ARTICLE
Reducing Brain Injury Misconceptions and Willingness to Risk Concussion with a Three-Week Introductory-level Neuroscience Course

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https://doi.org/10.59390/LEAF8930

Misconceptions of brain injury are common and persistent in the general public (Ralph and Derbyshire, 2013). Moreover, undergraduate students are in an age range where they are at high risk of concussion and traumatic brain injury, but often lack knowledge of the symptoms, severity, recovery, and varied impacts of brain injury on cognition. Introductory-level undergraduate neuroscience courses have the potential to reach a broad audience and improve students' knowledge of the brain. It is also important to know, however, if neuroscience courses can combat common misconceptions and impact real-world behaviors like willingness to risk concussion and prevention of brain injury. An introductory-level immersive three-week course during January term was developed, targeted at first-year students and non-majors. The focus of the course was to help students understand the role of different brain regions in behavior by presenting neurological cases that demonstrate the human experience of brain injury. Following the course, all students displayed greater knowledge about brain injury and reduced willingness to risk brain injury or concussion. Although students with a history of concussion were more willing to risk future concussion overall, they did show a similar reduction in risk as those without a history of concussion but were also less likely to endorse safety practices like helmet use. Beyond improving basic knowledge of neuroscience, introductory-level courses also have an opportunity to impact students' understanding of brain injury in their personal and professional lives.

Key words: brain injury misconception; concussion knowledge; immersive course; introductory courses; traumatic brain injury

Traumatic brain injury (TBI) is one of the leading causes of death and disability in the United States, and individuals between 15-24 years old, an age range which includes most college students, are one of the highest risk age groups for sustaining a TBI (Faul et al., 2010; Taylor et al., 2017). Underreporting of TBI or concussion, however, is common due to lack of knowledge of symptoms and severity, and reluctance to seek care (Meier et al., 2015). Beyond reporting behavior, the general public's lack of knowledge of brain injury can also negatively impact the ways that individuals with TBI are treated. The invisible nature of disability following TBI and the complex and varying impacts on long-term behavior are frequently not fully appreciated by friends, family, and colleagues (Swift and Wilson, 2001). Increasing public awareness of the varied impacts brain injury can have on behavior and cognition is critical for decreasing risky behavior, increasing the likelihood that individuals will seek medical care and report brain injuries, and for reducing stigma and providing societal support for individuals with TBI (Block et al., 2016).

Multiple studies have shown that the general public holds many misconceptions of the symptoms, consequences, and recovery of brain injuries. Although "concussion" and "mild traumatic brain injury" are synonymous (Lumba-Brown et al., 2018), many in the general public do not realize this (McKinlay et al., 2011). Moreover, there has been little change in public knowledge over time (Ralph and Derbyshire, 2013), including similar accuracy rates on brain injury misconception inventories from the 1980s (Gouvier et al., 1988) to as recently as 2019 (e.g., Merz et al., 2017; O'Brien et al., 2019). For example, 46% of respondents believed that a second blow to the head could restore lost memories (Gouvier et al., 1988), and more recently, Guilmette and Paglia (2004) found that 41% of respondents believed the same. In general, there tends to be misconceptions about the memory loss and recovery associated with brain injury, post-concussion symptoms, and chronic traumatic encephalopathy (CTE), even among participants who had previously experienced a concussion (Gouvier et al., 1988; Hux et al., 2006; Merz et al., 2017).

Even with growing awareness of concussions, many studies report uneven knowledge. For example, Waltzman et al., (2018) found high awareness of causes of concussion, but less knowledge of the symptoms. Given the number of concussions that occur during athletics, and the increased awareness at the professional level of the consequences of concussion, nearly all high school and college athletes are now legally mandated to receive concussion education (Parsons and Baugh, 2018). There is varying data however, about the efficacy of concussion education programs on knowledge and real-world reporting behavior (e.g., Caron et al., 2015; Kroshus et al., 2015; Knollman-Porter et al., 2018). Moreover, the intention of these education programs is solely on concussion symptoms and recovery for athletes in the context of their sport but are less likely to address broader knowledge and misconceptions about brain injury.

