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Assessment Of Instructional Presentation For Emergency Evacuation Assistive Technology

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ASSESSMENT OF INSTRUCTIONAL PRESENTATION FOR EMERGENCY EVACUATION ASSISTIVE TECHNOLOGY

by

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ABSTRACT

It is often the case that emergency first responders are well equipped and trained to deal with a situation that involves evacuation of someone with a physical disability. However, emergency responders are not always the first line of defense, or they may be otherwise occupied with assisting others. This research examined the effects of instructions for emergency stair travel devices on untrained or novice users. It was hypothesized that through redesign of the evacuation instructions, untrained individuals would be able to successfully prepare an evacuation chair and secure someone with a disability more effectively and efficiently. A pre-post study design was used with an instructional redesign occurring as the manipulation between phases. There was an improved subjective understanding and improved performance metrics, such as reduced time on task and a reduction of the number of instructional glances, across three evacuation chairs when using the redesigned instruction sets.

The study demonstrated that visual instruction style can account for a significant portion of explained variance in the operation of emergency stair travel devices. It also showed that improvements in instruction style can reduce time on task across device type and age group. The study failed to demonstrate that there was a performance decrement for older adults in comparison to younger adults because of the cognitive slowing of older adult information processing abilities.

Results from this study can be used to support future iterations of the Emergency Stair Travel Device Standard (RESNA ED-1) to ensure that instructional design is standardized and optimized for the best performance possible.

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CHAPTER ONE: INTRODUCTION

Relevance of Problem

This dissertation describes two studies that examined how to better design instructions of evacuation devices for novice users and older adults. In a 2008 study, Tang, Lin, and Hsu looked at novices' and older adults' interpretation of symbols during evacuations. As would be expected, older adults performed slower and worse than younger adults due to cognitive slowing. This finding was expected because it is well documented in the literature that in complex scenarios such as evacuation, information-processing speed declines with increase in age (Fisk, Rogers, Charness, Czaja, & Sharit, 2009). In addition to age, task familiarity plays a significant role in performance. Task familiarity is developed through training / experience and practice.

The finding that task familiarity plays a significant role in performance explains the common claim that in order for individuals to use evacuation devices they need to be properly trained ahead of time. Due to their training, first responders are typically over-relied on in evacuation scenarios. This research demonstrated that novices, when given the proper instructional support, can effectively use devices, assist first responders, and improve performance time. Previous research indicates that individuals who are familiar with a task (e.g., understanding an evacuation plan and interpreting symbology), such as those with an architectural background, perform much more efficiently than those who are unfamiliar with such tasks (Tang et al., 2008).

Tang et al.'s findings (2008) are consistent with Charness' work (1991) that investigated the development of skill sets in old versus young chess players. As expected, individuals who were experienced performed better than those who were not. However, although experience is important for performance, one cannot assume that an experienced individual will always be present when needed. It could happen that first responders are occupied with another task (such as firefighting) or that the number of people to be evacuated exceeds the capabilities of evacuators, which is often the case in evacuation. As such, many organizations respond to this performance requirement by creating evacuation plans to expedite and facilitate the process, yet the presence of trained personnel cannot be assumed. The U.S. Department of Homeland Security, in its 2006 Nationwide Planning review noted how evacuation plans for special needs (the term used to describe people with disabilities plus others), are few in number (Sutherland, 2006). In one study, over half (56%) of emergency planners said they did not have a plan in place due to their not having expertise related to disability (Hess, 2007.)

A defining characteristic of an emergency is the unexpected nature of its occurrence. When an emergency occurs, evacuation is one potential method that can be used to escape from the emergency environment into one of greater stability and safety. When considering the evacuation of persons with disabilities, the interaction between humans and technology is paramount. For example, John Abruzzo is a quadriplegic who survived both World Trade Center terrorist attacks. During the first attack in 1993, it took 6 hours to evacuate Abruzzo from his 69^{th} floor office. After that attack, emergency management personnel implemented evacuation procedures involving the use of emergency stair travel devices, also known as stairchairs. Consequently, during the September 11, 2001, attack, Abruzzo was safely evacuated from his office in only an hour and a half. This example demonstrates how the use of human factors principles can improve human performance and potentially save lives.

Using this example as the foundation for this research, the researcher sought to establish how different types of instructional interventions could support both individuals with disabilities and people assisting in the evacuation.

To enable better understanding of the population and the challenges associated with the devices, the next section provides background on both disabilities and evacuation chairs. This knowledge is then applied to evacuation planning to figure out specific interventions that can be made to improve human performance.

Mobility Impairment Statistics and Stairchair Background

According to 2010 data from the American Community Survey, 11.9% of the population of the United States reported a disability (Erickson, Lee, & von Schrader, 2012). Additionally, an estimated 20.9% of that population, or 3,842,300 people, hold a full-time or an equivalent to full-time job. Many of these individuals are employed at entities that may not be adequately prepared to ensure their safety in case of an emergency such as a fire or bomb threat. Research has documented that persons with disabilities have a higher risk of death in situations that require evacuation (Rooney & White, 2007). Additionally, the Department of Homeland Security has identified evacuations of individuals with functional limitations as an important research need (Sutherland, 2006).

A rescue evacuation, according to Christensen, Blair, and Holt (2007), is a type of evacuation that occurs immediately following an emergency event. Of specific interest for this research is identifying how assistive technology can help a person with a disability escape a hazardous situation. The International Classification of Functioning, Disability, and Health (ICF) defined assistive technology as “any product, instrument, equipment, or technology adapted or specially designed for improving the functioning of a person with a disability” (WHO, 2001, p. 173). The role of assistive technology for emergency evacuation continues to grow as more disabled individuals are joining the work force and as they are also receiving services in hospitals, assisted living facilities, and nursing homes (Boyce & Smither, 2012).

Evacuation of individuals with mobility impairments is especially challenging because of their reliance on assistive technology such as manual or powered wheelchairs to successfully ambulate. As of 2008, 259,000 individuals in the United States sustained spinal cord injuries. Seventy percent of those use wheelchairs or similar technology (McClure et al., 2011). Yet, most evacuation strategies for people with mobility impairments suffer from lack of appropriate training, lack of communication with disabled individuals, and poor understanding of their needs. Furthermore, only 57% of individuals with disabilities report having a workplace evacuation plan, and the level of detail in that plan is not clearly defined (Fox, White, Rooney, & Rowland, 2007).

The lack of planning and appropriate training is relevant not only for the individual with the disability but also for the emergency planner coordinating the evacuation. In a study involving 30 randomly selected FEMA disaster areas, Fox et al. (2007) found that although federal training programs on the needs of people with disabilities existed, they were not often used by emergency managers. Only 27% of emergency managers reported completing the training and only 20% of emergency managers even reported having disability guidelines in place. Sixty-six percent of the emergency managers surveyed indicated that they had no intention of modifying their guidelines concerning persons with mobility impairment because of cost, staffing, and lack of awareness. Instead, people with disabilities are often erroneously grouped in with “special needs individuals” such as pregnant women and children even though their needs may be totally different. Human Factors professionals need to place their focus on the interaction between humans and technology during an evacuation instead of looking at the policies and programs and why they are not used. Clearly, more specific research on this interaction is needed.

The major piece of technology in this interaction is a device known as a “stairchair.” This type of device is used to move an individual between stair landings on either a carry, track, or sled-based system. Transfer of the disabled individual is facilitated through the assistance of able-bodied personnel. In theory, these able-bodied personnel are pre-selected to form a “buddy system” for the disabled individual. In the event that one buddy is not available, the next one on the list is found. These buddies have to interact with both the person with the disability and the evacuation chair, which makes their task performance critical. However, since evacuations are seldom coordinated or conducted seamlessly and since individuals for the buddy system may or may not be available, other able-bodied individuals who happen to be in the vicinity of the person with the disability would have to come to that person’s aid. Unlike the trained buddies, these volunteers probably have little or no experience using assistive devices and therefore would have to rely on whatever instructional material is provided with the device.

There is no research available on whether volunteers are able to comprehend the instructions and then operate stairchair devices in an emergency situation. Thus, there is a need for investigating whether that is the case and, if so, the development of alternative instructions that are easy to understand and follow by untrained users.

Evacuation Planning

Traditional models of evacuation planning have focused primarily on evacuation outcomes (i.e., whether an individual was successfully evacuated or not). However, new models are being developed that focus on the actual decision-making process during an evacuation and not just the final outcome. One model proposed by Dash and Gladwin (2005) was developed on the basis of three interrelated factors: individual-level indicators, event-oriented variables, and risk perception. Individual-level indicators are those characteristics of a person that are viewed as being important when making decisions. These factors exist before, during, and after an evacuation and are completely independent of it. Event-oriented variables are those that are event specific and directly relate to the hazardous conditions at hand. Risk perception is an individual's interpretation of how hazardous an event really is, thereby affecting the protected actions taken. How much risk an individual is willing to take at a given moment could be affected by how well that individual handles decision making within stressful environments.

Since an evacuation is an unplanned occurrence within a hazardous situation, those in the midst of evacuating can be faced with anxiety, stress, and uncertainty. In addition to having to deal with these emotional states, those involved also have to manage the conditions of the hazard at hand. According to Van de Walle and Turoff (2008), individuals in such situations tend to focus on dominant cues and act in the manner that is most familiar to them. This behavior is known as the threat rigidity hypothesis. The challenge with such a frame of mind occurs when the emergency situation is drastically different from any other situation experienced beforehand. Thus, given the variable nature of emergencies, a question arises as to how to properly train individuals to cope with uncertainty which basically involves training people to think creatively and to look for connections between a current situation and whatever experience they may have had in the past.

Adding to the uncertainty of an emergency situation is the necessity of using technology or equipment that one may not be familiar with and that is not typically used on an everyday basis. For example, although an evacuation chair may be in place in a particular building, its actual use is limited to training sessions and extreme emergency situations where all other opportunities for evacuation have been considered and ruled out by emergency management personnel. Such infrequent use is problematic because individuals forget how to transform the stairchair from its stored state into an operational state and, as such, performance is downgraded and the evacuation of the disabled individual is at best delayed and at worst prevented. However, an emergency management team that practices with the evacuation chair during each fire drill and provides the employees and disabled individuals the opportunity to become familiar and comfortable with the device in order to use it effectively in an emergency is more likely to complete the evacuation successfully. Furthermore, routine practice drills allow the team to address any possible performance issues that may occur. All of this leads to a reduction in stress and a greater likelihood of positive outcome.

Another source of stress comes from the person being evacuated. If the technology (i.e., the stairchair) does not properly fit the physical needs of an individual with a disability, the disabled person is less comfortable and less able to properly support the evacuation. Ergonomics can be used to maximize function and improve task performance for both the evacuee and evacuator.

Human-Technology Ergonomics

As Human Factors professionals assess technology, they tend to rely heavily on anthropometric data. A challenge in adopting an anthropometric pathway when dealing with people with disabilities is that the target population (e.g., someone with a spinal cord injury) can be very different from the population that served as the basis for the original anthropometric data (i.e., able-bodied individuals). The variable nature of disability further complicates the use of anthropometric data. For example, the reach envelope of someone with one level of a spinal-cord injury can be very different from that of someone else at a different level (Openshaw & Taylor, 2006).

