, thereby allowing for a greater degree of flexibility and autonomy than might have been permitted before. But what exactly is the explanatory theme that holds our discipline together? A secondary motivation for this project, therefore, is to begin to characterize the theoretical predilections of contemporary college students both as they pertain to the relationship between the brain and mind, as well as the world more broadly. In a later phase of this project, this belief characterization process can then be extended to the current, rather than the future, practitioners of these disciplines—neuroscientists themselves.

MATERIALS AND METHODS

Pre- and post-test data were collected from students enrolled in three formats of a 200-level, introductory Brain & Behavior course (n = 312): a conventional class (n = 239); a learning community (LC; n=47); and an immersion term (IT; n = 26). Both the LC and IT forms of the class were taught twice, with the second offering a year after the first, and the LCs were offered prior to the ITs. Overall, students enrolled in these classes were of traditional college age (19-22 years) with few exceptions, 218/312 (69.9%) were female, and a majority were Psychology majors with Neuroscience majors increasing in number following the program's introduction in 2010. The LC and IT formats of the class tended to draw students from a wider range of majors than the conventional format, largely because these experiences satisfied a number of general education requirements, and also tended to have a lower proportion of females (LC: 25/47, 53.0%; IT: 9/26, 34.6%) than the conventional format. Only students who completed all items at pre- and post-test were included in the final analyses reported here. The smaller sizes of our classes in general (<30 students per section; and <17 in each IT) and the less frequent offering of both the LC and IT classes necessitated a 5-year period of data collection.

Measures included a modified 16-item version of Coan's (1979) Theoretical Orientation Scale (TOS; see Table 1); a 14-item questionnaire that included statements about dualism, the nature of our perceptions, the predictability of behavior, and personal responsibility, among others (see Table 2); and the Organicism-Mechanism Paradigm Inventory (OMPI; see Table 3; Germer et al., 1982, as cited in Johnson et al., 1988). For the first two scales, level of agreement with each item was indicated using a 5-point scale (strongly agree, 1, to strongly disagree, 5, with a neutral midpoint, 3). For the modified version of the TOS, 9 items were taken directly from the original scale (see Table 1, items marked with asterisks) with the remaining items added to address other issues or in an effort to improve the clarity of the original test items. Items were worded to be either consistent or inconsistent with a mechanistic orientation. Those worded to be inconsistent were then reverse scored since the most "mechanistic" response to a non-mechanistic statement would be to strongly disagree (i.e., a response of 5 was scored as a 1, a response of 4 as a 2, and so on). Two "filler" items about whether research requires a clear social utility and whether the universe is fundamentally chaotic, 1 and 15, were not used in the calculation of composite TOS scores and, thus, with 14 items and a 5-point scale, scores could range from 14 to 70 (midpoint 42), with scores below the midpoint being indicative of a more mechanistic orientation. On the third scale, the OMPI, students assessed 26 pairs of statements and chose the statement that was most consistent with their worldview in a forced-choice manner. Scores on the OMPI could range from 0 (highly mechanistic) to 26 (highly organismic). The paper-and-pencil pre-test was administered on the first day of class, with the post-test administered during the last week of classes, 10 weeks later. Repeated measures ANOVAs were used to look for changes in composite TOS and OMPI scores, and paired-samples t-tests were used to test for changes on individual scale items (with the exception of the OMPI item-level analyses, where χ-square tests were used to compare the distribution of A and B responses at the two intervals).

RESULTS

The modified TOS and the 14-item survey were administered to a total of 312 students who completed all items. Composite TOS scores were analyzed using a 2 x 3 repeated measures ANOVA with test interval (pre and post) and class format (conventional, LC, and IT) as factors, and revealed a significant main effect of test interval, $F(1,309)=45.529$, $p<0.001$, $\eta^2=0.128$ (see Figure 1). Overall, TOS scores decreased from 46.9 to 44.5 suggesting a small decrease in organismic thinking. There was no main effect of class format, $F(2,309)=0.264$, $p=0.768$, $\eta^2=0.002$, but there was a significant interaction of test interval and class format, $F(2,309)=3.79$, $p=0.024$, $\eta^2=0.024$. This interaction, which is apparent in Figure 1, reveals that the change in TOS scores was smallest in the conventional class (46.7 to 44.9, a change of -1.9), largest in the IT format (47.8 to 43.4, a change of -4.4), and intermediate in the LC format (47.2 to 43.4, a change of -3.8). These results suggest that students were moderately organismic at the beginning of the term, on average, became somewhat less organismic (or, somewhat more mechanistic) across the term regardless of class type, and that the more intensive forms of the class engendered larger changes in composite TOS scores.

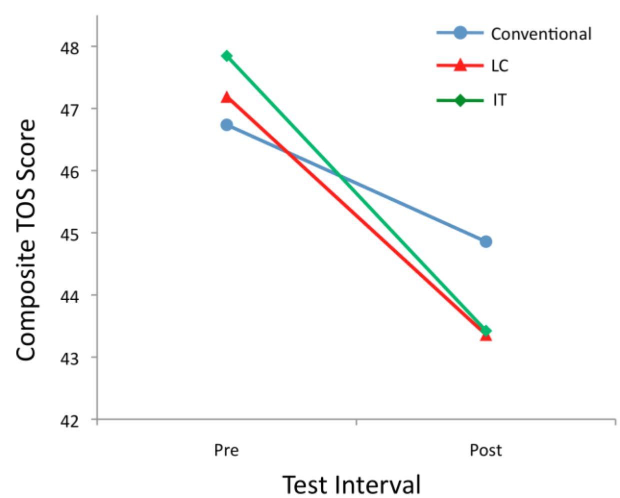

Figure 1. Composite TOS scores for each class format as a function of test interval. Although students reported slightly less organismic orientations by the end of the term in each of the classes, the magnitude of this change varied with class format, being smallest in the conventional format and larger in the two more intensive formats (LC and IT). These more intensive formats also differed in that they involved considerably more attention to the Philosophy of Mind.

