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Reaction to Safety Equipment Technology in the Workplace and Implications: A Study of the Firefighter's Hood

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Abstract

In the 1990s the firefighter's hood became a standard article of safety equipment worn by municipal firefighters, eliciting a negative reaction among many of these firefighters. I used data from interviews with 42 firefighters to explain why this reaction occurred. Data analysis revealed that negative reactions ultimately stemmed from the hood's disruption of autonomy, repudiation of the complex mental and physical skill needed to perform tasks required of firefighters, and hindrance in negotiating the life-threatening environment created by a fire. These findings indicate that when introducing new safety equipment technology to emergency response workers, their reaction to this equipment, and its effect on their autonomy and ability to complete complex occupational tasks, may have important prevention implications.

Keywords

Firefighting, Technology, Autonomy, Skill Complexity, Prevention, Risk, Qualitative, Semi-Structured Interviews, Thematic Analysis

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Reaction to Safety Equipment Technology in the Workplace and Implications: A Study of the Firefighter's Hood

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In the 1990s the firefighter's hood became a standard article of safety equipment worn by municipal firefighters, eliciting a negative reaction among many of these firefighters. I used data from interviews with 42 firefighters to explain why this reaction occurred. Data analysis revealed that negative reactions ultimately stemmed from the hood's disruption of autonomy, repudiation of the complex mental and physical skill needed to perform tasks required of firefighters, and hindrance in negotiating the life-threatening environment created by a fire. These findings indicate that when introducing new safety equipment technology to emergency response workers, their reaction to this equipment, and its effect on their autonomy and ability to complete complex occupational tasks, may have important prevention implications. Keywords: Firefighting, Technology, Autonomy, Skill Complexity, Prevention, Risk, Qualitative, Semi-Structured Interviews, Thematic Analysis

Introduction

Background

The importance of understanding technological change and its impact on the worker has long been established, dating back to Karl Marx's 1867 seminal work *Das Kapital* (1976). In this study, Marx's focus on technological change was in understanding the manufacturing process, its alienation of the worker, and the workers' struggle to maintain control over this process (Attewell, 1990). After World War II, this argument was updated by contemporary claims on the pattern of skill change (see Spenner 1983, 1995; Vallas & Beck, 1996). Arguments were made that new technologies would act as a mechanism for increasing the skill levels of workers (Blauner, 1964; Kerr, Dunlap, Harbison, & Meyers, 1964). Others then followed contradicting these claims (Braverman, 1974), arguing that technology would strip workers with as much skill as possible in an effort to increase productivity (Vallas, 1990). These studies mainly consisted of antithetical, theoretically-based arguments absent of empirical evidence (Spenner, 1983, 1995).

Over the past few decades, there has been a new focus on the introduction of technology in the workplace. With the exponential increase of the adoption of computers and information technologies (IT), and availability of new data sources (Ward 2010), many studies now examine how IT effects the worker. Similar to earlier work, more recent research has focused on the relationship between technology and workers' skill levels (Autor, Levy, & Murnane, 2002; Bound & Johnson, 1992; Goos & Manning, 2007; Katz & Murphy, 1992; Levy & Murnane, 2004; Pianta, 2005; Piva, Santarelli, & Vivarelli, 2005).

It has also been recognized that before the impact of new IT can affect the skill levels of workers and productivity, the workers must accept and use this technology. A multitude of conceptual models seeking to understand technology acceptance have been developed and empirically tested. The result has been a unified theory of acceptance and use of technology (UTAUT) that finds performance expectancy, effort expectancy, social influence, and facilitating conditions all play a role in whether technology is accepted and subsequently used

(Venkatesh, Morris, Davis, & Davis, 2003). While criticisms of the UTAUT do exist (Bagozzi, 2007), there is agreement that understanding workers' reactions to new technologies may be just as important as understanding how a technology impacts the workers' themselves.

Even with this long history of studying the introduction of new technology into the workplace, there still remains gaps in our understanding. The majority of previous research studies have maintained focus on manufacturing industries or the "white-collar" context of the professional office environment. Other industries, specifically those in the public service and non-profit sectors, remain understudied. In addition to this gap, there is another regarding the type of technologies that recent research has studied. While computers and IT have become the main focus of the majority of research on technology and workers' acceptance/reaction, they are not the sole type of technology being introduced. For example, advances in biochemical engineering and materials sciences have led to new technologies that now play a direct and/or indirect role in many occupations, whether one may realize it or not. Studies focusing on occupations that may fill these gaps, such as firefighting, have potential to add further understanding to the broader literature.¹

Firefighters and New Technology

Research focusing on firefighters has been completely absent from the literature. In recent years a handful of studies have examined various aspects of the occupation of firefighting, including why individuals (particularly men) become firefighters in spite of the life-threatening hazards faced (Desmond, 2006, 2007, 2011), the ergonomics of wearing firefighter clothing (Park, Kim, Wu, & Allen, 2014), and firefighter-perceived occupational health and safety risks (Walker, 2016). In addition, two other studies have examined the introduction of new technologies to firefighting, and the reactions of firefighters to these technologies (Ericson & Mellström, 2016; Morris, 2015).

Ericson and Mellström (2016) examined the association between technology and masculinity, how it informs the "occupational ethos of firefighters" (p. 165), and how operational services' micro-management of disasters is gendered. Drawing from a series of interviews and research studies conducted with firefighters in the Swedish rescue service, their main conclusions discuss the historical celebration of masculinity in firefighting and how it has excluded women from this occupation. However, they also note that new technologies (particularly those used for fire suppression and search and rescue) have played a notable role. The introduction of these technologies has challenged the exclusive nature of firefighting in Sweden, and the ability to demonstrate heroism in a traditional sense, which has historically been celebrated (Ericson & Mellström, 2016). Thus, while the acceptance and reaction to new technology may be viewed in a positive light by some firefighters, for others with a more traditional view this perspective may not be shared.

