The Effect of Critical Reading Workshops on Individual Ability to Identify Pseudoscience

Lan Lou (Biochemistry), Sunny Makwana (Biochemistry), and Abby McCartney (Biological Sciences)

ABSTRACT

Pseudoscience, or scientific research presented with manipulated data or conducted with flawed methods, has measurable and potentially dangerous impacts on society. With increasing media focus on pseudoscientific data, learning how to identify pseudoscience is vital to the modern public. As such, this research project seeks to assess if the average person can distinguish pseudoscience from peer-reviewed science based on visual cues within the writings, such as experimental methods, tone, and organization of the paper. A critical reading workshop will be implemented to train individuals to recognize pseudoscience so that they may base important, life-altering decisions on reliable sources. Individuals in six different age groups will be presented with two medical research articles, one peer-reviewed and one pseudoscientific, and will be asked to label which is which and explain their answers. Afterwards, we will lead a short language workshop designed to develop critical reading skills. Next, we will survey the age groups again. We expect to find close to half of each age group in the sample will be unable to determine the pseudoscientific article from the initial survey. Our estimates may increase for specific age groups based on prior research. After completing our workshop, we expect meaningfully larger portions of individuals will be able to recognize falsified work. In summary, the workshop strategy suggests that workshops should be implemented into educational systems so that citizens are better prepared to analyze scientific research when making important decisions for themselves and their children.

INTRODUCTION

Scientific research based on altered data, conducted with flawed methods, or presented with manipulated visuals classifies as pseudoscience. Several distinguishing aspects of pseudoscience include unsupported conclusions, small and/or unrepresentative sample sizes, cherry-picked/manipulated data, or the lack of a control group, among others ("A Rough Guide to Spotting Bad Science," 2014). Although scientists have purposefully faked data and lied about experimental results, scientists may also make mistakes unintentionally. Most scientists conduct their experiments with speculation or an expectancy of some sort at the beginning of their research. Therefore, because of a preconceived notion of the way that the experiment should go, scientists can intentionally or unintentionally misinterpret their results or selectively review data to support their initial hypothesis, which can reduce the researcher's reliability ("A Rough Guide to Spotting Bad Science," 2014).

In order to organize, access, and utilize scientific research to improve the world by developing new medicines and technology, scientists must conduct their research ethically and honestly without bias. When a scientist writes an article that makes conclusions off of faked data or data obtained using flawed methods, he offers false information to the scientific research community. This can cause setbacks in important research or lead scientists down purposeless paths wasting valuable time and energy. In order to prevent false information from negatively affecting the scientific research community, scientists have implemented techniques to analyze and expose science conducted illegitimately or with flawed methods using a peer-review process.

Generally, in order to test research, scientists in the same field of the article in question, or peers, review the articles and attempt to repeat the experimental methods. If another scientist cannot repeat the experiment or replicate the experiment's results, the conclusions of the experiment are deemed unreliable. However, sometimes articles slip through the initial review process and achieve publication despite faulty conclusions. Although articles can be retracted and labeled pseudoscientific after publication, they can still have dangerous and lasting impacts on society. While untrue scientific research can sometimes pose no harm to the general public and scientific research community, other times it can present a great threat to people's health and safety.

As a popular example, Andrew Wakefield's article proposing a link between vaccinations and autism has impacted the public's important medical decisions. In the past couple decades, parents have decided not to vaccinate their children because of Wakefield's proposed link, one that was based on a small sample size including children predisposed to autism. In 2015, a measles outbreak occurred after an unvaccinated child visited Disneyland in California, California hospitals diagnosed 110 children with measles, 45% of which were unvaccinated (Zipprich et al., 2015). In this specific case, a pseudoscientific article persuaded numerous parents to refuse to vaccinate their children, resulting in a measles outbreak. Wakefield's research article based on faulty scientific research lead many people to make life-threatening medical decisions for their children (Rao & Andrade, 2011).

Because of the dangerous effects pseudoscience has had in the past, this research project aims to discover if the average individual can distinguish pseudoscience from true science. The research project also attempts to determine if the average person can be trained to distinguish pseudoscience from peer-reviewed scientific research by attending a workshop.

A workshop strategy will be implemented to train individuals to recognize pseudoscience. After an initial survey asking the sample to identify one of two research articles as pseudoscience, a 15 minute workshop will be given to six different age groups to prepare individuals to identify distinguishing characteristics of pseudoscience. The workshop serves as an attempt to help people pinpoint condemning flaws in scientific articles so that they can better make important decisions on reliable sources. After the workshop, the sample will take another survey to determine if the workshop improved the individuals' ability to identify pseudoscience.

