Prospectus

Patient Augmented Reality and Vibratory Array (PARVA)
(Technical Topic)

User Configuration and Crash Test Dummies
(STS Topic)

By

Marissa Marine

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Technical Project Team Members: Kathryn "Eve" Costanzo, Lauren Gonzalez

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: __*Marissa Marine*______

Approved: ____ Date __________________________
Benjamin Laugelli, Ph.D., Department of Engineering and Society

Approved: ____ Date __________________________
Zoe Roecker, School of Medicine

Introduction

Laryngology is a medical subspecialty within the field of otolaryngology that treats diseases of the larynx, vocal cords, and trachea. Many laryngology procedures can be performed in a minimally invasive way in the clinic setting without the use of general anesthesia, however these procedures can cause significant patient discomfort. Patients are often so dissatisfied with their in-office experience that they will elect to have any follow up procedures in the operating room under general anesthesia, which comes with many risks and costs (Shah, 2019). To address this problem, my team is designing the Patient Augmented Reality and Vibratory Array (PARVA), which consists of a vibrational device and augmented reality experience to reduce patient pain and discomfort during in-office laryngology procedures.

Along with the technical aspect of the problem, it is also important to consider the science, technology, and society concept of user configuration. In designing the technical project, we will be configuring ideas about the user into our design. In order to provide insight into how critical it is to take into account the diversity of users in our technical project, I will analyze how designers embedded certain ideas and assumptions into the design of the crash test dummy, and the impact this has on the safety of women in automobile accidents. Focusing only on the technical aspects of the problem would result in a device insufficient to effectively improve patient experience. It is essential to understand the diversity of users in order for our device to help all patients. For example, our device must be adjustable to a wide range of head and neck sizes to accommodate the whole patient population.

To best improve patient experience during laryngology procedures, both technical and social aspects of the problem must be addressed. For the technical component, my team and I will design a wearable vibratory device and augmented reality experience to reduce patient pain and discomfort. To address the social aspect of the problem, I will analyze how inaccurate ideas and assumptions about users were embedded into the design of the crash test dummy. This will illustrate the importance of considering the diversity of users when designing the PARVA, which will help ensure that our device is safe and effective for all users.

Technical Problem

Common laryngology procedures can often be performed in-office in a minimally invasive manner without the use of general anesthesia. Some of these procedures include laryngoscopy, trans-nasal esophagoscopy, biopsy, vocal fold injection, and laser treatment of laryngeal pathology (*Out of Committee*, 2020). While these in-office procedures are safe and effective, patients can experience significant pain and discomfort due to the sensitive anatomic structures involved, such as the neck and the larynx.

Current standard of care practice is to perform these procedures with only a local anesthetic, such as lidocaine (Rosen et al., 2009). While local anesthesia decreases pain at the specific procedure site, patients can still experience significant discomfort. Additionally, the delivery of the local anesthetic itself is often painful. In other areas of medicine, vibrational devices have been developed to reduce pain during procedures, for example during venipuncture in children (Susam et al., 2018). This is based on the gate-control theory of pain, which proposes that neural networks distributed along the dorsal horn of the spinal cord relieve pain in a specific location when a tactile stimulus is applied at the same location (Ropero Peláez & Taniguchi, 2015; Susam et al., 2018). Augmented reality, which blends a person's real surroundings with virtual elements, has also been used as a means to distract children from needle-induced pain (Yuan et al., 2017). These potential methods of pain reduction have not yet been applied to the field of laryngology, and the use of vibrational stimulation in combination with augmented reality has not yet been explored.

A means to reduce patient pain and discomfort during in-office laryngology procedures is needed in order to improve patient experience and decrease the need for the use of general anesthesia. There are many risks associated with general anesthesia, especially for certain patient populations such as those with diabetes, heart disease, or high blood pressure (*Anesthesia Risks and Assessment - Made for This Moment*, n.d.). Rare but serious risks of general anesthesia include heart attack, stroke, pneumonia, and death (*General Anesthesia | Michigan Medicine*, n.d.). It is much safer for patients to undergo in-office procedures without the use of general anesthesia. In-office procedures are also less time consuming for physicians, allow for more patients to be treated in one day, and are less costly compared to an operating room surgery.

The goal of the technical project is to develop the Patient Augmented Reality and Vibratory Array (PARVA), which will include a wearable vibrational device and an augmented reality experience to reduce patient discomfort during in-office laryngology procedures. The vibrational device will deliver an appropriate frequency and magnitude of vibration required to induce tactile stimulation at or around the site of the procedure in order to reduce pain. The augmented reality experience will be a simple game that maximizes distraction and minimizes movement of the patient during the procedure. This device will combine vibratory stimulation with augmented reality to effectively reduce patient discomfort and the need for general anesthesia.

