

## **Effectiveness of refutational teaching for high- and low-achieving students**

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*Abstract:* We assessed the effectiveness of refutational readings and lecture on decreasing psychological misconceptions for students of high versus low levels of achievement. During the course of a semester we addressed introductory psychology students' misconceptions with refutational readings, refutational lecture, or not at all. From pre- and post-test measures of student misconceptions, we calculated gain scores and from first semester GPA we identified students' achievement levels. High-achieving students had fewer misconceptions after completing refutational readings, or after hearing the refutational lecture. Low-achieving students, however, had fewer misconceptions only after hearing the refutational lecture. We conclude that students who are lower achievers in college may need more than just refutational readings to change misconceptions.

*Keywords:* refutational text, student achievement, student misconceptions

### **I. Introduction.**

Misconceptions about psychology are pervasive among both the general public and among psychology students (Lilienfeld, Lynn, and Lohr, 2003; Taylor and Kowalski, 2004). Teachers of psychology are justifiably concerned that traditional teaching methods do little to decrease these misconceptions (Higbee and Clay, 1998; McKeachie, 1960; Vaughan, 1977). There are, however, teaching techniques that do appear to be somewhat successful in reducing conceptual misunderstandings for some students (Chew, 2004; Miller, Wozniak, Rust, Miller, and Slezak, 1996; Winer, Cottrell, Gregg, Fournier, and Bica, 2002). Among the successful techniques is the use of refutation to dispel misconceptions. Refutation, as used in texts and in lectures, has these critical attributes: It first activates the misconception. The misconception is then explicitly identified as being a false conception. The correct scientific information is then provided, so that students have a sensible, alternative conception that can replace their prior misconception (see Hynd, 2001 for more detail).

In a recent study designed to address student psychological misconceptions, we provided evidence for the efficacy of targeting misconceptions directly and refuting them with lecture and readings designed to present evidence supporting the correct scientific claim (Kowalski and Taylor, 2009). In that study, we identified claims representing information normally covered in introductory psychology. We then presented material that discussed each claim in one of the following ways. For some of the claims we explicitly identified the misconception as a misconception and then provided evidence to refute it. This refutation occurred by addressing the claim either in the classroom lecture, in the course readings, or in both lecture and in readings.

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For some of the other claims we provided evidence for the correct information without first activating the misconception and provided a standard or traditional exposition of the evidence in support of known information. As with the refutational presentation of material, we provided this standard presentation of material either in lecture, in readings, or both in lecture and in readings. Finally, we purposefully omitted covering some of the claims in either course readings or lectures. We found that refutational lecture, either alone or with refutational readings, produced significantly greater change in students' misconceptions compared with standard presentations. Refutational lecture, even without readings, produced greater gains than did providing standard lecture and readings together. However, refutational readings alone produced significantly less reduction in students' misconceptions, when compared to refutational lecture alone.

The success of refutational lecture in our study supported the claim that effectively reducing misconceptions requires instruction that first directs students' attention to their false beliefs and then discusses the scientific claims directly. Both the science education and the psychological misconceptions literatures recognize the importance of calling students' attention to or activating prior knowledge before attempting to alter a false belief (Driver and Bell, 1986; Chew, 2004; Posner, Strike, Hewsen, and Gertzog, 1982; Winer, et al., 2002). What remained unclear after our study was the independent contribution made by refutational readings compared with refutational lecture in dispelling psychological misconceptions when we provided students with both. Refutational readings alone were about as effective as standard readings and lecture together. However, refutational readings alone were significantly less effective than refutational lecture alone. Although reading research has repeatedly shown the value of refutational readings, there is also evidence that assigned readings often need to be supplemented with lecture to be effective in reducing misconceptions (Guzzetti, Snyder, Glass, and Gamas, 1993; Marshall, 1989). Chi (2008) reasons that although some misconceptions can be changed to correct conceptions with the use of refutational readings alone, other misconceptions cannot. For those misconceptions additional instruction may be necessary, particularly for students at lower levels of achievement, as these students may be less likely to comprehend the readings.