In the second study, Morris (2015) used the technology acceptance model (one of the conceptual models used to inform the UTAUT; Venkatesh et al., 2003) to explicitly examine interoperability of communications technologies, and their acceptance by sworn and civilian firefighters in a single U.S. fire department. He found that longer tenured, older, and more experienced firefighters had lower perceived ease of use of these technologies. In addition, he also found that higher ranking and more senior firefighters had a higher perception of the usefulness of these technologies (Morris, 2015). These findings show variation in different dimensions of technology acceptance by demographic and individual characteristics, but do not deduce the rationale behind this acceptance, or perform any in-depth exploration of why

¹ This is not to imply that IT and computerization are absent from firefighting. These types of technologies have also been introduced, and are many times required to be used by firefighters to perform the tasks required by their occupation (Ward, 2010).

these associations exist. While both studies have provided a first glance at reaction to new technologies in the fire service, there is still much more room for examination.

The two aforementioned studies focused specifically on the equipment used to actively fight fires and communicate while doing so. However, my study examines a component of the firefighters' clothing, or personal protective equipment (PPE). Over the past twenty years the PPE worn by firefighters has changed quite drastically; literally from head (a shift from metal to non-metal breakaway helmets) to toe (a shift from three-quarter rubber to composite material boots). Such innovations often have occurred after rigorous scientific testing, always with an ultimate goal of enhancing the safety of firefighters while they are engaged in combating fire. Yet even with the PPE's scientifically-supported increase in personal safety and injury prevention among firefighters, a pattern of resistance to some of these safety-driven technologies has emerged (e.g., not wearing certain portions of the PPE in compliance with standard operating guidelines). One particular article of clothing that has been a prevailing source of contention, and is the technology focused upon in my study, is the *firefighter's hood*.

While the negative reaction to the introduction and mandated use of the firefighter's hood is interesting in itself, it also serves as a prime example for the study of the adverse reaction to new safety equipment technology among emergency response workers. Therefore, focusing on this technology, I sought to inform the broader question of why adverse reactions to the use of prevention-related technologies may exist among emergency response workers. Here I use thematic analysis (Boyzatis, 1998; Braun & Clarke, 2006) to draw from raw data and reach key themes and an overarching argument as to why this reaction occurs. Through this systematic, qualitative data analysis of semi-structured interviews conducted with professional (i.e., non-volunteer) firefighters at two independent U.S. fire departments, I show that such reactions may be better explained by understanding firefighter views on life-threatening situations, and how the firefighter's hood affects the skills traditionally used to both prevent death and successfully perform complex firefighting tasks. In addition to informing the broader body of literature, it is also my hope that the data collection and analyses used are presented in a manner to provide insight into performing qualitative studies among firefighters and other emergency response workers.

Background of the Firefighter's Hood

While understanding the empirical literature on the study of acceptance and reaction to new technology is important, I also feel it is important to provide a brief history and description of the firefighter's hood itself. In 1997 the National Fire Protection Agency (NFPA) issued an updated version of *NFPA 1971: Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*, which serves as a guideline for clothing that is to be worn by firefighters while fighting structure fires.² Although clothing codes/standards for firefighters had previously existed, it was not until this updated standard that the NFPA declared firefighters should wear a protective hood underneath their helmet. Prior to this, firefighters wore only a helmet and facemask attached to a breathing apparatus that supplies oxygen to the firefighter. In combination with the remainder of the PPE, the helmet and facemask prevented the majority of the firefighters' skin in the face, head, and neck region from being exposed to flames and the resulting heated atmosphere. Yet even with this rather comprehensive clothing

² The NFPA is a nonprofit organization that began in 1896. Its mission is to reduce the burden of fire on quality of life through consensus standards (or codes), research, training, and education (NFPA, 2010). Fire departments in the United States are not required to follow these NFPA standards; however, many departments across the United States do use them as guidelines. The NFPA 1971 is one of over 300 NFPA standards (NFPA, 2010). The number 1971 does not refer to a particular year, but rather an identification number for this specific standard assigned by the NFPA.

ensemble, firefighters were not fully encapsulated: skin area on their face, ears, and neck was still exposed. This changed with the introduction of the firefighter's hood. When worn in combination with the helmet, facemask, and remainder of the PPE, the hood allowed a firefighter's head, face, and neck region to now be completely covered. This left firefighters fully encapsulated in their PPE ensemble, which (when worn properly) leaves no areas of skin exposed to flame or heated environment.

The hood itself fits over and around the firefighter's head. Attached to the main portion of the hood is a bib that is able to be tucked into the firefighter's PPE coat. The main portion of the hood is then pulled up and over the firefighter's head, leaving an opening for the firefighter's face. A facemask is then worn over the exposed facial area, and the opening in the front of the hood is placed around this facemask to create a seal. A helmet is then worn by the firefighter over the top of the hood. The firefighter's hood itself is created using a flame resistant, synthetic cloth material referred to as Nomex. Often hoods may be constructed using double layers of Nomex material (Prezant, Malley, Barker, Guerth, & Kelly, 2001a) with the material being cut in such a way that minimal knitting is needed to construct the hood. The hood's construction allows water from either one's own perspiration or a fire hose to be released. The ability to release water/steam from the hood is an extremely important feature as water trapped inside can evaporate and cause a firefighter to suffer steam burns from within his/her PPE ensemble.

The call for a standard implementation of these hoods was done after testing conducted by the NFPA (1997) provided support that the firefighter's hood enhanced fireground safety and protected firefighters from burns to previously exposed areas on the head and neck. The findings of this testing have since been replicated by additional research that examined the protection provided by the hood to firefighters in New York City (Prezant et al., 2001a, 2001b). Through both laboratory and field testing, Prezant and colleagues found dramatic reductions in head burns among firefighters who wore a hood. Laboratory testing showed significant decreases in burns among the left and right ears, front and back of the neck, and total head burns. The field testing supported this finding and showed the use of hoods led to significant decreases in ear burns (60%), neck burns (54%), and total head burns (46%). As the NFPA's research did not test instances where the firefighter's hood was wet, Prezant et al. built upon previous research by accounting for this limitation. Their results indicated that the same protective effects of a dry hood were present when a firefighter was wearing a hood that was either damp or saturated with water (Prezant et al., 2001a, 2001b).

