Prospectus

Positive-Pressure Powered Filter Mask

An Examination of Cultural Attitudes Toward Mask Use Through Social Construction of Technology

By

Kallia Smith

November 5, 2020

Technical Project Team Members:
Emily Hubbard
Hannah Lothrop
Kimmie Louie
Pascale Starosta

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.

Signed: ____Kallia Smith____
Technical Advisor: ____Gavin Garner_____
STS Advisor: _____Sean Ferguson_____

Introduction

The technical project is focused on the design and construction of a powered filter mask for runners. The mask will use fans to push air through inlet and outlet filters, filtering the air that flows in and out of the mask. The inside of the mask will be at a positive pressure compared to atmospheric pressure, ensuring that unfiltered air does not enter the mask even if the mask's seal around the face is not airtight. The mask assembly will be lightweight and comfortable enough to be used by runners and other athletes. The aim of the technical research is to encourage mask use among a particular group, such as runners, by using technology to overcome barriers, such as difficulty breathing while exercising in a mask, against mask wearing.

The aim of the STS research is to use STS frameworks to determine strategies for encouraging mask use among various social groups. The research will use social construction of technology (SCOT) theory to examine the composition of different social groups and those groups' attitudes toward mask use. The goal of the research will be to encourage domestication, the process by which masks may become accepted as a part of everyday life by a particular social group.

Technical Topic

Masks are a vital tool used to prevent the spread of COVID-19. However, some people are unable to wear them or feel that they are too uncomfortable to wear. Therefore, the technical research is focused on creating a powered mask that can force air through inlet and outlet filters. The apparatus will fit easily over the face and reduce many of the problems that people have with cloth, surgical, or N95 masks. Products with a similar function, called powered air purifying respirators

(PAPR), already exist. These devices fit over the user's head and use fans to filter air entering the device.

Figure 1. A commercially available PAPR from 3M (3M, 2020).

However, existing PAPRs do not filter air going out of the device (CDC, 2005). The main 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 masks causing skin irritation. The technical research also aims to include these design features.

The question of whether it is necessary to wear a mask while running is disputed. Some cities, such as Los Angeles, require masks in public except when exercising, while others, such as Boston, include exercise in their mask mandates (Murphy 2020). However, the University of Maryland Medical System recommends wearing a mask while exercising when unable to maintain six feet of distance from others (University of Maryland Medical System, 2020). In addition, the Centers for Disease Control and Prevention (CDC) recommends wearing a mask when

exercising indoors (CDC, 2020). Since it can be difficult to exercise outdoors in inclement weather and to maintain a six foot distance in a crowded area, a mask that can be worn comfortably while exercising will be beneficial to runners and those around them.

Runners need to breathe more heavily while running, and wearing a fabric mask can interrupt airflow. Therefore, the technical research will be focused on creating a comfortable PAPR for long distance runners to wear. Research will be conducted on how to make the PAPR as lightweight as possible and to address the problems runners have with conventional masks. The final objective for the technical research will be to create a low cost PAPR. Current designs of PAPRs can run for hundreds of dollars, which is not cost effective for the average person to purchase. With a focus on 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 project is currently designed to use 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 and reduces the spread of COVID-19. 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. Positive

pressure 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 enough to be used while running. 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 have been identified and include ensuring that the PAPR is lightweight, comfortable to wear while moving, and unable to be damaged by sweat or water.

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. PAPR masks are currently available from McMaster-Carr starting at $1,422.69 (see product #2428N11 from McMaster-Carr), and other manufacturers' products are similarly expensive. It is also important to note that this PAPR from McMaster-Carr does not filter the output flow and therefore would not be suitable in this application. This cost is prohibitive and not reasonable 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 to be then inhaled by the user (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, wearing the device, and cleaning the respirator. This document on safe operating procedures was of use in the design process as it was important to note that the filter material must be incorporated into the device such 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 tight-fitting PAPRs must eliminate all chemical odors to be effective. Fit tests will be implemented at multiple stages in the iterative design process to ensure that the device is tight-fitting and effectively maintains the positive pressure gradient while filtering all airborne particles.

The CDC outlined requirements for approved PAPR devices in the document "Concept for Industrial Powered Air-Purifying Respirator Standard" (CDC, 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 document also establishes the requirement that a positive pressure gradient must be maintained within the enclosure during use, and also states minimum breathing rates for the machine. The operation of the device will be simulated in a flow simulation software and CFD will be employed to ensure that the minimum breathing rates outlined in this document are satisfied. The document also details

service time limitations, breathing gas tests, valve leakage tests, and low-temperature fogging considerations, all of which will be accounted for in our project.