We predict that approximately half of the sample will be unable to distinguish the pseudoscientific articles from legitimate scientific articles. However, after the workshop, 1-9% more of people, depending on the age group, will be able to distinguish pseudoscience from peer-reviewed science.

METHODS AND EXPERIMENTAL

In order to test how workshops can influence an individual's ability to distinguish pseudoscientific research, two medical research articles will be used to survey the individuals organized into age groups. One of the articles will be peer-reviewed, and the other will be pseudoscientific.

For our peer reviewed article, we will use "Immune-Correlates Analysis of an HIV-1 Vaccine Efficacy Trial" by numerous accredited scientists (Haynes et al., 2012). The lead author, Barton F. Haynes, lists over 1,000 publications on his faculty webpage for Duke School of Medicine, and the chosen article has been cited in other work over 1,000 times itself (Haynes, 2019). The article uses a large sample size, discusses how the sample was chosen, includes specific but visually descriptive figures, and generally follows the guidelines for scholarly literature (Haynes et al., 2012).

For our pseudoscientific article, we will use Andrew Wakefield's infamous article, "Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children," in which a causal link between the MMR vaccine and Autism in children is supported (Wakefield et al., 1998). Wakefield's work has been criticized by many other scientists in his field, and this article has been retracted for making conclusions on insignificant and biased data (Wakefield et al., 1998). Individuals will be asked to read the articles, label each article as peer-reviewed or pseudoscientific, and explain their answers.

As prior knowledge of Wakefield's work may result in skewed responses, we will actively search for individuals that are uninitiated in the field of study. Replies will be recorded by age range: Individuals will be divided into six groups by age range; 10 to 15; 16 to 20; 21 to 30; 31 to

45; 46 to 60; 61 to 80. Individuals in the 10 to 15 age range are considered inexperienced children. Those in the 16 to 20 age range are considered teenagers and adolescents; The 21 to 30 age range consists of young adults. The 31 - 45 age range consists of working adults with ongoing social interactions. The 46 - 60 age range is considered working adults with limited ongoing social interactions. Finally, those in the 61 - 80 age range are considered retirees. The study intends to work with 600 individuals divided into 100 per age group.

Afterwards, individuals will attend a critical reading workshop in the form of a short lecture and discussion without being given the answers to the survey. The workshop will be 15 mins long and will teach individuals how to distinguish pseudoscience from scientific work by looking for aspects of pseudoscience as outlined by Gregory Lof (2018). The workshops will help individuals identify misleading titles, misinterpreted and/or irreplicable results, improper or erroneous experimental procedure, the distinction between correlation and causation, samples, language, and citations to develop critical reading (Lof, 2018). After the workshop, individuals will be asked to label the same articles as before, and explain why they chose their answers again before our data is collected and organized. We will be comparing the average ability of each age group to correctly identify the pseudoscientific article from the peer reviewed article. The initial survey will serve as our control, and the change in replies tested by the second survey as our experimental trial.

Before the experiment, all individuals will be asked to give informed consent. Consent forms will be signed voluntarily, and parents will sign consent for their kids. An ethics committee will supervise and inspect all experimental procedures.

DISCUSSION

Based on prior research and statistics, we have expected outcomes for the experiment. We hypothesize that all age groups will experience an increase in ability to identify pseudoscientific articles. We also speculate that the increase will differ in magnitude for each age group with the 21 to 30 age group experiencing the greatest increase of 10% and the 10 to 15 and 61 to 80 age groups experiencing the smallest increase of 1%.

Expected Outcomes

We speculate that the results from the survey will emulate the data displayed in Table 1. Before the workshop, individuals in the 21 to 30 age range will achieve the highest average of correct responses because they have the highest level of education and are most socially active. Individuals in the 10 to 15 age range will show the lowest average of correct responses because they are still too young to understand the content of the articles. After 31 years old, as age increases, the correctness decreases as individuals are less often exposed to social interactions and are gradually distanced from critical thinking skills.

After individuals take the workshop and finish the second survey, we will calculate the change in correct responses. We assume that individuals with younger age will have a small increase to average change. Similarly, people who are over 36 may have decreasing ability to study critical thinking and apply their social skills in distinguishing pseudoscience from true science. According to research discerning the relationship between age and ability to learn new information, to a great extent, voluntary attention affects the efficiency of learning. The attentional brain circuits which are connected to the frontal lobe of children and older groups may be inchoate or degenerated. The weak attention span may affect the extent of learning from the workshop and can cause less improvement (Janacsek, Fiser, & Nemeth, 2012). Our expected rates of improvement are displayed in Table 1, and this data is visualized in Figure 1.

