Prospectus

Positive-Pressure Powered Filter Mask

The Politicization of Mask Wearing Among Differing Relevant Social Groups

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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.

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Introduction

The year of 2020 has been largely defined by the COVID-19 pandemic and humanity's response to it. The general consensus agreed upon by public health experts is that spread of the disease is airborne and that wearing a mask or other face covering over one's mouth and nose while in public is an important way for people to protect themselves and others from the spread of the virus. Based on this information, some state or local governments have implemented advisories or mandates for people to wear masks in public spaces, and many private companies require face coverings for customers to enter their places of business. Despite this, mask wearing in America is far from universal. According to the Pew Research Center, in June of 2020, only 65% of American adults reported that they wore masks or face coverings in public places all or most of the time, with this number rising to a higher but still incomplete 85% in August 2020 (Kramer, 2020).

The technical portion of this research seeks to provide an alternative type of face covering and protection through the design of a Powered Air Purifying Respirator (PAPR). This design hopes to target and understand the needs of a particular user group beyond normal daily wear, specifically runners and athletes on the whole. Masks can be inconvenient during heavy physical activity, and this can potentially discourage people from wearing them while working out, even when they are in public places. The ultimate goal of this technical project is to create a protective face covering that is convenient and comfortable for people during athletic activity that people are encouraged to wear while being active in public spaces.

The STS portion of this research seeks to understand how the political divisiveness of mask wearing within America developed. As noted earlier, a not insignificant number of American adults are unlikely to where masks in public spaces. According to this same Pew Research Study, only 53% of people who identify as a Republican or leaning Republican regularly wore masks in public spaces in June, with this number rising to 76% in August, while 76% of those who identify as Democrat or leaning Democrat wore masks in June and 92% in August (Kramer, 2020). This research seeks to understand how the wearing of masks became politicized in America and how the relevant social groups pertaining to mask wearing developed with respect to partisan politics.

Technical Topic

The technical research is focused on creating an alternative to masks that can effectively filter air in and out through fan powered airflow. The apparatus will fit easily over the face and reduce many of the problems that people have with masks. Similar products that already exist, like those shown below in Figures 1 and 2, fit loosely over the user's head and use fans to filter air entering the device. However, existing PAPRs do not filter air going out of the device (Center for Disease Control and Prevention, 2005). A major function of a mask is to protect others around the user from the potential spread of COVID-19, so existing PAPRs fail in this respect. In addition, PAPRs have a clear face shield in the front so the user's facial expressions are easily visible, and no material directly touches the user's face, reducing the problem of skin irritation. The technical research also aims to include these design features.

Figs. 1 & 2: Currently available PAPRS (Powered & supplied air respiratory protection; Powered Air-Purifying Respirators)

Although many people wear masks while doing everyday tasks, many runners are resistant to wearing masks during athletic activity due to discomfort. Runners need to breathe more heavily while running and wearing a fabric mask can interrupt airflow. Risk is lower in outdoor spaces, but transmission by runners is still possible when distance cannot be consistently maintained, particularly in the slipstream of air behind a moving person (Murphy, 2020). It is not always possible to maintain proper distance, especially in more populous areas. The goal of this technical research is to create a comfortable PAPR for long distance runners to wear. The research will attempt to make the PAPR as lightweight as possible, to address the problems runners have with conventional masks, and to create a low cost PAPR. Current designs of PAPRs can run for thousands of dollars, which is not affordable for the average person. Through the use of 3D printed parts, the cost of producing a PAPR can be greatly reduced.

The technical research has three main requirements for success. First, the mask must effectively filter air in and out in order to protect both the user and the people around them. The current design uses a filter material that will filter out at least 90% of small particles. A main

feature of PAPRs is that the inside of the device has a positive pressure compared to the atmospheric pressure outside. The positive pressure allows for the PAPR to have a universal fit so the user does not have to get fit tested before using it (Powell, 2007). Fit testing ensures that masks and other devices fit correctly on a user's face so that the device works to its best ability. The positive pressure works to keep unfiltered air from entering the PAPR. If there were any holes in the seal, the positive pressure would push air out rather than in. This is achieved with the use of fans regulating the air coming in and out of the device.

Second, the mask must be lightweight and comfortable. The target group for the technical research is long distance runners who will be able to wear the device for long periods of time without any issues with comfort. Areas of concern include ensuring that the PAPR is lightweight, comfortable to wear while moving, and resistant to damage from sweat.

Third, the device should be low-cost to manufacture. Minimizing cost will include the use of 3-D printing to cheaply and quickly prototype parts for the PAPR. PAPRS currently on the market currently can sell for over $1,000 (see product #2428N11 from McMaster-Carr). This cost is prohibitive for individuals seeking protection from COVID-19 during distance runs. It is important to minimize the cost of the design as the alternative, yet less comfortable, solution is an inexpensive cloth or disposable mask.

According to the University of Texas at Austin Environmental Health and Safety Department, the function of a fan-filter system within a PAPR is to decrease the stress on the respiratory system of a user as it forces air from the environment through purifying filters (Powell, 2007). PAPRs are useful in hazardous environments with airborne contaminants, including respiratory viruses. This documentation describes the proper procedures for replacing the filters, inspecting the respirator, adorning the device, and cleaning the respirator. Based on

this, it is important that the filter material must be incorporated into the device in such a way that it can be replaced, especially after high-impact activity where sweat and other elements that could damage the filter material are present. In addition, this document stressed the importance of fit testing, as PAPRs must eliminate all chemical odors to be effective. Fit tests must be implemented during the design process to ensure that the device effectively maintains the positive pressure gradient while filtering airborne particles.