Although the average shift on this modified version of the TOS was modest—the mean shift in TOS scores for the entire sample was just -2.4—there were a number of students who reported more sizable shifts (see Figure 2). In fact, 101/312 (32.4%) had shifts of -5 or more and 38/312 (12.2%) had shifts of -10 or more. In contrast, 125/312 (40.1%) demonstrated either no change at post-test or an increase in scores suggesting more organismic thinking.

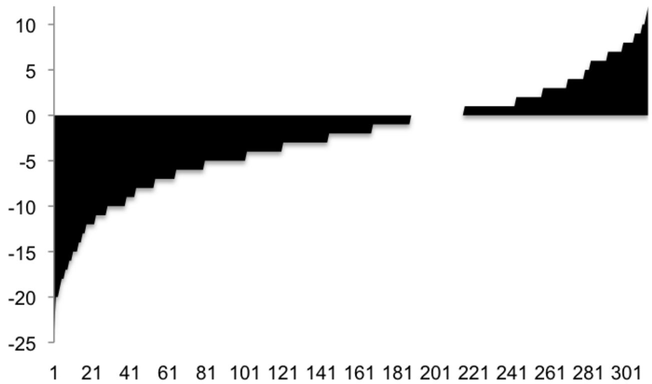

Figure 2. Distribution of changes in TOS scores (y-axis) sorted by magnitude across the 312 participants. Negative scores indicate lower TOS values at post-test and, therefore, more mechanistic thinking. Note the asymmetry of the distribution with its bias toward larger negative scores, as well as the smaller subset of the sample in which post-test TOS scores were higher than those at pre-test.

TOS Item	Pre	Post	*P*
1. Scientific research should have a clear social utility as defined by a majority of people.	2.56	2.54	0.710
2. Belief in deities is inconsistent with a scientific worldview. (+)	3.13	2.73	<0.001
3. Human behavior is characterized by lawful regularity and thus, in principle, is completely predictable. (+) *	3.73	3.45	<0.001
4. All behaviors, except for simple reflexes, are learned. (+) *	2.83	2.71	0.096
5. Psychologists should be as concerned with explaining private conscious experience as they are with explaining overt behavior. (-) *	2.24	2.08	0.005
6. In principle, human behavior cannot be completely predicted, because people can choose to act in ways we have no basis for expecting. (-) *	2.02	2.59	<0.001
7. The individual subject's personal account of his or her private experience is one of the most valuable sources of psychological data. (-) *	2.41	2.52	0.072
8. A theory should consist mainly of inductive generalizations based on observations, with little in the way of constructions or hypothetical formulations contributed by the theorist. (+) *	3.21	3.23	0.702
9. Human actions are just as strictly determined by whatever causes are operating as all other physical events are. (+) *	2.82	2.59	0.001
10. Any meaningful statement about mental events can be translated into a statement about behavior with no serious loss of meaning. (+) *	3.52	3.22	<0.001
11. In principle, an individual's choice or decision can never be fully predicted from preceding conditions or events. (-) *	2.56	2.86	<0.001
12. We would gain more valuable information if researchers spent more time studying complex behaviors in their natural contexts and less time studying simple responses. (-)	3.08	3.04	0.544
13. Intuition is central to good science and scientific method. (-)	3.02	2.96	0.353
14. Science can never prove any theory conclusively true. (-)	2.34	2.25	0.159
15. The universe is fundamentally chaotic.	2.38	2.37	0.782
16. Psychology cannot in principle be reduced to physical science. (-)	2.66	3.12	<0.001

Table 1. Grand average pre- and post-test responses to individual TOS items. Of the 16 items, 9 (marked with asterisks) were taken from Coan's original scale (1979) with the rest of the items added in the spirit of the original. Items consistent and inconsistent with mechanism are identified by + and -, respectively. Grand average responses at each test interval are shown along with the *p* value associated with their comparison. The 5-point response scale ranged from strongly agree (1) to strongly disagree (5) with a neutral midpoint (3).

Survey Item	Pre	Post	*P*
1. On bodily death, a person continues to exist in a non-physical form.	2.42	2.86	<0.001
2. God exists.	2.07	2.30	<0.001
3. I am the same person now that I was when I was 5 years old.	4.03	4.27	<0.001
4. I am always responsible for my actions.	2.03	2.36	<0.001
5. Ghosts exist.	3.38	3.58	<0.001
6. One day there will be computers that understand Shakespeare better than I do now.	2.93	2.87	0.445
7. The best way to treat depression is to inject chemicals into the brain.	3.80	3.77	0.521
8. If I had been born into a different environment, I might have become a professional killer.	2.62	2.20	<0.001
9. The future is fixed; how one's life unfolds is a matter of destiny.	3.77	3.69	0.140
10. The life of a young child is more valuable than the life of an 85-year-old Alzheimer's patient.	3.25	2.81	<0.001
11. The mind exists as something separate from the body.	3.24	3.50	0.001
12. Our senses allow us to experience the world as it truly is (objectively).	2.93	3.36	<0.001
13. Other people are always responsible for their actions.	2.62	2.70	0.291
14. If our brains work like complex machines, we cannot possible have free will.	3.57	3.13	<0.001

Table 2. Average pre- and post-test responses to survey items. Average pre- and post-test scores on the 5-point scale are listed for the entire sample, and *p*-values were obtained from paired-sample t-tests. Significant changes were observed on 10 of the 14 items. The same response scale was used here as in Table 1.