Introductory undergraduate courses have the potential to educate a broad audience, are ideally suited for helping students develop an appreciation of the field and can minimize the impact of myths and misconceptions on their future personal and professional lives. Introductory courses have been shown to reduce misconceptions that are common in the general public in psychology (Taylor and Kowalski, 2004) and can change students' beliefs about the relationship between mind and brain in neuroscience (Harrington, 2013). Much of the literature around neuroscience education has focused on dispelling "neuromyths" like using only 10% of the brain and right/left brain personalities, especially for future educators, with mixed results (Macdonald et al., 2017; Novak-Geiger, 2023). It remains to be seen, however, if brain injury knowledge and misconceptions can be impacted by information from an introductory-level undergraduate course that is not focused on concussion education per se, but instead is part of a general background in understanding brain function and brain-behavior relationships. Beyond improving knowledge, it is also important to consider the potential impact neuroscience courses can have on our students' real-world behavior and decision-making related to willingness to risk concussion and prevention of brain injury.

Many colleges and universities offer immersive condensed courses, which are short (typically less than 6 weeks) but intensive courses where students take a single course that equates to the credit load of a single full semester course (Richmond et al., 2015). Typically, these courses are held during transitional periods in the academic year, such as January (J-term) or May (Maymester). Multiple researchers have found that students perceive immersive courses to be more effective (Kucsera and Zimmaro, 2010; Walsh et al., 2019) and are associated with higher student satisfaction (Richmond et al., 2015). There is debate, however, about the impact on student performance (Richmond et al., 2015 and see Whillier and Lystad, 2013) and the long-term retention of information due to the compressed duration of the course (Walsh et al., 2019). At Augustana College, January term courses are required for first-year students and are frequently introductory-level courses that expose students to a variety of disciplinary ideas. For many students, the J-term course may be their only exposure to the field as many go on to pursue other majors. Therefore, since immersive courses are typically well received in terms of student satisfaction and effectiveness, it is a potentially useful educational tool to expose students who might not otherwise take a full semester neuroscience course to fundamental neuroscientific knowledge and reduce misconceptions commonly found in the general public. The goal of this study was to see if a three-week introductory-level course focused on the human experience of brain injury would lead to change in knowledge, awareness, and willingness to risk brain injury.

MATERIALS AND METHODS

Course Details

The course titled "Tales of Brain Injury" is a 100-level elective without prerequisites housed in the Department of Psychology and Neuroscience at Augustana College in Rock Island, IL. Augustana College is a four-year residential college with roughly 2,500 students. At the time of the two course offerings included in this study (January term of 2021-22 and 2022-23), all first-year students at Augustana College and any students who were participating in an athletic program required to be on campus had to enroll in a J-term class. Thus, the course was targeted towards first-year students and non-majors, as most students in the course had very little experience with Psychology or Neuroscience (41% had not taken any college or high school level Psychology or Neuroscience courses). The course is capped at 20 students, and the cap was met both years, though one student dropped the course in 2021-22, so the final sample size was 39 students. The course met for 3 hours per day for 17 days and utilized popular press book chapters and films to introduce students to neurological cases (see supplemental materials for reading list). Importantly, the focus of the course was not on concussion education, prevention, or symptoms directly, but instead to help students better understand the role of different brain regions in behavior by studying the varied impacts of focal and traumatic brain injury. Beyond this, the goal was to present the human experience of brain injury, including the challenges, struggles, resilience, and recovery of individuals who had experienced a brain injury. Included were some of the most well-known cases of brain injury in neuroscience, including H.M. (hippocampus), S.M. (amygdala), and E.V.R. (ventromedial prefrontal cortex).