Keeping the designated user in mind while assessing assistive technology is essential for successful performance. In a 1990 study, Batavia and Hammer used the delphi method to determine and prioritize factors for users of assistive technology devices. The delphi method consists of a three-stage process where a group of expert users are consulted. Prior to consulting the experts, the authors, who had extensive experience in rehabilitation engineering and assistive technology, identified 12 important factors: affordability, consumer reparability, dependability, durability, ease of assembly, ease of maintenance, learnability, operability, personal acceptability, physical comfort, physical security, and supplier reparability.

In Stage One, Batavia and Hammer's participants added five factors to the initial list: compatibility, effectiveness, portability, supportability, and flexibility. In Stage Two, the list of factors was compiled and participants were asked to rank them in accordance with level of importance. In Stage Three, the same participants received the aggregated ranking and then ranked them again. This process allowed for group-oriented restructuring and communication among the group members as to the priority of a given factor (Batavia & Hammer, 1990).

Surprisingly, out of the 17 factors identified, ease of assembly was ranked as the least important factor to consumers. However, there were several factors that could be considered relevant to an evacuation study. These included operability, which relates to the ease to operate and respond to commands; dependability, which relates to the device's operating with repeatable and predictable levels of accuracy over repeated use; and learnability, which is related to the quick ease of use at the customer's initial experiences with a given device (Batavia & Hammer, 1990). These factors can contribute to how users decide to interact or not interact with a device.

Users can be different in terms of their physical and cognitive abilities. This is especially apparent when we compare older and younger adults since as we age, human performance capabilities tend to decline. Some age-related declines that could affect the performance of an operator of a stairchair include cognitive processing, physical lifting tolerance, hazard recognition, and sensory limitations. Given these declines, reliance on technology and instructional material becomes increasingly important.

Aging and the Evacuation Environment

The aging population is growing rapidly around the globe. There is a documented trend of the 'greying of America' as a result of the baby-boomer generation reaching the age of retirement and the elderly living longer (Howden & Meyer, 2011). Older individuals sometimes find themselves with mobility impairments or other health conditions that limit their everyday functionality. As such many of these individuals take advantage of their community's assisted living residences and nursing facilities. In the event of an emergency, large numbers of older adults living with disabilities in these residences face the challenge of evacuating in a timely and effective manner while accommodating for their disability.

In the case of adult residential facilities, one must also consider that those assisting in the evacuation are likely to be elderly themselves. This is relevant here because one of the factors known to be correlated with decrements in human performance is aging. However, Posthuma and Campion (2009) looked at age-related stereotypes in a work environment. Results from the Posthuma and Campion study were encouraging as they demonstrated that older workers do not need more training than younger workers; however, they demonstrated less mastery of trained skills and completed the training more slowly. These results are relevant to emergency evacuation, because training procedures and manuals often encourage the selection of the most physically able co-workers to assist in the evacuation. However, in a situation such as a nursing home or assistive living facility there will be emergency situations where older adults have to function as assistive technology operators and, as such, in order for them to achieve mastery, their training may need to be more specifically tailored and longer in duration.

Definition of the Problem

As mentioned above, this research focuses on the interpretation of instructions by novice users as they relate to emergency evacuation assistive technologies. At the present time there is research underway focusing on the usability of these devices for first responders, but there is a research gap in examining learning of instructions in general, especially with regard to untrained individuals.

In order to provide a solid theoretical framework for this research, it is necessary to review the literature on instructions and their development. Instructional graphics, as defined by Clark and Lyons (2010) are "pictorial expressions of information designed to promote learning and improve performance in work settings" (Ch. 1). They went on to say that the value of any instruction is characterized by the method by which it is delivered, the content of the instruction itself, and the user population it is intended to serve.

A person's prior experience can have a large effect on whether an evacuation is successful. Dowse, Ramela, Barford, and Browne (2010) performed a series of studies in which they tested a number of pictogram illustrations to convey meaning to non-literate individuals. A pictogram is a simple drawing used to convey a specific action or activity that an end user must take. These researchers found that tangible objects, such as a human being or a cigarette could be interpreted with little difficulty, but complicated health images proved to be a source of confusion for the individuals reading the instructions.

Along the same lines as leveraging prior knowledge is the development or use of schemas for understanding. Sweller (1994) explained that schemas are a way of organizing information so that new and existing information can be combined for a more complete mental model. A contributing factor in delay of understanding instructions is the human brain's limited short-term memory. If an individual has too many instructional elements to consider within a design it becomes difficult to comprehend. There is an added challenge when there is a need to comprehend and interpret instructions simultaneously as in an emergency situation. Schemas allow for the chunking of aspects of design into fewer groups, thus improving comprehension. The rate at which an individual can use schemas directly impacts task performance.

As familiarity with the device increases, the need to concentrate heavily to successfully accomplish tasks decreases. Chase and Simon (1973) looked at this phenomenon with regard to chess players and found that practice allows for improved schemas. What distinguishes the best experts from others is their ability to relate their previous experience to the situation at hand and thereby make the most educated decisions. Application of schemas is extremely important in the use of evacuation chairs because knowledge of similar types of devices contributes to task performance in trying to operate assistive technology in emergencies.

Assistive Technology

Research into emergency evacuation assistive technology has greatly increased since the attacks on the World Trade Center on September 11, 2001. Hignett, Willmott, and Clemes (2009) investigated mountain rescue stretchers that are used in a team-based format to pull injured individuals off ski slopes. Using two mountain rescue teams, the researchers were able to generate recommendations for the development of future evacuation products. These recommendations included using lighter-weight materials and mesh platforms for reduced weight, adjustable handles, flexible carrying systems with harness attachments if needed, ease of assembly in hazardous environments, and larger carrier capacities to accommodate heavier passengers.

Other factors that affect willingness to use a piece of assistive technology go beyond technical specifications and expand into the realm of person-technology identity. Hocking (1999) argued that whether people with disabilities abandon or stop using an assistive device has a lot to do with an individual’s perception of self. For example, a wheelchair user may receive mixed or negative reactions from people in the community and that may impact his or her self-perception.

Person-technology identity relates to the selection of an emergency evacuation device. It is crucial that manufacturing companies be aware of its influence and be sensitive and responsive to the functional evacuation needs of the disabled individual. Another factor to consider is the individual’s willingness to interact with assistive technology. In other words, just because an assistive technology is present and someone needs it does not mean that that person will willingly use the device. How people view themselves and what sort of values or attitudes they have related to evacuation can affect the person-technology relationship.

When developing an optimized set of instructions for emergency stairchair devices it is important to assess the individual task breakdown for the assembly of the stairchair. A specific emphasis here is placed on what activities a user needs to perform at minimum to get the stairchair operational. There are three ways where this information can be acquired. One is through observation, a second is through technical documentation, and a third is developing use-case scenarios that describe how an individual is supposed to use a device in a particular environment. From these sources of information comes a prioritization of tasks.

Priority one tasks are those that the user must be able to successfully complete irrespective of impairment in order for the product to be usable. If an individual cannot complete a priority one task it would likely limit the accessibility or usability of that device for a group of users. In the context of a stairchair this could be getting the seat into a position where it can be used. Priority two tasks are secondary tasks that may be performed on occasion to access specialized functionality. In a case of an evacuation chair this could be a head strap for someone who doesn't have control of head and neck. Priority three tasks are those that are not necessarily performed by every user but must be able to be performed on occasion, such as handle adjustment, carrying capability on track-based chairs, etc. Priority three tasks could be a benefit in the development of an instruction set for a specific assistive device because it could provide some insight into how operational task sequences can be modified and streamlined to increase speed and improve performance.

CHAPTER TWO: LITERATURE REVIEW

Evacuation Safety Guidelines

This research supports individuals with disabilities who have mobility impairments. The National Fire Protection Association (NFPA; 2007) represented disability in five categories for the purposes of evacuation, one of which is mobility. As a foundation for evacuation work it is important to understand how to appropriately plan for people with disabilities. NFPA created guidance documentation that involved five planning activities:

1. Learn the building layout. During evacuations, structures can either serve to promote effective movement of evacuees (adequate distribution of persons to stairwells, alternative routes in the event of blocked pathways, clear and definitive signage, etc.) or they can serve to bottleneck or impede person flow (overcrowded stairwells, inadequate contingency planning, unclear direction in the event of a hazardous environment).

2. Identify the disabled in the workplace. Although the task of locating and identifying persons with disabilities appears straightforward, it becomes more complicated with health care privacy laws. Persons with disabilities must self-disclose their disabilities to employers in order to be considered in evacuation planning. With more visible disabilities such as wheelchairs, this is not a problem. Issues arise when dealing with “invisible disabilities.” An example of an invisible disability is someone who has epilepsy from which seizures could occur, or someone who has a cognitive disability and cannot maintain instructions in short-term memory in stressful scenarios. In these cases, the individuals may have developed compensatory strategies that may not be available in emergency situations.

3. Review evacuation equipment. Evacuation equipment can be present in a given environment but the staff and personnel may be unaware of its existence. For example, at the University of Central Florida environmental health and safety personnel have identified emergency stair travel devices in buildings throughout campus, which could potentially be used in the event of an evacuation.

4. Train the staff. Training is more than the operation of assistive devices. Training also consists of providing information to policy and decision makers throughout the organization about the benefits of using these devices. In an effort to reduce liability, a common emergency management approach is to wait for first responders. However this places the individual with the disability at a crossroads as to when to take action as the dynamics of an emergency environment unfold. Through the proper training of those around the person with the disability as well as including individuals with disabilities in the discussion, more clarity can be developed for the evacuation.

5. Coordinate with local law and emergency enforcement. Since the first responders are the preferable persons performing evacuations, developing a plan facilitating ease of access and understanding for them can increase performance during an emergency. Potential ways to accomplish this could be through the establishment of a communication system between first responders and persons with disabilities (McClure et al., 2011).

In 2009, Shields, Boyce, and McConnell conducted a study in which they used one-on-one interviews to assess behavioral patterns during the September 11, 2001, attacks. In this work, the research team specifically focused on the evacuation experiences of individuals with mobility impairments. According to a 2005 report from the National Institute of Standards and

Technology (NIST), during the 9/11 evacuation 51% of Tower 1 & 33% of Tower 2 occupants stated injured/disabled people in stairwells constrained evacuation. All the participants interviewed had evacuation training consisting of drills where they walked to the stairwell lobby to wait for responders. However, when the actual emergency occurred none of the participants waited for first responders for very long (average 5 minutes or fewer). Depending on the nature of assistance needed, all participants engaged in activities of self-preservation, leveraging co-workers to provide assistance (Shields et al., 2009).

In one particular case, a woman who used a scooter and crutches enlisted a "cage of people" to carry her down the stairs to prevent her being stampeded (she thought ahead and reacted accordingly). She proactively (and without planning) created what the researchers refer to as her own Personal Emergency Evacuation Plan (PEEP). This group moved and changed shape to properly accommodate rest periods and contra flows. The effectiveness of this behavior hinged on communication. They had a clear mission and clear direction from the person with the disability, and they adapted their actions according to environmental events. The activities of this group also began to attract followers behind the group. This scenario can be viewed as affiliate group behavior, where the lead group provides directionality to subsequent groups. By acting in this manner, the groups following afforded another layer of protection for the person with the disability.

