Master's Research Project Proposal

Overcoming Vaccine Hesitancy: The Development of a Multimedia Animation on the Biological Mechanisms of Vaccines in Conjunction with the Immune System

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June 30. 2021

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ABSTRACT

This project aims to produce an educational animation surrounding the cellular and molecular mechanisms of vaccines, as well as the significance of herd immunity in providing community protection from infectious disease. The goal of this animation is to alleviate concerns of vaccine hesitancy and to demystify anti-vaccination sentiment by providing knowledge in the form of a dynamic visual to a public audience. The material of the animation will be developed through content analysis of existing literature, wherein a script and storyboard will be created, followed by the construction of 3D assets and a 2D animatic. This project will contribute to the current pool of intervention strategies intended to reduce vaccine hesitancy through the visual simulation of the real- life microscopic mechanisms and conditions under which vaccines operate. This animation will also combine a unique 2D/3D visual style in producing a compelling dynamic visualization for optimal understanding of the complex and critical biological processes underlying long-term immunological protection.

Key words: Vaccine mechanisms, public education, herd immunity, dynamic visualization

INTRODUCTION

Vaccine hesitancy is defined as the reluctance to become vaccinated despite the extensive availability of vaccines. This delay in the acceptance of vaccination services poses a threat to public health and often stems from a distrust in the science surrounding vaccine development and their mechanisms of action. Ironically, it is often said that vaccines are a victim of their own success; they have been effective in eradicating the age-old disease smallpox, as well as greatly reducing the transmission of polio and rubella, and so modern-day healthcare consumers perceive the risks associated with vaccines to be greater than the dangers of infectious disease. (Kata, 2010; Orenstein & Ahmed, 2017).

Convincing evidence for discussion-centered and knowledge- based interventions successfully reducing vaccine hesitancy has not been found primarily because of a lack of post-intervention evaluation in many of the studies conducted (Jarett et al., 2015 & Sadaf et al., 2013). Effectively communicating the underlying science of vaccines in an effort to resolve skepticism may result in better acceptance of these biomedical substances as life-saving immunological tools. In fact, the status of scientific literacy and public understanding of scientific concepts in North America is poor (Liu, 2009), and it has been demonstrated that low health literacy regarding vaccines is correlated with low vaccination rates in age-specific groups (Lorini et al., 2018). Therefore, a potentially effective strategy in overcoming vaccine hesitancy may be educating the public on the biology underlying vaccines as a means of demystifying and better communicating their intricate mechanisms.

This approach is supported by the information deficit model of science communication in which misconceptions of science are due to insufficient knowledge. This model was developed in the 50s by the academic community with the assumption that simply providing information on a scientific topic is sufficient in countering ignorance and increasing the scientific literacy of the public (Lewenstein, 2003). However, it does not consider the different modes of representation information can be portrayed as, and the cognitive constraints such representations can prevent on an audience not accustomed to complex scientific content. Consequently, counteracting public misconceptions of vaccines through public health initiatives may lie not so much in the sole dissemination of verbal or textual knowledge, but also by how such knowledge is represented and communicated.

BACKGROUND

The reasons for vaccine hesitancy

Vaccine hesitancy is a complex and multifaceted issue that must be considered within a broader sociocultural and economic context. Kumar et al. (2016) posits an interaction between environmental, agent (vaccine) and host (parents) factors as the basis of decision-making concerning vaccination; environmental factors like the media, social norms and policies interact with vaccine- related factors such as their efficacy and safety and with host- related factors concerning a person's race/ethnicity, education level and knowledge of vaccines. Additionally, there is the proposed 3 Cs model of vaccine hesitancy: interaction between confidence in the efficacy of vaccines as well as the policy makers and healthcare system, complacency and low self perceived risk, and convenience associated with accessibility, affordability, and availability (MacDonald, 2015).