Table 1. Workshop before and after percent differences by age group

Age	Before	After	Change
10 to 15	50.5%	51.5%	1.0%
16 to 20	57.0%	66.0%	9.0%
21 to 30	59.0%	69.0%	10.0%
31 to 45	56.0%	62.0%	6.0%
46 to 60	53.0%	56.5%	3.5%
61 to 80	52.0%	53.0%	1.0%

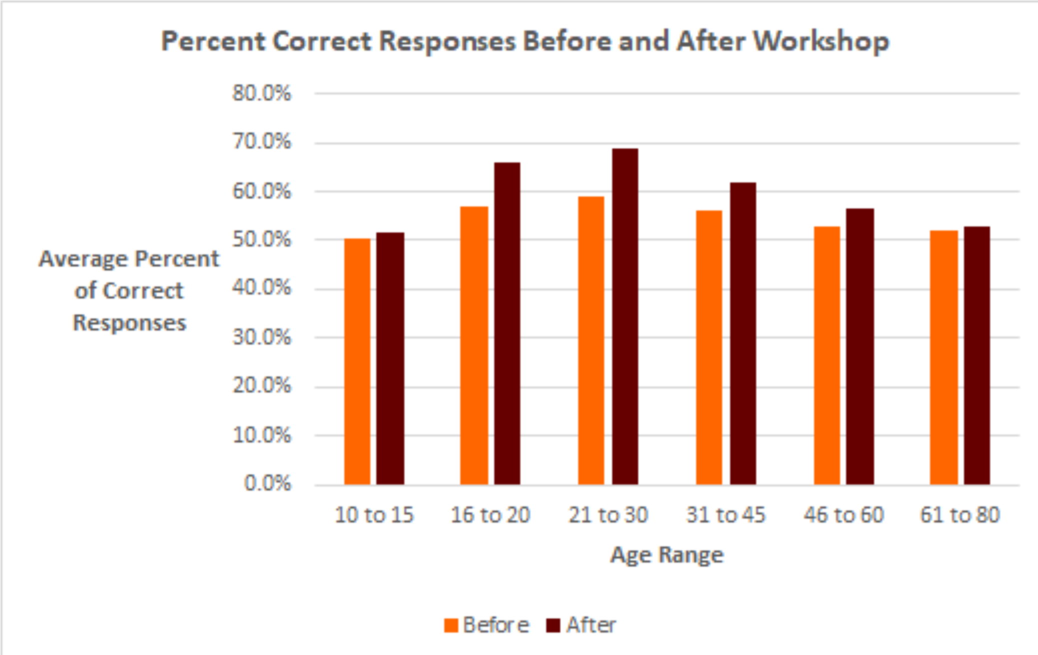

Figure 1. The response differences before and after the workshop by age group

Future Implications

We found critical reading workshops have the potential to meaningfully increase public awareness of pseudoscience.Therefore, more workshops and classes should be implemented into educational systems to better prepare citizens to analyze public information. Given the expected success of our strategy, further research into the ability of the general public to distinguish pseudoscience is clearly supported.

Ethical Concerns and Assessment of Pitfalls

Our experimental necessitates a sample unable to read critically, so our results are susceptible to potentially varied levels of education. We could combat this by slightly increasing our expected baseline from 50%, but choosing any number above 50% would be an arbitrary act. Therefore, we have made a conscious decision to retain a baseline of 50% as an outcome of the law of large numbers given identical individual trials per age group ("Law of large numbers," 2019).

As we are reusing our test materials, namely, our peer-reviewed and pseudoscientific articles, an imperfect sample may also include individuals who have previously encountered these articles. In this case, there is a possibility that a few of these individuals know the peer-reviewed article from the pseudoscientific one through direct prior experience.

Of course, there are also considerations to be made concerning the use of human subjects. While our experiment is virtually harmless, we will still take all precautions as suggested by the Institutional Review Board's (IRB) guidelines ("Institutional Review Board").

All individuals will be given informed consent, and consents will be signed voluntarily by the participants or the parents of the minor participants.

CONCLUSION

Despite differing magnitudes, all age groups are expected to improve their critical reading skills after the workshop, and more individuals may be able to distinguish pseudoscience from legitimate, peer-reviewed scientific research. Our experiment demonstrates that the average individual of any age group can be taught to distinguish pseudoscience from peer-reviewed science, but those between ages 16 to 45 are the most susceptible to learning this key skill. If a larger portion of the population learned how to identify unreliable and faulty sources of information, a greater number of people would be able to make important medical and lifestyle decisions based on accurate information.

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