Thus, both laboratory and field testing have uniformly produced scientific evidence that shows when fighting fire, the proper use of the hood significantly increases protection from burns to a firefighter's head, ears, and neck. Yet even with such strong evidence, more than a decade and a half after the NFPA (1997) published its revised 1971 standard the firefighter's hood remains a point of contention among a number of firefighters who are mandated to wear it. This raises the question of why do firefighters continue to have negative views on the mandated use of the firefighter's hood? To answer this research question, I collected and empirically analyzed data from semi-structured interviews. Here I present the results of this analysis, and follow with a discussion of the implications these findings have for understanding why adverse reactions to the use of certain safety equipment technologies may exist.³

³ It is useful to provide some information on my background and position for insight as to how these may have shaped this current research (Malterud, 2001). This current study on the firefighter's hood resulted from my larger dissertation study conducted that examined changes in skill used to perform job tasks among professional firefighters, and how technology has (or has not) impacted this change (Ward, 2010). The occupation of firefighter was chosen for this larger study for two reasons. First, as most previous work has examined changes in skill in either manufacturing or "white-collar" occupations, a study of firefighters allowed for skill change to be examined in a different industry (i.e., public service). Second, I have always had a personal interest in the public service

Methods

Context and Sample

The data I collected for this research included 42 semi-structured interviews of professional firefighters (Ward, 2010). The firefighters interviewed were employed at one of two independent fire departments located in the mid-Atlantic region of the United States: the Waterville City Fire Department (WCFD) or the River City Fire Department (RCFD).⁴ I conducted interviews at these two departments as the RCFD was comprised of only professional firefighters, and the WCFD had only a limited number of volunteers, which allowed for adequate samples of professional firefighters to be drawn at each of these departments. The WCFD and RCFD were urban fire departments founded in their non-volunteer form in 1895 and 1859, respectively. The WCFD served an area of roughly 37,000 residents and consisted of 17,000 housing units (approximately 7% of which were vacant; U.S. Census Bureau, 2009). On the other hand, the RCFD was responsible for over 631,000 city residents who resided in approximately 296,000 housing units. Compared to Waterville City (7%) and the national-level (12%), there was a much larger percentage (20%) of vacant units in River City (U.S. Census Bureau, 2009).

Although differences existed between Waterville City and River City, they both shared certain similarities with other historic cities throughout the United States. Waterville City initially served as a major railroad hub during the U.S. expansion, and grew to a modest size that has remained in the present day. Further development has occurred within the city's borders, but it has maintained its original downtown area. River City is a large urban area with a shipping port and was a major manufacturing city during the U.S. industrialization period. However, as with other U.S. cities that developed during this period, post-industrialization caused many employment opportunities within River City to move outside its borders subsequently increasing the overall poverty levels. More recently large pockets of gentrification have sprung up throughout River City creating a polarization of the socioeconomic status among its residents.

Both Waterville City and River City fire departments had different organizational structures. The WCFD was composed of six fire stations that housed a number of vehicles, or apparatuses: five fire engines (containing the pump, hoses, and water) and two fire trucks (containing ladders and tools for forcible entry). One of these stations also housed a utility vehicle that responded to emergency incidents. Working at these fire stations and on these WCFD apparatuses were approximately 80 professional firefighters and 20-25 active volunteer firefighters. The WCFD consisted of three shifts of firefighters, each shift working 24-hours followed by 48-hours of time off. During each shift, all fire engines and trucks were operated by at least two professional firefighters. All three shifts were overseen by the WCFD Fire Chief and Deputy Chief. Each of the three shifts had its own battalion chief and captain who directly managed and oversaw the day-to-day activities, including all firefighters currently serving on that shift. In addition to these firefighters and their commanding officers, the WCFD also had a handful of personnel who worked in administrative or fire prevention education positions.

The RCFD had 41 fire stations, 39 of which housed a total of 36 engines, 18 trucks, 24 emergency medical service (EMS) units, and a variety of specialty units including special/heavy rescue, hazardous materials, fire boats, aerial rescue, and mobile command units.

industry/sector, and as such have met or have relationships with a number of individuals who work in this industry/sector. Through these relationships, I had key contacts at the WCFD and RCFD that allowed me contact firefighters with whom I could conduct the needed interviews.

⁴ Names of the fire departments and firefighters in this study were changed to maintain confidentiality.

The RCFD had approximately 1,700 professional firefighters and no active volunteers. The RCFD had four different shifts, and the firefighters in this department all worked an eight-day rotating schedule. This schedule consisted of two 10-hour days, followed by two 14-hour nights, and then four days off. The organizational structure was rather extensive in the RCFD. The Department was led by a Fire Chief who oversaw two assistant fire chiefs. One Assistant Chief managed the operations, including four shift commanders and the EMS Deputy Chief. The other Assistant Chief oversaw five different deputy chiefs, including chiefs for the training academy, community relations, information technology support, logistics, and other support services. For each shift, there were five battalion commanders each overseeing a different geographical region of River City. The various fire engines and trucks were dispersed throughout each battalion and (depending on the shift) were each headed by either a captain or lieutenant and stationed by three additional firefighters. Each EMS vehicle was operated by two firefighters, at least one trained as a paramedic. As with the WCFD, the RCFD also had a number of personnel who performed administrative and support staff roles.