Obviously, changes in composite TOS scores must have been paralleled by specific item-level changes, which are reported in Table 1. Of the 16 items included on the scale, 8 showed significant changes at post-test (neither of the two filler items excluded prior to the calculation of the composite score showed any change). It appears that much of the observed shift on this measure can be explained by changes on a subset of items related to the predictability of behavior. Specifically, items 3, 6, 9, and 11 all related to this issue and on each of these there was a statistically significant change that was consistent with a more mechanistic orientation, as defined by Coan (1979). Students were more willing to accept that human behavior is caused and, therefore, at least in principle, can be predicted. In addition, on item 2, "Belief in deities is inconsistent with a scientific worldview," responses shifted from 3.13 (between neutral and disagree) to 2.73 (between neutral and agree). But there was one item on this scale that perhaps addressed the primary themes of the course most directly, namely, item 16, "Psychology cannot in principle be reduced to physical science." On this item average responses shifted from 2.66 (between agree and neutral) to 3.12 (between neutral and disagree). Related to this, on item 10, students became less likely to disagree with the possibility of describing mental events in behavioral terms, perhaps because this behaviorist statement is not too unlike explaining mental events in terms of the behavior of the brain. It should be noted that not all of the shifts at post-test were consistent with increasing mechanism. On item 5, for example, "Psychologists should be as concerned with explaining private conscious experience as they are with explaining overt behavior," students' responses shifted from 2.24 to 2.08, indicating more agreement by the end of the term. According to Coan (1979), this statement is inconsistent with a mechanistic worldview. Students were also neutral at both intervals about whether scientists should study complex behaviors in their natural contexts rather than simple responses (item 12). However, I do not view the responses on this item, much like those on item 5, as problematic.

Of the 14 items included on the second survey which asked about issues including metaphysical dualism, the nature of our perceptions, the predictability of behavior, and personal responsibility, among others, 10 items showed significant change at post-test (see Table 2). By the end of the term, students were less likely to endorse the existence of ghosts, their own continuity in non-physical form after death, the objectivity of their perceptual experiences, that they and others were always responsible for their actions, or that the mind exists as something separate from the body. They were more likely to endorse the profound influence of their past experiences on their present behaviors and dispositions, the greater value of the life of a young child as compared to an 85-year-old Alzheimer's patient, and the possibility that neuroscience is inconsistent with traditional beliefs about free will. Somewhat unexpectedly, there was also a small, though statistically significant, decrease in their willingness to endorse the existence of God, with scores shifting from 2.07 to 2.30 overall. Although this topic is rarely if ever addressed in the conventional format of the course, it is discussed in the formats involving the Philosophy of Mind. Nevertheless, although the average response (with standard deviation) to the statement "God exists" appeared slightly lower in the conventional format [pre 2.03 (1.18), post 2.21 (1.32)] than in the LC [pre 2.23 (1.15), post 2.62 (1.41)] and IT formats [pre 2.15 (1.16), post 2.58 (1.24)], these format differences were not significant at pre-, $F(2,309)=0.636$, $p=0.53$, or post-test, $F(2,309)=2.492$, $p=0.084$. Thus, these changes were largely independent of class format and could occur in the absence of explicit instruction.

OMPI scores were analyzed with a repeated measures ANOVA with class type as a between subjects factor. There was a significant main effect of test interval, $F(1,212)=20.2$, $p<0.0001$ (see Figure 3). Composite pre- and post-test OMPI scores (with standard deviations) for the sample of 214 participants averaged 17.5 (3.23) and 18.5 (3.42), respectively, putting students closer to the organismic end of the spectrum in general, and closer still by the end of the term. There was no main effect of class type, $F(1,212)=0.235$, $p=0.629$. When the sample was sorted into those students who completed the conventional and IT format of the class (the OMPI was not administered in the LC), composite scores were not found to differ at pre-test (17.6 and 17.0, respectively), $F(1,212)=0.925$, $p=0.34$, or post-test (18.5 for both). Overall, the average increase in OMPI scores between test intervals was just 0.94, although there was some variation across the sample (see Figure 4). Although the average change in OMPI score appeared smaller in the conventional (M=0.86, SD=2.58) than the IT (M=1.54, SD=2.32) format of the class, this difference was not significant, $F(1,212)=1.61$, $p=0.2$, and there was no interaction between test interval and class type, $F(1,212)=1.606$, $p=0.206$. Scores at both intervals were significantly higher than those reported by Johnson and colleagues (1988) for their 25-year-old sample of college students (M=15.5, SD=3.3), $F(1,290)=21.3$, $p<0.0001$, as well as their US standardization sample (M=16.1, SD=4.0), $F(1,290)=10.9$, $p=0.0001$, and were more similar to those reported for sociobiologists and personality psychologists (both 18.7). There were modest correlations between composite TOS and OMPI scores at pre-test ($r=0.29$, $p<0.0001$) and post-test ($r=0.26$, $p=0.0002$), suggesting that the two measures were related, although there was not a significant correlation between the pre- to post-test change on the two measures ($r=0.11$, $p=0.083$).