In the classic view of conceptual change, student comprehension is critical. Students must experience dissatisfaction with the misconception, and then have the new idea explained in a way that is understandable, plausible, and fruitful (Posner et al., 1982). Descriptions of the change process also emphasize the importance of the student becoming aware of the contradiction between the prior concept and the new concept (e.g., Chi, 2008). In addition, several researchers note critical learner characteristics that contribute to this change (Sinatra and Mason, 2008). Among these characteristics are differences in students' learning strategies that tend to differ with level of achievement. Studies comparing higher- with lower-achieving students have shown that lower-achieving students use less effective reading strategies, are less likely to see the relation between prior concepts and new concepts, are less likely to comprehend the argument in favor of the new concept, and are less likely to use new information at time of test (Guzzetti, 2000; Guzzetti, Williams, Skeel, and Wu, 1997). As a result, these lower-achieving students are more likely to need additional support in the form of lecture or teacher-led discussion to effectively process the refutational readings, relate it their prior concept, and change their misconception (Guzzetti, et al., 1997).

Research on psychological misconceptions also finds that student characteristics influence whether students alter their false beliefs after instruction. For example, compared with higher achieving students, lower achieving students hold more misconceptions (McCutcheon, Apperson, Hanson, and Wynn, 1992) and are less likely to change their misconceptions

following the introductory class (Gutman, 1979; Kowalski and Taylor, 2004). Gutman (1979) found that when he compared students who performed at higher levels in the course with lower performing students, the latter changed few of their original misbeliefs. He suggested that because of these achievement level differences, considering only overall course effects can underestimate change for high-achieving students and overestimate change for low-achieving students.

One of the questions left unanswered in our previous work, but for which we have data, concerns a closer examination of this effect of student achievement and the efficacy of refutational pedagogy. In our study, it is possible that refutational readings differentially influenced students who demonstrate high versus low levels of achievement in the college classroom. Low-achieving students may need the refutational lecture to become aware of the contradiction between their prior belief and the new information, and to make sense of the claim. High-achieving students may notice the discrepancy and understand the argument from reading alone. Thus, in our previous study, the overall effect we observed for refutational readings may have masked a differential effect of reading for high and low achieving students. Knowing the differential effectiveness of refutational techniques for students at varying levels of achievement would help instructors better understand the value as well as the limitations of the forms of refutational teaching.

Thus, the purpose of the current paper was to assess the differential effectiveness of refutational readings on decreasing misconceptions for students of high versus low achievement levels. In the previous study, all students, on average, benefitted less from refutational readings alone compared with refutational lecture alone. This effect, however, could have been accounted for mainly by the performance of the low-achieving students. In the present study, therefore, we reanalyzed a portion of our previously reported data, together with an additional variable measuring student achievement. We expected to find that the effect of pedagogy depended on student level of achievement. Both high and low-achieving students would benefit from the refutational lecture. High-achieving students would show reductions in misconceptions when provided only with refutational readings but not presented with a refutational lecture. We expected to observe little change in misconceptions for low-achieving students who did not hear a refutational lecture in addition to their having refutational readings over the material.

## **II. Method.**

### *A. Participants.*

Sixty-five introductory psychology students, primarily freshmen, participated for course credit. Students attended sections of the introductory psychology course taught by the authors at a private liberal arts college on the west coast. Nearly 80% of the participants were women. The average age of these traditional college students was 18 years.

### *B. Course Design.*

We designed the course to allow us to assess the effect of method of addressing misconceptions in lecture and in readings. We covered items from our Psychological Information Questionnaire (described below) in either a refutational lecture, a standard lecture, or not at all. We also provided readings in a refutational manner, in a standard manner, or not at all. For this study we

reanalyzed only four conditions. The four conditions included in this reanalysis were (a) refutational lecture and refutational readings (R/R), (b) refutational lecture and no readings (R/N), (c) no lecture and refutational readings (N/R), and (d) no lecture and no readings (N/N).

### *C. Materials.*

*Psychological Information Questionnaire.* The questionnaire contained 100 true–false items assessing students’ knowledge of psychological information (Kowalski and Taylor, 2009). Fifty-five items assessed material normally covered in an introductory psychology course but not reflecting common misconceptions (e.g., The cognitive approach focuses on the mental processes involved in thinking). Forty-five items reflected frequently held student misconceptions (see Appendix 1). We drew items from previously published tests of misconceptions in psychology (e.g., “A schizophrenic is someone with a split personality”; Vaughan, 1977) and from the popular literature (e.g., “Mozart’s music increases infant intelligence. We then randomly inserted the 45 misconception items among the 55 fact-based items. In constructing the measure this way, our purpose was to mask the misconceptions items, and to obtain a comparison to items of specific information taught in a standard introductory course in psychology.