My final sample for this study consisted of 20 firefighters from the WCFD and 22 firefighters from the RCFD. Of the 20 WCFD respondents, 18 were regular professional firefighters, one was a battalion chief, and one was the officer/director of fire prevention services. All 20 of these individuals were white males, and ranged in age from their early 20's to mid 50's. Out of the 22 respondents from the RCFD, 18 were regular professional firefighters (three were captains and three were lieutenants). The remaining four respondents included a deputy chief, two captains who served under the fire investigation branch, and one firefighter who retired from the RCFD just two months prior to being interviewed. Seventeen of these RCFD interviewees were white males, four were black males, and one was a black female. The age range of those interviewed at the RCFD was from the late 20's to the early 60's.

Data Collection Procedures and Analysis

Prior to data collection for this research, I secured approval from the University of Maryland's Institutional Review Board. I collected all data through semi-structured interviews. For this particular study, conducting interviews had a clear benefit over other methods. This technique allowed the interviewee the opportunity to provide a rich, detailed description of the use of safety equipment and other technologies within the fire department, his/her specific reactions to these technologies, and the reasoning behind these reactions. As the data I collected focused on technologies that were primarily used by firefighters during emergency situations, data collection through observations was not realistic. Prior to conducting these interviews, both the WCFD and RCFD fire chiefs each granted permission for these interviews to be conducted at the fire stations. Each interview was conducted at the specific WCFD or RCFD fire station at which the interviewee was currently stationed during his/her given shift. The reason behind conducting interviews at the interviewee's fire station during his/her shift was that it required less effort and time on the interviewee's part as they were already scheduled to be at a particular station on a particular day. In addition to easing the burden on interviewees, this also made it easier to use a snowball sampling technique to identify additional firefighters who may have been willing to participate in this study.

I conducted all interviews for this research between November 2008 and June 2009. Although data are approximately eight years old, they remain relevant the firefighter's hood continues to be worn as part of a firefighter's PPE. Through two different key contacts, data collection was able to be arranged. Prior to interviewing, I conducted site visits at both fire departments allowing me to introduce myself to a number of firefighters, spend time with them to informally discuss my research, observe some of the daily procedures that occurred at the fire stations, begin to coordinate with my key contacts as to how I should proceed with

conducting interviews, and ultimately build rapport with members of the two different departments.

Both the WCFD and RCFD interview samples were drawn in a similar manner using a combination of two different approaches. First, the key contacts helped organize initial interviews with firefighters from each department. After conducting these initial interviews, a snowball sampling method (see Handcock & Gile, 2011; Suri, 2011) was used where the interviewees were asked if they knew any other firefighters who may be willing to participate in an interview. If an interview was arranged using this method, this snowball sampling process was attempted to be continued with the next firefighter. During this process interviews at each department were also being arranged through the key contacts. In the end, the snowball sampling technique proved more effective for drawing a sample at the RCFD, while more interviews at the WCFD were arranged through the key informant. The different sizes of the two fire departments were the reason for this difference. Relative to the WCFD, the RCFD had a larger number of firefighters actively working, and a larger density of firefighters at any given fire station that more easily facilitated the snowball sampling technique.

The majority of firefighters were interviewed while on duty, where at any time an interview could be disrupted by an emergency call. These occurrences were not frequent; however, when they occurred the interviews were placed on hold while the firefighter responded to the call. In all instances except one these interviews were continued later. As the firefighters interviewed were all familiar with these emergency responses, these disruptions did not appear to have any apparent negative impacts on the interviews.

During the interviews I utilized a semi-structured questionnaire that not only provided flexibility during the aforementioned interruptions, but also allowed the firefighters freedom to discuss certain technologies in detailed manner. I developed the questionnaire based on a review of literature (i.e., general trade journals, manuals, written standards, and also specific written histories of the WCFD and RCFD), and observations from two site visits (one each to WCFD and RCFD). After these site visits, a few pre-testing interviews were conducted to further refine the instrument (Ward, 2010). A full copy of the questionnaire can be found elsewhere (Ward, 2010, Appendix A). The length of the interviews was variable, but the average duration of interviews was between 60-75 minutes.

Once completed, I transcribed each interview within one week (or less) of it being conducted (no other persons were used for any part of the transcriptions). After all 42 interviews had been transcribed, I analyzed the interview data using a general thematic analysis approach (Boyzatis, 1998; Braun & Clarke, 2006). To begin the data analysis, all interview transcripts were read to identify data that related to the research question: why do adverse reactions to prevention-related technologies – specifically the firefighter's hood – exist among emergency response workers? In this step of the analysis, open codes were assigned and used to identify specific categories. These categories were then organized into three larger themes: life-threatening situations, effects on skill, and perceived benefits. The next step of the analysis was axial coding, where each theme was developed and examined in relation to one another. Finally, through the process of selective coding, the theme of *perceived effects on skill* was identified as a core category that served as a connection between all three themes.

Results

Life-Threatening Situations

The first major theme uncovered was firefighters' concern over the hood's effect on negotiating the potentially life-threatening environment created by a structure fire. It was not the hood's relation to minor/moderate injuries or burns that were of concern to these

interviewees, as the firefighters recognized that when they entered a building that was engulfed in flames, the occasional injury or burn does occur. Rather it was the hood's relation to potentially life-threatening injuries or burns that worried these firefighters. The firefighters interviewed uniformly agreed that the ability to detect if an environment was life-threatening must be learned, such that the firefighter can protect both himself/herself and his/her fellow firefighters.

When the need for this skill was discussed, the interviewees often related it with the mandated use of the firefighter's hood. In these instances, the hood – a piece of equipment that functions with a sole purpose of enhancing safety and preventing injury among firefighters – was viewed as potentially detrimental to one's ability to negotiate a burning structure and identify areas posing a high likelihood of major injury. A number of firefighters interviewed claimed that with the hood now covering the last remaining exposed areas of skin (i.e., face, neck, and ears), a firefighter was more prone to placing himself/herself in life-threatening situations than when not using the hood at all. As stated by Joshua, a firefighter at the WCFD:

You're better protected, but at the same time you're killing more firefighters because they're going deeper into the fire where maybe they shouldn't be because of those places [exposed skin] that weren't protected in the past. If you started feeling really hot and getting burnt, you knew it was time to get out.