A large majority of students agreed with the organismic position that things can look different if we change how we see them (item 2), that all things tend to change over time (item 6) and are influenced broadly (item 17), that life is a process of exchanging supplies back and forth (item 12), that all of their relationships are different (item 16), that it is unrealistic to live independently of others (item 19), and that people and their environments mutually influence each other (item 25). However, students were more evenly split on items including whether organisms are changed from the outside or can change themselves (item 3), whether scientific progress comes more from imagination or experimentation (item 5), whether a business executive needs more time for the analysis of facts or creative thinking (item 7), whether knowledge is limited by observation or imagination (item 11), whether divorce follows from incompatible personalities or is a phase in the partners' growth (item 14), and whether facts are more useful than a good idea (item 15). Of the 26 items on the OMPI, only 7 showed significant change at post-test when analyzed with χ-square, "goodness of fit" tests (see Table 3). Used here, this test indicates whether the distributions of preferences for the two alternatives on each item were the same at the two test intervals, and is dependent upon the similarity of the distributions as well as the total number of observations. For a particular question and test interval, given 214 participants, proportional response ratios greater than or equal to 0.43/0.57 were indicative of an overall response preference; response ratios smaller than that did not differ statistically from 0.50/0.50. Of the 7 items that showed significant change at post-test, all but one was

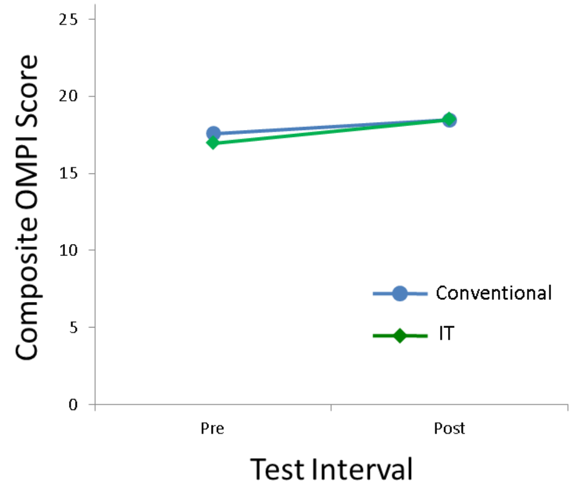

Figure 3. Composite OMPI scores for the two class formats tested as a function of test interval. Although the increase in score was modest it was significant and did not differ between the two classes.

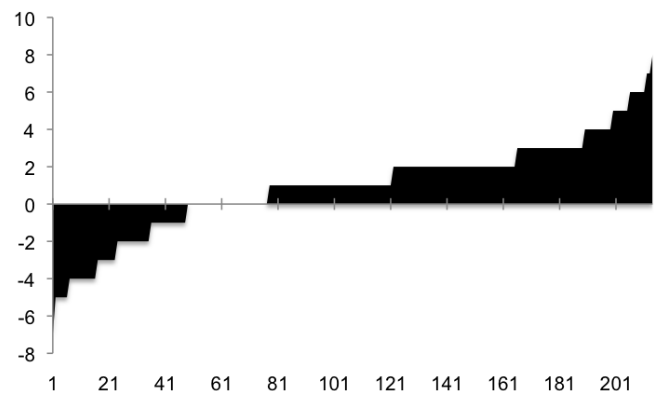

Figure 4. Distribution of changes in OMPI scores (y-axis) sorted by magnitude across the 214 participants who completed the full measure. Negative scores indicate lower OMPI values at post-test and, therefore, more mechanistic thinking. Note the asymmetry of the distribution with its bias toward positive scores (i.e., increasingly organismic thinking).

	Survey Item	Pre	Post	*X-square (Pre vs. Post)*	*P*
1	*Schools should be where a child learns to think for him/herself.* Schools should be where a child learns basic information.	0.68	0.76	3.35	0.067
2	*Things really look different if we change how we see them.* Things really look different only if they are changed.	0.99	0.98	---	0.449
3	Organisms change by forces from outside themselves. *Organisms can change themselves.*	0.54	0.55	0.01	0.920
4	A good judge is purely objective. *A good judge is not objective and knows it.*	0.55	0.67	6.15	0.013
5	*Great discoveries come from scientific imagination.* Great discoveries come from scientific experimentation.	0.56	0.56	0.01	0.920
6	All things stay basically the same over time. *All things change from one moment to the next.*	0.84	0.90	7.34	0.007
7	A business executive needs time to analyze the facts. *A business executive needs time for creative thinking.*	0.46	0.50	0.46	0.498
8	*Before making a big decision, I like to sleep on it.* Before making a big decision, I like to get all the information.	0.14	0.19	1.69	0.193
9	*Progress in science occurs when there is a new way of looking at events.* Progress in science occurs when an important observation is made.	0.58	0.62	0.48	0.488
10	A criminal is just a burden to society. *A criminal has a function in society.*	0.71	0.82	6.81	0.009
11	Our knowledge is limited by our observations. *Our knowledge is limited by our imagination.*	0.51	0.57	0.94	0.332
12	Living is a process of using up the available supplies. *Living is a process of exchanging supplies back and forth.*	0.88	0.90	0.21	0.647
13	Events are sometimes just the same as before. *Events are always new and different in some way.*	0.81	0.86	1.69	0.194
14	*Divorce is often a phase in each partner's growth.* Divorce is usually the result of incompatible personalities.	0.40	0.50	4.17	0.041
15	Facts are more useful than a good idea. *Facts are less useful than a good idea.*	0.55	0.59	0.61	0.435
16	*Each relationship I have is different.* Each relationship I have is much like the previous one.	0.94	0.94	0.00	1.000
17	Things are changed only when they are directly affected. *Things are changed by everything else.*	0.91	0.89	0.41	0.523
18	We learn by carefully examining individual facts. *We learn by finding order in an array of facts.*	0.86	0.86	0.00	1.000
19	*To live independently of other people is not a realistic goal.* To live independently of other people is a realistic goal.	0.85	0.88	0.98	0.322
20	*War can be understood by examining what purpose it served.* War can be understood by examining its causes.	0.36	0.40	0.36	0.549