Contributing to evacuation performance outside of group dynamics is the nature by which the emergency is communicated. One area that is typically measured is pre-movement time. Pre-movement time, according to Shi et al. (2009), can be defined as the time after the alarm has sounded but before someone moves toward an exit. Pre-movement time can be broken up into two primary parts: recognition and response time. Olsson and Regan (2001) investigated the use of a traditional evacuation siren versus the use of a PA recorded evacuation message. Results showed that individuals in the evacuation with the pre-recorded PA alarm were faster in completing the pre-movement activities than those in the evacuation with the siren-type alarm.

These results are further confirmed by Shi et al. (2009) when the research team noted the strong influence that different types of alarming systems can have on pre-evacuation behavior. Results from a literature review on fire evacuations showed that pre-movement times ranged from 150 to 582 seconds. The minimum time occurred when two-state fire alarm systems were installed inside every apartment, and the maximum was recorded when single-state central fire alarm systems were installed on corridor walls.

In a study performed by Proulx (2001), researchers found that in the buildings where the alarm had good audibility, the mean delay time to start evacuation was around 3 min. In these buildings, three-quarters of the total evacuation time was due to the delay time in starting and one-quarter in movement time. In the two buildings where over 20% of the occupants judged that the alarm signal was not loud enough inside their unit, the mean time to start evacuation was around 9 min. In a different study focusing on Canadian government offices, the individual time to start of over 1000 occupants was recorded. The mean time to start evacuation for the three buildings was 50 seconds. Although all these office workers had received training and were fully aware of the evacuation procedure, they nevertheless spent time finishing phone calls, saving data on computers, securing files, and gathering belongings before leaving their desks.

Assistive Technology

Every situation tests the boundaries of human capability, and evacuation is no exception. From a human factors standpoint it is understood that there are workload limits for every user. Therefore human technology systems that shift some of the burden of performing evacuation activities from the human to the technology need to be developed. In the disability community these types of systems are known as assistive technology. Assistive technology can be defined as devices, tools, or interfaces that allow someone with a functional limitation to improve performance in life activities. Evacuation assistive technology often seeks to augment the functional limitation of mobility. For the purposes of this research, assistive technology is sub-divided into four categories: instructional/operational guidance, human-machine interaction, planning, and usability. The reasoning behind this structure is that it forms linkages between subject areas to better represent the problem space of evacuation stair travel devices.

A significant subset of assistive technology research, which also serves as a foundation point for the current research, is the understanding and use of instructions to convey proper operation of technology. In 2011, Shih, Chung, Shih, and Chen assessed how to use videos and images to convey exercise techniques for individuals with severe and complex disabilities. The research team was able to increase performance as well as compliance with instructions by using a reward stimulus for correct action. This result benefited the current research because it showed that through providing appropriate instructions and feedback even cognitively low functioning individuals can learn how to operate technology.

Lawson (2003) described a series of human factors/usability principles to assist in designing technology for persons with disabilities:

1. Equitable Use—The device or technology provides the same functionality for all users regardless of ability level. In the event that a particular aspect of the technology cannot be made accessible for all groups an equivalent method of access should be developed. In addition to being functional the design should also be appealing to all user groups.

2. Flexibility in Use—Not everyone uses a device in the same way; therefore, technology developers should look for ways to leverage the preferences of each individual user. This can be accomplished through activities including accommodating left or right handedness, speeding up or slowing down the interface to better meet the user's pace, and increasing the user's accuracy and precision.

3. Intuitiveness of Use—Use of the device should be easy to comprehend and learn regardless of the expertise of the user. This goal is accomplished through eliminating unnecessary complexity, incorporating consistency throughout the device, highlighting important information and content, and providing simple and effective feedback when needed.

4. Perceptible Information—The design communicates effectively to the user regardless of environmental conditions, a principle that is specifically applicable to this evacuation study. Potential guidelines include multiple modes of presentation such as visual versus verbal, adequate contrast, and easy-to-follow processes for instruction.

5. Tolerance for Error—In using devices individuals are going to make mistakes. The device should arrange elements to minimize errors, provide fail-safes, and use warning documentation. There should be a level of adaptability so that it is still usable under different sequences of operation.

6. Low Physical Effort—The device should be able to be used without causing high levels of fatigue and discomfort. The design should minimize repetitive action, allow the user to maintain a neutral body position, and not require large use of force.

7. Size and Space for Approach and Use—There needs to be adequate space and size to allow for easy access and use by persons with disabilities. All major device components need to be accessible for both a standing or seated user. Additional space should be allocated to accommodate for other assistive devices and personal assistants. Finally, ergonomic affordances such as hand grips should be implemented to accommodate the maximum range of user ability possible (Lawson, 2003).

People of Varying Ability in Evacuation

To mitigate the potential hazards in evacuation there is a need to mitigate the risks and develop proper planning and guidance documentation. Clearly defined evacuation planning can greatly assist in meeting the needs of persons with disabilities. In Nick et al. (2009) research was conducted that looked at common themes and barriers in development of emergency evacuation plans. Common themes included risk communication, evacuation procedures, and continuity of services. Common barriers included difficulty in identifying/locating vulnerable groups; lack of coordination between Emergency Medical Services (EMS), public health, Community Based Organizations (CBO), and community leaders; and a lack of emergency planning.

McClure et al. (2011) interviewed 487 wheelchair users who also have spinal cord injuries. In discussing how individuals receive assistance during emergencies 51.8% reported relying on other people and 26.6% on assistive technology in the home. With regard to workplaces, 47% rely on others and 23% rely on assistive technology. Almost 80% of individuals interviewed had an emergency evacuation plan in place at their jobs; however, the ability to evacuate was not consistent across groups. Those who thought they could evacuate tended to be younger and white males. Individuals stated that although human assistance is usually more dependable (as in being present when needed), assistive technology devices tend to be more reliable (as in being less likely to fail to accomplish their function). Technology is not susceptible to calling in sick or being preoccupied with other things. Technology is always present.

In an effort to remediate some of these issues, persons with disabilities have started to use geographical information system technology (GIS). GIS systems can specifically target and display resources that people with disabilities can use in an event of an evacuation. GIS was used following hurricane Katrina to assist in locating transportation resources for persons with disabilities within a 400-mile radius of New Orleans (Enders & Brandt, 2007). The further advancement of technology such as GIS to incorporate information for evacuation support of people with disabilities is needed and can demonstrate quantitative returns on investment.

In 2004, Easter Seals created an emergency evacuation guide for egress of transit systems for persons with disabilities. In this document they also advocated for the development and the maintenance of an emergency evacuation plan for all passengers but also talked about specific needs related to transportation. Communication appears to be one of the largest challenges for persons with disabilities using the transit system, and the authors recommended the use of notebooks and pictograph cards to communicate with passengers who cannot speak or are deaf.

Most often trouble occurs when individuals make assumptions about the capabilities of persons with disabilities during emergency situations.

Rather than diagnosing someone's ability based on their disability it is advocated that inputs from persons of various disabilities be included in the discussion. Easter Seals (2004) also discussed handling persons with disabilities after evacuation and noted that often assistive equipment may have been left behind to perform the evacuation. This equipment may need to be recovered, or an alternative aid may need to be provided. Finally, persons with disabilities may need assistance on reuniting or reconnecting with their family members or their travel companions.

In an effort to support evacuation efforts by persons with disabilities, the Department of Homeland Security has developed the Office of Disability Integration and Coordination (ODIC) under the Federal Emergency Management Agency (FEMA). The directive for this office was initiated in 2004 through Executive Order 13347: Individuals with Disabilities in Emergency Preparedness. Through this office there is now a method for cooperation between federal, state, local, and tribal governments as well as private organizations for emergency planning and preparation that relates to persons with disabilities. This order is one of the first to emphasize that emergency evacuation needs to be customized to the unique needs of employees and individuals with disabilities. ODIC is in full support of this research and is in discussions for the transition of this work to FEMA.

Aging and Human Performance

Human performance as it relates to aging has been researched thoroughly for over half a century. A key area of interest to researchers that is relevant to the emergency evacuation paradigm is that of problem solving. Charness (1985) found the relationship between age and performance often takes the form of an inverted u function. As people get older they build up experience through their lives, and this in turn improves performance. However once they have reached adulthood and begin to move into middle and later life their biological systems begin to decline. Thus aging has a negative effect on their ability to perform tasks and complete actions.

Another type of research relevant to the older adult population is the assessment of comprehension of a previously taught training procedure. An experiment is set up in three phases: the first phase is where the training actually occurs, the second phase consists of an immediate posttest as an assessment of knowledge, and the third phase involves a delayed posttest. The delayed posttest is experimentally designed to test how well the knowledge is retained over a period of time. Labouvie-Vief and Gonda (1976) used this method and examined the use of self-instructional statements by older adults. They found that elderly subjects tend to speak out loud to minimize error and increase human performance.

The study subjects (Labouvie-Vief & Gonda, 1976) were divided into four training groups: two instructional groups (cognitive training and anxiety training) and two control groups (unspecific training and no training). Cognitive training included planning and self-guided tasks, and anxiety training was aimed at assisting the handling of various situations, improving self-image, and reducing stress. The research team found significant effects for the cognitive and anxiety training groups on the immediate posttests. Surprisingly, the unspecific training group showed the most significant gains on both the immediate and posttests in transfer of skills compared to the control group. One potential reason for this finding is that unspecified training provided greater flexibility in how the gained knowledge could be applied.

One of the largest and best-known studies to investigate cognitive ability, problem solving, and older adults is the ACTIVE study, which was conducted from 1998 to 2004 and involved 2,000 participants (Willis et al., 2006). This study looked at the effect of cognitive training over an extended period of time and contained three treatment groups: memory training, reasoning training, and speed training. Memory training consisted of using mnemonic strategies such as organization, visualization, and association for remembering verbal material such as lists and text. Reasoning training consisted of finding patterns in a series of letters and words and then predicting the next item in a series. Speed training assessed visual search and divided attention such as identifying signals at increasing smaller exposure and choosing between two different search tasks.

Besides these three training interventions the study also implemented booster training (Willis et al., 2006). Booster training was conducted at 11 months and 35 months after the initial training and involved similar strategies for cognitive improvement as those mentioned above. The research showed that cognitive training was retained by older adults after a five-year period and that the reasoning and speed of processing treatment groups produced significantly better performance than memory training. With regard to the cognitive training's transferring to problem solving performance on everyday tasks (also known as activities of daily living (ADLs)), effects were significant only for the reasoning group, and decline in function was witnessed for all groups initially between years two and three. Thus, while cognitive training cannot stop the aging process it can assist in maintaining functionality in older adults and supplementing their problem-solving abilities.

In 2007 Ball, Edwards, and Ross performed a study assessing whether the introduction of cognitive training programs can prevent, delay, or slow down this cognitive decline by compiling results of six previous studies focusing on speed of processing training as it transfers to the everyday ability of older adults. Ball et al. also used a useful field of view (UFOV) test to establish a baseline performance for older adults and then determined the impact of the training application for each individual participant. Interestingly, education, age, and mental status did not correlate with overall training gain. The strongest correlation for training gain was the baseline speed of processing performance as indicated by the UFOV. This means that individuals with the worst processing performance at baseline had the most room for improvement.

Even with all these gains related to cognitive training, large issues remain that could be relevant to emergency evacuations, such as how much of the training skill set transferred to unrelated cognitive domains. In other words, if someone has expertise in working on an automobile or participating in building construction, that does not demonstrate transfer to operating an emergency stair travel device. In addition, two of the downfalls of processing speed training are the lack of a pure measure for processing speed and the fact that any experimental design to improve processing speed will likely affect other areas of the brain as well.

