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Students' misconceptions in psychology: How you ask matters…sometimes

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Abstract: Misconceptions about psychology are prevalent among introductory students. Just how prevalent and what can be done to change these misconceptions depends on valid methods of assessment. The most common method of assessment, the true/false questionnaire, is problematic. The present study compared true/false with forced choice formats to determine whether the formats give different estimates of student misconceptions. Introductory psychology students (N = 165) answered 39 misconceptions in both the true/false and forced choice formats. Students differed in accuracy when assessed with the different formats, with 33.05% accuracy for true/false and 41.29% accuracy for forced choice. In the analyses of individual items we observed that some items did not differ in level of accuracy across formats and other items did differ. We conclude that the true/false method of assessing misconceptions may overestimate students' level of misconception and recommend continued attention to how researchers assess misconceptions.

Keywords: assessment, psychology, student misconceptions

I. Introduction

Research in cognitive psychology has much to say about how people learn (Bransford, Brown, & Cocking, 2000). We know that meaningful learning is an active process. It involves the use of prior knowledge to help make sense out of new information. When prior knowledge supports or fits with new information, then the new information can be learned more easily. However, when prior knowledge contradicts new information—as when students have misconceptions—it actually makes learning the new information more difficult than if there were no prior knowledge at all (Lipson, 1982).

For over a decade we have been investigating the misconceptions that students bring with them to the introductory psychology classroom (see Taylor, Kowalski, & Laggren 2000 and Taylor & Kowalski, 2004). Consistently, we find low levels of accuracy in students' beliefs, ranging from 30% to 39% accuracy. In the time since our first studies, a number of other studies have reported similar findings (Amsel, et al., 2009; Kuhle, Barber & Bristol, 2009; Lilienfeld, 2010). Students come into the introductory psychology course with strongly held beliefs that are in contrast to the preponderance of the scientific evidence, and, unless there is some strong intervention to challenge these false beliefs, they blissfully leave the introductory psychology course with those beliefs still intact. Furthermore, examples of misconceptions that do not change based on simple instruction have been documented across a wide variety of academic disciplines such as earth science (Harackiewicz, 1999), physics (Baser, 2006; Dykstra, Boyle, & Monarch, 1992), biology (Boyes & Stanisstreet, 1991), political science (Lorenzo, 1999) and philosophy (Williamson, 2007).

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As scholar/teachers of psychological science we believe this low level of psychological science literacy is not an acceptable outcome. Reflecting on the tenacity of some students' misconceptions, our primary focus has shifted from enumerating beliefs and their sources to whether we can change students' false beliefs, how we can effect such change, why we should do so, and for how long or short a time such changes endure. In investigating how students might be encouraged to change their misconceptions, we have followed the lead of the science education and reading research literatures (Guzzetti, Snyder, Glass, & Gamas, 1993; Strike & Posner, 1992). Much of this literature suggests that to alter a misconception, students need to understand that what they think they know does not match the current scientific view and need to be presented with a plausible and useful alternative in a way they can understand. The strategy of presenting the misconception followed by a clear discussion of the scientifically correct view is referred to in the reading research as refutational text or refutational teaching (Guzzetti et al.). By using refutational texts and lectures in our introductory psychology course, we found that we significantly reduced student misconceptions and that students maintained much of this change over time (Kowalski & Taylor, 2009; Taylor & Kowalski, 2010).

Despite the desire to move forward in understanding how to change student misconceptions, we realize we may first need to step back. If we want to study factors that promote change in misconceptions we need a meaningful way to measure those beliefs. At a classroom level, Angelo & Cross (1993) recognized the importance of assessing student misconceptions as a way of informing instruction and suggested creating simple questionnaires, focusing on a number of troubling beliefs students are likely to hold. Within various disciplines, researchers have developed diagnostic instruments to assess such deficient understanding. The Force Misconceptions Test (Eryilmaz, 2002) and the Chemistry Concepts Inventory (Mulford & Robinson, 2002) are examples of such tools. Both instruments rely on multiple choice questions to sample the extent of alternative concepts in the discipline, and to study changes that occur following course instruction.