Survey Instruments

Students completed the survey instruments on the first and last days of the course. Students were asked about their status as an athlete and whether they had previously experienced a concussion. Eighteen true/false questions regarding brain injury knowledge and misconceptions were taken from multiple previous studies (see Table 1 for a full list of questions). To assess knowledge and attitudes related to concussion, the Rosenbaum Concussion Knowledge and Attitudes Survey—Student Version (RoCKAS; Rosenbaum and Arnett, 2010) was used. The RoCKAS yields a *Concussion Knowledge Index* score, using true/false questions, knowledge of symptoms, and applied scenarios (possible scores 0-25, with higher scores representing more knowledge). The RoCKAS *Concussion Attitudes Index* score measures attitudes towards concussion and safety using Likert scale questions (possible scores 15-75, higher scores represent safer attitudes towards concussions). Finally, to attempt to assess real-world behavior, a measure of willingness to risk concussion or brain injury was adapted using a hypothetical scenario from Garavito et al. (2019). This study had students imagine they were playing football and asked what level of probability (selecting a value between 0-100%) of getting a concussion or brain injury they would be comfortable with. In the current study, the scenario was adapted to skiing to remove potential confounds with athletics as 61% of the participants identified as college athletes, and risk of knee injury was added as a control condition. Finally, students were also asked about their

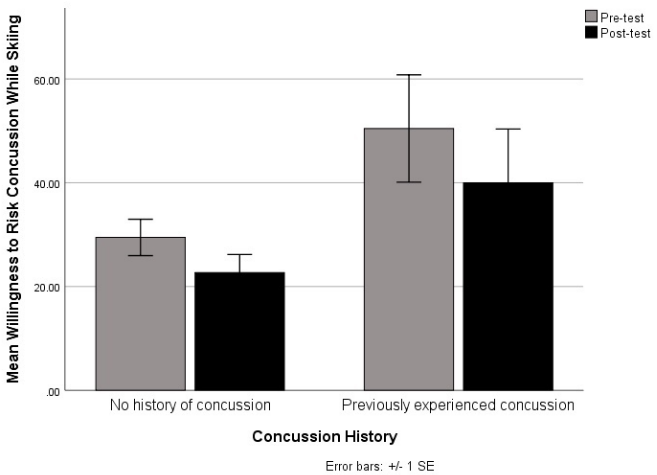

Figure 1. Willingness to risk concussion. Overall, students with concussion history were significantly more willing to risk concussion, but all students showed a similar decrease in reported willingness to risk concussion after the class.

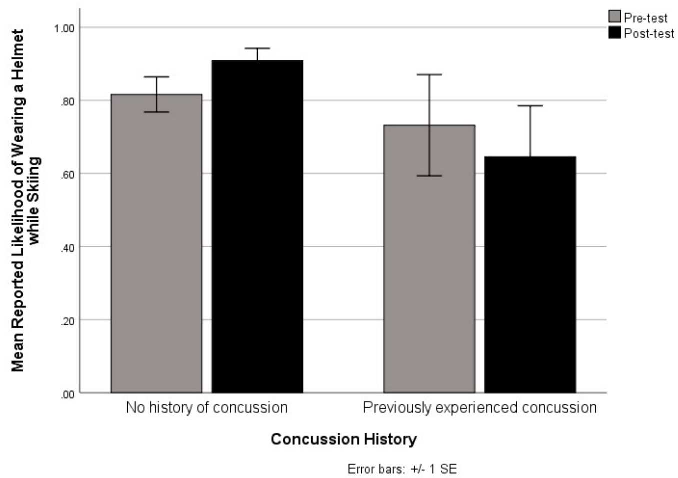

Figure 2. Reported likelihood of wearing a helmet. Students who had no history of concussion reported being more likely to use a helmet after the course, while students with a history of concussion had a lower reported likelihood of wearing a helmet.

likelihood (0-100%) of using a helmet or knee pads while skiing. Study procedures were approved by the Institutional Review Board at Augustana College.

