TIPS, TRICKS & TECHNIQUES

Using Astrology to Confront & Discuss Pseudoscience in the Classroom

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ABSTRACT

Surveys have shown that a proportion of the American public accepts pseudoscientific claims as scientific facts. The critical evaluation of these claims via classroom discussion about pseudoscience is important because instructors and students cannot test every pseudoscientific claim. Instructors can provide a framework to use in evaluating such claims both inside and outside the classroom, arming students with knowledge. I describe an activity that provides both an example of a pseudoscientific claim – astrology – and a framework for classroom discussion of pseudoscience as students work in groups to experimentally test predictions of horoscopes. The activity is appropriate for freshman college students in an online or classroom biology laboratory and can be adapted for high school students.

Key Words: *Astrology; horoscope; scientific method; experimental design pseudoscience.*

○ Introduction

Pseudoscience is a broad category of activities and claims with similarities to scientific activities but lacking specific aspects of scientific work, such as use of the scientific method to test hypotheses and logical plausibility (Shermer, 1997; Lilienfeld, 1998; Ruscio, 2006; Lilienfeld & Landfield, 2008). Although the value of teaching about pseudoscience in a science classroom has been controversial, Martin (1994) argued that using examples of pseudoscience to teach critical thinking about pseudoscientific claims is an important part of science education.

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Pseudoscientific claims are accepted by some portion of the U.S. population, including science students and educators (Frazier, 1984; Harrold & Eve, 1987; Miller, 1987; Eve & Dunn, 1990; Gallup & Newport, 1991; Huffington Post, 2010). A survey by the National Science Foundation (2006) showed that about 75% of Americans maintain that at least one pseudoscientific claim is true. These claims include extrasensory perception (ESP), haunted houses, existence of ghosts, telepathy, clairvoyance, astrology, communication with the dead, witchcraft, reincarnation, and channeling. While seen by some as harmless, the acceptance of misconceptions and pseudoscientific claims has had negative consequences, including serious impacts on public health (Allchin, 2012).

Misconceptions (or alternative conceptions) are ideas that students have that differ from the current, accepted scientific explanation. Not all misconceptions are based in pseudoscience, but both misconceptions and pseudoscientific claims share the property of being difficult to change using traditional and instructor-centered teaching approaches, and both remain until the claim is no longer useful and a new conception can replace it (Guzzetti et al., 1993; Winer et al., 2002). Thus, instructors need to provide evidence to their students that the pseudoscientific claim is incorrect and provide an alternative and scientifically accepted explanation. Realistically, instructors do not have the time to address every pseudoscientific claim that students hold. Thus, it is important to provide the tools needed to address *any* pseudoscientific claim, regardless of whether the student is inside or outside a classroom (Moore, 1992).

Various pseudoscientific topics have been proposed for activities in science classrooms, including extrasensory perception (ESP; Manza et al., 2010; Schmaltz & Lilienfeld, 2014), unidentified flying objects (UFOs; Fraknoi, 2003; Schmaltz & Lilienfeld, 2014), and homeopathy and alternative medicine (Bausell, 2007). In this activity, I build on the work of others who have used astrology as a vehicle to address pseudoscientific claims in the science classroom (Eve & Dunn, 1990; Kallery, 2001) in an attempt to make the pseudoscientific claim no

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longer relevant. A list of warning signs (adopted from Lilienfed et al., 2012) is used to provide a guided discussion of pseudoscience. The discussion is based on the results of testing astrological predictions and also addresses the second goal of providing students with the tools to address pseudoscientific claims.

Brief Description of Astrology

Astrologists are interested in intersections of the sun, moon, and eight planets (excluding Earth and including Pluto) in relation to the tropical zodiac, the 12 traditional signs or constellations. The positions of these celestial bodies are calculated and then displayed on the horoscope. The horoscope allows one to define a series of signs and "houses" that are interpreted subjectively.

