Synthesis of Computer Vision and Website Design for Misinformation-Checking Website
(Technical Paper)

Identifying Major Themes in Anti-vaccination Misinformation Surrounding the COVID Vaccine and Childhood Vaccines
(STS Paper)

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Computer Science

By
Abigail Morgan

November 1, 2021

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

ADVISORS

Daniel Graham, Department of Computer Science

Bryn E. Seabrook, Department of Engineering and Society

Prospectus

During the COVID-19 pandemic, the world faced two battles: the battle against the novel coronavirus itself and the battle against the misinformation surrounding it. Instead of merely focusing on mitigating the spread of, treating, and finding a vaccine for the coronavirus, the United States government had to develop strategies to combat misinformation as it spread at an unprecedented speed and scale (Murthy 2021). Misinformation that focused on the vaccines developed was particularly prevalent and caused many to delay or forgo vaccination. Vaccine misinformation is not a new phenomenon - misinformation surrounding vaccines administered during childhood has given strength to anti-vaccine (anti-vax) movements that seek to decrease vaccine uptake because of perceived but ultimately baseless safety concerns (Geoghegan et al. 2020). Despite federal and local efforts to combat misinformation and increase vaccine uptake rates in both cases, anti-vax groups continue to disseminate vaccine misinformation that is then believed by members of the public, which can weaken the herd immunity and lead to outbreaks of disease. Comparing the main themes present in the misinformation that circulated around both childhood and the coronavirus vaccines and how the public interacted with that misinformation in both scenarios can give insight into how best to develop strategies to more effectively combat vaccine misinformation in the future. This research will be presented in a research paper.

To slow the spread of misinformation during the pandemic, social media sites like Instagram, Twitter, and Facebook used third-party fact checkers to screen user posts and flag any that appeared to contain misinformation (Instagram 2020). However, fact-checking organizations are not a perfect solution - there are not fact-checking organizations in all countries, and even in countries where they do exist they simply cannot handle the amount of misinformation that circulates on social media sites (Lyons, 2018b). To better flag misinformation, machine learning

algorithms can be employed. In many cases machine learning-based fact checking only focuses on text-based user posts, limiting its efficacy as in many cases misinformation is spread through images or videos. Employing computer vision to, for example, read text from an image or determine the content of a video could drastically increase the abilities of fact-checking algorithms and help fact-checking organizations to process and flag more misinformation. Moreover, the public usually only interacts with algorithmic fact-checking in environments where they are one step removed from the fact-checker - for example, social media sites employ fact-checkers but there is no way for a user to submit posts to a fact-checker on their own. Users do sometimes have the option of flagging a post as misinformation if they think it contains misinformation, but this does not allow them to ascertain the factual nature of a post they believe to be of dubious accuracy. By combining the ideas of computer vision, machine learning, and website design from two upper-level computer science courses, Computer Vision and Advanced Software Development, a website could be created that employs computer vision to see if user-submitted images contain misinformation or not. An individually-authored technical report will synthesize computer vision and software design principles and discuss the construction of the fact-checking website. This website would bridge the gap between the public and fact-checking algorithms and increase access to algorithmic fact-checking.

Technical Report: Synthesis of Computer Vision and Website Design Principles for Misinformation-Screening Website

The technical report will discuss a synthesis of ideas from two upper-level computer science classes offered at the University of Virginia, namely CS 4501: Introduction to Computer Vision and CS 3240: Advanced Software Design. The topics covered in Introduction to Computer Vision included image classification, object recognition, and the use of machine

learning in computer vision. Computer vision is the use of computers to extract information from images and can be used in a variety of ways. In the class, students used computer vision to detect corners and lines in images, combine photos from different points of view into panoramas, and train and use a machine learning model to classify images. Such strategies enable algorithms to be created that could extract text from images. Pulling text from images is not a new idea: for example, the Google Translate mobile app allows users to scan text using a camera and translate it into a different language. However, extracting text from images and then screening that text for misinformation is a new idea.

Advanced Software Design focused on a semester-long group project where students created a website while following common software development practices. Students used the programming language Python and Django, a Python web framework, to develop the website. The use of agile development strategies was emphasized. Agile development involves the use of short work periods called sprints (usually a few weeks long) in which developers work only on a few requirements at a time. After the sprint is done, the work done during the sprint is reviewed and the goals for the next sprint are selected. This iterative process allows the development team to remain focused on smaller, more achievable tasks while remaining responsive to changing requirements. By combining the topics from these two classes, a website could be created that uses computer vision and machine learning to identify text in images that could then be screened for misinformation in the same way that user-generated content is screened for misinformation on many social media platforms. Users could submit images to this site that would then be screened for misinformation, allowing them to more critically evaluate the factual nature of the information they come into contact with on the Internet. The website's functionality could be extended by creating a browser plugin that automatically screens images that the user views (for

example, on social media sites). The use of a browser plugin reduces the effort the user needs to put forth to evaluate images since they do not have to manually submit the images to the site. Incorporating both voluntary and automatic screening of images widens the reach of computer-vision-assisted algorithmic fact-checking and helps users avoid falling prey to misinformation.