This view is somewhat surprising given that previous scientific testing has found support for the hood's prevention of burns (Prezant et al., 2001a, 2001b). However, reflecting back to those studies, one can see their incompatibility with the findings of the present study. The focus of these past laboratory and field tests was on the effectiveness of the hood at preventing *burns*, not necessarily preventing *major injuries and death*. To further explore this claim by the firefighters interviewed, annual counts of both fireground deaths of firefighters (Fahy, LeBlanc, & Molis, 2009) and the occurrence of structure fires (Karter, 2009) in the United States can be used (both compiled by the NFPA). Using these data, rates can be created for the number of fireground deaths by the number of structure fires both preceding and following the year the NFPA recommended the use of the hood. If firefighters' accounts in the present study are valid, one would expect to find no decrease in the rate of firefighter fireground deaths after the NFPA standard was published.

In years following the implementation of the *NFPA 1971 Standard* there was an overall decrease in the fireground death rate (Table 1), it is rather small (a decrease of only 0.22 deaths per 100,000 structure fires). From 1986-2008 the death rate tends to fluctuate every few years, but the overall rate remains around seven deaths per 100,000 structure fires. In sum, these rates do not show a substantial decrease in fireground deaths since 1997 (when the NFPA implemented its *Standard*), and provide no strong evidence that refutes the concern over negotiating potentially life-threatening injuries that was raised by a number of the WCFD and RCFD firefighters interviewed.

Table 1. Firefighter Deaths at Fireground and Number of Structure Fires, United States 1986-2008

Year(s)	Fireground Deaths ^a	Structure Fires ^b	Rate (per 100,000)
<i>Individual Years</i>			
1986	48	800,000	6.00
1987	54	758,000	7.12

1988	65	745,000	8.72
1989	59	688,000	8.58
1990	48	624,000	7.69
1991	53	640,500	8.27
1992	38	637,500	5.96
1993	34	621,500	5.47
1994	61	614,000	9.93
1995	42	573,500	7.32
1996	32	578,500	5.53
1997^c	41	552,000	7.43
1998	40	517,500	7.73
1999	56	523,000	10.71
2000	39	505,500	7.72
2001	38 ^d	521,500	7.29
2002	46	519,000	8.86
2003	29	519,500	5.58
2004	30	526,000	5.70
2005	25	511,000	4.89
2006	38	524,000	7.25
2007	36	530,500	6.79
2008	29	515,000	5.63
Combined Years			
1986-1996	534	7,280,500	7.33
1998-2008	406	5,712,000	7.11
Total (1986-2008)	981	13,545,000	7.24

^a Data source: Fahy et al. (2009).

^b Data source: Karter (2009).

^c Year that the NFPA (1997) published the *NFPA 1971 Standard*.

^d To maintain consistency with NFPA data reporting, this number does not include the 340 fireground deaths that occurred at the World Trade Center during the 9/11 terrorist attacks.

Effects on Skill

The second theme discovered in the analysis provided an underlying explanation as to exactly *why* the hood, and not external factors or other components of the PPE, was targeted

as the culprit in allowing these situations to occur. Ultimately the firefighters' contention was not directed at this safety equipment technology itself, but instead at how the hood removed certain skills that the firefighters used on a regular basis to perform the tasks required by their occupation.

More specifically, the interviewed firefighters discussed that the exposed skin areas now covered by the hood had traditionally played a critical role in the determination of whether or not an environment was too dangerous to enter or remain in while fighting a fire. André, a firefighter in the RCFD, summed this by stating:

One thing I've noticed though since we're more encapsulated with all the turnout gear [PPE], I'm finding we're going further in these buildings and sometimes getting in spots that we shouldn't be in. Years ago, you would use your ears. When your ears start burning it was time to back up. But now since your ears are covered I think we're going in a little further than we should... So yeah, it's good if somebody is trapped, we need to make a rescue, it's good to have all this on but other times I think we're going in a little too far sometimes... And now especially with the new generation of firefighter we don't have a lot of experience, so they're not seeing things and, you know, we're pretty fortunate so far, nobody really getting seriously hurt, but, uh, I think the new equipment's kind of made things a little more dangerous really. I kind of used to like use my ears and say, "Hey, it's getting hot in here. Let's back up and regroup."

As André discussed, using one's ears in a certain manner was a skill held by firefighters that helped prevent them from entering life-threatening situations. The heat experienced on one's ears would signify when the physical environment was unbearable, in essence placing a biological limit on the firefighter's body as to what heated environments s/he could withstand. The feeling of heat to the ear would allow the individual to initiate a mental process that informed a decision regarding one's own personal safety. In fact, during a full-fledged fire where a building was fully involved, this sense of touch to the ear may have been one of the only senses readily available to firefighters. Sight may often be hindered by the presence of smoke. The breathing apparatus worn by firefighters to supply oxygen helped camouflage smell and taste, and using sound to gauge the level of danger present may be difficult, especially in the midst of a large fire with numerous tasks being performed by various firefighters. Thus, with the potential for these four senses to be compromised, the ability to feel heat via one's ear may be the only sense readily available to firefighters. Using this sense was seen by a number of firefighters as a true occupational skill that was valuable in preventing both themselves and others from entering and remaining in potentially life-threatening situations.

The identification of heat levels via exposed skin initially may be thought of more as a biological reaction than skill, as it is an individual's human nature to shy away from exposure to extreme heat. In fact, acknowledgement of this initial reactionary response did arise in the interviews. Peter from the RCFD stated it best by claiming that it is simply "unnatural" to purposely move closer and closer to the source of a fire and into an increasingly dangerous environment. However, firefighters needed to learn and understand how to negotiate this reaction so that they can differentiate between identifying when an environment was unnatural, and when it was unnatural *and* potentially life-threatening. This skill, until the mandated use of the firefighter's hood was learned and used by sensing heat on the exposed skin of one's ears. When this skin was exposed firefighters could internally negotiate the benefits of pushing forward to extinguish a fire or perform a rescue in a specific environment relative to the risk of major injury or death posed by this same environment.