○ Methods & Materials

Begin this project at the end of the previous laboratory, to ensure that students have enough time to collect data. Asking the students to complete the experiment using the students in the lab as participants may not result in enough people with different astrological signs. Students who find participants outside the laboratory will have more data to discuss and the possibility of more logical conclusions. In addition, the more individual experiments that are conducted, the more data and conclusions the class will have to discuss. As time is the only limiting factor (there are no supplies to purchase), the instructor should consider the number of presentations that can occur while still leaving enough time for a robust discussion of pseudoscience.

Observations

In this step, the instructor provides the students with a list of traits for each of the 12 astrological signs (Table 1). This list of traits was compiled by searching five astrology websites for traits that define each sign

- http://www.astrology-online.com
- http://zodiac-signs-astrology.com/
- http://www.creativechoices.com/step-two—explanations-of-the-signs.html
- http://www.futurescopes.com/children-by-zodiac-sign
- http://psychiclibrary.com/beyondBooks/aries

Traits listed on one site do not always match those listed on another site. Therefore, the traits listed in Table 1 are those that appeared on three or more of the websites (as indicated by the number in parentheses).

Hypothesis & Prediction

In the next step, students construct a hypothesis based on patterns that emerge from the information in Table 1. Students then state one or a series of predictions in support of their hypothesis. For example, one of the traits associated with Aries is impatience, and a trait associated with Taurus is patience. Students might hypothesize that these astrological signs are related to patience/impatience. Predictions that support this hypothesis include that

- people born under the sign of Aries will be impatient,
- people born under the sign of Taurus will be patient, and
- people born under one of the other 10 signs will be neither patient nor impatient.

As a side note, it is useful to make predictions about all of the signs, because students with predictions about only one or two signs will need to find 50 people born under those one or two signs. This is more difficult than asking 50 random people. This step should take 5–10 minutes.

Experimental Design

Next, students should construct an experiment that will test their hypothesis. This step should take 10–15 minutes. Students should understand independent, dependent, and control variables. Students should consider how they will measure the dependent and independent variables. It can be useful to require students to have their experimental designs approved before proceeding to the experiment. This can be done by short presentations (if time allows), or the instructor can approve the design with each group after a short consultation. It can also be useful to allow students to make experimental errors and discuss them during the discussion about pseudoscience. These experimental errors are often part of the pseudoscientific claim and can influence the validity of the claim.

For the example given above, a potential methodology is as follows. All participants receive a half piece of paper with two questions: (1) "What is your birthday?" and (2) "Are you patient?" Participants are asked to write their birthday next to the first question and to circle only one response, either "Yes," "No," or "It depends," under the second. Data from participants who do not follow the directions will not be used in the experiment. The experiment will be conducted until at least 50 people have responded to the questions.

Research

Students will be able to complete their experiment during the time until the next laboratory session. Students should be encouraged to collect enough data so that their results will be meaningful. The author has found that it was necessary to have at least 50 people respond to the survey to ensure that all astrological signs were represented in the example described above.

○ Results

Students should return to the next class period prepared to briefly present their results. Students should be able to state their hypothesis and prediction, discuss their results, and make a conclusion based on the results. A graph will assist in this presentation (Figure 1).

Example

Worksheet 1 (Table 2) is provided to help students articulate their ideas and shows an example experiment.

○ Class Discussion of Pseudoscience

Discussing and evaluating pseudoscientific claims is a strategy that science instructors can use to help students think critically about the overwhelming amount of information they are exposed to (Martin, 1994). Providing students with the opportunity to test pseudoscientific claims is one step in changing beliefs in these claims. It is also necessary for students to replace the claim with a viable alternative. Since it is impossible for an instructor to address every pseudoscientific claim, students must learn to think critically when evaluating all

Table 1. A list of personality traits for each of the 12 astrological signs. This list was compiled by searching six websites for personality traits associated with each astrological sign. Personality traits shared by three or more websites are included. The number in parentheses is the number of websites that listed this trait.