The Center for Disease Control and Prevention (CDC) outlined requirements for approved PAPR devices in "Concept for Industrial Powered Air-Purifying Respirator Standard" (Center for Disease Control and Prevention, 2005). It establishes the following required components: respiratory inlet covering, filter units, harness assembly, blower, breathing tube, battery, pressure indicator, battery indicator, and operation switch. All of these units will be included in the design, with the exception of the battery indicator, as the device will include a fail-safe mechanism in the form of breathable material that will allow for air flow in the event of a dead battery. Breathing tubes will also not be included in the device, as the fans are incorporated directly into the head harness assembly. The CDC also requires that a positive pressure gradient must be maintained within the enclosure during use and states minimum breathing rates for the machine. The operation of the device will be simulated in a flow simulation software, and Computational Fluid Dynamics (CFD) will be employed to ensure that the minimum breathing rates are satisfied. Service time limitations, breathing gas tests, valve leakage tests, and low-temperature fogging considerations are also detailed, all of which will be accounted for in this project.

STS Topic

The opinion of American adults on whether or not to wear masks in public is not an apolitical issue. Pew Research Center's data shows a percentage point gap of 16-23% between those who identify as Republicans or leaning Republican and those who identify as Democrat or leaning Democrat between June and August of 2020, with Democrats being more likely to wear masks in public places all or most of the time (Kramer, 2020). This partisan divide on the issues of wearing masks is also reflected in the difference between Democratic and Republican leadership. At the time of writing, 15 of the 16 US states without statewide mask mandates have Republican Governors, and throughout the 2020 presidential campaign, the Democratic candidate, former Vice President Joe Biden, has discussed plans to implement a mask mandate on the national level or on as wide a scale as presidential power can legally reach, while incumbent Republican President Donald Trump has argued against such a measure (*What U.S. States Require Masks In Public? (Updated Daily)* 2020; Stolberg, 2020). There is clearly a partisan political element to the decision of whether or not to masks, but if wearing masks in public places is backed by scientists and public health experts, how did this discrepancy develop?

Social Construction of Technology, or SCOT, is a theory that examines how technology develops relative to different relevant social groups that interact with the technology in different ways. In a 1987 article discussing SCOT, Pinch and Bjiker lay out how social groups are defined both by user groups with different relationships to a technology, in their example, a bicycle, and also by explicit non-users of the technology (Pinch & Bjiker, 1987). Groups that are actively opposed to the usage of a particular technology are still interacting with that technology in a meaningful way that is important to examine. In the case of examining masks as a technology,

those who wear masks in public regularly and advocate for their use are an important relevant social group, as are so called anti-maskers who argue against the need for themselves and others to wear masks in public spaces. The divide between these two groups in America does not fall directly along partisan political lines, but as previously noted, political affiliation and opinions on the use of masks in public spaces are not entirely independent. It is therefore important to understand the mechanics of how political debate and affiliation influenced the formation of these social groups with respect to the usage of masks and how they continue to interact with this technology.

An important element of understanding the divide in opinions of masks between social groups is understanding how political opinions diverge around the scientific background of the issue. In a 2004 article, Sarewitz argues that using that entangling science with the policy making can harm both the ability of policy to be made and the overall integrity of scientific fact. He asserts that when uncertainty exists in scientific knowledge, groups with different interests are able to use these areas of conflicting scientific fact to to support their own specific interests and moral positions (Sarewitz, 2004). Scientific uncertainty has been a major part of the COVID-19 pandemic, with the public often watching scientific facts about the virus develop in real time. While COVID-19 was declared a pandemic in the beginning of March of 2020, in the US, the CDC did not endorse the general public wearing masks until early April and did not openly recognize the virus as an airborne disease until late September (Dwyer & Aubrey, 2020; Laguipo, 2020). Before the April update to mask guidelines, the CDC discouraged the general public from wearing masks in public and limited their recommendations for the use of mask to healthcare workers and those who were ill, making the April recommendation a large shift for Americans (*Transcript for CDC Telebriefing: CDC Update on Novel Coronavirus,* 2020). This

kind of uncertainty could have contributed to polarization of the issue of mask wearing. In his writing, Sarewitz argues that political debate over areas of scientific uncertainty can ultimately weaken the general belief in scientific facts (2004). If different relevant social groups leverage these gaps and changes in expert opinions to support their own moral positions, they can end creating wider confusion about these discrepancies and weaken scientific support for an argument on the whole. It is therefore important for understanding the politicization of the importance of wearing masks in public to examine the relevant social groups, their moral positions, and the way that they leverage scientific uncertainties around COVID-19 and the principles of masks to argue these moral positions both in relation to policy and larger public opinion. Sarewitz goes so far as to argue that policy should ultimately be formed without bringing science into the debate, but it is difficult to see a path where policy could be made and behavior could be defined regarding a major public health crisis without being informed by scientific information about the virus itself, so this examination needs to go farther than these conclusions (2004).

Next Steps

- Clearly define relevant social groups with respect to the use of masks in public spaces in America
- Map the uncertainty and changes in publicly available COVID-19 science as well as public recommendations over time in America with mask wearing data for relevant social groups
- Do research to understand the relationship of various social groups' positions to these scientific changes and uncertainties

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