*Reading.* The course text was Melucci’s (2004) *Psychology: The easy way*. This concise text allowed us to control the type and amount of information to which we exposed the students. We supplemented the text with 17 readings, directly related to specific misconceptions assessed on the Psychological Information Questionnaire. Reading length ranged from one to 15 pages. Sources for readings included chapters from books (e.g., Stanovich, 1998), periodicals (e.g., Wallis, 2004), and internet sources (e.g., Catharsis increases rather than decreases anger and aggression, 1999).

Although course readings addressed claims in either a refutational or a standard manner, for this paper we focused only on 18 claims addressed by refutational reading (conditions R/R and N/R) and on 18 claims not addressed at all in the readings (conditions R/N and N/N) (see Kowalski and Taylor, 2009, for more detail).

*Lecture.* Refutational lectures focused on 18 of the popular misconceptions. In each lecture we started by presenting the common misconception and then presented the scientific view, followed by evidence supporting the scientific claim. For the 18 claims in the N/R and N/N, we did not cover the topic in class at all.

*Achievement.* To estimate student achievement, students provided us with permission to obtain their first semester GPA from the university registrar. The registrar calculates GPA on a 4-point scale (A = 4.00). This method of estimating achievement is time-frame specific to the semester during which we assessed change, and has been found to represent a meaningful student characteristic in previous studies of student misconceptions (Kowalski and Taylor, 2004; McCutcheon, et al., 1992).

### *D. Procedure.*

Participants completed the Psychological Information Questionnaire as a pretest during the first class. During the semester, we assigned readings from the Melucci (2004) text as well as additional articles. Exams included multiple-choice or short-answer items over the readings. We

covered item content in class with refutational lecture, standard lecture, or not at all. On the last day of class, students again completed the Psychological Information Questionnaire in class.

### III. Results.

To answer the question of whether the effectiveness of refutational lecture and refutational text depend on student achievement, we used a median split to divide students into high and low achievement levels based on first semester GPA. Student GPAs were normally distributed ( $Md = 3.00$ ,  $M = 2.91$ ,  $SD = 0.64$ ). High achieving students ( $N = 32$ ) started the semester with a mean of 26.0% correct on the misconception test and ended the semester at 70.0% correct. Low achieving students ( $N = 33$ ) started the semester at 27.0% correct and ended at 58.6 % correct.

In addition to percent correct for the misconception items, we calculated average normalized gain scores according to the method described by Hake (2002, 2005). This statistical method accounts for differences in each student's prior knowledge, as well as each student's potential amount of improvement. According to Hake (2002), "the average *normalized gain*  $\langle g \rangle$  is the *actual gain* [ $\langle \%post \rangle - \langle \%pre \rangle$ ] divided by the *maximum possible gain* [ $100\% - \langle \%pre \rangle$ ]" (Hake, 2002, ¶9). Thus, we computed each student's individual normalized gain, and then averaged these gain scores across the group of students. In this way, the final evaluation of posttest scores takes into account the level of pretest performance.

We then conducted a  $2 \times 2 \times 2$  (Achievement [high, low] x Reading [refutational, none] x Lecture [refutational, none]) mixed model ANOVA, with  $\langle g \rangle$  as the dependent measure. Means and standard deviations for high and low achieving students appear in Table 1. The overall ANOVA indicated a significant main effect for Achievement,  $F(1, 63) = 39.75$ ,  $p < 0.001$ ,  $\eta^2 = 0.39$ . High-achieving students showed higher normalized gain scores,  $\langle g \rangle = .57$  (.14) than did low-achieving students,  $\langle g \rangle = 0.36$  (0.14). There was also a significant main effect for Reading,  $F(1, 63) = 13.54$ ,  $p < 0.001$ ,  $\eta^2 = 0.18$ , and Lecture,  $F(1, 63) = 395.40$ ,  $p < 0.001$ ,  $\eta^2 = 0.86$ . Significant two- and three-way interactions qualified these findings. A Reading x Achievement interaction,  $F(1, 63) = 7.44$ ,  $p = 0.008$ ,  $\eta^2 = 0.106$ , suggested the effect of reading depended on level of achievement. However, the three way interaction Achievement x Reading x Lecture was also significant,  $(F1, 63) = 4.55$ ,  $p = 0.04$ ,  $\eta^2 = 0.07$ , qualifying the effect of the two-way interaction.