Aries	Taurus	Gemini	Cancer	Leo	Virgo
March 21–April 20	April 21–May 21	May 22–June 21	June 22–July 22	July 23–August 21	August 22–September 23
Courageous (3)	Greedy (3)	Adaptable (3)	Clingy (4)	Generous (4)	Analytical (5)
Energetic (3)	Materialistic (3)	Inconsistent (3)	Emotional (4)	Patronizing (3)	Fussy (4)
Enthusiastic (3)	Patient (4)	Inquisitive (3)	Moody (3)		Perfectionist (4)
Impatient (3)	Persistent (3)	Superficial (3)	Sensitive (3)		Reliable (3)
Impulsive (3)	Possessive (3)	Tense (3)			
Independent (3)	Reliable (3)	Witty (3)			
	Self-indulgent (3)				
	Warm-hearted (3)				

Libra	Scorpio	Sagittarius	Capricorn	Aquarius	Pisces
September 24–October 23	October 24–November 22	November 23–December 22	December 23–January 20	January 21–February 19	February 20–March 20
Charming (3)	Jealous (4)	Freedom-loving (3)	Ambitious (5)	Friendly (3)	Compassionate (3)
Diplomatic (4)	Magnetic (3)	Irresponsible (3)	Disciplined (3)	Humanitarian (3)	Easily deceived (3)
Idealistic (3)	Obsessive (3)	Optimistic (3)	Patient (3)	Intellectual (4)	Escapist (3)
Indecisive (3)	Passionate (5)	Restless (3)	Pessimistic (3)	Inventive (4)	Idealistic (3)
Peaceful (5)	Secretive (3)			Original (3)	Imaginative (3)
				Unemotional (3)	Intuitive (3)
				Unpredictable (3)	Sensitive (4)
					Sympathetic (3)

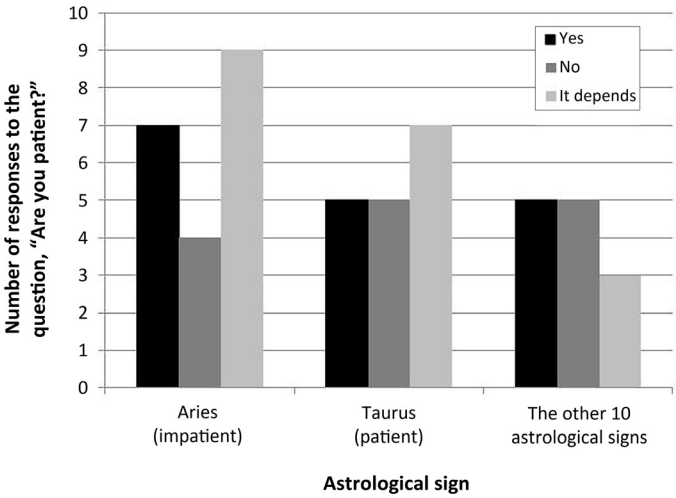

Figure 1. Fifty people were asked the question "Are you patient?" to evaluate the relationship between astrological sign and patience. People born under the sign of Aries are predicted to be impatient, and people born under the sign of Taurus are predicted to be patient. People born under the other 10 astrological signs are not predicted to be either patient or impatient.

claims both inside and outside the classroom. The results students obtained from this experiment are an excellent starting point for such a discussion. Provided below is a list of warning signs (adapted from Lillienfeld et al., 2012) that can be used to determine whether a claim has scientific merit or is pseudoscientific.

- Lack of falsifiability and the use of ad hoc hypotheses to support the claim
- Emphasis on confirmation of the claim
- Lack of self-correction
- Extraordinary claim without data to support it
- Data used to support the claim rely heavily on anecdotal observations
- Terminology used to describe the claim is imprecise or hypertechnical

Below is a description of these warning signs and some possible information that might assist in this discussion of pseudoscientific claims.

Lack of Falsifiability & Significant Use of Ad Hoc Hypotheses to Support the Claim

One significant difference between science and pseudoscience is falsifiability (Popper, 1968). Science tries to show that ideas are

Table 2. Worksheet 1: An example experimental design.