Park, Gutchess, Meade, and Stine-Morrow (2007) noted that there has been an increased emphasis on specific training methods; however, there has been far less research on activities that can assist in transfer of knowledge to applied situations. Jastrzembski and Charness (2007) attempted to fill the gap between the cognitive and psychomotor performance of older adults by creating a model of human processing for use with older adults. The research team adapted this model from Card, Moran, and Newell (1983) and was able to demonstrate older adult processing parameters that can be used for modeling interfaces that have to interact with users.

According to Jastrzembski and Charness's work (2007), general slowing of older adult cognition results in their requiring approximately 1.5 times longer for operational tasks than their younger adult counterparts. On the other hand, although they take longer, older adults tend to be more accurate than younger adults, especially for problem solving. Charness (1985) attributed this improvement in accuracy while problem solving to expertise. He noted that problem solving is related to the size of the problem solver's knowledge base. This knowledge base is developed through life experiences and is proportional to the time spent on related tasks; therefore, experience may serve as an advantage to older adults because in a specific domain increased familiarity can leverage improved performance.

Charness (1985) noted the work of Hayes and Simon (1977), which stated that in order for people to understand instructions they must evoke a representation that contains three aspects. The first is the goal state, in which a given task is deemed to be complete or satisfactory to performance requirements. The second aspect is the initial state, which is the current state of the problem before problem solving begins. The third are the methods for operating on these representations or more specifically understanding the procedural nature of the instructions.

Human performance challenges are present for older adults not only in activities of daily living but also within the workforce. Older adults are typically subject to negative bias regarding their ability to perform tasks when compared to their younger counterparts. Reio and Sanders-Reio (1999) noted that in a study by the National Council of Aging more than 50% of employers surveyed believed that older workers cannot perform as well as younger workers. When this problem is examined in more detail, it is not age by itself that is the factor but rather the amount of information that is conveyed to the older adult. When equal information is provided to younger and older adults, test results show that older adults learn just as much as younger adults. Performance gaps result from the greater need of older adults to get up to speed in the designated topic area.

Spatial Ability in Older Adults

Spatial abilities include spatial perception, mental rotation, and spatial visualization. Spatial perception refers to how an individual’s body relates to objects in the surrounding environment. Mental rotation is an individual's ability to rotate a 2D or 3D object cognitively, similar to actions that are needed in playing Tetris. Spatial visualization is multiple manipulations across several steps in a complex scenario. Spatial visualization is applicable to the current research because in interpreting instruction sets participants are actively performing a spatial visualization task. Likewise they are performing spatial perception by orienting themselves to the various evacuation chairs (Borella, Meneghetti, Ronconi, & De Beni, 2013).

Spatial ability in older adults needs to be taken into consideration, especially when dealing with complex technological systems such as computers and evacuation chairs. Pak, Czaja, Sharit, Rogers, and Fisk (2008) demonstrated that spatial ability affected performance of older adults on non-visual computer tasks. Proctor, Vu, and Pick (2005) developed guidelines for improving performance and reducing the effect of spatial ability deficiencies in older adults. A few guidelines that relate to this area of research include

1. The maximization of compatibility, where compatibility is the match between display and controls (or in this case actions), especially in complex tasks.

2. The minimization of complex tasks in favor of more simple, straightforward ones (Proctor et al., 2005).

There were other guidelines as well; however, those (such as advance information and practice) may not be applicable in an emergency situation.

It is important to recognize that older adults are not a homogenous group. For example, research has shown noticeable declines in cognitive abilities for 70-year-olds (Baltes, 1987), whereas several studies have shown that this is not the case with 60-year-olds (Borella et al., 2013; Hertzog, 1989). This distinction is further supported by the work of Salthouse (1991) on speeded measures in which he demonstrated that age affects reaction time.

Gyselinck et al. (2013) found that when middle-aged adults were performing a navigation and recognition task or when discussing spatial relationships they scored worse than younger adults. Klencklen, Després, and Dufour (2012) confirmed poorer navigation performance for older adults as well. In a comprehensive literature review focusing on spatial ability and older adults they identified specific aspects of spatial ability that either were or were not affected by age. The researchers found that visual spatial perception performance held constant regardless of age while mental rotation and information processing were impaired.

Graphical Interpretations of Instructions

In instances of emergency, time is of the essence and the smallest misinterpretation of instructions could result in life or death consequences. In these high-stress scenarios, proper graphic design of instructions is critical in maintaining low levels of cognitive load.

Citing the modality effect, Baddeley (1998) found that images and text both drain cognitive resources through the same working memory channel unless the text is verbalized. Therefore, to avoid cognitive overload when adding pictograms in an instructional set, proper guidelines must be followed. These findings coincide with those of Van Merrienboer and Sweller (2005), who found that when they presented information in multiple formats (i.e., text plus images), participants more easily understood what needed to be accomplished.

When designing instructional graphics it is important to keep in mind aspects that can lead to cognitive overload. Mayer and Moreno (2003) described many conditions that can lead to such an overload and proposed different means to reduce the likelihood of an overload occurring. One situation Mayer and Moreno proposed is when a processing channel is overloaded with essential processing demands, meaning that there is too much essential information being provided for a person to dedicate any meaningful attention to important information. Mayer and Moreno suggested pre-training individuals so that they might be able to focus more on other areas of a graphical instruction. In the context of this research this could mean pre-training individuals who work or live near a physically disabled person who may need to use a stairchair evacuation device.

Mayer and Moreno (2003) also described a situation in which a processing channel is overloaded by a combination of essential and incidental information. In this scenario a person's cognitive load is increased by information that is not essential to the situation he or she is in. Mayer and Moreno suggested two methods for eliminating such problems. The first, and arguably the better of the two, is weeding: removing the incidental information from what is presented and leaving only information essential to the learner. The second method is through signaling: making known to the learner which information is essential and which information is incidental, increasing the amount of cognitive resources the learner spends on the essential.

In another approach, Pastore (2009) conducted a study that investigated the effects of diagrams and time-compressed instruction on student achievement and learners' perceptions of cognitive load. Cognitive load can be divided into three subsections: extraneous (affected by the design of the instruction), intrinsic (affected by high element interactivity), and germane (generated by instructional activities leading to schema development and automation) (Sweller, van Merrienboer, & Paas, 1998). In Pastore's (2009) experiment, the extraneous load was manipulated to determine which instructional principles would result in the lowest amount of cognitive load and the quickest comprehension time frame. He found that the multimedia approach, which emphasized receiving instructions in verbal and non-verbal (text and visual) form, resulted in the least amount of cognitive load and the highest rate of comprehension for drawing, identification, and terminology tasks. Pastore was also able to confirm the cognitive load theory finding that as speed of instruction increased, cognitive load did as well, to a point where at 50% compression a subject could no longer learn.

Instructions presented visually can have different levels of effectiveness depending on the surface features of the visual, the communication function of the visual, the goal of the instruction, and differences of prior knowledge of learners. In 2010 Dowse et al. performed a study looking at low-literate individuals and their comprehension of health-related pictograms. The research team found that visuals that were simple, had a clear focus, and reflected familiar life experiences were successful at conveying information. However, when dealing with more complex conceptual instructions, participants, particularly those with lower education levels, had problems with interpretation.

Based on these results, Dowse et al. (2010) argued that instructional images and their effectiveness can be successful only through involvement with target users rather than the typical research population, college students. Representative target users have existing knowledge and beliefs different from those of college students. But having target users participate in the design of instructional materials is not in itself sufficient for instructional success. If the visuals are not done well, users will still not perform well. Effective graphical components can be incorporated by involving a graphic artist who takes the understanding, culture, and skills and abilities of target users into consideration throughout the design process. And as with any development project, developers must realize that instructional design is an iterative process; it cannot be expected that an instruction set will adequately convey information on the first try. Therefore, graphically, the design process should have several iterations to assist in developing a user-centered, streamlined product.

It is not the case that more is better, however. Contrary to popular opinion, an excess of graphical elements can be just as confusing as too few. Dowse et al. (2010) argued that pictograms should be used only to clarify a process or convey a complete message. For example, if the purpose of the pictogram is to convey a series of mental operations that a user must execute to prepare for an emergency evacuation, defining something such as cognitive processes can be challenging. On the other hand, physical actions—such as assembly of an evacuation chair—can be more clearly defined in each individual step, making them more suitable to be portrayed in pictograms.

Not all instructions are represented well in a step-by-step graphical format. Marcus, Cooper, and Sweller (1996) did a study involving students' assembling electronic circuits through the use of graphical instructions. This research is novel because Marcus et al. were specifically interested in the simultaneous processing of instructions and how they affect cognitive load. The natural thought process, based on the capability of the average human being, is that the more information needed to be processed simultaneously, the greater the decrement of human performance. Marcus et al. instead proposed that there is a complex interaction between the built-in schemas of the learner, the ability to apply those schemas to the task at hand (i.e., task transfer), and how both of those aspects affect each simultaneous task.

Given all these constraints in learning instructions, a challenge occurs in finding effective solutions to assist novices. Clark and Lyons (2010) recommended several tools for guiding new learners:

1. The instructions should direct the learner's attention to the important information in the lesson. When looking at something for the first time, novice users may be overwhelmed with information flow, may be unsure as to the location of the beginning or the end of the instructions, and may not be able to place the designated action in the context of the technology in front of them.

2. The instructions should attempt to activate prior knowledge in the memory of novice end users. In the context of this evacuation study, determining prior knowledge of the end user is

particularly difficult because of the large variability in prior knowledge through a public sample and the inability to classify participants beyond categories such as job type, age, and number of years in college. If through this research common trends of knowledge can be established (e.g., through the Psychometric Success Mechanical Reasoning Test or other metrics), the instruction sets can be better customized, allowing reduced mental load and greater learning.

3. Providing motivation and feedback to learners to persevere through times of confusion and misunderstanding. In a high-stress situation such as evacuations, if confusion becomes too great the user may become unwilling to use the emergency stair travel device. Steps within the instructions need to provide feedback (e.g., clear changes in the device assembly state) so users know they are performing the correct actions.

4. The use of transformational graphics. Transformational graphics are those that link the activities of two instruction steps, thereby providing a before-and-after comparison for the user. In doing this the novice user has a point of reference with regard to spatial orientation, proper technique, and an indication or preparation of steps to come. Providing transformational graphics through the use of arrows, motion symbols, and other visual cues can help keep the assembly process moving smoothly for the novice user.

Hayashi et al. (2003) addressed the problem of developing signs relevant for use in disaster situations. They identified three types of instructional media—icons, signs, and educational tools—and for each they made recommendations to achieve greater effectiveness. Their recommendations for icons were to use a distinctive design, a concrete design, a simple design, and a design that can be correctly understood under different conditions of visibility. For signs they advocated for a process similar to the Japanese Kanji in which characters are merged to represent novel situations. This recommendation is applicable to emergencies because no emergency situation is exactly alike, so these signs need to be continually adaptable as new information is gained. For educational tools they recommended establishing a standard to which the community can adhere. Standards can support the development of instructions as educational tools to help those attempting to evacuate so they can assess the options available to them, adapt, and evacuate safely.

CHAPTER THREE: METHODOLOGY

The research question that this effort sought to address is whether improved instructional formatting, through the use of visual design techniques such as pictograms, can improve on-task performance for novice users. The problem space is an evacuation scenario where an emergency stair travel device must be used. The device is already present in the environment, but the individual has no experience with using the device. The objective is to get the device operational and ready for passenger load as quickly as possible.