Although recognizing heated environments using exposed skin may not appear difficult, the mental and physical processes involved were actually rather complex. A strong understanding had to be developed of one's biological limits, the dangers of the changing environment surrounding oneself, and the relation of these to one another. As Carlson from the RCFD stated:

Back when I first came in you always left your ears exposed so when you crawled down the hall, you know, depending on how hot it was, your ears were always telling you... If the place wasn't being ventilated properly, you knew it because; of course you get close to the ground where it was a little cooler and as soon as you pick your head up, you could tell how hot it was. And when your ears start tingling you know that the truck company is not ventilating the place, so back up a little bit. Right now you're so well protected that you feel nothing. We've had people, their helmets, they just absolutely melt. And they can stay there because they're so well protected – which is bad... You know [Laughs], it's good that you're protected that well, but it's bad because now you're in an environment where if something happens to your mask, you're dead.

With the mandated use of the hood at both the WCFD and RCFD, and the subsequent covering of one's exposed ears, detecting a super-heated, life-threatening environment could no longer be performed in the traditional manner. This took a certain level of autonomy and control away from the firefighter and left him/her in the undesirable position of being reliant on the technology itself to remain in an environment, without always be certain if that environment was life-threatening.

With this loss of autonomy in identifying life-threatening situations, it may be difficult for the firefighters to maintain these skills (see Attewall, 1990). In fact, the hesitancy and resistance to the use of the firefighter's hood among firefighters shows the recognition of this loss of autonomy/control. As discussed in an interview by RCFD firefighter Chad:

But the thing is, when you have a chief outside, or any officer telling you to go somewhere, when your ears are telling you you can't go there 'cause it's too damn hot, the environment will not allow it. Wearing that hood takes that power away from the guy on that pipe [fire hose]. Or that man looking for; doing search and rescue.

It is true there are other methods of making the types of decisions Chad describes (e.g., interpreting the type of smoke being produced by the fire); however, it was not the dominant manner in which firefighters traditionally exerted control over the situation and maintained a connection to the environment. This loss of control was an extremely important concern for firefighters, and appeared to be a primary culprit of the adverse reaction that firefighters had towards the mandated use of the hood.

In response to this loss, a few firefighters interviewed described actions they took in response to the mandated use of the hood. A firefighter named Ryan at the WCFD described his solution to the hood's negation of this autonomy:

The thing that I've done and take a beating over is I won't wear my hood the whole way. I'll keep an ear open. And the reason being is because I don't feel the heat in my gear. And it's gotten people into trouble as well. They go in too deep, they don't feel anything, they feel okay, and then it's like "Oh! Whoa,

whoa, whoa – hold on!” You know, and by the time they feel it, it’s way too bad.

This example shows that Ryan (and a few of the other firefighters) still wore the hood, but made alterations in how it (or other components of the PPE ensemble) were worn. Although the mandate may include procedures on how the hood is to be worn, Ryan shows that firefighters may not be following this mandate verbatim (for another example of such behavior, see findings by Weinschenk, Ezekoye, & Nicks, 2008). This action was in no way taken with a goal of resisting authority, but instead was used as a mechanism to retain control of the skill involved with negotiating if a particular environment is life-threatening. Such alterations of one’s PPE ensemble allowed for the ability to still use the sense of touch to assess an environment while not completely disregarding the mandated use of the hood.

The amount of control maintained in identifying and negotiating potentially life-threatening environments was not the only reason for holding adverse reactions to the firefighter’s hood. Many firefighters interviewed also saw this safety equipment affecting the complexity involved the process of successfully performing search/rescue or fire suppression, a task requiring the integration of numerous mental and manipulative tasks. To perform this skill the firefighters must first proceed (sometimes blindly) through a smoke-filled environment towards a fire that may be potentially unseen due to a combination of smoke and the interior design/layout of the structure. Next, a systematic method must be used such that firefighters are familiar with their environment in case the incident of a backdraft or flashover⁵ arises and a rapid exit is needed. As there is often a number of firefighters each performing a specific task (e.g., search and rescue for victims, spraying water using a hose, ventilation of the building, etc.), open communication must be maintained throughout this entire process. During each of these steps, the firefighters must each have sufficient physical strength to wear the PPE (including an air supply canister), and use some specific tool (e.g., axe, fire hose, etc.) to complete physically challenging tasks, such as spraying water onto the fire with a hose or forcing entry into a blocked portion of the structure. Throughout this entire process, an ongoing negotiation of whether the danger present in the environment has breached one’s biological limitations and become life-threatening must also simultaneously occur.

Clearly the elements involved in performing this skill are rather high. A few WCFD and RCFD firefighters I interviewed even jokingly stated that the effort and skill a firefighter exerts while going through this process a single time is more than many persons exert at their job throughout an entire week’s worth of work. During the interviews, two types of instances were given where the use of the hood was also viewed by a number of firefighters as disrupting the complexity involved in this process. The first involved disruption in the actual process of finding a fire. Prior entering a life-threatening environment, a firefighter had to physically arrive at the location. In certain situations, particularly when a fire had not yet developed to a large magnitude, the touch of heat to exposed skin was vital in navigating oneself to the area of a structure containing the fire. As stated by Tim from the RCFD:

⁵ Backdrafts and flashovers were both extremely dangerous situations that would have detrimental consequences for firefighters caught in their wake. A backdraft is an instance where a fire burning in an airtight room depletes all the oxygen in that room. The heat and fuel still remain in this room, and the instance that the room’s airtight seal is broken and oxygen is introduced back into that environment, an explosive flame results. A flashover is an instance when a room may have oxygen and a small fire burning, but lacks the heat required to reach an ignition temperature. In this instance, heat can continually build from the small fire in the room, or elsewhere in a structure via gases produced by the fire. This process increases heat throughout the entire room until the room reaches a certain ignition temperature. The result is an instantaneous flame that engulfs the room and its contents.