Observations	Briefly describe the observations that you have made for this project.	*Taurus is patient and Aries is impatient.*
Hypothesis & Prediction	Write a statement that explains patterns that emerged from Table 1 and a prediction that supports the hypothesis.	*Astrological sign and patience are related. Individuals that are born under the sign of Taurus should be the most patient compared to individuals born under the sign of Aries. People born under one of the other 10 signs will be neither patient nor impatient.*
Independent (Experimental) Variable	Define the independent variable(s) in your experiment.	*Astrological signs of the students at this institution*
Dependent Variable	Define the dependent variable(s) in your experiment.	*Student answer to a question about patience.*
Control Variable	Define/describe the control variable (s) in your experiment.	*Participants represent a random sample of college students.* *The question will be written on a half sheet of paper and presented to each participant in the same manner.*
Methodology	Describe how you will conduct your experiment.	*All will receive a half piece of paper with two questions:* *1. What is your birthday?* *2. Are you patient?* *The responses "Yes," "No," or "It depends" will be written under the question "Are you patient?". Participants will be asked to circle one of the three responses. The data from participants who do not follow directions will not be used in this experiment.* *The experiment will be conducted until at least 50 people have responded to the questions.*
Results	Provide a graphical or tabular representation of your data	*Figure 1 shows the data collected for people who answered the question "Are you patient?".*

incorrect rather than show that ideas are correct. Pseudoscience, on the other hand, attempts to prove that a claim is correct. Ad hoc hypotheses are hypotheses added to a theory to prevent falsifiability of the theory.

As hypotheses are tested and new data are discovered, some hypotheses are falsified and others are supported. Astronomers (scientists who study the physical universe) have shown that there are 13 constellations that intersect with the tropical zodiac, instead of the 12 used by astrologists (Zarka, 2011). Therefore, a 13th sign, called "Ophiuchus," should be added to the zodiac. In response, astrologers have claimed that Ophiuchus is not a sign, though it is a constellation. Astrology is based on the four seasons, not on constellations (Daily Horoscope, no date), with three zodiac signs in each season.

The data collected and the conclusions made by students can provide an opportunity to evaluate their thinking about falsifiability. For example, a student may collect data that support the prediction that people born under the sign of Taurus are more patient than people born under the sign of Aries and conclude that astrological signs can predict an individual's traits. This provides the opportunity for instructors to help students think critically about the broad nature of the stated conclusion (one test of two astrological signs and two traits leading to the conclusion that all of astrology is scientifically plausible) and how the additional research done by other students in the classroom does not support the conclusion that astrological sign predicts traits.

It can be difficult to state a hypothesis that can be falsifiable. When a statement is falsifiable it does not have to be false, but it must be able to be demonstrated to be false. It is possible to falsify that the Earth rotates around the sun, even if the statement that the Earth rotates around the sun is not false. It is not possible to falsify the claim that ESP exists, whereas it is possible to falsify that ESP will occur under a set of specific conditions. If the hypothesis being tested is not falsifiable, then the claim in itself may be pseudoscientific. This understanding about falsifiablity and science can be used to think critically about all claims.

Emphasis of Confirmation of the Claim

Confirmation bias occurs when a researcher looks for evidence in support of a claim while simultaneously dismissing evidence not in support of the claim (Tavris & Aronson, 2007). An example of confirmation bias in astrology occurs when individuals recall reading a horoscope and having one of the predictions be true. However, the same individual will not recall the numerous predictions that were not true (Nickerson, 1998). An example of confirmation bias that might occur when students are presenting their research is the choice of participants. If the researcher has a close personal relationship with the participants, it is possible that his or her choice of those participants was based on previous knowledge of their astrological signs and a guess that they would agree or disagree with a question.

Confirmation bias can be unintentional, and researchers have developed a variety of experimental designs to decrease the likelihood that unintentional confirmation bias will occur. One of these strategies is the use of randomized controlled trials in which subjects are randomly chosen from a very large population and variables such as age, gender, socioeconomic status, education, and others are controlled for to ensure that the demonstrated effect can only be explained by the change in the dependent variable and not by a confounding variable not controlled by the experimenter.