RESULTS

Brain Injury Knowledge and Misconceptions

Overall percent accuracy was compared pre- and post using a one-tailed paired samples t-test. On average, students accurately responded to 80.0% (SD = 6.8%) of the items correct on the pre-test, and this significantly increased to 90.7% (SD = 7.9%) on post-test, t(38)=8.68, p<0.0001, d=1.39. To test for changes on individual items, χ2-square tests of goodness-of-fit were used to compare the post-test distribution of correct responses to pre-test distributions (treated as the expected values). Table 1 shows that four items significantly improved in the distribution of correct responses in the post-test, including two items related to the cause and diagnosis of CTE, recognition that concussion and mild TBI are synonymous, and a better understanding of memory impairments following brain injury. There was one item that remained relatively low (56.4% accuracy), showing no post-test change, related to lack of complete recovery in severe brain injury.

RoCKAS

For the *Concussion Knowledge Index*, at pre-test, students scored an average of 19.06 (SD = 2.01), and post-test scores were on average 19.81 (SD = 2.02), and this change was small but statistically significant t(38)=1.96, p = 0.029, d=0.31. There were 14 true/false questions regarding concussion knowledge included in the index, and χ2-square tests of goodness-of-fit showed significant improvement in accuracy on two misconceptions related to the ability of brain imaging to show physical signs of concussion and the definition of coma. For the *Concussion Attitudes Index*, at pre-test, students scored an average of 57.33 (SD=6.80), and post-test scores were on average 58.86 (SD=6.58), this change did not reach statistical significance t(38)=1.50, p=0.071, d=0.24.

Risk Threshold for Concussion and Brain Injury

Overall, change in reported willingness to risk injury and likelihood of safety equipment use was compared pre- and post- using one-tailed paired samples t-tests. On average students were significantly less willing to risk concussion (Pre: 35.38, Post: 27.56%, t(38)=2.79, p=0.004, d=0.45), or brain injury (Pre: 22.94%, Post: 16.53% t(38)=1.98, p=0.025, d=0.32) after the course, while there was no change in the control scenario of the willingness to risk knee injury (Pre: 36.92%, Post: 37.16%, t(38)=0.83, p=0.934, d=0.01), or likelihood of wearing knee pads (Pre: 36.15%, Post: 36.54%, t(38)=0.83, p=0.934, d=0.01). There was a slight increase in students' reported likelihood that they would wear a helmet while skiing (Pre: 79.23%, Post: 83.46% t(38)=1.31, p=0.098, d=0.21), but this was not significant.

Concussion History

Of the thirty-nine students in the sample, eleven (28%) self-reported that they had previously experienced a concussion. To see if concussion history impacted the results, repeated measures ANOVAs were conducted using concussion history as a between-subjects factor.

Interestingly, as Figure 1 shows, students who had reported previously experiencing a concussion had higher willingness to risk concussion at both before (M=50.45%; no history M=29.46%) and after the course (M=40.00%; no history M=22.67%), (F(1,37) =5.9, p=0.020, ηp2 =0.138). There was a significant main effect of time, as all students reported being significantly less willing to risk concussion after the class F(1,37) =7.5, p=0.009, ηp2 =0.169. There was no interaction between time and concussion history, suggesting that both those with and without concussion history had a similar decrease in reported willingness to risk concussion after the class, F(1,37) =0.341, p=0.563, ηp2 =0.009.