When you're in there, and trying (sic) a lot of these buildings, they're long. They're deep. When you're going in there and even some of these big frames that are like that. It's, it's almost impossible to know what direction that fire's in. When I came in, your ears told you that. So if I walk through the door and I'm feeling the heat on this side, I'm going to start crawling that way. And then I might feel the heat on this side and I might start crawling that way. And that's how you work that way.

As Tim mentions, before a firefighter could even worry about the potential for danger at a location, s/he first needed the ability to arrive at the location. The use of one's exposed ears would help facilitate finding the fire itself through feeling and mentally processing heat exposure to one's body, then physically moving in that direction. However, as the firefighter's hood covered the last portion of skin exposed to the environment, this traditional process of locating fire was disrupted.

A second instance where the complexity needed was hindered by the firefighter's hood was in the ability to mentally process if and when an environment became too dangerous, and when a firefighter should pull himself/herself out. An example of this was provided by a RCFD firefighter named Marvin:

When I came in your ears were burning (sic), your body will not allow you to keep going, number one. Number two, you'll be pushed to the ground. If you haven't found it [the fire] by then, it's time to go. The only time that you might push past that, and you're not going to get very far, is if you know there's somebody in there. And you're trying to get to them. That's a whole different ballgame, because adrenaline is taking over. But when that isn't a factor, and this; you're basically in a shithole that doesn't mean anything to anybody, it's not worth it. But you cannot make that decision when you have that hood on.

Comprehending one's biological limits plays an important role in understanding how long a firefighter knows s/he can sustain himself/herself in a particular environment. Yet other factors add to the complexity involved. For example, firefighters must also mentally process if the possibility of a trapped victim exists, and when the ability to perform this rescue is possible (even if one's body is telling him/her otherwise). All of these mental aspects were enabled by the exposure of one's ears to the environment; now to some extent hindered by the use of the hood. Thus, it becomes clear that the removal of the autonomy used to negotiate the environment created by a fire is not a complete explanation of why certain firefighters hold a negative view of the hood, but that to fully understand this adverse reaction the complexity involved when searching for victims and suppressing the fire itself must also be considered.

Perceived Benefits

A number of firefighters interviewed had an adverse reaction to the mandated use of the hood due to its effects on the autonomy and complexity involved in performing search/rescue and fire suppression while negotiating the potentially life-threatening environment created by a fire. However, it is important to note that not all views of this safety clothing were negative. A third theme found through the data analysis showed that there were also perceived benefits of using the firefighter's hood, specifically through intervention (*not* prevention) of a life-threatening situation. This was not a dominant view held by firefighters, but it was still a prevalent theme that appeared in the analysis.

This recognition was made explicit by a handful of firefighters I interviewed, many (but not all) of whom were less experienced and had not begun their firefighting career until after 1997 when the *NFPA Standard* was updated. As Donovan, a RCFD firefighter, saw it:

But, you know, the older school mentality was you know, if you got in there and the thing started to heat up too much you could feel it. Now you can't really feel it when you wear that hood. It's almost like you don't feel it until it's really biting you and then it's almost like, "Uh oh." You know, you got to get out. But on the other hand, if it did flashover you'd have a better chance of survival if you had it on compared if you didn't have it on.

While the firefighters' adverse reactions to the hood were in regards to the levels of control and complexity that were lost over the *prevention* of a potentially deadly situation, some firefighters interviewed did recognize the hood offered protection during the *intervention* of a backdraft, flashover, or other life-threatening situation. Although the hood removed the initial skill involved in this situation, in the instance that a firefighter's situation took a turn for the worse this technology was seen as helpful. Firefighters were now fully encapsulated with the hood, and during the instance that a flashover or backdraft occurred, the firefighter's hood provided extra protection that increased the time a firefighter had to exit that particular environment. Independent of the decision-making and mental/physical processes used to enter or remain in such an environment, firefighters did recognize that the hood (and other PPE components) increased their safety if they were already located within a life-threatening environment. During these situations the need for the initial decision-making and complexity had passed, and the firefighter's hood was viewed in a positive light as it provided increased protection from the environment, and ultimately a greater chance of survival.

Discussion

Conclusions

Through a study of firefighter's hood, I sought to inform the broader question of why adverse reactions to the use of prevention-related technologies exist among emergency response workers. Through a systematic, qualitative data analysis of semi-structured interviews conducted with professional firefighters, I identified three themes. The first theme was that firefighters saw the hood as having an adverse effect on their ability to recognize and negotiate whether an environment was life-threatening. The use of this safety equipment covered the last remaining area of exposed skin on their bodies, which traditionally was used to identify the danger in a given environment. Analysis revealed that the firefighters' concerns of danger were not with minor/moderate burns, but rather with situations that had potential to be life-threatening. They perceived use of the hood as increasing the risk of them entering into an environment that had potentially life-threatening consequences.

The second theme unearthed through the analysis was that firefighters saw the hood as impacting the skills needed not only to perform the tasks required by their occupation, but also those needed to identify dangerous environments. Firefighters perceived the hood to remove both their autonomy in such a situation, and hinder the complex mental/physical processes needed to perform their duties. By covering the remaining portion of exposed skin on their bodies, their ability to control the decision-making process of whether they should remain in the environment was perceived as being removed. At the same time, firefighter's hood was also perceived as hindering the complex processes that were used to deduce where a fire was located, and continually negotiate if the environment containing this fire exceeded biological

limits. This theme – the perceived effects on skill – was at the core of the adverse reactions expressed by the firefighters.