We will use computer-aided design and 3D printing to develop prototypes of the vibrational component of the PARVA that will safely house electronic components and a power source. We will also build and install the circuitry required to generate the appropriate vibration to reach the Pacinian corpuscles responsible for sensing vibration (Bajwa & Al Khalili, 2021). In order to develop the augmented reality experience, we will be using Unity software to create a simple game. We will also select an appropriate augmented reality headset for a clinical setting by considering size, adjustability, weight, flexibility, comfort, and stability.

To demonstrate the efficacy of our device we will collect patient electrocardiogram data and calculate heart rate variability as a measure of pain and stress (Shaffer & Ginsberg, 2017; Ye et al., 2017). We will also conduct patient surveys and analyze survey data regarding anxiety, pain, discomfort, and overall satisfaction. We will also seek feedback from physicians on how the device impacts their experience during the procedures and their interactions with patients. These results will help us to improve upon our design, as well as demonstrate its value and efficacy.

STS Problem

Crash test dummies are used to study the effects of automotive accidents on the human body. The first crash test dummy was developed in 1949, originally to be used to evaluate aircraft ejection seats for the United States Air Force (Bellis, 2019). Crash test dummy technology has evolved significantly since then, and the current standard dummy is the Hybrid III (*NHTSA's Crash Test Dummies | NHTSA*, n.d.). This dummy behaves very similarly to the human body and contains many sensors, including accelerometers, load sensors, and motion sensors to evaluate the effects of collisions on the body. The results of crash dummy testing determine the design of car safety features such as airbags, and which cars will meet National Highway Traffic Safety Administration regulations. Based on the purpose of crash test dummies to ensure the safety of vehicles, it appears that crash test dummies, and therefore vehicles, have been designed for everyone who wishes to travel safely in a vehicle and minimize injury if an accident does occur.

While this may be true, other aspects of the design of the crash test dummy suggest that certain implicit assumptions and biases concerning the user's identity have been embedded into the product. The most widely used dummy, the Hybrid III, is based on the 50th percentile adult male. In fact, female crash test dummies are rarely used in car crash testing, and an average adult female crash test dummy does not exist (Bergmann, 2019). This suggests that the implicit assumption that an average male can represent all vehicle users has been embedded into the design of the crash test dummy. The implicit bias of the designers towards men simply ignores the fundamental anatomical and physiological differences between males and females. Considering how the designers' ideas about the homogeneity of users were embedded into the product underscores the ways implicit assumptions and biases can affect product design and user experience. In this case, the implicit assumptions and biases put women at a far greater risk of injury in car accidents than men. Women are 17 percent more likely to be killed in a car accident than a male occupant of the same age, and 73 percent more likely to be seriously injured in a frontal car accident than a male occupant (Bergmann, 2019).

Drawing on the science, technology, and society framework of user configuration, I argue that the designers embedded the assumption that the average male is an accurate representation of the whole population of car users into the design of the crash test dummy. The framework of user configuration states that engineers configure user identity and practice by embedding certain assumptions and biases about the users into the technologies they design, whether intentionally or not. User configuration states that engineering design results in a configured user, which is a user as imagined by the designer and embedded into the technology's design (Oudshoorn &

Pinch, 2003; Woolgar, 1991). In the case of the crash test dummy and cars, the configured user is an average male, which is not representative of the diversity of the actual user. Specifically, the crash test dummy is not representative of the female population which differs in size, anatomy, physiology, and driving posture from the average male. As a result, females are more likely to be killed or injured in a car accident than males.

To support my argument, I will analyze evidence from the National Highway Traffic Safety Administration report, *Injury Vulnerability and Effectiveness of Occupant Protection Technologies for Older Occupants and Women*, which will provide data on the effectiveness of crash test dummy testing at protecting women in vehicles (Kahane, 2013). I will also analyze the characteristics of the currently available crash test dummies to identify specific features potentially impacted by the designers' implicit assumptions and biases.

Conclusion

The technical project will deliver a wearable vibratory device and augmented reality experience to reduce patient pain and discomfort during in-office laryngology procedures. The STS project will deliver a better understanding of the importance of accurately configuring the user by taking into account the diversity of users. I will achieve this by analyzing how designers embedded their ideas and assumptions about users into the design of the crash test dummy, and how this has impacted the safety of women, a group of users who do not align with the configured user. The results of the technical project will help solve the broader sociotechnical problem of improving patient experience during laryngology procedures by quantitatively reducing patient pain. The findings from the STS project will highlight the critical importance of taking into account the diversity of the patients who will use our device in order to effectively improve patient experience. It is essential to understand the wide variety of patient populations and their experiences in order to design a device that can benefit them all.

Word Count: 1783

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