Hypotheses

For this experiment I considered only a single operator and no teams. Three hypotheses were examined in this study (H3 was added after the completion of Phase I):

H1: Visual instruction style can account for a significant portion of explained variance in the operation of emergency stair travel devices.

H2: Improvements in instruction style can reduce time on task across device type and age group.

H3: There would be a performance decrement for older adults in comparison to younger adults based on the cognitive slowing of older-adult information processing.

Study Plan

The experiment was organized into a pilot study and three main experimental phases. The pilot study was performed to establish a problem space prior to initiating the full study. Phase I involved the acquisition and testing of existing stairchair devices and their accompanying set of instructions. Testing in this phase specifically consisted of participants assembling the stairchairs in a lab setting to mimic conditions just before an actual evacuation of a person with a disability. For the purposes of experimental feasibility there were two age groups represented: young adults from 18 to 35 and older adults 55 and over. The reason for choosing the divisions was due to a convenience sample of older adults. Phase II consisted of the development of improved instructions for each of the evacuation chairs based on the results from Phase I and the use of four focus groups to provide feedback as to the effectiveness of the instructional design. Phase III mirrored Phase I but included a new instruction set and an additional chair.

The original plan for Phase I data collection was to study 117 (39 young, 39 middle aged, and 39 older) people; however, actual data acquired for Phases I and III totaled 39 older adults and 18 older adults for each phase. Middle aged were deleted because of lack of population, and older adult stopped at 18 due to recruitment challenges and being able to balance the numbers. Data were collected through two main sources: oral reports from the participants in the format of a think-aloud protocol and video recordings of the participants' interactions with the devices' instructions and performance as they assembled the product.

Participant Recruitment

Participants for this study were recruited through several different means. For the college-age population, recruitment occurred through the Psychology Department's SONA System for undergraduate research participation. For the older adult population, I recruited participants from Learning Institute for Elders (LIFE) at UCF.

Environment

The environment which the study took place varied due to participant recruitment needs. Data were collected in three locations. The first was a room at St. Isaac Jogues Catholic Church, the second was a room at Beardall Senior Center, and the third was the Aging and Technology Laboratory at the University of Central Florida. All three locations were in Orlando. All had similar overhead halogen lighting. In all three locations the participants were given an 8 foot by 8 foot square within which I asked them to stay while assembling the chairs. All participants were facing the same way relative to the experimenter. Outside noise was minimized to the greatest extent feasible.

Procedure (Phases I and III)

After the participants read the consent form, I confirmed that they were 18 years of age or older, and the participants agreed to participate in this study. First they were given a brief vision test designed to measure whether their visual acuity qualified as 20/40 (corrected or uncorrected). ThenI provided them with a series of paper-and-pencil–based tests to assess their spatial ability. Following this, they were given an assistive-technology product designed for emergency evacuations of persons with disabilities. The subjects were asked to assemble the device as best they could and as quickly as possible, in such a way that a person with a disability would be able to use it in the event of an emergency situation. I asked them to prepare this device according to the directions provided with the equipment.

In addition to the assembly task, I asked that they describe their thought processes aloud as they completed the assembly process. I told them I would be recording their time-on-task during this session in an effort to compare performance among different individuals. I informed them that the assembly process would require a small amount of heavy lifting to correctly prepare the device. Once the assembly session was completed, I gave the subjects a debriefing session and a feedback questionnaire to allow them to report any positive or negative feedback regarding their interaction with the device. All data were coded, input into spreadsheets, and analyzed using IBM SPSS Statistics Version 21.

Equipment

Three evacuation devices were donated by national manufacturers to support the research effort. These chairs were the Stryker evacuation chair 6254, the Garaventa Evacu-trac evacuation chair CD7, and the Evac+chair 300H. The current assembly process for the Stryker evacuation chair is as follows (see Figures 1–4):

Figure 1: Stryker Step 1—Pull Seat Down

Figure 2: Stryker Step 2—Extend Top Bar by Pulling Red Wire Upward While Pulling Top Bar Up

Figure 3: Stryker Step 3—Grip Horizontal Red Bar, Squeeze to Release Track

Figure 4: Stryker Step 4—Secure Person Into Chair by Buckling Three Safety Straps

The current assembly process for the Evacu-trac evacuation chair is as follows (see Figures 5–6):

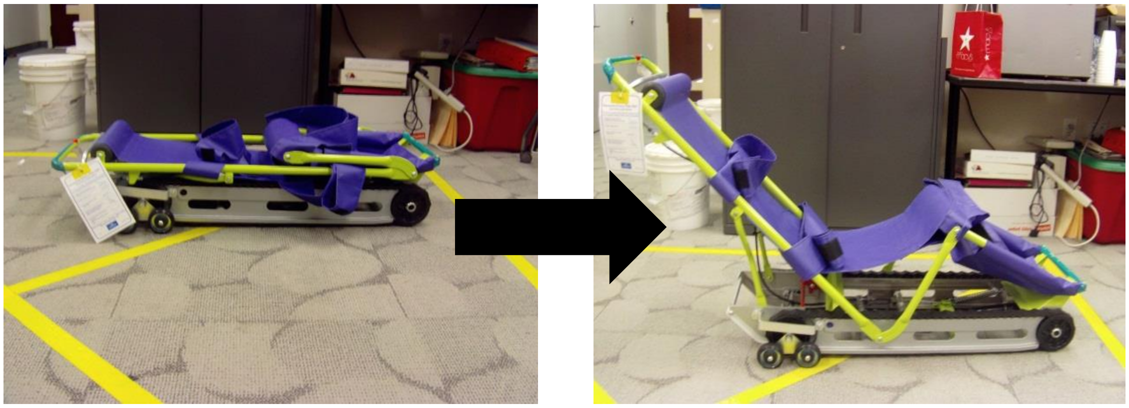

Figure 5: Evacu-trac Step 1—Open Unit, Ensure Latch Is Engaged, and Transfer

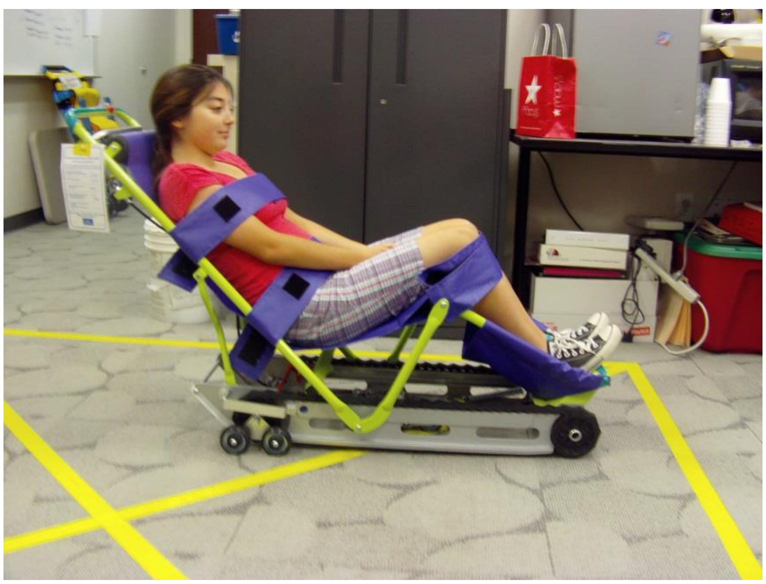

Figure 6: Evacu-trac Step 2—Secure Passenger With Strap

The current assembly process for the Evac+chair is as follows (see Figures 7–12):

Figure 7: Evac+chair Step 1—Place Foot on Bottom Bar

Figure 8: Evac+chair Step 2—Grip Both Sides of Extension Handle, Then Pull Up Until It Self-Locks

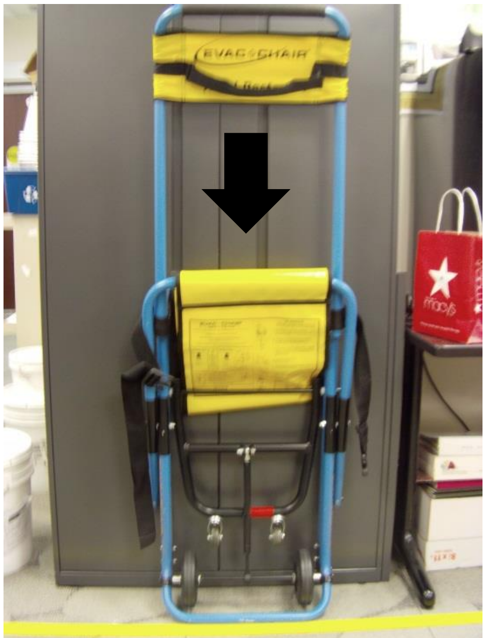

Figure 9: Evac+chair Step 3—Slide Head Restraint Fully Down

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Figure 10: Evac+chair Step 4—Unbuckle Seat Belt

Figure 11: Evac+chair Step 5—Pivot Seat Frame Down

Figure 12: Evac+chair Step 6—Pull Tracks Towards You

The STEREO OPTEC 2000 was used to screen for visual acuity of all research participants. Participants needed a minimum visual acuity of 20/40 (corrected or uncorrected) to participate in the study.

Pilot Study

A pilot study was performed to establish the problem space prior to initiating a full-fledged study. Two vendors of emergency stair travel devices (Stryker and Garaventa) agreed to lend the research team devices to perform the pilot study. These two devices were the only two used for the pilot, due to the fact that the Evac+Chair had yet to arrive, along with the Safety Chair, which would be removed prior to Phase 1.The layout and functionality of these two stairchairs are very similar, and both can be guided down flights of stairs with a treaded track on the bottom of the device. Participants were instructed to assemble the chairs into an evacuation-ready composition; however, no evacuations took place. Members of the research team were used as stand-in “evacuees” to sit in the assembled chair and allow participants to secure them into place with Velcro straps according to manufacturer instructions.

Prior to beginning the experiment, subjects were tested on visual acuity using the Stereo Optec 2000 vision testing system to ensure they had adequate acuity to distinguish instructions. Although there is no commonly agreed-upon standard for visual capabilities for viewing instructions, I selected a threshold of 20/40 corrected to normal, the same threshold used by the Department of Motor Vehicles for driver’s license examination. After the visual examination participants were shown the device and were asked how difficult they perceived the assembly to be on a scale of 1 to 10. Participants also completed a spatial-ability battery and a mechanical-ability test to rule out incoming knowledge or skill that could give an added advantage for the assembly of the stairchairs (used as covariates in the pilot). More information about each of the tests is provided below:

1. Psychometric Success Mechanical Reasoning Test (scale)—The Psychometric Success Mechanical Reasoning Test is used to assess mechanical aptitude of an individual, often done when applying for positions. It assesses skills in areas such as physical principles, mechanical operations, and spatial reasoning capabilities. The test provides a series of physics-type problems to which the subject has to choose the right answer.

2. Spatial Orientation (scale)—The spatial orientation score was derived from the ETS kit of Factor Referenced Cognitive Ability. This is defined as “the ability to perceive spatial patterns

or to maintain orientation with respect to objects in space" (Eckstrom, 1976). The spatial orientation module consists of a card rotations test and a cube comparison test. In the card rotation section, the subject is asked to decide whether two images are of the same object, just rotated in a different direction. In the cube comparison section, the subject is asked to do the same process as with card rotation; the only difference is a cube versus a flat image.