A final, albeit minor, theme found through data analysis was that the hood did have its benefits. While it was not perceived as preventing a firefighter enter a life-threatening situation, some firefighters did view it as beneficial in intervening during a life-threatening situation. Here the hood provided a layer of protection that gave a firefighter a better chance of escaping such a situation. Interestingly, this theme was mainly expressed by younger firefighters who had little to no experience in the fire service prior to the *NFPA 1971 Standard* and the hood's mandate. Regardless, it is important to note that even with an overall pervasive negative reaction, a perceived benefit of the hood also existed.

Through recognition that the firefighter's hood decreased and removed skill that many firefighters saw as vital to the tasks required by their occupation, a more robust understanding of why firefighters elicited such a reaction to this particular technology is reached. The firefighters interviewed were not reacting negatively to the use of the hood itself or the authorities mandating it, nor did they view it as a threat to the traditional masculine heroism (Ericson & Mellström, 2016). They also provided no indication of disbelief of past scientific research (Prezant et al., 2001a, 2001b) that found the hood to reduce burns received while on the fireground. Instead, they were reacting to the removal of the discretionary, mental, physical, and interpersonal components that were needed to prevent the placement of themselves and others in a situation that presented a heightened risk of major injury or death. In sum, underlying this entire adverse reaction was the diminishing or decreasing impact that the firefighter's hood had on the skill used to successfully complete the tasks required by their occupation.

It is important to note a few limitations when interpreting the findings of the present research. This research was a study of one specific technology, and while it was meant to inform those working in the broader field of emergency response, one should be careful not to over interpret the results found in these data analyses. Also, the WCFD and RCFD firefighters interviewed in this study tended to be the older and more experienced firefighters. Interviewing these individuals was vital in understanding how technology has affected the skills of firefighters over time, which is why more experienced firefighters were sought out for interviews. However, based on the history of resistance to change in fire departments (Coleman, 2004), it would appear the firefighters may have been biased towards a negative reaction. Although a few less experienced firefighters were interviewed, interviewing a few more (particularly those who had not worked until after the hood was mandated) may have allowed for an alternative perspective on the reaction to use of the firefighter's hood.

Implications and Recommendations for Safety Equipment Technology

Despite these limitations, recommendations are able to be made from this research study regarding the implementation of new firefighting safety equipment technology. One recommendation is that when new technology is introduced to firefighters, a more holistic approach should be taken to fully understand its impact and benefits. In the case of the firefighter's hood, rigorous testing was conducted to ensure the hood reduced burns received to the neck and head (NFPA 1997; Prezant et al., 2001a, 2001b). None of the firefighters interviewed refuted these claims, but instead showed concern over the perceived skill lost by being mandated to wear a hood, many viewed as essential to successfully completing the tasks required by their occupation. While injury prevention is extremely important in this instance, recognizing the effects on occupational skill, performance of required tasks, and firefighters' compliance with standards are aspects that would ideally be considered prior to the widespread implementation of a new technology. This would require not only a scientific testing of the

physical properties of the safety equipment, but also examination of how the equipment would be used by firefighters in real situations, their reaction to its use, and an understanding of why this reaction occurs.

Firefighters in this study clearly viewed the skills required by their occupation to be compromised by the introduction of the firefighter's hood. A second recommendation would be that if the introduction of a specific safety equipment technology was identified by firefighters as removing needed skills, alternative skills with the same effectiveness should be developed and substituted. For example, the hood was viewed as preventing firefighters from negotiating life-threatening situations; therefore, working with these individuals to develop alternative methods for negotiating the life-threatening situations created by a fire would help prevent this adverse reaction. Realistically, this may be useful for certain technologies, yet instances may exist where alternative skills are unable to be developed. In these situations, a decision would need to be made as to whether the loss of skill stemming from the introduction of new safety equipment technology outweighs the injury prevention-related and other benefits of introducing said technology. This would be a difficult decision; one beyond the scope of this study and most likely to be determined on a more case-by-case basis.

Summary

Through the results of study, I hope to provide insights to the implementation and use of new safety technologies among emergency response workers. Negative reactions to safety equipment may not necessarily be directed at its ease of use, or at the perceived usefulness of this technology itself (Bagozzi, Davis, & Warshaw, 1992; Davis, 1989; Venkatesh et al., 2003). Instead the underlying reason this negative reaction was spawned was that it was perceived by its users as diminishing and/or removing important skills possessed by firefighters. While both ease of use and perceived usefulness have been argued as important factors when considering the introduction of new technologies, findings here show that it is also important to consider the impact a technology will have on workers' skills.

These findings also imply the importance of considering both manifest and latent consequences of safety equipment technologies introduced to emergency response workers. New safety equipment may be introduced with specific consequences in mind; however, its introduction can yield unexpected results. Even if these manifest consequences are achieved, the unexpected consequences could be concerning. In regards to the firefighter's hood, past researchers found this technology successful in meeting its intended goal of reducing the burns firefighters received on the fireground. However, the present study revealed that although minor/moderate burns may be reduced, there was the latent consequence of removing important skills used by firefighters. This removal was ultimately perceived by firefighters as hindering not only their ability to suppress fire, but also increasing the risk of major injury or even death. In their view, this latent consequence outweighed the initially intended consequence. Thus, attempting to recognize any latent consequences before the implementation of new safety equipment may prevent these adverse reactions to such technology. As it may often be difficult to foresee consequences, perhaps the consultation of workers for whom this technology will affect may provide additional insight.

As evidenced by the present study, controlled experiments and lab tests may be beneficial in testing for the intended the consequences of safety technology; however, the perception and experiences of emergency response workers may yield valuable insight into latent consequences of the technology's implementation, such as the diminishment of crucial skills needed to perform the tasks required by their occupation. This in turn may help prevent any backlash or negative reactions to this technology when it is introduced and its use during an emergency is mandated. With new safety equipment technologies continually being

introduced, some that have a sole intent of increasing worker safety, a fundamental understanding of how these technologies affect workers' skill remains an important consideration. By accounting the safety equipment's effect on skill, this may not only allow for emergency response and other workers to better and more safely perform the tasks required by their occupation, but also minimize adverse reactions to this technology.

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