Within the field of psychology, the current methods of measuring misconceptions in psychology appear to be problematic. Psychological misconception assessments have been criticized for including outdated items, items that are not important in the science, and items that reflect claims that introductory texts do not cover (Griggs & Ransdell, 1987; Lamal, 1979). In addition, most studies have used a true/false approach in which students read a series of statements and designate each statement as being true or false. Although many criticisms of true/false testing may be misconceptions themselves (see Burton, 2005), it is generally agreed that true/false questions are difficult to write and that because of the role of guessing, true/false assessments make it difficult to know whether student responses reflect incorrect knowledge or simply a lack of knowledge. This distinction between incorrect knowledge and no knowledge is particularly important for misconception assessment because the intent is to identify student misinformation that may be tenacious and in need of being forcefully refuted.

There are additional aspects of the true/false assessments that make them particularly problematic in the study of misconceptions. Because of the nature of most misconceptions, these true/false assessments tend to phrase all items as "false" in order to be answered correctly—in other words, the misconception is a false statement students tend to believe. With all of the items needing to be correctly responded to as "false," it is difficult to know the degree to which responses reflect actual beliefs or reflect a demand characteristic, a response bias, or some other artifact of the test's format rather than the test's content. Sax (1989) noted that when students guess on true/false questions they tend to mark the statement "true". A "true" response set,

therefore, would overestimate student misconceptions. As an alternative to the true/false only questionnaire, Gardner & Dalsing (1986) found that by just adding an option for "I don't know," they reduced the level of reported misconceptions, presumably more accurately reflecting the students' level of misconceptions.

Perhaps the strongest criticism of misconception assessments is that the questions include claims that are not clearly countered by the evidence, are poorly worded, or may hold a "grain of truth." As McKeachie (1999) noted, it is difficult to write true/false questions that are clearly true or false. Brown (1984) and Ruble (1986) levied such a criticism of the true/false format for psychological misconception questionnaires. Both researchers provided evidence that the constraint of developing a single, brief statement about some complex behavior leaves most true/false statements of misconceptions ambiguous. Frequently such brief statements are only partly true and partly false. For example, many students accept as true what is known as the 10% myth, the statement that "Most people only use 10% of their brains." Researchers in the psychological sciences clearly consider this statement false. However, outside of the research community people may have various interpretations of the word "use" in the sentence. It could be interpreted as meaning that at some point in time some people only use 10% of their available processing capacity, preferring to be lazy or in a deep stage of sleep, even if most of the brain itself is in constant use to maintain bodily functions and homeostasis. The ambiguity in interpreting true/false items becomes more obvious when one tries to write true versions of false statements. A straightforward "true" version of the 10% item could be, "Few people only use 10% of their brains." or "Most people use 90% of their brains." Neither of these options is a satisfactory "true" contrast to the "false" statement in that each could be read as suggesting there are some people who do use only 10% of their brains.

The problem with true/false assessments must be addressed before researchers can begin to evaluate the effectiveness of different pedagogies to effect change in misconceptions. We need an instrument that is reliable, valid, and sensitive enough to detect change without the ambiguity inherent in the true/false statements. In the present study we compared two formats which addressed the same content. A format which Bensley and colleagues have recently developed is a 2-item forced choice format (Bensley & Lilienfeld, 2010; Bensley, Lilienfeld, Ferree, Powell, & Southerly, 2011; Southerly, Bensley, Lilienfeld, Ferree, & Powell, 2011). The 2-item (A/B) forced choice format generally has a true/false statement as one option (usually the misconception) along with a complementary statement of the contrasting viewpoint based on the preponderance of the evidence. For the example above of the 10% myth, we adopted a version of the item taken from Bensley et al. (2010), "Which is most true about how much of the brain people typically use? A. People use all of their brains, but not all at once. B. Most people only use about 10% of their brains." In this case, the two options do not exactly negate each other; however, the alternative provides a more accurate representation of what the evidence shows, in contrast to the incorrect option, the one which most students incorrectly mark as "true" in the true/false format (see Higbee & Clay, 1998; Kowalski & Taylor, 2009). The forced choice format, therefore, assesses whether the student both accepts the correct claim and rejects the incorrect claim when presented with the two alternatives simultaneously.