There is also increasing public skepticism towards science and technology which includes a distrust of scientific data collection and difficulty accepting new scientific advancements that challenge pre-existing beliefs (Rossen et al., 2016). Furthermore, the benefits and disadvantages of information dissemination in a modern world allows for medical knowledge to be easily accessed in assisting with patient decision making, but it can also serve to vilify medical procedures and practices to those prone to confirmation bias (Hussain, 2018). Vaccine hesitancy therefore results from an interplay of numerous factors that influence perspectives on benefits vs risks of vaccination, where the balance is highly skewed towards risk. Additionally, in today's globally connected world, this biased decision making is highly exacerbated by the rapid spread of misinformation made possible by the internet.

Implemented vaccine hesitancy interventions

The data on the effectiveness of implemented interventions in an effort to counter vaccination hesitancy is highly varied depending on intervention strategy, target population, and geographical location. An analysis of peer reviewed literature for evaluating the effectiveness of strategies utilizing social media, influential religious figures and financial incentives found the most successful interventions were those employing multiple strategies and tailored for low to middle income-based populations (Jarett et al., 2015). A systematic review conducted to evaluate literature on interventions addressing vaccine hesitancy found little evidence for intervention benefits in parents refusing to vaccinate children (Sadaf et al., 2013). Furthermore, strategies utilizing pamphlets, social media, email communications and mobile apps to improve vaccine uptake were not found to be sufficient in addressing hesitancy (Dubé et al., 2015).

Numerous vaccine hesitancy interventions have failed to evaluate post-intervention effectiveness to assess for adequacy in reducing vaccine apprehension. For instance, a systematic review of interventions was conducted aiming to understand vaccine reluctance and whether getting vaccinated to benefit the community influenced an individual's decision to become vaccinated (Hakim et al., 2018). However, there was no post- intervention assessment which is necessary in determining the success of these methods and tools. Therefore, many of the studies assessing the benefits of interventions in addressing vaccine hesitancy failed to evaluate post-test effectiveness and where they were assessed, interventions failed to mitigate vaccine skepticism.

Public understanding of vaccine science

A systematic review conducted to examine opinions on controversial scientific topics and predictors of science-related skepticism discovered the significance of scientific literacy in predicting vaccine skepticism (Rutjens et al, 2017). Because molecular and cellular biology are specialized fields of study requiring years of training, it is assumed that the general public has moderate to poor understanding of these topics. An audience with little to no scientific background can have difficulty distinguishing between numerous and subtly distinct medical procedures (Federman, 2014). Likewise, slight distinctions in the different types of vaccines can allow for misinterpretation of seemingly minor differences from a lay audience's point of view. These misconstrued notions surrounding vaccines and their method of operation can then result in the propagation of myths, and so understanding the microscopic mechanisms of vaccines is vital in countering the circulation of misinformation.

Frequent myths regarding vaccines include mRNA vaccines supposedly becoming incorporated into a patient's DNA (Schlake, 2012), the administration of multiple vaccines "overwhelming" the immune system (Geoghegan et al., 2020) as well as certain adjuvants and delivery vehicles behaving as neurotoxins (Baker, 2008). Additionally, immunity acquired naturally through infection is believed by some to be superior to vaccine-induced immunity; however, this is false as vaccines not only prevent immediate and severe complications from infection but also the detrimental long-term effects of an infectious pathogen (Kumal, 2016). The existence of misleading and unfounded beliefs diminishes the perception of vaccine effectiveness and serves as a basis for anti-vaccination sentiments. Therefore, communicating the science underlying vaccines and their mechanisms can work to prevent misinformation and resolve vaccine hesitancy.

The benefits of visual representation over verbal and textual information

Although the implementation of educational approaches regarding vaccines and their biological functions can assist in alleviating vaccination concerns, merely focusing on increasing the rate of vaccine literate people does not automatically translate into better public engagement with science and reduced vaccine skepticism as assumed by information deficit model (Lewinstein, 2003). This model of science communication posits that misconceptions of scientific topics in the general public arise due to insufficient knowledge. However, the acceptance of science is not fully dependent on one's knowledge and understanding of complex concepts as proven by the numerous and unsuccessful hesitancy-reducing interventions utilizing knowledge- based strategies (Master & Resnik, 2013). Additionally, providing factual information is inadequate for debunking myths as demonstrated with the famous but unfounded theory linking the measles, mumps, and rubella vaccine to autism. Despite the vast amount of contradicting research and immense effort spent falsifying this claim, the detrimental effects of this false association spread throughout the West and resulted in a decrease in MMR vaccination rates as well as multiple measles outbreaks around the world. Therefore, communicating the underlying science of vaccines to a low scientific literacy lay audience is greater than just knowledge dissemination, as science communication to the public lies in accessibility and comprehensibility (Federman, 2014).