21	*The world is like a large, living organism.* The world is like a large, complex machine.	0.80	0.71	4.09	0.043
22	A child discovers the world by being praised and punished. *A child discovers the world by testing his/her dreams and fears.*	0.76	0.71	0.77	0.380
23	I can change things in my family only by planned action. *I can change things in my family just by being who I am.*	0.75	0.86	6.53	0.011
24	*A child's world is different from mine.* A child's world is like mine, but he/she knows less.	0.61	0.73	6.59	0.010
25	Persons are made by their environments. *Persons and their environments affect each other.*	0.93	0.95	0.68	0.410
26	*To resolve a family dispute, it is important how we look at the facts.* To resolve a family dispute, it is important to discover all the facts.	0.57	0.59	0.04	0.840

Table 3. Average pre- and post-test responses to individual OMPI items. Items were presented in a two-alternative, forced-choice manner. The alternative shown in italics is the one consistent with an organismic worldview. Values in the pre and post columns indicate the proportion of responses (for 214 participants) that were consistent with the organismic alternative. Within a test interval proportions <0.43 or >0.57 can be considered an overall response preference (i.e., $p \leq 0.04$ when compared to a 50/50 response profile). χ-square tests were used to determine whether the distributions at pre- and post-test were the same (the Yates corrected value is reported along with its associated two-tailed p-value).

consistent with increasing organicism. Specifically, more students came to agree with the organismic statements: “A good judge is not objective and knows it”; “All things change from one moment to the next”; “A criminal has a function in society”; “Divorce is often a phase in each partner’s growth”; “I can change things in my family just by being who I am”; and “A child’s world is different from mine.” On item 21, on the other hand, the percentage of students agreeing with the statement that the world was like a large living organism rather than a large complex machine decreased from 80% to 71%. Despite this mechanistic shift, however, the fact remains that a sizable majority of students still endorsed the organismic alternative at post-test.

DISCUSSION

This study was motivated by a simple question: What impact can a single introductory course in biological psychology have on a student’s worldview? To address this question, three separate measures—a modified version of Coan’s (1979) Theoretical Orientation Scale (TOS), Germer and colleagues’ Organicism-Mechanism Paradigm Inventory (OMPI; 1982; as cited in Johnson et al., 1982), and a 14-item survey with items related to biological psychology and the philosophy of mind—were administered to students enrolled in several formats of a 200-level (yet introductory) Brain & Behavior course, at the beginning and end of the 10-week term. One format was a conventional class, another was a “learning community” (LC) in which the class was taken in parallel with one in the Philosophy of Mind, and the third was an “immersion term” (IT) in which a small cohort participated in a team-taught, 4-course-equivalent program in Neurophilosophy (Harrington et al., 2013). The short answer to the motivating question was that students did report changes in their response profiles for these measures, that these changes were generally, though not always, consistent with the objectives of the class, and that greater change was sometimes seen in the more intensive (and “philosophy heavy”) formats of the class.

On the modified version of the TOS used here, students tended to cluster near the midpoint of the scale at both test intervals, though they moved slightly away from the organismic end of the continuum by the end of the term. On a scale with a range of 56 points, the entire sample shifted by an average of just –2.4 points. The shift was smallest in the conventional format of the class (–1.9), largest in the IT (–4.4), and intermediate in the LC (–3.8). Many of the item-level changes were consistent with increasing mechanism with the average changes in composite scores driven by students’ greater willingness to endorse the predictability of human behavior. In fact, it might be more appropriate to limit conclusions to this statement alone rather than to say that students became more “mechanistic” in general, particularly in light of the results of the OMPI (described below). There was also one item where the change at post-test was said to be explicitly inconsistent with increasing mechanism: “Psychologists should be as concerned with explaining private conscious experience as they are with explaining overt behavior.” Students were more likely to agree with this statement by the end of the term. Although this might be inconsistent with a mechanistic worldview as defined by Coan in 1979, it is certainly not inconsistent with contemporary research in biological psychology (e.g., Coghill et al., 2003; Lutz and Thompson, 2003) or with the teaching objectives of my class. Perhaps this is the best evidence that the TOS is beginning to show its age. The TOS, developed for the assessment of psychologists in the late 1970s, reveals a lingering behaviorist bias whereby all inquiries into private conscious experience were to be avoided, and this bias has certainly had its parallel in the neurosciences. The epigraph of Crick's *Astonishing Hypothesis*, for example, includes the following from philosopher, John Searle: "As recently as a few years ago, if one raised the subject of consciousness in cognitive science discussions, it was generally regarded as a form of bad taste, and graduate students, who are always attuned to the social mores of their disciplines, would roll their eyes at the ceiling and assume expressions of mild disgust." I don't believe this renders the scale items themselves useless, but would rather suggest that we might either need to reconsider what we mean by a mechanistic explanation of behavior and experience, or we will need to decide whether our discipline is best considered as a wholly mechanistic one.