Lack of Self-Correction

Science is a process that corrects and refines scientific ideas because hypotheses are evaluated and tested over time by multiple individuals (Quine & Ullian 1978). Pseudoscience does not change or refine its ideas over time. As discussed above, there are 13 constellations that intersect with the tropical zodiac. If astrologists took the 13th constellation into account and added Ophiuchus to the signs of the zodiac, there would be changes in the birthdates for all of the astrological signs (Table 3). As described above, astrologers have proposed an ad hoc hypothesis to explain why this is not relevant to astrology. The unwillingness to consider the additional information that is provided by astronomy is an example of the lack of self-correction in astrology.

Discussing that pseudoscientific claims remain static for centuries can help students critically evaluate claims they encounter outside the classroom. Many pseudoscientific claims are based in long-held beliefs that haven't changed in centuries, whereas scientific claims that were made centuries ago have been refined over time. For instance, Aristotle believed that life could appear from nothing. As our knowledge of basic biology improved, this notion was replaced and refined into a more scientifically plausible notion of how life comes to be. On the other hand, individuals in support of UFOs describe them as being reported during Biblical times, and similar descriptions are reported today.

Extraordinary Claims without Data to Support Those Claims

Carl Sagan (1995a, b) stated that "extraordinary claims require extraordinary evidence." The theory of evolution is an example of a claim that draws on data from multiple disciplines, including paleontology, genetics, and development biology. Data from these different biological disciplines support the theory of evolution.

When an astrologer reads a person's chart and makes predictions about the person's future, their traits, and potential romantic interests, the predictions should be specific and measurable. Instead the predictions are vague and could be applied to a wide range of people. In addition, a mechanism should be proposed to explain why the position of the astrological bodies at the time of one's birth should have a large influence on a person's future. To date, no such mechanism has been proposed.

Discussing the lack of data to support pseudoscientific claims can help students critically evaluate other claims. Science isn't a democracy in which researchers vote on which theory is supported and which is not. Theories are falsified and refined (see above) because researchers are consistently collecting data that address potential weaknesses in theories. Individuals defending pseudoscientific claims do not seek the same rigorous experimental data.

Data Used to Support the Claim Rely Heavily on Anecdotal Observations

Anecdotal observations are based on an individual's experience. In a scientific study, such observations are tested to determine whether they are based in reality and not simply in subjective, personal experience. Pseudoscientific claims can be based entirely on anecdotal

Table 3. Birthdates for the astrological signs ignoring shifts in the position of the Earth (traditional date rage), and birthdates for the signs that take the shifts in the position of the Earth into account. The astrological sign Ophiuchus is added when the position of the Earth is taken into account.

Zodiac Sign	Traditional Date Range	Shifted Date Range
Capricorn	December 22–January 19	January 20–February 16
Aquarius	January 20–February 19	February 17–March 11
Pisces	February 20–March 20	March 12–April 18
Aries	March 21–April 19	April 19–May 13
Taurus	April 20–May 20	May 14–June 21
Gemini	May 21–June 20	June 22–July 20
Cancer	June 21–July 22	July 21–August 10
Leo	July 23–August 22	August 11–September 16
Virgo	August 23–September 22	September 17–October 30
Libra	September 23–October 23	October 31–November 23
Scorpio	October 24–November 22	November 24–November 29
Ophiuchus		November 30–December 17
Sagittarius	November 23–December 21	December 18–January 19

observations, without the scrutiny of the scientific method. Anecdotal observations have the quality of supporting, rather than refuting, the claim, particularly when the individual believes the claim to be true. In other words, students who believe that horoscopes are true are more likely to provide an anecdotal observation in which a horoscope accurately predicted an outcome. They are less likely to provide an anecdotal observation of the day when the horoscope did not accurately predict an outcome. Anecdotal observations are linked with confirmation bias and lack of falsifiability.

In conclusion, pseudoscientific claims need to be addressed in the science classroom and can be an interesting tool to assist students in critical evaluation of all the information they are consuming.

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