Visually representing scientific information in the form of a dynamic visualization can be an alternative solution for fostering public engagement with science. Several studies have boasted the beneficial effects of animations in educational psychology; Barak et al., (2013) investigated and found the potential benefits of using animations to enhance and motivate learning of scientific material, which can especially assist in the comprehension of abstract microscopic concepts. Additionally, Schnotz & Rasch (2008) found that animations can help with facilitating learning in those with low prior knowledge by reducing cognitive load and energy spent inferring minute detail not otherwise explained in text or images alone, as animations display second to second information about a dynamic process. They have the potential to guide a lay audience learn imperceptible information by aiding them in building a more accurate mental model of a 3D environment. Animations can therefore assist with promoting learning about vaccine biological mechanisms by helping to visualize the cellular dynamic processes involved.

Media Audit

Current visualizations depicting the biological mechanisms of vaccines utilize narrative storytelling to communicate ideas but many of them are missing key pieces of information such as a certain type of vaccine, are lacking in the use of a scientifically conventional colour palette and have uncoordinated integration of verbal narration, visuals, and background music. Existing 2D animations utilize a combination of visuals, sound, cues, and narration to effectively represent abstract ideas such as herd immunity, statistics associated with infection and comparisons of the two components of the immune system. Therefore, a 2D graphical style with the aid of visual metaphors helps to disseminate information on this topic in order to make the content comprehensible. Current 3D animations about this subject matter better visualize the real-life cellular processes under which vaccines operate by utilizing revolving camera angles to reinforce the illusion of a vast 3D environment and are therefore ideal for representing the cellular mechanisms of the immune system.

My criteria for an animation addressing vaccine hesitancy by visualizing vaccine biological mechanisms includes the use of appropriate and clear language and allocating sufficient time for explaining and simplifying concepts of the immune system, viral mutations, and herd immunity. For visual style, a combination of a 2D infographic style to visualize abstract concepts such as herd immunity and a 3D animation style to illustrate concrete concepts like the cellular and molecular components of vaccines and immune system will best work together for effective visual communication. Additionally, I will utilize the effective use of visual cues, saliency, verbal narration, background music and organization of information in order to reduce cognitive load and enhance learning.

RESEARCH AIMS AND OBJECTIVES

Research Problem: Public understanding of vaccine mechanisms are poor and countering the issue with verbal or textual knowledge dissemination does not remedy the issue as demonstrated with the many failed interventions utilizing knowledge- based strategies

Research question: How can knowledge about the complex cellular and molecular immunological mechanisms of vaccines be effectively communicated to an audience with low to no scientific literacy in order to combat vaccine hesitancy, and how do we engage this type of audience in an animated narrative that is both visually compelling and informative without constraining the audiences' cognitive resources?

Research project objectives:

1.) The primary objective of this research project is to provide information on the different types of vaccines and how they operate with the innate and adaptive immune systems to produce immunological protection
2.) To combine factual knowledge with learning principles of educational psychology to produce a 2D/3D hybrid multimedia animation for optimal knowledge dissemination regarding vaccine biological mechanisms and the importance of herd immunity
3.) To integrate visual and verbal cues with information presented in order to reduce cognitive load thereby enhancing comprehension and ultimately maximizing the public understanding of vaccines

METHODS

Target audience: The primary target audience is the general public aged 18-64, with a specific focus on vaccine hesitant immigrant populations. The animation will be used on social media platforms including YouTube, twitter, Facebook, and Instagram as a means of targeting the intended audience.

Procedure

1.) Scripting and storyboarding through content analysis: Extensive research on each of the following topics will be done in order to choose which vital concepts to visualize for this audience. Using this information, a script will be developed, and time allocated to each of the topics will be finalized based on content and significance for achieving the project objectives. The planned visual narrative will be broken down into a series of sketches to determine the shot-by-shot sequence and concept images will be developed to convey the overall vision and provide a creativity reference point.

