Human-Powered, Illuminated Runner's Vest

(Technical Paper)

How the Lack of a 50th Percentile Female Crash Dummy Affects Female Drivers

(STS Paper)

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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

Introduction

Women are actively being discriminated against by governmental regulations on car safety. Crash dummies have been around since the 1940s in order to test the effectiveness of seat belts and ejection seats in planes (Asaro, 2016). Yet even after close to 80 years with these dummies, only one of the three adult dummies used by the National Highway Traffic Safety Administration is female, and it only represents a fifth percentile female. Currently in the United States, there about 114 million licensed female drivers, and 111.5 million male drivers (Statista, 2017). While more males than females are killed in car crashes every year, "females are more likely than males to be killed or injured in crashes of equal severity" (IIHS, 2017). Regardless of being involved in fewer fatalities, societally, there are stereotypes regarding women being bad drivers that are repeated in shows like Family Guy and South Park. This stereotype, stemming from various cultural reasons, has an active impact on females today, and has been shown to negatively impact the way that females perform while driving (Moè et Al., 2015).

The impact of the problem is clear, women are being disproportionately impacted by a lack of safety testing surrounding female car drivers and occupants. With over 30,000 motor vehicle crash deaths every year, this is a pressing problem with actively occurring consequences (CDC, 2017). In the following STS proposal, actor-network theory will be used to analyze the players involved in the design of car safety around females, and how they can impact this process. Vehicular collisions present another issue as well, over 5,000 pedestrians were killed by traffic crashes in the United States, and 129,000 were treated for non-fatal injuries in 2015 (CDC, 2017). In the following Technical Research Capstone, a human-powered LED jogging vest will be discussed in its ability to provide greater safety for pedestrians and reduce their energy consumption.

Technical Topic

While jogging, humans exert large amounts of energy through their motion that has the potential to be harnessed for various uses. In addition, over 100,000 pedestrians are injured every year, with an increased likelihood of crashes occurring at night due to reduced driver and pedestrian visibility (CDC, 2017). In an attempt to solve both of these issues, a team consisting of myself, Katarina Catallo, Garret Hanrahan, Trevor Cook, Kyle Peter, and Jacob Fishman, will research, design, and construct a human powered light emitting diode (LED) running vest to be packaged and sold on the consumer market. This illuminated running vest will address not only safety concerns for users, but also satisfy an increased demand for constant access to electricity in order to function in modern society.

The design of the vest consists of two linear generators placed on the upper chest area of a reflective safety vest. These generators are attached to supercapacitors to store the energy produced, which, in turn, are connected to LED strips that are attached to the front and back of the vest. The linear generators function off of Faraday's law and the principle of magnetic induction. As a magnet passes back and forth within a conductive coil, a current is generated due to the motion of the induced electromagnetic field. While running, the magnets inside of the linear generators will move up and down with the user’s stride, bouncing off of springs at the top and bottom of the generators. The coils connect to superconductors that will store the energy and slowly dissipate it out the LEDs on the vest. LEDs were chosen as light sources due to their efficiency in electricity consumption, and small bulb size.

Currently, illuminated jogging vests sell from anywhere between $15 to $60 on the market. The goal for our technical project is to completely produce the device for under $50. Given the lack of other external monetary sinks, like batteries or electricity to recharge, it is

acceptable for the vest to be priced higher than others currently on the market. In addition, as work continues on this vest, investigations into part availability and price will be conducted in the next semester to determine if the overall price can be further reduced. Most of the research and investigation will be completely proprietary, as there are no other self-powered illuminated safety vests. In addition, the literature relating to linear generators typically revolves around large scale applications such as wave energy rather than such personal, small-scale use, so most knowledge will come from hands on practice and prototyping with linear generators.

We will work within a 9-month timeframe, with major milestones occurring in December 2019 and May 2020. In December, we will have completed a detailed drawing of our anticipated design, as well as ordered any necessary materials. Over the following four months, we will assemble our product and subject it to prototype testing, completing our final product in May. To do so, we have access to all of the machines in the laboratories such as 3D printers, soldering irons, and a broad range of adhesive devices. The ideal result is a functional, ergonomic, and marketable product that will be patented and packaged for sale.

STS Topic

Currently, three adult dummies are used for crash testing by the National Highway Traffic Safety Administration (NHTSA): the HYBRID III 5th Percentile Female, HYBRID III 50th Percentile Male, and HYBRID III 95th Percentile Male (NHTSA, 2019). These dummies are supposed to represent the safety characteristics of the general population that they are being sold to, and their test results are published by the NHTSA and car manufacturers to inform the public. It is impossible, however, for these dummies to accurately represent the population at large due to the lack of a 50th percentile female dummy. In addition, “the characteristics of the 50%

percentile male roughly correspond to a 90th to 95th percentile female and so only the extremes of the female population are accounted for by either the 50th percentile male dummy or the 5th percentile female dummy" (Welsh & Lenard, 2001). The following STS proposal of this problem will use Actor-Network theory to analyze the impacts different actors have on the issue and the power they hold over it.