STS Topic

While the technical thesis aims to address physical reasons why people may choose not to wear masks, such as comfort and cost, it does not address the social or cultural factors that influence mask use. Based on simulated case studies from April, widespread mask use was predicted to have a strong effect in reducing mortality rates from COVID-19 (Eikenberry, 2020). The study concludes that "hypothetical mask adoption scenarios, for Washington and New York state, suggest that immediate near universal (80%) adoption of moderately (50%) effective masks could prevent on the order of 17–45% of projected deaths over two months in New York, while decreasing the peak daily death rate by 34–58%, absent other changes in epidemic dynamics." Mask use is important for the safety of oneself and others, and more widespread use of masks can save lives. Therefore, the objective of this research is to define cultural attitudes surrounding mask use in order to investigate how to encourage mask wearing among all the user groups examined in the research. The research will use social construction of technology (SCOT) theory to examine the composition and views of various social groups and to determine what factors might lead to domestication of mask technology within a group. In addition, the research will use the idea of technology domestication, the process by which a technology is adopted as an integral part of everyday life (Lehtonen, 2003). In particular, the early stages of domestication are of interest, since the assessment of whether a technology is "needed" is performed collectively

and largely relies upon recommendations and advice from members of one's social groups.

As identified by ethnographic research performed at hacker- and makerspaces in the United Kingdom, one of the social groups with a unique relationship to mask wearing is made up of makers, people interested in collaborative design and building (Richterich, 2020). During the early months of the COVID-19 pandemic, they volunteered to design homemade personal protective equipment (PPE). The research identifies that the "synergy of open source design, use, adjustment, and hardware production was characteristic of communities' activities responding to the COVID pandemic." Makers are one community that has responded to COVID-19, and their response shows that they view the PPE shortages caused by COVID as a problem that they can help solve. This view of PPE, including masks, may also influence makers' views toward mask use in general.

In addition, cultural attitudes toward masks vary by country. In the United States and Europe, masks were slower to gain widespread adoption because mask use was not previously established or common in North America and Europe (Kaiser & Smelik, 2020). In contrast, mask use was already more established in some locations, particularly in Asian countries. This attitude is likely shaped by the SARS outbreak in 2003, as mask use has become even more widespread in Asian countries since 2003 (Kaiser & Smelik, 2020). In contrast, other countries did not have an already established culture of mask use, but adopted masks on a widespread scale more quickly than the United States. For example, a grassroots campaign in the Czech Republic led to a government mask mandate, showing that

support for masks was created among the social group of Czech citizens. (Tufekci et al., 2020).

Social construction of technology, or SCOT, theory, explores the development of technologies as a process of selection by various relevant social groups. Technological artifacts can have different purposes and meanings for different groups, and so different social groups will value and select for different qualities in an artifact. SCOT theory ties in with my exploration of the domestication of technology. In order for a technology such as masks to gain widespread adoption into daily life, stakeholders must define the technology's appeal and present the technology as appealing to a variety of social groups for a variety of reasons.

The primary question in determining the scope of this framing is the question of what groups to consider, and how to form those groups. There are many possible factors to form groups around and many ways of sorting people into those groups. Due to the limited scope of the thesis, the selection of which social groups to focus on will likely be somewhat arbitrary, but will always be taken from the evidence. It will be important to ensure that the firsthand sources of evidence are used to generate categories and groups, not the other way around. Ways to sort groups may include age, geographical region, income level, and political viewpoint, as mask use was found to vary heavily along these lines by a National Geographic survey (Blakemore, 2020).

Primary sources of evidence will be used to examine attitudes towards mask use. For example, the behavior of influencers and reality TV stars has been linked to health outcomes in other areas such as vaccination and alcohol consumption, and could also influence views on masks (Grose, 2020). Television and social media

are just two examples of sources of evidence, and part of the research process will include determining which sources clearly show examples of domestication or rejection of masks. Other potential sources of evidence may include news articles or advertisements targeted at particular groups. Important questions to consider when examining the evidence include: what groups are these primary sources targeting? what message about mask use are they trying to send? what strategies are they using to appeal to those groups?

In addition to primary sources, academic articles will also be considered. These will include research papers focusing on SCOT, which will help determine how to define a social group and how to map a group's relationship to mask use. Anthropological or ethnographic articles about cultural attitudes toward mask use will also prove useful, particularly if different nationalities are selected as a relevant social group for study.

Next Steps

First, research will be performed to preliminarily identify individuals' demographic affiliations and attitudes toward masks. This will be the longest stage of the research, and will begin over winter break and likely extend into February. Next, the evidence gathered in the previous step will be used to sort individuals into social groups based on SCOT. This step will likely take place during the end of February and beginning of March. The evidence will then be used to determine each group's prevailing attitudes toward mask use, and whether the group can be described as having accepted masks as a domesticated technology. Next, the evidence will be used to determine each group's overarching values and priorities. Ethnographic and anthropological research may also be useful in this step. These

two steps can be performed simultaneously, and will likely take place throughout March. Finally, the views and priorities of each group will be assessed in an attempt to recommend strategies for making mask use appealing as a domesticated technology for each group. This step will be performed at the end of the thesis writing process, likely at the beginning of April.

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