STS Topic: Identifying Major Themes in Anti-vaccination Misinformation Surrounding the COVID Vaccine and Childhood Vaccines

In 1998, Andrew Wakefield published a paper in the medical journal *The Lancet* that suggested a link between the administration of the measles, mumps, and rubella (MMR) vaccine and the development of autism (Rao & Andrade, 2011). Although 10 of the 12 original authors of the paper retracted the original interpretation of the data on the grounds that the data was insufficient soon after, the paper received widespread publicity (Rao & Andrade, 2011). Due to this misinformation, "parents across the world did not vaccinate their children out of fear of the risk of autism" and multiple outbreaks occurred in the UK, Canada, and the USA that "were attributed to the nonvaccination of children" (Rao & Andrade, 2011). Despite the fact that measles had been declared eradicated in the United States in 2000 by the World Health Organization (Centers for Disease Control and Prevention, 2020), outbreaks of measles (which can be fatal) were caused by the publication of a single paper, illustrating the danger of misinformation. Moreover, time and resources that could have doubtless been better utilized elsewhere then had to be wasted to prove Wakefield's claims to be unsubstantiated.

Vaccine misinformation has been widespread during the COVID-19 pandemic. Social media proved to be full of false claims about the coronavirus itself, such as "COVID-19 has been invented to make people use contactless payments so that the government can track individuals"

(Lockyer et al., 2021). The vaccine was also the subject of misinformation on social media; for example, some claimed that it would "make people infertile" or "[contained] a chip that [would] track individuals" (Lockyer et al., 2021). This widespread misinformation contributed to lagging vaccination rates despite the availability of doses, which then led to continued high case numbers, especially in the United States. Despite the presence of strategies to counteract misinformation like those released by the United States Department of Health and Human Services (2021), misinformation did not disappear. Strategies to combat misinformation existed before the start of the COVID-19 pandemic, but misinformation was incredibly widespread and harmful, signifying the need for better strategies.

In the book *States of Knowledge*, American social scientist Sheila Jasanoff (2006) explains that "[w]hat happens in science and technology today is interwoven with issues of meaning, values, and power in ways that demand sustained critical inquiry." This idea of bidirectional influence is a change from the frameworks of technological determinism, which states that technology alone influences the course of history, and the social construction of technology (SCOT), which posits that human action alone shapes the development of technology. This idea that society and technology both influence and are influenced by each other over time is called co-production and it will be used to analyze the interactions between society and vaccine technology, most notably in the production of vaccine misinformation. There are two strands of co-production: the constitutive and the interactional. The constitutive approach concerns itself with understanding "how particular states of knowledge are arrived at" (Jasanoff, 2006). For example, a constitutive approach would examine how the public forms opinions about vaccines given the information (or misinformation, in the context of this paper) that they encounter. The interactional approach seeks to understand "how human beings organize, and

periodically reorganize, their ideas about reality" (Jasanoff, 2006). An interactional approach might investigate how people change their opinions on vaccines when presented with new information about vaccines. In short, the constitutive approach is concerned with *what* is known and the interactional with *how* it is known (Jasanoff 2006). Co-production is especially applicable in the context of vaccine misinformation - as vaccine technologies are developed, societal opinions of vaccines change, often alongside the spread of misinformation. This societal shift then necessitates the development of technologies like fact-checking algorithms to combat the misinformation. Thus society and technology influence each other.

Co-production will be useful in formalizing the interactions between vaccine technology and society, but since it is a relatively new concept, critics say "it requires a stronger agreed understanding and evidence base to make a real impact in policy" (Boyle & Harris, 2009). Jasanoff (2006) states that "research on science and technology has not sought to build systemic connections between the micro-worlds of scientific practice and the macro-categories of political and social thought". One paper will not be sufficient to create insights that inform large-scale policy change or the development of strategies that entirely eliminate misinformation, but such research is undoubtedly important in beginning to understand the ways that society and technology interact.

Methods

The research question that this paper aims to answer is "how do the main themes present in misinformation about childhood vaccines and the COVID-19 vaccine compare, and how can that comparison be used to create strategies that more effectively combat vaccine misinformation?".

To answer this question, a documentary review will be conducted and findings will be grouped thematically. Some sources detail themes and common arguments present in vaccine misinformation (Moran et al., 2016; Hughes et al., 2021; Geoghegan et al., 2020), while others identify current strategies for identifying misinformation and curbing its spread (Zhang et al., 2021; LaSalle, 2020; Lyons, 2018a, 2018b; Instagram, 2019; Department of Health and Human Services, 2021), and others that discuss how and why people interact with vaccine misinformation (Lockyer et al., 2021; Goldenberg, 2021; Bond, 2021). Many of these sources were found by searching for the keywords "vaccine hesitancy," "childhood vaccine hesitancy," and "vaccine misinformation" in the University of Virginia's Virgo library search system, which catalogs more than 8 million books, papers, manuscripts, and theses. Other sources, such as those that detail the actions that popular social media platforms are taking to slow the spread of misinformation, were found using a general-purpose search engine. Additionally, a historical case study approach will be used to analyze both the controversy surrounding childhood vaccines (primarily in the early 2000s) and the resistance by some to the COVID-19 vaccine. Discourse analysis will also be used to analyze the misinformation produced and disseminated in both scenarios.