A total of 32 college students were recruited for the study, 16 for each chair. The design was a between-subjects multivariate analysis of covariance (MANCOVA) with a two-level categorical variable for type of chair as an independent variable. The dependent variables were time on task, total number of times referencing instructions, and NASA TLX composite scores. As mentioned above, the mechanical and spatial ability tests were used as covariates. Details about the dependent variables are listed below:

1. Time On Task Total (scale)—The time from when the research team tells the subject to begin the assembly process to the time when assembly is complete (when an individual is strapped into the evacuation chair and the participant says the task is finished). This time was measured by a stopwatch held by the research team and verified through video recordings.

2. Number of Instructional Glances (scale)—The number of times a subject refers back to the instructional material while attempting to assemble the device. This variable was measured using a three-person review of the subject's session and developing an average score of the three reviewers.

3. NASA Task Load Index (NASA TLX) Composite Score (scale)—A validated subjective workload assessment measure for human–machine interaction. It has a series of subscales and relationships between different domains to determine an overall score. The

subscales rate on six different workloads: Mental Demand, Physical Demand, Temporal Demand, Performance, Effort, and Frustration.

This multivariate analysis of covariance (MANCOVA) was conducted to test the hypothesis that there would be one or more mean differences between chair models (Stryker and Garaventa) and assembly performance. A statistically significant MANCOVA effect was obtained: Pillais' Trace = .441, $F(3, 26) = 6.826$, $p < .002$. A series of one-way analyses of covariance (ANCOVA) on each of the three dependent variables was conducted as follow-up tests to the MANCOVA. A statistically significant ANCOVA effect was obtained for all of the dependent variables: Time to Complete, $F(3, 31) = 4.024$, $p < .017$; Number of Instructional Glances, $F(3, 31) = 6.614$, $p < .002$; NASA TLX, $F(3, 31) = 3.577$, $p < .026$. This result demonstrated the viability and capability of obtaining significant results in a larger experimental study.

Main Study

This experiment consisted of three phases.

Phase I

Phase I had a between-subjects design, each subject interacting with a single emergency stair travel device (stairchair). The stairchair was represented as a dummy coded variable consisting of 3 levels (Level 0: Stryker Evacuation Chair; Level 1: Garaventa Evacuation Chair; Level 2: Evac+Chair Evacuation Chair). These chairs were chosen because they represent some of the most common evacuation chairs.

In order to assess performance there is a need to assess several different variables that may assist in predicting the outcome. In addition to the variables previously discussed in the pilot study (time on task, number of instructional glances, NASA TLX, spatial ability, and mechanical ability) the following were included in Phase I:

1. Time To Chair Readiness (scale)—The time it takes the person to correctly assemble the chair to allow someone to sit in it. According to the National Fire Protection Association (2007) there are no code enforceable time limits for evacuation of buildings because of the large number of variables related to number of occupants, type of structure, number of exits, and number of floors.

2. Spatial Ability (scale)—The visualization score is derived from the ETS kit of Factor Referenced Cognitive Ability. This is defined as "the ability to manipulate or transform the image of spatial patterns into other arrangements" (Eckstrom, 1976). Although the visualization may seem to be the same as spatial orientation, where it differs is that visualization requires both rotation and serial processing of visual stimuli while spatial ability requires only mental rotation of an object. Visualization comprises five separate sections: Form Board Test, Card Rotation Test, Cube Comparison, Paper Folding Test, and Surface Development Test. In the form-board test participants are asked to fill in an outline of a figure through a composition of smaller pieces, like a jigsaw puzzle. In the paper-folding test, participants are asked to determine which of a group of options represents the folded version of the initial problem. In the surface-development test participants need to determine how a surface was created by identifying matching letter and number pairs. This test is very similar to the paper-folding task except now the subject is working with figures. In the card-rotation test participants are asked to mentally rotate an object

to determine if the shape provided matches the sample shape. Participants are not permitted to rotate the paper. In the cube-comparison test the participants have to compare an example cube to a reference cube and determine if the two cubes are the same.

Phase II

Phase II entails the proposal of theoretical models of "ideal" (i.e., universally understandable) product assembly instructions, based on information from the results of Phase I as well as other data aggregated from the literature review. Once the data for the first study were collected and analyzed, Yuppify Inc., an Orlando-based graphic design firm, partnered with the project to begin to develop improved instructions for each of the evacuation chairs. This was accomplished in two ways: 1. A reliance on existing research of instructional design. Dowse et al. (2010) showed that even individuals with very little education and understanding of the topic area could relate to experiences in reference to their own bodily movement and capability.
2. Having graphics that were clear, concise, oriented toward common body positions, and maintaining a clear central focus facilitated a more complete understanding of the instructional message.

The validation of this instruction set was accomplished by using four focus groups to provide feedback to the research team as to the effectiveness of the instructional design. Subjects were given the instruction set and asked to describe what actions they believed to be occurring. After they went through all sets of instructions, they were told the intended operational procedure of the instructions and any differences in interpretation were discussed.

Phase III

The activities for Phase III were almost exactly the same as those for Phase I. The only differences were the inclusion of a new instruction set and an additional chair (Evac+Chair).

CHAPTER FOUR: RESULTS

Phase I

Phase I experimentation had a few differences from the original plan laid out in the proposal. First an additional hypothesis was added. This hypothesis was that there would be a performance decrement for older adults in comparison to younger adults based on the cognitive slowing of older adult information processing. This hypothesis was added to the two existing hypotheses: H1: Visual Instruction style can account for a significant portion of explained variance in the operation of emergency stair travel devices. H2: Improvements in instruction style can reduce time on task across device type and age group.

Several other changes evolved away from the original study proposal. The design had to be modified to exclude the Safety Chair. The reasoning behind this was that the Safety Chair, unlike the other devices, did not have attached instructions. In an effort to provide the manufacturer with human-factors–related improvements a report has been generated based on heuristic evaluations of the personnel in the Technology and Aging lab at UCF. Another modification was that due to the proprietary nature of the Bennett test of mechanical ability and its cost, an alternative, no-cost test of mechanical ability was used instead: Psychometric Success (Newton & Bristoll, n.d.). This test is a 20-question, multiple-choice assessment that contains questions similar to the Bennett Mechanical Comprehension Test. All other measures remained the same.

To compensate for a smaller-than-desired sample size, middle-age and older adults were grouped into the same category, and both of the remaining categories (young and old) were bootstrapped using 50 cases. Bootstrapping provides a method for hypothesizing what a larger sample would have indicated with the assumption that the characteristics of the data remain the same.

Phase I data collection consisted of 40 young adults, 13 middle-aged, and 9 older adults for a total of 62 participants. Predictors of the regression model included sex, condition, total test scores of the aggregate measure of the spatial ability battery (Ekstrom, French, Harman, & Dermen, 1976), instructional glances, NASA Task Load Index, and total scores of the Psychometric Success Mechanical Ability Test. It was discovered that the data for time to complete and instructional glances exhibited non-normality, so the data transformed using a log transformation. The log transformation takes a distribution that is highly skewed and makes it less skewed. See Figure 13.

For young adults the overall model explained a significant proportion of variance in time to complete: adjusted R^2= .737, $F(7, 37) = 15.83$, $p < .05$. Number of instruction glances significantly predicted time to complete: $\beta = .783$, $t(40) = 7.989$, $p <$ 05. Total test scores on the spatial ability battery also significantly predicted time to complete: $\beta = -.364$, $t(40) = -3.35$, $p < .05$. See Tables 1, 2, and 3 for detailed information.

Table 1: Phase 1 Young—Model Summary

Model	R	R square	Adjusted R square	Std. error of the estimate
1	.887[a]	.787	.737	.11303

[a] Predictors: (Constant), TLX, Aggregate Spatial Abilities, Sex, Trans_Glances, Age, Device Type, Mechanical Ability

Table 2: Phase 1 Young—ANOVA

Model 1	Sum of squares	df	Mean square	F	Sig.
Regression	1.415	7	.202	15.825	.000 [a]
Residual	.383	30	.013		
Total	1.798	37			

[a] Predictors: (Constant), TLX, Aggregate Spatial Abilities, Sex, Trans_Glances, Age, Device Type, Mechanical Ability

Table 3: Phase 1 Young—Coefficients

	Unstandardized coefficients		Standardized coefficients		
Model 1	B	Std. error	Beta	t	Sig.
(Constant)	1.510	.322		4.690	.000
Trans_Glances	.455	.057	.783	7.989	.000
Device Type	.016	.027	.058	.585	.563
Age	.023	.015	.144	1.483	.149
Sex	.028	.041	.065	.697	.491
Mechanical Ability	.003	.006	.040	.393	.697
Aggregate Spatial Abilities	-.001	.000	-.364	-3.351	.002
TLX	.002	.001	.140	1.482	.149

In the combined group of the middle-aged and older adults the overall regression model explained a significant proportion of variance in time to complete: adjusted $R^2 = .673$, $F(7, 23) = 7.756$, $p < .05$. Number of instruction glances significantly predicted time to complete: $\beta = .605$, $t(23) = 4.184$, $p < .05$. See Tables 4, 5, and 6 for detailed information. Transformations were applied to Time to Complete and Instructional Glances but didn’t have as significant an effect as with the young population. Results from the bootstrapping indicate that for the young group both total test scores and number of instructional glances would remain significant: $p <.05$. For the middle-aged and older age group instructional glances also showed significance at the $p <.05$ level. In examining the means of number of instructional glances per evacuation chair, Stryker = 16.59, followed by Evac+ = 10.21, and finally Evacu-trac = 5.39. See Figure 13 for a comparison of time to complete and glances by chair. Post hoc analyses using the Scheffé post hoc criterion for significance at a .05 level indicated number of instructional glances was significantly lower for the Evacu-trac than the Stryker, $p < .05$.