The five main components of my project are:

a. **The four main types of vaccines** (live attenuated, inactivated, nucleic acid and adenoviruses): a comprehensive summary of the strengths and weaknesses of different vaccine designs, the conditions under which they are optimal, and their different mechanisms and resulting immune responses (Iwasaki & Omer, 2020).

b. **The innate and adaptive immune system**: The innate immune system is the initial defense system that does not discriminate between invading pathogens and offers protection through the inflammation of the area, phagocytes, proteins, and natural killer T cells- The adaptive immune system is the slower and more prolonged arm of the immune system that allows our immune system to remember a pathogen and stimulate a quick and coordinated defense when that pathogen is encountered again (Vetter et al., 2017).

c. **How vaccines work with immune system to produce immunological protection**: Vaccines trigger both an immediate and nonspecific innate immune response and a more prolonged and specific adaptive immune response (Clem, 2011).

d. **Vaccines and mutating pathogens**: understanding the dynamic nature of pathogens to evolve and become more dangerous. Changes that occur over time in parts of the viral genome can cause the virus to gradually change and evade antibodies produced by the immune system, and so the solution to ever- evolving viruses is to increase the rate of vaccination while curbing the spread of the pathogen through preventative measures (Clark et al., 2021).

e. Herd immunity: Herd immunity is a dynamic state and can be lost by an overall decrease in immunity in an individual (maintained by booster shots), through population turnover, changes in population contact patterns, and mutations in infectious pathogens causing the disease. Herd immunity through vaccination and constantly evolving pathogens are two processes continually competing against one another and so becoming vaccinated as soon as possible is vital in order to outrace mutating pathogens (Ashby & Best, 2021).

2.) 3D Modelling and 2D layout

Development of the animation will involve collecting references from SEM images and extracting molecular data from PubChem of antibodies, proteins, cell membrane components and genetical material. A combination of software will be used to develop 3d models: Zbrush and blender for organic modelling and Maya and Cinema4D for any hard surface modelling. Additional software such as VMD and chimera will be used for processing of molecular components. For the 2D component, a layout of the scenes with proposed lighting, camera angles and shading will be developed, followed by the proposed animatic as the final stage of development before animating.

3.) Animating

A combination of 2D and 3D animation will be used with a 2D style visual being used to explain abstract concepts like herd immunity with a combination of software: Adobe Animate, Adobe Aftereffects and Blender. 3D animation will be used for visualizing cellular and molecular processes and this component will be accomplished through the use of Maya, Cinema4D and blender with the final animation being assembled in Adobe Aftereffects.

SIGNIFICANCE

The proposed project aims to serve as a public intervention on vaccine hesitancy by presenting the biological mechanisms of vaccines and reiterating the importance of herd immunity through the production of a multimedia narrative animation. Vaccines are innovative technological tools fundamental for global health and are responsible for the reduction of numerous infectious diseases. Therefore, solving vaccine hesitancy and building confidence in them is crucial for the decline and eventual eradication of virulent and bacterial pathogens. The elimination of disease- causing agents through herd immunity depends on much of the population becoming vaccinated to 'outrace' the constantly mutating pathogen.

By using a dynamic visualization to convey this information, viewers do not have to infer second- to-second changes and understanding processes that require considerable mental effort become possible to comprehend with less cognitive exertion (Schnotz & Rasch, 2008). I hope to engage the public audience by combining a unique 2D/3D hybrid visual style for integrating the real-life microscopic conditions under which vaccines operate with an informative pro- vaccination message that has its basis in empirical science. Understanding the biological processes of vaccines is vital as most myths regarding them tend to originate from misinformation on how they operate. By effectively combining factual knowledge with dynamic visuals, I hope to make a multifaceted complex scientific problem more accessible for an audience with little to no background on the topic and for whom understanding this current issue is vital for global public health security. By producing a cued multimedia animation for public education, I will contribute a unique 2D/3D design style for visualizing both abstract and concrete scientific concepts.

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