Actor-Network Theory (ANT) insists that relationships between 'actors' (people, places, things, organizations, etc.) are what is most important. These relationships are ever changing, and can be used to describe technological situations and social happenings. A large critique of ANT is in regards to the ability for nonhuman actors to participate in relationships. This will be combatted and used in the following analysis as cars themselves, seats, seatbelts and test dummies are intricately involved in this problem of better protecting car drivers and occupants. Another critique is in regards to researchers uninvolved from networks making calls regarding which actors are important or which are not. To address this, I will actively keep track of and mention that certain areas and actors will be focused on, and conduct expert interviews to gain insight into which actors these should be.

In addition to not being accounted for in safety tests, the average woman is more susceptible to increased injury due to their increased physical fragility (Kahane, 2013). The fact that average female safety is not being considered or designed around in car specifications is compounded by the fact that females are more likely to be injured by similar forces (Evans, 2001). Testing has shown that "the odds for a belt-restrained female driver to sustain severe injuries were 47% higher than those for a belt-restrained male driver involved in a comparable crash" (Bose et. Al, 2011). These gender differences are not only seen in frontal impacts, "females had a 50% higher risk of reporting a whiplash injury in rear-end crashes and double the

risk of whiplash injury with symptoms lasting longer than one month" (Kullgren, 2010). It is clear that female occupants and drivers are being affected by this issue, but it is unclear if the lack of change is due to a lack of power female consumers possess, or a lack of awareness surrounding the issue.

Just as females are a large portion of this network, it must also be considered why only the average male is being accounted for. In general, crashes involving male drivers are often more severe than those involving female drivers (Li et. Al, 1998). In addition, male drivers engage in high risk behaviors that result in fatal crashes such as speeding and driving under the influence (IIHS, 2017). Males also typically judge their driving skills as higher than women, and view dangerous activity as less likely to result in serious accidents (DeJoy, 2002). It follows, then, that males are the at-risk group that are involved in higher crash rates, so it does make sense to highly consider them in the design. However, the lack of any consideration for the average female is causing higher injury rates for a group that typically drives safer, in safer vehicles, with greater concentration (Portin et. Al, 1999)(Savage, 2018). All of these factors may be influencing how the U.S. Government and car manufacturers, two of the most powerful actors, are evaluating the urgency behind additional testing for the average female.

One last, and possibly the largest consideration, is the cost of creating a new 50^{th} percentile female dummy. In order to save money, the attempt could be made to simply scale down the male dummy design to represent the 50^{th} percent female. Scaling, however, would not be applicable as males and females differ in their physiological fragility and female's fragility changes over time (Kahane, 2013). In addition, in a simulation test, it was found that scaling down the male dummy to a female size produced far different results from an actual female biomechanical simulation (Mordaka, 2017). The dummies used for these tests can cost up to

$500,000 which does not include further research into the impact biomechanics the average woman would have and how to replicate that in a dummy.

The power that each actor in this network has significantly plays into how this situation came to be. As discussed, there are many actors at work and the relationship between them is not entirely understood. Car manufacturers have to design and build cars to meet with certain governmental regulations that are influenced by independent organizations as well as contracted out researches. These manufacturers, however, can also have their own research done to better represent their car safety as the government does not crash test every new model that goes to market. Consumers obviously hold a very large power as well, and "find safety to be very important car features" (GFK, 2019). The further research to be conducted will be presented in a following paper, and address how the center of car safety design came to be the 50th percentile male and why this has not changed. The impact, however, is clear: females are at risk due to a lack of consideration from governmental regulations and car companies.

Research Questions and Methods

The central question of the STS research is: why is the 50th percentile female not considered in car safety and how does this affect the population at large? To pursue this question, documentary research and expert interviews will be conducted. More papers and articles will give insight into the outlook of car companies and their willingness to investigate this issue. In addition, these documents will shed light on the cultural impact of how the situation came to be and the positions of power that females, governments, and manufacturers are currently in. The UVA Center for Applied Biomechanics has conducted research and published papers on the topic of biomechanical differences due to gender, and interview with these experts could shed

light onto the physical response during crashes, as well as how researchers consider positioning, size, and other factors during car impact testing.

Conclusion

The proposed STS Research Question will address the differences in female and male car crash responses and how they came to be. This analysis will hopefully shed light on the process and flaws of testing and regulations in the car industry. The Technical Deliverable will consist of a LED vest powered by the user themselves. This vest will help consumers save energy and money, in addition to increasing their visibility. This increase in visibility will hopefully reduce the number of car to pedestrian crashes since a majority of these happen at night or in places with an obscured view.

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