Table 4: Phase 1 Middle / Old—Model Summary

Model	R	R square	Adjusted R square	Std. error of the estimate
1	.879[a]	.772	.673	.14782

[a] Predictors: (Constant), NASATLX, ConditionStryker1Evacutrac2Evac3, SexFemale1Male2, Age, Trans_Glances, TotalTestScores350, MechanicalAbility20total

Table 5: Phase 1 Middle / Old—ANOVA

Model 1	Sum of squares	df	Mean square	F	Sig.
Regression	1.186	7	.169	7.756	.000[a]
Residual	.350	16	.022		
Total	1.536	23			

[a] Predictors: (Constant), NASATLX, ConditionStryker1Evacutrac2Evac3, SexFemale1Male2, Age, Trans_Glances, TotalTestScores350, MechanicalAbility20total

Table 6: Phase 1 Middle / Old—Coefficients

	Unstandardized coefficients		Standardized coefficients		
Model 1	B	Std. error	Beta	t	Sig.
(Constant)	1.786	.248		7.195	.000
Trans_Glances	.376	.090	.605	4.184	.001
ConditionStryker1Evacutrac2Evac3	.002	.043	.007	.046	.964
Age	.005	.003	.299	2.067	.055
SexFemale1Male2	.037	.087	.070	.423	.678
MechanicalAbility20total	-.005	.015	-.068	-.340	.738
TotalTestScores350	-.001	.001	-.245	-1.332	.201
NASATLX	.001	.002	.088	.663	.517

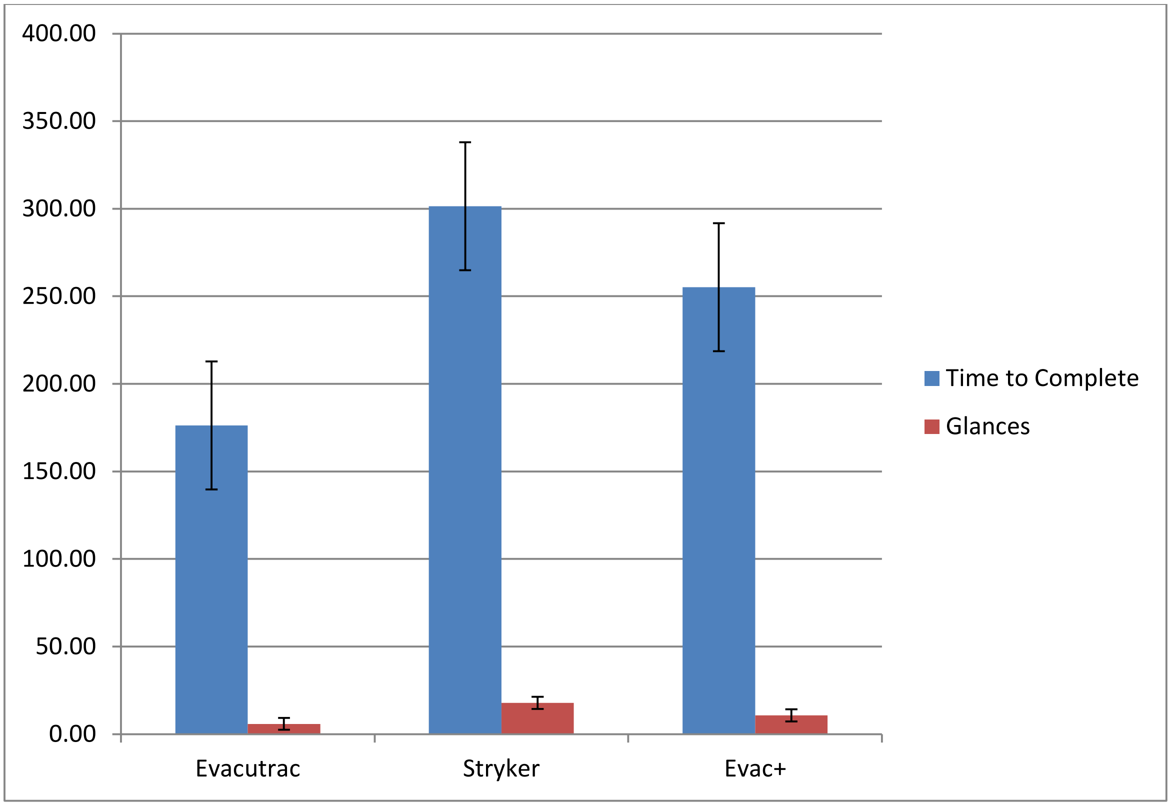


Figure 13: Phase I Time to Complete and Glances by Chair

Phase II

There were four focus groups during Phase II. Each focus group consisted of 8–10 students who were asked to work in groups to assemble each of the evacuation chairs. This assembly task was followed by a discussion on how they chose the particular actions that they did, followed by a troubleshooting session by the entire group as to instructional improvements.

Evacu-trac

For focus groups 1, 2, and 3 straps were a source of confusion. By focus group 4 participants had a clear understanding of the process of securing the straps, thereby demonstrating improvement through the iterative redesign. Here is a breakdown of the problems related to strapping across the 4 focus groups: focus group 1: confusion of where to secure straps. Focus group 2: confusion of whether or not the straps were secure. Focus group 3: confusion of where to secure straps. Focus group 4: concerned about length of straps.

All four of the focus groups had difficulty understanding the operation of the latch mechanism. The original instruction set dictates that the user ensure that the latch is engaged. Instead of focusing on proper wording for the latch, focus was instead placed on how to properly position and grab the device so as to cause the lock to engage automatically. This change allows for the operation of the device to be more intuitive and natural, giving the participant a clear understanding that the chair is ready to be loaded. Focus group 1: confusion as to the wording for "confirm latch is engaged." Focus group 2: confusion about how to open latch; needed to specify where to pull and easiest position to open (side or behind headrest). Focus group 3: confusion of where to pull to complete the assembly, which was resolved by changing the wording of the instructions. Focus group 4: minor confusion on red indicators. To help assist participants in understanding the primary bar for assembly, a red sticker was placed across the top of the evacuation frame to indicate a place to grab. However, focus group participants got this confused with the red bar going across the bottom of the chair to recollapse the device.

After the first focus group the manufacturer's drawings were substituted for pictograms to increase ease of understanding. The number of straps in step 2 was added to make sure participants were aware of number of straps for proper securing.

Upon the completion of the second focus group the instructional step 1 was completely changed to focus around the position of the evacuation chair for opening rather than transferring an individual with a disability. An additional second step to verify that the system was ready for evacuee transfer. For step 3 the location of the straps was added.

Following the third focus group the wording in step 1 was completely modified to indicate the required positioning of the chair to complete the steps. Also words describing the location of the action were added to simplify proper positioning of the person relative to the chair. The phrase “fasten safety straps” was changed to “undo velcro straps” in step two to provide more description. Step 3 was added to show how the Velcro straps were positioned relative to the body of evacuee. Any additional steps involving the operation of stair descent were removed due to the focus of the study.

Evac+

Instructional issues related to Evac+ revolved around two primary topics: operating the track extension and unbuckling the straps to open the chair. As far as the difficulties relating to the track extension, the focus groups found the following. Focus group 1: uncertainty about what the track was. Focus group 2: difficulty of location of track extension. Focus group 3: no difficulty with the track extension. Focus group 4: no difficulty with track extension. As the instructions developed further we were able to minimize the issues with the track extension so that participants had no difficulty with this.

We experienced similar success with the second issue of unbuckling the straps to open the chair. Participants had some issues unbuckling the straps to assemble the device. Focus group 1: no problems with unbuckling seatbelt. Focus group 2: difficulty due to absence of instructions to unbuckle seatbelt. Focus group 3: no problems with unbuckling seatbelt. Focus group 4: no problems with unbuckling seatbelt. One of the focus groups, focus group 2, had a great deal of challenge unbuckling the seatbelt, thereby making their time to complete extremely long. However, with redesign of the seatbelt instructions the issue was eliminated.

Two other issues manifested themselves throughout the study but were not addressed due to their being more mechanical-related issues rather than design of the instructions. One is that the location of the instructions on the bottom of the seat was consistently a problem. Although instructions are also located in the headrest compartment, no participant found these instructions. The location on the bottom of the seat caused a great deal of awkwardness once someone was seated in the chair, because participants would have to look underneath the seat behind the person's legs to read the directions. Also, the participants were often confused about whether to place a person's arms above or below the waist strap.

This chair had a large number of instructions which were both hard to read and there was too much wording. The number of instructions were immediately condensed to five steps. Pictograms were added to illustrate the actions required for the written steps. To emphasis the need to unbuckle the outside strap which held the unit together the word "first" was added in step 1. A green sticker was added to step 2 to make it easier to locate where a participant had to pull down to complete the step. A zoomed in image of the required kicking motion was added to step 3 so the participants would know exactly where and how to kick. To show that 2 straps were needed to be buckled to safely evacuate someone, wording was added describing where the straps had to be buckled on an evacuee's body.

Focus group 2 still struggled to push out the correct wheels to complete step 3. To increase awareness of where the foot must be placed to complete the step, a green sticker was added and was mentioned in the instructions.

Following focus group 3 participants were confused on the redundancy of the green stickers. As a result both green stickers were removed. The wording in step 2 was modified to specify what handle had to be grabbed. The words “handle with grip” were added because only one handle had grip. Step 3’s green sticker was replaced with a red sticker to indicate where the action had to take place in order to complete the step. Finally for step 5 the three body parts needed to safely evacuate an individual were added to clarify arm and head positioning.

Stryker

The major issue for the evacuation chair related to step two, which requires pulling on a wire while at the same time extending the handle. Focus group 1 noted that there was difficulty with the interpretation of the images and recommended text be included with the various steps. Focus group 2 had challenges with the wording of the instructions. By the time focus groups 3 and 4 were involved, redesign of the instruction for step two resulted in no difficulty completing the action. The second issue for the evacuation chair was one of color scheme, specifically as it relates to the two bars that are colored red currently. All four focus groups expressed a need for clarity related to distinction of the red bars. However by the time focus group 4 attempted to perform the action it took only four seconds upon reading the instructions. Other findings included confusion by participants as to the functions of the various handlebars (i.e., the handles to perform carrying) on the device.

After the first focus group words describing each action were added to the existing instructions which were just pictograms. Modifications to the instructional design converted a 2 X 1 X 3 to a 2 X 1 X 2 X 1 layout to increase readability. The word “Instructions” was added across the top to emphasize and draw attention to the area. Following the second focus group the word “and” was added to step two to further demonstrate the necessity of the dualistic action needed to complete the step. Step three’s wording was changed to reflect the purpose of the action being performed.

Upon the completion of the third focus group the word “bar” was changed to the word “wire” to better describe the horizontal attachment used to complete the step. Also the word “grab” was changed to “pull” to indicate the action needed to perform the step more specifically. For step three the word “between” was added to better locate the grab location. Each step was now presented in a vertical 1 X 1 X 1 X 1 layout. After focus group four the word “downward” was added to step 3 to orchestrate the action needed to complete the step. All words for all the steps were then properly aligned for more efficient reading.

Phase III

A MANCOVA was run to compare the differences between Phase I and Phase III. Using a larger older adult population with the assistance of Life at UCF we were able to backfill participants running Phase I instructions to allow for equal groups in both phases. Upon completion of data collection each group contained 39 young adults and 18 older adults. All significance values are reported at the alpha level of .01. More restrictive criteria were put in place to help accommodate for a small sample size.

Spatial ability scores were run as a covariate because it was discovered that the spatial ability score explains some of the variance by age group. In order to meet the assumption of multivariate normality according to Box's M Test and equality of variance according to Levene's Test, time to complete and instructional glances had to be transformed using a log transformation. The null hypothesis for Hypothesis 2 (instruction improvements would not decrease time to complete) was rejected (Phase I: M = 244 seconds; Phase III: M = 156 seconds).

There was a significant main effect for phase: $F(2, 85) = 12.952$, $p < .01$; Wilks' $\Lambda = .766$, $\eta = .234$. There was a significant main effect for condition: $F(4,170) = 4.371$, $p < .01$; Wilks $\Lambda = .822$, $\eta = .093$. There was a significant condition x phase interaction $F(4, 170) = 3.869$, $p = .005$; Wilks $\Lambda = .840$, $\eta = .083$. (See Tables 7 and 8 for the multivariate and between-subjects test results.) Figure 14 shows the differences between chairs in terms of time to complete and glances. Post hoc analyses using the Scheffé post hoc criterion for significance indicated that there were no significant differences at the .01 criterion level.