Most surprisingly, on average, students who had previously experienced a concussion decreased their reported likelihood of wearing a helmet during skiing after

Question (answer in parentheses)	Pre-test	Post-test	χ2 (Pre vs. Post)	p-value	Recent published data
1. A little brain damage does not matter because people only use a small portion of their brains anyway (F)	100	100	0	1.0	89.6^
2. How quickly a person recovers from a brain injury depends mainly on how hard they work on recovering (F)	71.2	82.0	2.02	0.15	67.8^
3. Complete recovery from a severe brain injury is not possible, no matter how badly the person wants to recover (T)	56.4	56.4	0	1.0	51.8^
4. After a brain injury it is usually harder to learn than before the injury (T)	84.6	79.5	0.78	0.38	63.2^
5. A head injury can cause brain damage even if the person is not knocked out (T)	97.4	100	1.02	0.31	90.6^
6. Whiplash injuries to the neck can cause brain damage even if there is no direct blow to the head (T)	100	100	0	1.0	83.7^
7. Most people with brain damage look and act disabled (F)	97.4	100	1.02	0.31	77.5^
8. The word “concussion” means the same thing as “mild traumatic brain injury” (T)	58.9	89.7	15.26	<0.001	67.4^
9. Chronic traumatic encephalopathy (CTE) can only be diagnosed after death (T)	41.0	97.5	51.29	<0.001	45.6^
10. Scientific evidence suggests a relationship between multiple concussions and problems with thinking skills (T)	94.9	100	2.10	0.15	87.9^
11. Scientific evidence suggests a relationship between multiple concussions and emotional disturbances (T)	94.9	97.4	0.53	0.47	88.6^
12. A concussion is harmless and never results in long-term problems or brain damage (F)	100	97.4	1.02	0.31	85.0^
13. Once a person feels “back to normal,” the recovery process is complete (F)	94.9	94.9	0	1.0	80.5^
14. CTE can be caused by a single event/injury (F)	33.3	74.4	29.54	<0.001	38.1^
15. It is obvious that someone has brain damage because they look different from people who do not have brain damage. (F)	100	100	0	1.0	86.4^^
16. It is possible that a person’s personality will change after a brain injury. (T)	97.4	100	1.02	0.31	83.7^^
17. A person with brain injury may have trouble remembering events that happened before the injury, but usually does not have trouble learning new things. (F)	35.8	74.3	25.07	<0.001	31.9^^
18. Most people with severe brain injuries are eventually able to return to their previous jobs (F)	82.0	89.7	1.57	0.21	40.8^^^

Table 1. Brain Injury Knowledge Questions. The percentage of the sample that answered correctly (i.e., did NOT endorse the misconception) pre- and post-test. Questions 8, 9, 14, and 17 showed significant change in the distribution of correct responses in the post-test. For comparison, the most recent published data surveying the general public is provided from ^Merz et al. (2017) U.S. Sample, ^^O’Brien et al. (2019), or ^^^Guilmette and Paglia (2004).

the class relative to before the class. There was no main effect of time, $F(1,37) = 0.1$, $p=0.922$, $\eta p2 = 0.00$, or main effect of concussion history, $F(1,37) = 2.84$, $p=0.10$, $\eta p2 = 0.071$. As Figure 2 shows, there was a significant interaction between time and concussion history, $F(1,37) = 7.338$, $p=0.010$, $\eta p2 = 0.166$, such that students who had not previously experienced a concussion reported being more likely to use a helmet after the course (Pre M= 81.61%, Post M=90.89%), while students with a history of concussion had a lower reported likelihood of wearing a helmet (Pre M= 73.18%, Post M= 64.55%).

No other differences were found based on concussion history for knowledge of brain injury or concussion, or attitudes regarding concussion.

DISCUSSION

Overall, a three-week introductory-level neuroscience course was able to improve student misconceptions of brain injury, increase concussion knowledge, and led to a decrease in reported willingness to risk concussion or brain injury. Importantly, the course was focused on using stories of brain injury due to different etiologies, with impacts on various brain structures and aspects of cognition, to help students better understand the function of the brain and brain-behavior relationships. The course was not a concussion education course and did not directly address most of the misconceptions evaluated. Instead, introductory undergraduate courses are an ideal way to impact misconceptions commonly held by the general public by providing students with the necessary background knowledge to help them understand why the misconceptions are not true.