We therefore compared a true/false version with a force choice version of a test of misconceptions in psychology. We wanted to know whether there would be different estimates of introductory psychology students' misconceptions across the two formats. We expected that items that show similar patterns of response across the two formats more closely represent what we might consider to be a "misconception." In other words, if students pick the incorrect forced

choice response at the same rate as they designate the false statement as being "true," then we believe that the item more clearly reflects a genuine level of misconception among the students. However, if students when presented with two options show a greater tendency to favor the more correct option, even if they incorrectly designate a false statement as being "true" in the true/false format, then that pattern of response suggests that the estimated level of misconception is tied to how we ask rather than to students' underlying beliefs

For the present study we asked these research questions: Is there an overall tendency for students to respond differently to questions regarding psychological misconceptions when they evaluate true/false items compared with forced choice items that simultaneously include the incorrect and correct alternatives? When students agree with an item in the true/false format, is the agreement a result of the item format, or because they have underlying false beliefs? Evidence that students' responses are related to item format would be suggested by a difference in the level of false belief between the true/false and force choice formats.

II. Method.

A. Participants.

The participants for this study included 164 introductory psychology students who completed the two questionnaires. Only 155 students completed both questions all the way to the end, so that the final analysis included only the 155. We did not collect demographic information; however, the 164 students comprised approximately 80% of the individuals in the introductory psychology subject pool. The individuals in the subject pool for that semester were primarily female, Caucasian, and traditional college-age freshmen. All participants received course credit for completing the questionnaire.

B. Materials.

We selected 39 items from previous questionnaires that we have used (Kowalski & Taylor, 2009; Taylor & Kowalski, 2004) as well as from the forced choice format developed by Bensley & Lilienfeld (2010). We worded all true/false (T/F) items so the correct response was "false," except for the statement "The suicide rate is higher among the elderly than among adolescents," which is true. For each item there was a (T/F) version and a forced choice (A/B) version. For example, the T/F version of the item regarding sugar and hyperactivity reads, "Too much sugar, such as from eating candy and sugary snacks, causes hyperactivity in children." The forced choice version read, "Which statement about the effect of sugar on behavior is most true? A. Too much sugar, as from eating candy and sugary snacks, causes hyperactivity in children. B. Sugar has a limited effect on behavior, similar to any carbohydrate, such as potatoes or pretzels." The preponderance of the scientific evidence favors response "B." Furthermore, most legitimate websites that disseminate parenting information and which examine the origins of hyperactivity in school-aged children emphasize this finding rather than the "sugar = hyperactivity" explanation (see Comisarow, 1996; Huynh, 2010.).

C. Procedure.

The participants, all of whom were students in the Introductory Psychology Subject Pool for the fall 2011 semester, received notification of the study via an email announcement. The announcement provided instructions on how to access the survey online, where participants began with informed consent and then completed the questionnaire. The entire questionnaire took less than one hour to complete.

III. Results

For almost all of the items accuracy was greater when we tested participants with the A/B rather than the T/F version. Overall, a *t*-test comparing accuracy showed a significant difference with $t(38) = -4.539$, $p < .001$. On average, accuracy was 33.05% correct with the T/F format and 41.29% with the A/B format.

To determine whether students' responses differed depending on the format of the item, we calculated *t*-test differences between mean accuracies for each item based on either the T/F response or the A/B forced choice response. We then corrected the significance level for all comparisons by using Simes' (1986). Table 1 lists the items which met this standard of comparison. Fourteen of the 39 items met this criterion. For each of the 14 items, a greater percentage of students reported holding the misconception when answering the T/F item compared with the A/B item. Thus, for 36% of the items students' responses depended on how we asked the question.

We then subdivided the remaining items into two categories. There were those which did not meet this stringent Simes' correction procedure for significance but which independently met the .05 level of significance. Ten items met this criterion. On each of these 10 items, students also tended to favor misconceptions more frequently when responding to T/F items. Finally, the remaining 15 items met neither criterion for statistical significance. These were the items to which the participants responded at the same level of accuracy no matter how we asked.

We included items in this questionnaire based on the items' inclusion in previous questionnaires used by us and by others. There is, in fact, no absolute way to define what constitutes a misconception. Previous research has tended to differentiate items which truly represent wide-spread misconceptions from those which do not by using a criterion of 50% accuracy (Lamal, 1979; Vaughn, 1977). That is, if at least 50% of students hold a particular belief that contradicts the preponderance of scientific evidence, that is a sufficiently large percentage to consider that belief a popular misconception. Using this criterion, nine items would be considered misconceptions with the T/F format but not the A/B format. These nine items included seven of the 14 items that resulted in truly different responses across formats (T/F vs. A/B) and two additional items from the set showing significant differences without the Simes correction. We also noted that five items on the questionnaire failed to meet the 50% criterion of accuracy in both the T/F and the A/B formats and would not have been considered misconceptions with either format. Thus, of the 39 items we identified from the previous literature as reflecting frequent student misconceptions, 25 items appeared to be common misconceptions regardless of how we asked, nine depended on how we asked, and five did not appear to be misconceptions no matter how we asked the students.