**Table 1. Comparison of high- and low-achieving students across teaching pedagogies for average normalized gain.**

Teaching Pedagogy	Student Achievement	
	High	Low
Refutational Lecture		
Refutational Reading	0.84(0.17)	0.60(0.25)
No Reading	0.80(0.20)	0.57(0.21)
No Lecture		
Refutational Reading	0.54 (0.28)	0.16 (0.30)
No Reading	0.24 (0.26)	0.14 (0.23)

*Note.* Standard deviations are noted in parentheses following means.

We then investigated the nature of the two-way interaction (Reading x Lecture) for students at high and low achievement levels. For students characterized by high levels of achievement, the main effects of Reading  $F(1, 31) = 176.78, p < 0.00, \eta^2 = 0.85$  and Lecture,  $F(1, 31) = 25.86, p < 0.00, \eta^2 = 0.45$ , and the interaction  $F(1, 31) = 11.48, p = 0.002, \eta^2 = 0.27$  were significant. In contrast, for students characterized by low levels of achievement, there was a main effect of Lecture,  $F(1, 32) = 222.16, p < 0.00, \eta^2 = 0.87$ . However, neither the main effect of Reading nor the Reading x Lecture interaction was significant.

When students heard a refutational lecture covering the misconceptions, the effect of refutational reading was similar for high- and low-achieving students. However, when they did not hear a lecture, high-achieving students demonstrated significant gains in understanding when given a refutational reading; low-achieving students showed little gain in understanding when given a refutational reading.

#### **IV. Discussion.**

Previously, we found that students demonstrated greater gains in overcoming psychological misconceptions when we addressed misconceptions in a refutational manner (Kowalski and Taylor, 2009). In assessing the value of refutational readings independently of refutational lecture, the conclusions of the previous study were unclear. In the overall analysis, coverage by refutational lecture together with refutational readings was similar to coverage by refutational lecture alone but superior to coverage by refutational readings alone in reducing student misconceptions. The current follow-up study assessed whether these previous findings masked differences in the effectiveness of refutational readings for dispelling misconceptions in high-versus low-achieving students.

We found differences in the effect of refutation for students of different achievement levels. High-achieving students reduced misconceptions when they heard a refutational lecture or when they read refutational readings. Thus, this study indicates that for high-achieving students, the typical misconceptions students hold in the introductory psychology class can decrease when students read refutational readings, even when there is no instruction in class to address these claims. Low-achieving students, however, gained no more from the refutational readings alone than they did when we did not cover the misconceptions at all. Our findings are consistent with previous reading research indicating low-achieving students require support beyond readings to change misconceptions (Guzzetti, et al., 1993; Guzzetti, et al., 1997).

This follow-up study answers the question about student achievement level differences in the effectiveness of targeting misconceptions. We cannot expect lower-achieving students to change misconceptions based on refutational readings alone. The study, however, does not help us answer the question of why low-achieving students benefit less from readings. Reading research shows that there are a number of characteristics that can influence change in students' misconceptions. Low-achieving students may not change misconceptions following refutational readings because they have ineffective reading strategies or have difficulty drawing inferences from readings (Guzzetti, et al., 1997). It may also be that low-achieving students lack the metacognitive skills, epistemological beliefs, and motivation to engage in effortful processing necessary to become aware of the contradictions between their prior conception and the new information and to understand the new information (Chi, 2008; Sinatra and Mason, 2008). These motivational factors may be particularly important contributors to enduring student learning. We

are currently studying how various student characteristics contribute to students' maintaining correct conceptions over time.