On their face, the results of the modified TOS and the OMPI might appear to be in opposition. The composite TOS scores suggested that students became less organismic, whereas those from the OMPI suggested they became more so. The scope of the modified TOS used here is certainly narrower than the full TOS (which I have now begun to administer) as well as the OMPI, the latter point being evident when we compare the items on these two measures. In short, the results of the OMPI are more likely to be indicative of the *general* mechanistic-organismic beliefs of the students. The results of the OMPI showed that students had a more organismic worldview at the beginning of the term and became slightly more organismic by the end of the term. Indeed, of the 214 participants who completed the OMPI, 166 (77.6%) showed either no change at post-test or an increase in organicism. In contrast to what was observed for the TOS, there were no differences between students completing the conventional and IT formats of the class on the OMPI. Consistent with an organismic worldview, for example, students tended to believe that the world is constantly changing; that our perspectives on events matter; that each of our relationships is unique; and that people and their environments mutually affect one another. However, they were less clear about the relative contributions of experimentation and imagination to scientific discovery, the relative importance of facts and our perspective on them in resolving disputes, or whether the organism or its environment more strongly influences behavior. Their confusion about whether science advances by way of experimentation or imagination as revealed on the OMPI was also evident in the way they responded to several items on the TOS. Specifically, students were more or less neutral at both test intervals when asked whether intuition plays a central role in science (TOS item 13), or whether the scientist should contribute hypothetical formulations in theory development (TOS item 8). Although this pattern of response might be explained by a failure to fully appreciate the question posed, a more charitable possibility might be that they regarded these forced-choice alternatives as a false dichotomy. Can we not have it both ways?

Some of the survey items addressed course content more directly than others. One of the items, "The mind exists as something separate from the body," can be used to illustrate the nature of the changes that can occur from the beginning to the end of the term on a particularly contentious topic. This statement, addressing the topic of dualism, showed a statistically significant change from the beginning (M=3.24) to the end of the term (M=3.50) with students becoming slightly less likely to agree that mind and body are separate. As described earlier, the organizing theme of this class has been Crick's decidedly non-dualistic astonishing hypothesis (1994), that "You are nothing but a pack of neurons." On the dualism item, my students began the term close to neutral on average and came to disagree a little more by the end of the term. But there is more to this story than just a small shift in the average response. The distribution of responses across the 5-point scale from strongly agree through neutral to strongly disagree at pre-test was 19, 71, 69, 122, and 31, and at post-test it was 12, 71, 51,108 and 70 (see Figure 5). Ninety (28.8%) students agreed (or strongly agreed) with dualism at pre-test, compared to 83 (26.6%) at post-test. The bulk of the change that occurred, therefore, seems to have involved students who had been neutral at the beginning of the term moving toward disagree at the end. There were 18 fewer students who responded "neutral", and 25 more students who disagreed or strongly disagreed, at post-test. Despite the mean shift in responses across the term, therefore, these data suggest that many of those who arrived as dualists, likely departed the same way.

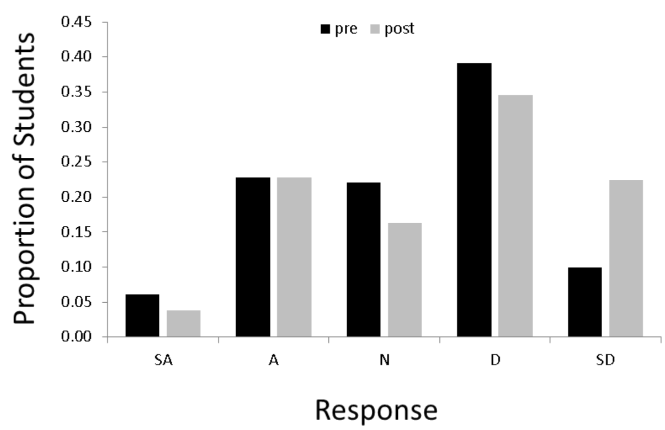

Figure 5. Distribution of responses of 312 students to the survey item "The mind exists as something separate from the body." Bars indicate the proportion of students who made each of the five possible responses at pre- (black) and post-test (gray). Similar proportions of students agreed with dualism at both intervals with the shift in mean response at post-test accounted for by students moving away from neutral at the end of the term.