Conclusion

The STS research paper will compare common themes present in misinformation surrounding childhood vaccines and the COVID vaccine, which will give insight into how to create strategies to more effectively combat vaccine misinformation. The capstone technical report will discuss how computer vision and website design can be synthesized to create a website that identifies text in images and screens it for misinformation in the same way that user-generated content is screened for misinformation on many social media platforms. These

two projects will shed light on the threat that vaccine misinformation poses to global public health and provide ways to slow its spread and lessen its effect. Finding more effective ways to combat misinformation, especially vaccine misinformation, will be a valuable tool in future public health crises.

References

Bond, S. (2021, August 21). Facebook's most viewed article In early 2021 raised doubt about COVID vaccine. NPR. https://www.npr.org/2021/08/21/1030038616/facebooks-most-viewed-article-in-early-2021-raised-doubt-about-covid-vaccine

Boyle, D. & Harris, M. (2009). *The challenge of co-production: How equal partnerships between professionals and the public are crucial to improving public services.* New Economics Foundation. https://neweconomics.org/uploads/files/312ac8ce93a00d5973_3im6i6t0e.pdf

Centers for Disease Control and Prevention (2020, November 5). *Protection against measles.* https://www.cdc.gov/measles/about/faqs.html

Geoghegan, S., O'Callaghan, K. P., & Offit P. A. (2020). Vaccine safety: myths and misinformation. *Frontiers in Microbiology, 11(*1). https://doi.org/10.3389/fmicb.2020.00372

Goldenberg, M. J. (2021). *Vaccine hesitancy: Public trust, expertise, and the war on science.* University of Pittsburgh Press.

Hughes, B., Miller-Idriss, C., Piltch-Loeb, R., Goldberg, B., White, K., Criezis, M., & Savoia, E. (2021). Development of a codebook of online anti-vaccination rhetoric to manage COVID-19 vaccine misinformation. *International Journal of Environmental Research and Public Health, 18*(14). https://doi.org/10.3390/ijerph18147556

Instagram. (2019, December 16). *Combatting misinformation on Instagram.* https://about.instagram.com/blog/announcements/combatting-misinformation-on-instagram/

Jasanoff, S. (2006). Ordering knowledge, ordering society. In S. Jasanoff (Ed.), *States of Knowledge: The co-production of science and social order* (pp. 13-45). Routledge.

LaSalle, G. (2020). *Let's talk vaccines: A clinician's guide to addressing vaccine hesitancy and saving lives.* Lippincott Williams & Wilkins.

Lockyer, B., Islam, S., Rahman, A., Dickerson, J., Pickett, K., Sheldon, T., & Sheard L (2021). Understanding COVID-19 misinformation and vaccine hesitancy in context: Findings from a qualitative study involving citizens in Bradford, UK. *Health Expectations : an International Journal of Public Participation In Health Care and Health Policy,* 24(4), 1158-1157. https://doi.org/10.1111/hex.13240

Lyons, T. (2018, May 23). *Hard questions: what's Facebook's strategy for stopping false news?* Facebook. https://about.fb.com/news/2018/05/hard-questions-false-news/

Lyons, T. (2018, June 14). *Hard questions: how is Facebook's fact-checking program working?* Facebook. https://about.fb.com/news/2018/06/hard-questions-fact-checking/

Moran, M. B., Lucas, M., Everhart, K., Morgan, A., & Prickett, E. (2016). What makes anti-vaccine websites persuasive? A content analysis of techniques used by anti-vaccine websites to engender anti-vaccine sentiment. *Journal of Communication in Healthcare, 9*(3), 151-163. https://doi.org/10.1080/17538068.2016.1235531

Rao, T. S., & Andrade, C. (2011). The MMR vaccine and autism: Sensation, refutation, retraction, and fraud. *Indian journal of psychiatry*, 53(2), 95–96. https://doi.org/10.4103/0019-5545.82529

United States Department of Health and Human Services (2021). *Confronting health misinformation: the U.S. Surgeon General's advisory on building a healthy information environment.* https://www.hhs.gov/sites/default/files/surgeon-general-misinformation-advisory.pdf

Zhang, J., Featherstone, J. D., Calabrese, C., & Wojcieszak, M. (2021). Effects of fact-checking social media vaccine misinformation on attitudes toward vaccines. *Preventive Medicine*, 145. https://doi.org/10.1016/j.ypmed.2020.106408