The in-class design of the present study did not allow us to eliminate an alternative explanation for our findings. We do not know the degree to which students actually completed the assigned readings for our classes. Low-achieving students might simply have achieved a lower GPA secondary to not reading their assignments. We are currently pursuing experimental studies to determine the reasons for the different effects of refutational readings on student performance. Knowing when and how misconceptions change is of critical value to teachers of psychology interested in having students of all levels of achievement leave their classes armed with an understanding of the scientific claims in psychology.

## **V. Implications.**

Although the misconceptions in this study reflect students' knowledge of psychological science, the findings fit well within the accumulating body of knowledge on student misconceptions. Misconceptions exist in all disciplines (Bransford, Brown, and Cocking, 1998). Research across disciplines shows that refutational text can help reduce these misconceptions for at least some students (Guzzetti et al., 1997). It also shows, however, that text alone is often not enough. Teachers are needed to reduce student misconceptions, particularly for students with ineffective reading strategies. Teachers can help direct students' attention and aid comprehension (Guzzetti, 2000). As Marshal (1989) points out, although "...text functions admirably as a source of information, teachers are the optimal source of thought-provoking activity" (p. 329).

## **Appendix 1. Misconceptions Items on the Psychological Information Questionnaire.**

1. If you're unsure of your answer while taking a test, it's best to stick with your initial hunch.
2. There are striking stylistic differences between the two hemispheres of the brain, with the left being "analytic" and the right "holistic."
3. Most people use only 10% of their brains.
4. Most "crack babies" end up with serious neurological deficits.
5. Subliminal messages can be used to persuade others to purchase products.
6. Taste areas for sweet, sour, salty and bitter are well defined on the tongue.
7. ESP (extrasensory perception) has been empirically documented.
8. During "out of body" experiences, individuals can observe themselves from above.
9. Drug education programs (i.e., DARE) are effective in deterring drug use among teenagers.
10. Individuals can learn information (e.g., new languages) while asleep.
11. During sleep, your brain rests.
12. Most people who use heroin become addicted to it.
13. Human memory works like a tape recorder or video camera, and accurately records the events we have experienced.
14. Eyewitness testimony is usually reliable.
15. Many adults were abused as children but do not remember the abuse.
16. Hypnosis is useful for retrieving memories of forgotten events.
17. In criminal eyewitnesses, confidence is closely related to accuracy.
18. Playing classical music (e.g., Mozart) to infants and children increases their intelligence.
19. Too much sugar causes hyperactivity in children.
20. Babies who learned sign language as infants have a higher overall IQ.
21. Immediate contact between a mother and infant after birth is critical for bonding.
22. You can "spoil" a baby if you respond to its demands too quickly.
23. A baby's attachment for its mother is based on mom's filling the physiological need for food.
24. If you live long enough, you will eventually develop dementia.
25. The defining feature of dyslexia is seeing words backwards (e.g., "pal" instead of "lap").
26. The polygraph ("lie detector") test is a highly accurate means of detecting dishonesty.



27. It is generally better to express anger openly than to hold it in.
28. Most women experience a marked worsening of their moods during the premenstrual period.
29. Raising children similarly leads to similarities in their adult personalities.
30. High self-esteem is necessary for high achievement.
31. Astrologers can predict your personality from the arrangement of stars and planets at your birth.
32. People's responses to inkblots tell us a great deal about their personalities and propensities toward mental disorders.
33. People diagnosed with schizophrenia have a split personality.
34. People who attempt to commit suicide do not talk about it.
35. \*We experience stress even when good things happen to us.
36. "Psychological profiling" has been shown to be an effective means of identifying criminals.
37. \*The suicide rate is higher among the elderly than among adolescents.
38. A large proportion of criminals are acquitted on the basis of the insanity defense.
39. Clinical judgment and intuition are the best means of combining information to reach a diagnosis for a patient.
40. A well-trained psychotherapist can establish a person's true thoughts and problems by analyzing dreams.
41. All effective psychotherapies force individuals to confront the "root" causes of their problems in childhood.
42. Electroconvulsive ("shock") therapy is a physically dangerous treatment.
43. Opposites attract: People tend to have relationships with individuals who differ from them in their personality, interests, and attitudes.
44. There's safety in numbers: The more people present at an emergency, the greater the chance that someone will intervene.
45. Women talk more than men ("Men are from Mars, women are from Venus").

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\* These claims are true. All other claims are False.

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