Knowledge of brain injury and concussion increased in the course, primarily on questions related to CTE, the lack of physical signs of concussion on neuroimaging, recognition that concussion is a brain injury, and understanding the nature of memory impairments following brain injury. Although CTE has received significant public attention, many misconceptions about cause and symptoms prevail, so this is a critical area of education, especially for college athletes (Beidler et al., 2021). While the questions used to assess brain injury knowledge in the current study are limited in scope and breadth, and there is a call for the creation of more comprehensive brain injury knowledge inventories (Bryant et al., 2020), these are the most common questions used by multiple studies that allow for comparison with data from the general public. At pre-test, students were as or more accurate than previous studies on most questions (see Table 1 for comparison data). For example, the RoCKAS included the second blow to the head restoring memory misconception and only 23% of students endorsed the misconception at pre-test, versus ~40% reported by multiple previous studies for the general public. The gains experienced by students also demonstrate that their knowledge improved relative to the general public on nearly all questions. This assessment was also useful for understanding where students did not make knowledge gains, specifically their lack of understanding of the unlikely outcome of complete recovery in severe TBI. Students did not show a significant change on the *Concussion Attitudes Index*, however, many of these scenarios were related to decision making in athletics (e.g., role of athlete, coach, athletic trainer) and were not as applicable to the class material or indicative of students' risk thresholds.

Although the learning outcomes for most courses are focused on knowledge or skill development, it is important to also consider the impact neuroscience courses and pedagogy can have on real-world behaviors. This study measured a proxy of real-world behavior by measuring risk threshold using a hypothetical scenario and found that students reported less willingness to risk brain injury or concussion after the class. As educators, we would hope that an understanding of the function and importance of the brain as well as the impacts of brain injury might translate to real-world behavior. It would be important in the future to measure if greater knowledge of neuroscience impacts real world actions, such as reporting concussions, seeking medical treatment, engaging in risky behavior, or helmet use. Furthermore, this study is limited in that data was collected at the end of the three-week course, and it would be useful to follow up to see if changes in knowledge or risk threshold would persist over longer periods of time. Even though the current study focused on the impact of a condensed course, it is likely that with more time and exposure during a semester long course, similar effects might be seen, and might even have greater benefits for long-term retention.

Students with a previous history of concussion showed different patterns from students who did not report a history of concussion on two measures. First, students with a history of concussion were more willing to risk future concussion at both time points, although they did show a similar decrease across the course as those without a history of concussion. In addition, despite showing a reduction in their willingness to risk concussion, students with a history of concussion reported a lower probability that they would wear a helmet after the course compared to before. Both findings are in line with previous research showing that history of concussion is associated with riskier attitudes and endorsing unsafe practices like returning to play with a concussion, perhaps related to a milder previous concussion experience or a predisposition to risk-taking (Pearce et al., 2017; Rosenbaum, 2007,un-published thesis, [https://etda.libraries.psu.edu/files/final_submissions/288]). Importantly, helmet use, and the mechanism by which helmets protect the brain against injury was not addressed in class, and will be in the future. It is important to understand and consider the differences in risk threshold and perception of concussion for students with a history of concussion as these students are at higher risk for long term impacts if they experience multiple concussions.

There is substantial interest in developing neuroscience courses for first year students or non-majors in order to introduce students to the discipline, as seen in multiple reports published in JUNE (e.g., Willard and Brasier, 2014; McFarlane and Richeimer, 2015; Salomon et al., 2015; Roesch and Frenzel, 2016). These courses provide an ideal opportunity to engage with students who might not otherwise learn about the brain. Beyond improving their basic knowledge of neuroscience, we also have an opportunity to impact their understanding of brain injury in their personal and professional lives, including potentially preventing brain injury by reducing their willingness to risk concussion.

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Received July 19, 2023; revised September 18, 2023; accepted October 6, 2023.

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