Table 1. A comparison of accuracy rates for items stated in the true/false and forced choice formats and the difference between the two question formats.

Brief Item:	Accuracy T/F Percent	Accuracy A/B Percent	Accuracy A/B Accuracy T/F Percent
Items which provide different response accuracies based on question format.			
There's safety in numbers.	38.71	49.03	10.32
Opposites attract.	41.29	54.19	12.90
Women talk more than men.	45.16	58.06	12.90
Psychological profilers can describe a criminal.	17.42	30.97	13.55
Attachment is based on filling the need for food.	36.13	50.32	14.19
If unsure of a test answer, stick with the first hunch.	7.74	21.94	14.20
Right-brained and left-brained people are different.	18.06	33.55	15.49
Lie detectors are highly accurate.	57.42	73.55	16.13
It is better to vent your anger than to hold it in.	9.03	30.97	21.94
Most people experience a midlife crisis.	27.74	51.61	23.87
ESP is a well-established phenomenon.	49.68	75.48	25.80
Dyslexics see letters as their reverse.	43.23	16.77	-26.46
Autism has become an epidemic.	44.52	72.90	28.38
Dreams reflect symbolic wishes.	36.13	76.13	40.00
Items which provide different response accuracies based on looser statistical criterion.			
Too much sugar causes hyperactivity in children.	32.28	30.33	-1.95
Raising self-esteem improves achievement.	4.52	10.32	5.80
Playing Mozart increases infant intelligence.	38.71	32.36	-6.35
Subliminal messages affect buying behavior.	12.26	18.71	6.45
Elderly have higher suicide rate than adolescents.	15.48	22.58	7.10
People can learn while asleep.	49.68	57.42	7.74
People repress traumatic memories.	10.97	18.71	7.74
Crack babies have serious neurological deficits.	15.48	23.23	7.75
Immediate contact at birth is critical for bonding.	18.71	28.39	9.68
People with schizophrenia have a "split" personality.	44.52	54.84	10.32
Items which provide similar response accuracies regardless of how one asks.			
Most therapies are based on Freud.	46.45	46.45	0.00
Criminal acquitted based on insanity defense.	51.61	50.97	-0.64
Most people use only about 10% of their brains.	47.74	48.39	0.65
Electroconvulsive ("shock") therapy is dangerous.	26.45	27.10	0.65
Drug education programs are effective.	43.87	45.16	1.29
Full moon affects behavior.	77.42	78.71	1.29
Learning styles should match teaching styles.	10.97	9.68	-1.29
The first three years are critical to development.	3.87	7.74	3.87
Adolescence is a time of psychological turmoil.	19.35	15.48	-3.87
Older people are crankier and depressed.	54.19	49.78	-4.51
Inkblots reveal personalities.	39.35	43.87	4.52
Taste areas are defined on the tongue.	27.10	33.55	6.45
Therapy must examine childhood root causes.	29.68	36.77	7.09
Amnesiacs cannot remember their previous life.	30.97	39.35	8.38
Vision depends on light rays emitted from eyes.	64.52	85.16	20.64

IV. Discussion

The purpose of this study was to examine the different ways in which students can be asked about their misconceptions related to psychological science and whether these different assessment formats make a difference. One format which researchers previously used is a true/false format wherein students read a statement and designated whether they believe it reflects a true or a false statement. The second is a forced choice format in which researchers ask students to pick one of two options. We asked whether there is an overall difference in accuracy when we assess student misconceptions with true/false or forced choice formats. We also wanted to know whether student agreement with items in the true/false format reflects the question format or students' underlying false beliefs.

We found that for some items, how you ask matters, and for other items it does not matter very much. Overall, students reported fewer false beliefs when asked with the forced choice format. This suggests that our assessment of students' misconceptions can sometimes depend on how we ask. Although we do not know the exact thought processes, it is possible that for some claims, when students see only the more popular misconception (T/F version), they fail to think through the alternatives. However, when students see the correct response immediately next to the incorrect response (A/B version) they may stop to consider the correctness of the alternate choice. Further studies, perhaps with think-aloud procedures, may help determine these processes. Knowing what a student is thinking at the time of answering the item would help to determine if the student has an alternative understanding of the item rather than a misconception of the item.