It is also interesting to compare student responses to similar questions from the different instruments. Despite extensive discussions about how easily our perceptual experiences can distort or otherwise misrepresent the facts of the external world (and an instructor who also teaches a Sensation & Perception laboratory class), on the survey item "Our senses allow us to experience the world as it truly is (objectively)," the average response changed from 2.93 (near neutral) to only 3.36 (between neutral and disagree). Likewise, on the OMPI item, "A good judge is not objective and knows it," 55% of students agreed with this statement at the beginning of the term compared to 67% at the end. The pre- to post-test shifts on these items are certainly in a direction consistent with my teaching objectives, but their magnitude is underwhelming. This could mean that 1 in 3 students still believe that their perceptions are objective, unequivocal, and true. Then again, it might only indicate that students were willing to give their perceptions the benefit of the doubt because they generally appear to be objective.

After collecting responses to a total of 56 questions from several hundred students we appear to have some evidence of belief change engendered by a single introductory course in biological psychology. There are several limitations of the study that must be acknowledged. The first is that despite the benefits of the within-subjects design used here for demonstrating change, it is uncertain what drove the changes observed. While I am motivated to conclude that it was exposure to the course material that accounts for the change, given my inability to control for experiences outside of my class and my failure to collect data from students in different courses as a control condition, one cannot be certain. The lack of a control group followed in part from uncertainty about what the best control group would be, as well as from the practical challenges that collecting these data from someone else's students would have presented. A second obvious criticism is that perhaps what we have observed is simply a willingness to *report* ideological shifts. This issue, of great relevance when using any self-report measures, is not a trivial one and its ubiquity should not exempt us from considering its potential role in shaping these results. The possibility of both socially desirable and undesirable responding should temper any conclusions gathered using these techniques, particularly given that the questionnaires were not completed anonymously. However, one might also counter that regardless of whether the changes reported here were "real" or not, the fact that students were considering how their beliefs might compare to those of their peers or the practitioners of the discipline is valuable in its own right.

Despite any of these limitations, I would certainly like to take some credit for the changes reported in this paper and would like to use these results to provide some support for the effectiveness of the things I do in the classroom. But, beyond assessing instructional efficacy, what can be done with data like these? When I first began to administer these questionnaires, I would often review the average results with the class in the next meeting by making general statements like, "The most common response to the question about whether free will makes the prediction of human behavior impossible was to agree." From there we could talk about why we might suggest this or some of its alternatives and, once we completed the post-test at the end of the term, we could talk about any changes observed in the class as a whole. I remain mindful of protecting the students who hold minority views (even if those views were consistent with my own), giving them the opportunity to speak up in the discussions, though not mandating it. In my experience, students in my classes have been very open to minority views and, indeed, this openness might be related to their tendency as a group to espouse a more organismic orientation. I have also experimented with returning the scored instruments to the students so that they can see exactly how they responded to each item at both test intervals. The decision to do this was not made lightly because it would seem to increase the likelihood that students might adjust their responses to be more consistent with the responses of the class as a whole, and would even make advance study of the post-test (or even the pre-test if they could receive the instrument from a student who took the class in a previous term) possible. Fortunately, my students seem to be just indifferent enough to the instrument that the thought of "prepping" for the survey never arises, and indifferent enough to any discrepancies between their responses and those of others that they don't seem to socially calibrate. Furthermore, the pattern of responses obtained across terms has remained similar regardless of whether students had the opportunity to see their individual responses or not. Presently, my practice is to administer these questions via online survey, to talk in broad outline about the data after the pre-test, and to provide students with their individual item-level responses and any composite scores at the end of the term upon request. Regardless of the approach taken in test administration, however, asking these questions of students has proven to be a valuable activity in my course.

In my estimation, these surveys have had two primary benefits: one for me as an instructor and the other for my students. As an instructor, particularly at the end of the term, I get feedback about my students' positions with respect to the central course topics and themes. This kind of feedback should appeal to any empirically minded person on its face. But it also provides data that can be used to adjust instruction to better achieve certain teaching outcomes. For example, a student might respond to a question on an exam in such a way as to indicate that we shouldn't trust our perceptions (in cases of eyewitness testimony, for example), but if they would indicate on the survey that they still would trust their own eyewitness testimony, we have a conceptual disconnect. These kinds of disconnects are common in many disciplines and have been studied extensively in physics (e.g., Halloun and Hestenes, 1985), but, like the issue of socially desirable responding, their commonness does not make them any less troubling. As for the students, they get an opportunity to compare two intellectual "snapshots" of themselves. It's easy to forget what you used to believe. In fact, it is well established that people have a tendency to assume that what they believe now they have always believed, a phenomenon referred to as the hindsight bias (e.g., Fischoff et al., 1975; Bernstein et al., 2011). By having access to a simple report about their beliefs at two points in time, however, these discrepancies can be made plain and students can see whether (and, if so, to what extent) they have changed. I have no evidence of this, but my suspicion is that this activity would have greater appeal to organismic than mechanistic thinkers because those in the former group are said to appreciate change more than those in the latter group (Johnson et al., 1988).