We also noted that some claims on our instrument were not endorsed by the majority of students. We recommend that researchers pretest their instrument, which is likely to vary somewhat over time and over samples. For example, although other researchers have found support for the "extramission" misconception (Winer & Cottrell, 1996)—the idea that visual perception depends on light emitted from the eyes, rather than on the correct conception that visual perception depends on light entering the eyes—we failed to find support for this belief. Less than 35% of our participants thought this is an accurate statement when asked in the true/false format. (In visual perception, as a person sees something, tiny particles or light rays are emitted from the eyes.) The misconception rate fell to less than 15% when we asked about it with the forced choice format. (Which is most true about what happens in vision as a person sees something? A. Tiny particles or light rays emit from the eyes. B. Light is converted to nerve impulses in the back of the eyes.) Therefore, we conclude that how you ask matters but that cohort effects may affect beliefs; past cohorts endorsed extramission, current students do not. In addition, television programming may influence some of the misconceptions related to psychology. For several years we found that students strongly favored the misconception that the polygraph ("lie detector") test is a highly accurate means of detecting dishonesty (see Taylor & Kowalski, 2004); however, in recent years the accuracy rate of recognizing this as being false has risen perhaps due to the influence of television shows based on fictionalized court cases which these days more correctly portray that information. Based on our informal conversations with students, the programs that do represent the polygraph as being highly accurate ("Maury") tend to be perceived as having less credibility. Therefore, different cohorts of college students may express beliefs based on information they learn from various media outlets, and the content or quality of that information can change over time, leading to changing beliefs among the

general public, including students. Further investigations of the source of students' misconceptions will help clarify these types of cohort changes over time.

A. Conclusions

In conclusion, we found evidence that the use of the true/false format may over-estimate the prevalence of misconceptions that students endorse when they enter the introductory psychology classroom. Our overall data analyses showed that accuracy rates on average across all items, and across almost all individual items, were lower when we asked the true/false version of the item when compared to the forced choice version of the item. 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 across a wide range of disciplines (Bransford et al., 2000). Misconceptions exist in all disciplines. How you ask students about these preconceptions is likely to matter. Having the most accurate measure possible becomes important when instructors and researchers use the results of such tests in additional ways, such as examining the effectiveness of interventions to reduce these false beliefs. We recommend continued attention to methods of assessing misconceptions as researchers cautiously pursue factors which may reduce misconceptions in the classroom.

Appendix 1. Selected items, first in the True/False format and next as A/B forced choice format.

Drug education programs (i.e., DARE) are effective in deterring drug use among teenagers.
Which of the following statements about drug education programs is most true?
A. Drug education programs (i.e., DARE) are effective in deterring drug use among teenagers.
B. Drug education programs (i.e., DARE) are ineffective in deterring drug use among teenagers.

Too much sugar, such as from eating candy and sugary snacks, causes hyperactivity in children.
Which statement about the effect of sugar on behavior is most true?
A. Too much sugar, as from eating candy and sugary snacks, causes hyperactivity in children.
B. Sugar has a limited effect on behavior, similar to any carbohydrate, such as potatoes or pretzels.

Taste areas for sweet, sour, salty and bitter are well defined on the tongue.
Which statement is most true about the sense of taste?
A. Taste areas for sweet, sour, salty and bitter are well defined on the tongue.
B. People can perceive all taste qualities all over their tongue.

The suicide rate is higher among the elderly than among adolescents.
Which statement about the suicide rate is most true?
A. The suicide rate is higher among the elderly than among adolescents.
B. The suicide rate is higher among adolescents than among the elderly.

Most "crack babies" end up with serious neurological deficits.
Which is most true about "crack babies"?
A. Most "crack babies" end up with serious neurological deficits.

B. Most "crack babies" develop normally in the long run.

Immediate contact between a mother and infant after birth is critical for bonding.
Which statement about mother-infant bonding is most true?
A. Immediate contact between a mother and infant after birth is critical for bonding.
B. Mothers and infants do not need immediate contact after birth to develop a bond.

A baby's attachment for its mother is based on mom's filling the physiological need for food.
Which statement is most true about the source of the attachment?
A. Baby's attachment for its mother is based on filling the physiological need for food.
B. A baby's attachment for its mother is based primarily on physical contact and not nourishment.

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