In summary, I recommend the use of pre- and post-test survey instruments for a variety of reasons. Beyond the benefits just described for students who are willing to work with these instruments, they allow faculty to gain a clearer sense of how much of what happens in the classroom matters in the "minds" of our students, and where our efforts might be redirected in the future. One direction that might be beneficial for future work is to follow the lead of educators elsewhere in the natural and physical sciences who have developed inventories with the expressed intent of characterizing, in often exhaustive detail, the conceptual systems of their students (e.g., Halloun and Hestenes, 1985; Hestenes et al., 1992; Michael, 1998; Anderson et al., 2002). The production of such an inventory for the various sub-disciplines of our field seems almost inevitable given the current emphasis on the documentation of learning outcomes in higher education. Maybe this endeavor is misguided and the beliefs of our students are irrelevant to our goal of promoting their understanding of our discipline. My concern with this, however, is that if we exclude belief we will diminish what we mean by understanding. There is also no doubt that existing beliefs can act as impediments to future understanding. We all have entrenched conceptual systems that are resistant to change. This is why patience and humility are such critical attributes of educators. The news isn't always good. There are many times that you will not see the kinds of responses, or the kinds of changes, you would like to see. And while our students must shoulder some of the responsibility for any failure to come around to our way of seeing things—if for no other reason than that they are human—we suffer from the same shortcomings, too (Wood, 2000). Perhaps they are rejecting our evidence for a certain position because, in contrast to how clear that evidence appears to us, it simply isn't. We can only hope to get answers to these questions if we're willing to ask them.

REFERENCES

Ahluwalia R (2000) Examination of psychological processes underlying resistance to persuasion. J Consum Res 27:217-232.

Allen GE (2005) Mechanism, vitalism and organicism in late nineteenth and twentieth-century biology: the importance of historical context. Stud Hist Philos Biol Biomed Sci 36:261-283.

Anderson DL, Fisher K, Norman GJ (2002) Development and evaluation of the conceptual inventory of natural selection. Journal of Research in Science Teaching 39:952-978.

Bernstein DM, Erdfelder E, Meltzoff AN, Peria W, Loftus GR (2011) Hindsight bias from 3 to 95 years of age. J Exp Psychol Learn Mem Cogn 37:378–391.

Briñol P, Rucker DD, Tormala ZL, Petty RE (2004) Individual differences in resistance to persuasion: the role of beliefs and meta-beliefs. In Resistance to persuasion (Knowles ES and Linn JS, eds) pp 83-104. Mahwah, NJ: Lawrence Erlbaum Associates.

Coan RW (1979) Psychologists: personal and theoretical pathways. NY: Irvington.

Coghill RC, McHaffie JG, Yen Y –F (2003) Neural correlates of interindividual differences in the subjective experience of pain. Proc Natl Acad Sci U S A 100:8538-8542.

Crick F (1995) The astonishing hypothesis: the scientific search for the soul. London, UK: Simon & Schuster.

Demertzi A, Liew C, Ledoux D, Bruno M -A, Sharpe M, Laureys S, Zeman A (2009) Dualism persists in the science of mind. Ann N Y Acad Sci 1157:1-9.

Fischhoff B (1975) Hindsight not equal to foresight: the effect of outcome knowledge on judgment under uncertainty. J Exp Psychol Hum Percept Perform 1:288–299.

Gilbert SF, Sarkar S (2000) Embracing complexity: organicism for the 21st century. Dev Dyn 219:1-9.

Halloun IA, Hestenes D (1985) The initial knowledge state of college physics students. Am J Phys 53:1043-1055.

Harrington I, Geedey CK, Storl H, Heine R (2013) The immersion term experiment: reflections, one year later. Chalk: Teaching and Faculty Development 2:16-19.

Hestenes D, Wells M, Swackhamer G (1992) Force concept inventory. Phys Teach 30:141-158.

Johnson JA, Germer CK, Efran JS, Overton WF (1988) Personality as the basis for theoretical predilections. J Pers Soc Psychol 55:824 835.

Limón M (2001) On the cognitive conflict as an instructional strategy for conceptual change: a critical appraisal. Learning and Instruction 11:357-380.

Lord CG, Ross L, Lepper MR (1979) Biased assimilation and attitude polarization: the effects of prior theories on subsequently considered evidence. J Pers Soc Psychol, 37:2098-2109.

Lutz A, Thompson E (2003) Neurophenomenology: integrating subjective experience and brain dynamics in the neuroscience of consciousness. Journal of Consciousness Studies 10:31-52.

Michael JA (1998) Students' misconceptions about perceived physiological responses. Advan in Physiol Edu 19:S90-S98.

Morse SJ (2008) Determinism and the death of folk psychology: two challenges to responsibility from neuroscience. Minn J Law Sci Technol 9:1-36.

Nersessian NJ (1989) Conceptual change in science and science education. Synthese 80:163-183.

Reese HW, Overton WR (1970) Models of development and theories of development. In Lifespan developmental psychology: research and theory (Goulet LR and Baltes PB, eds). New York: Academic Press.

Sinatra GM, Brem SK, Evans EM (2008) Changing minds? Implications of conceptual change for teaching and learning about biological evolution. Evolution: Education and Outreach, 1:189-195.

Wood W (2000) Attitude change: persuasion and social influence. Annu Rev Psychol 51:539-570.

Received March 04, 2013; revised August 17, 2013; accepted August 21, 2013.

This work was supported by a post-tenure sabbatical awarded to the author. I would like to thank Prof. Heidi Storl, Department of Philosophy, for her willingness to corrupt a biological psychologist with just the right kind of philosophy; the students in my Brain & Behavior classes including two learning communities and two immersion terms; Augustana College for supporting the teaching experiments that were expressed in the forms of the learning communities and immersion terms; and Prof. Larry McCallum for his encouragement and for helpful discussions of these topics from the very beginning.

Address correspondence to: Dr. Ian A. Harrington, Department of Psychology and Program in Neuroscience, 639—38th St., Rock Island, IL 61201. Email: IanHarrington@augustana.edu