Table 7: Multivariate Tests for Phase III

Effect		Value	F	Hypoth. df	Error df	Sig.	Partial eta squared	Noncent. parameter	Observed power[c]
Intercept	Pillai's Trace	.946	745.145[a]	2	85	.000	.946	1490.290	1.000
	Wilks' Lambda	.054	745.145[a]	2	85	.000	.946	1490.290	1.000
	Hotelling's Trace	17.533	745.145[a]	2	85	.000	.946	1490.290	1.000
	Roy's Largest Root	17.533	745.145[a]	2	85	.000	.946	1490.290	1.000
Total_Test_Scores	Pillai's Trace	.072	3.322[a]	2	85	.041	.072	6.644	.366
	Wilks' Lambda	.928	3.322[a]	2	85	.041	.072	6.644	.366
	Hotelling's Trace	.078	3.322[a]	2	85	.041	.072	6.644	.366
	Roy's Largest Root	.078	3.322[a]	2	85	.041	.072	6.644	.366
Condition	Pillai's Trace	.178	4.196	4	172	.003	.089	16.785	.780
	Wilks' Lambda	.822	4.371[a]	4	170	.002	.093	17.484	.802
	Hotelling's Trace	.216	4.542	4	168	.002	.098	18.166	.822
	Roy's Largest Root	.216	9.298[b]	2	86	.000	.178	18.596	.904
Sex	Pillai's Trace	.015	.652[a]	2	85	.524	.015	1.304	.050
	Wilks' Lambda	.985	.652[a]	2	85	.524	.015	1.304	.050
	Hotelling's Trace	.015	.652[a]	2	85	.524	.015	1.304	.050
	Roy's Largest Root	.015	.652[a]	2	85	.524	.015	1.304	.050
Age_Group	Pillai's Trace	.022	.949[a]	2	85	.391	.022	1.899	.075
	Wilks' Lambda	.978	.949[a]	2	85	.391	.022	1.899	.075
	Hotelling's Trace	.022	.949[a]	2	85	.391	.022	1.899	.075
	Roy's Largest Root	.022	.949[a]	2	85	.391	.022	1.899	.075
Phase	Pillai's Trace	.234	12.952[a]	2	85	.000	.234	25.904	.980
	Wilks' Lambda	.766	12.952[a]	2	85	.000	.234	25.904	.980
	Hotelling's Trace	.305	12.952[a]	2	85	.000	.234	25.904	.980
	Roy's Largest Root	.305	12.952[a]	2	85	.000	.234	25.904	.980
Condition * Sex	Pillai's Trace	.099	2.238	4	172	.067	.049	8.953	.404
	Wilks' Lambda	.903	2.217[a]	4	170	.069	.050	8.867	.398
	Hotelling's Trace	.105	2.195	4	168	.072	.050	8.781	.393
	Roy's Largest Root	.067	2.891[b]	2	86	.061	.063	5.782	.308

Effect		Value	F	Hypoth. df	Error df	Sig.	Partial eta squared	Noncent. parameter	Observed power[c]
Condition * Age_Group	Pillai's Trace	.009	.202	4	172	.937	.005	.806	.024
	Wilks' Lambda	.991	.199[a]	4	170	.938	.005	.798	.024
	Hotelling's Trace	.009	.197	4	168	.939	.005	.790	.024
	Roy's Largest Root	.008	.359[b]	2	86	.699	.008	.718	.029
Condition * Phase	Pillai's Trace	.164	3.850	4	172	.005	.082	15.400	.729
	Wilks' Lambda	.840	3.869[a]	4	170	.005	.083	15.477	.732
	Hotelling's Trace	.185	3.887	4	168	.005	.085	15.550	.735
	Roy's Largest Root	.150	6.452[b]	2	86	.002	.130	12.904	.732
Sex * Age_Group	Pillai's Trace	.003	.148[a]	2	85	.862	.003	.297	.017
	Wilks' Lambda	.997	.148[a]	2	85	.862	.003	.297	.017
	Hotelling's Trace	.003	.148[a]	2	85	.862	.003	.297	.017
	Roy's Largest Root	.003	.148[a]	2	85	.862	.003	.297	.017
Sex * Phase	Pillai's Trace	.002	.073[a]	2	85	.930	.002	.146	.013
	Wilks' Lambda	.998	.073[a]	2	85	.930	.002	.146	.013
	Hotelling's Trace	.002	.073[a]	2	85	.930	.002	.146	.013
	Roy's Largest Root	.002	.073[a]	2	85	.930	.002	.146	.013
Age_Group * Phase	Pillai's Trace	.024	1.066[a]	2	85	.349	.024	2.132	.085
	Wilks' Lambda	.976	1.066[a]	2	85	.349	.024	2.132	.085
	Hotelling's Trace	.025	1.066[a]	2	85	.349	.024	2.132	.085
	Roy's Largest Root	.025	1.066[a]	2	85	.349	.024	2.132	.085
Condition * Sex * Age_Group	Pillai's Trace	.036	.792	4	172	.532	.018	3.169	.096
	Wilks' Lambda	.964	.790[a]	4	170	.533	.018	3.161	.095
	Hotelling's Trace	.038	.788	4	168	.535	.018	3.152	.095
	Roy's Largest Root	.037	1.600[b]	2	86	.208	.036	3.201	.142
Condition * Sex * Phase	Pillai's Trace	.059	1.298	4	172	.273	.029	5.193	.190
	Wilks' Lambda	.941	1.301[a]	4	170	.272	.030	5.203	.190
	Hotelling's Trace	.062	1.303	4	168	.271	.030	5.211	.190
	Roy's Largest Root	.060	2.589[b]	2	86	.081	.057	5.179	.267

Effect		Value	F	Hypoth. df	Error df	Sig.	Partial eta squared	Noncent. parameter	Observed power[c]
Condition * Age_Group * Phase	Pillai's Trace	.045	.988	4	172	.415	.022	3.953	.129
	Wilks' Lambda	.955	.983[a]	4	170	.418	.023	3.932	.128
	Hotelling's Trace	.047	.978	4	168	.421	.023	3.910	.127
	Roy's Largest Root	.040	1.741[b]	2	86	.181	.039	3.483	.159
Sex * Age_Group * Phase	Pillai's Trace	.005	.211[a]	2	85	.810	.005	.422	.020
	Wilks' Lambda	.995	.211[a]	2	85	.810	.005	.422	.020
	Hotelling's Trace	.005	.211[a]	2	85	.810	.005	.422	.020
	Roy's Largest Root	.005	.211[a]	2	85	.810	.005	.422	.020
Condition * Sex * Age_Group * Phase	Pillai's Trace	.026	.567	4	172	.687	.013	2.268	.063
	Wilks' Lambda	.974	.561[a]	4	170	.691	.013	2.245	.062
	Hotelling's Trace	.026	.556	4	168	.695	.013	2.222	.061
	Roy's Largest Root	.020	.849[b]	2	86	.432	.019	1.697	.066

Design: Intercept + Total_Test_Scores + Condition + Sex + Age_Group + Phase + Condition * Sex + Condition * Age_Group + Condition * Phase + Sex * Age_Group + Sex * Phase + Age_Group * Phase + Condition * Sex * Age_Group + Condition * Sex * Phase + Condition * Age_Group * Phase + Sex * Age_Group * Phase + Condition * Sex * Age_Group * Phase

[a] Exact statistic

[b] The statistic is an upper bound on F that yields a lower bound on the significance level.

[c] Computed using alpha = .01

Table 8: Tests of Between-Subjects Effects for Phase III

Source	Dependent variable	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared	Noncent. parameter	Observed power[c]
Corrected Model	Log transform of time to complete	2.973[a]	24	.124	3.488	.000	.493	83.711	.999
	Log transform of glance	3.821[b]	24	.159	2.149	.005	.375	51.586	.947
Intercept	Log transform of time to complete	39.005	1	39.005	1098.449	.000	.927	1098.449	1.000
	Log transform of glance	7.153	1	7.153	96.576	.000	.529	96.576	1.000
Total_Test_Scores	Log transform of time to complete	.234	1	.234	6.598	.012	.071	6.598	.477
	Log transform of glance	.191	1	.191	2.579	.112	.029	2.579	.159
Condition	Log transform of time to complete	.481	2	.241	6.778	.002	.136	13.557	.759
	Log transform of glance	1.312	2	.656	8.858	.000	.171	17.716	.886
Sex	Log transform of time to complete	.027	1	.027	.771	.382	.009	.771	.043
	Log transform of glance	.097	1	.097	1.313	.255	.015	1.313	.073
Age_Group	Log transform of time to complete	.029	1	.029	.810	.371	.009	.810	.046
	Log transform of glance	.001	1	.001	.007	.934	.000	.007	.010

Source	Dependent variable	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared	Noncent. parameter	Observed power[c]
Phase	Log transform of time to complete	.731	1	.731	20.589	.000	.193	20.589	.969
	Log transform of glance	.195	1	.195	2.633	.108	.030	2.633	.162
Condition * Sex	Log transform of time to complete	.144	2	.072	2.028	.138	.045	4.056	.194
	Log transform of glance	.421	2	.211	2.844	.064	.062	5.687	.301
Condition * Age_Group	Log transform of time to complete	.005	2	.003	.071	.932	.002	.141	.013
	Log transform of glance	.042	2	.021	.283	.754	.007	.565	.024
Condition * Phase	Log transform of time to complete	.108	2	.054	1.515	.226	.034	3.031	.132
	Log transform of glance	.547	2	.274	3.695	.029	.079	7.390	.417
Sex * Age_Group	Log transform of time to complete	.004	1	.004	.126	.723	.001	.126	.015
	Log transform of glance	8.291E-005	1	8.291E-005	.001	.973	.000	.001	.010
Sex * Phase	Log transform of time to complete	.004	1	.004	.104	.748	.001	.104	.014
	Log transform of glance	.001	1	.001	.008	.930	.000	.008	.010
Age_Group * Phase	Log transform of time to complete	.073	1	.073	2.059	.155	.023	2.059	.121
	Log transform of glance	.049	1	.049	.667	.416	.008	.667	.038

Source	Dependent variable	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared	Noncent. parameter	Observed power[c]
Condition * Sex * Age_Group	Log transform of time to complete	.012	2	.006	.167	.847	.004	.333	.018
	Log transform of glance	.047	2	.023	.314	.731	.007	.628	.026
Condition * Sex * Phase	Log transform of time to complete	.161	2	.080	2.266	.110	.050	4.532	.224
	Log transform of glance	.327	2	.164	2.209	.116	.049	4.418	.217
Condition * Age_Group * Phase	Log transform of time to complete	.062	2	.031	.879	.419	.020	1.758	.068
	Log transform of glance	.039	2	.020	.266	.767	.006	.533	.024
Sex * Age_Group * Phase	Log transform of time to complete	.012	1	.012	.338	.563	.004	.338	.023
	Log transform of glance	.029	1	.029	.392	.533	.005	.392	.026
Condition * Sex * Age_Group * Phase	Log transform of time to complete	.032	2	.016	.449	.640	.010	.898	.035
	Log transform of glance	.046	2	.023	.312	.733	.007	.623	.026
Error	Log transform of time to complete	3.054	86	.036					
	Log transform of glance	6.369	86	.074					
Total	Log transform of time to complete	566.175	111						
	Log transform of glance	98.580	111						

Source	Dependent variable	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared	Noncent. parameter	Observed power[c]
Corrected Total	Log transform of time to complete	6.026	110						
	Log transform of glance	10.190	110						

[a] R Squared = .493 (Adjusted R Squared = .352)

[b] R Squared = .375 (Adjusted R Squared = .201)

[c] Computed using alpha = .01

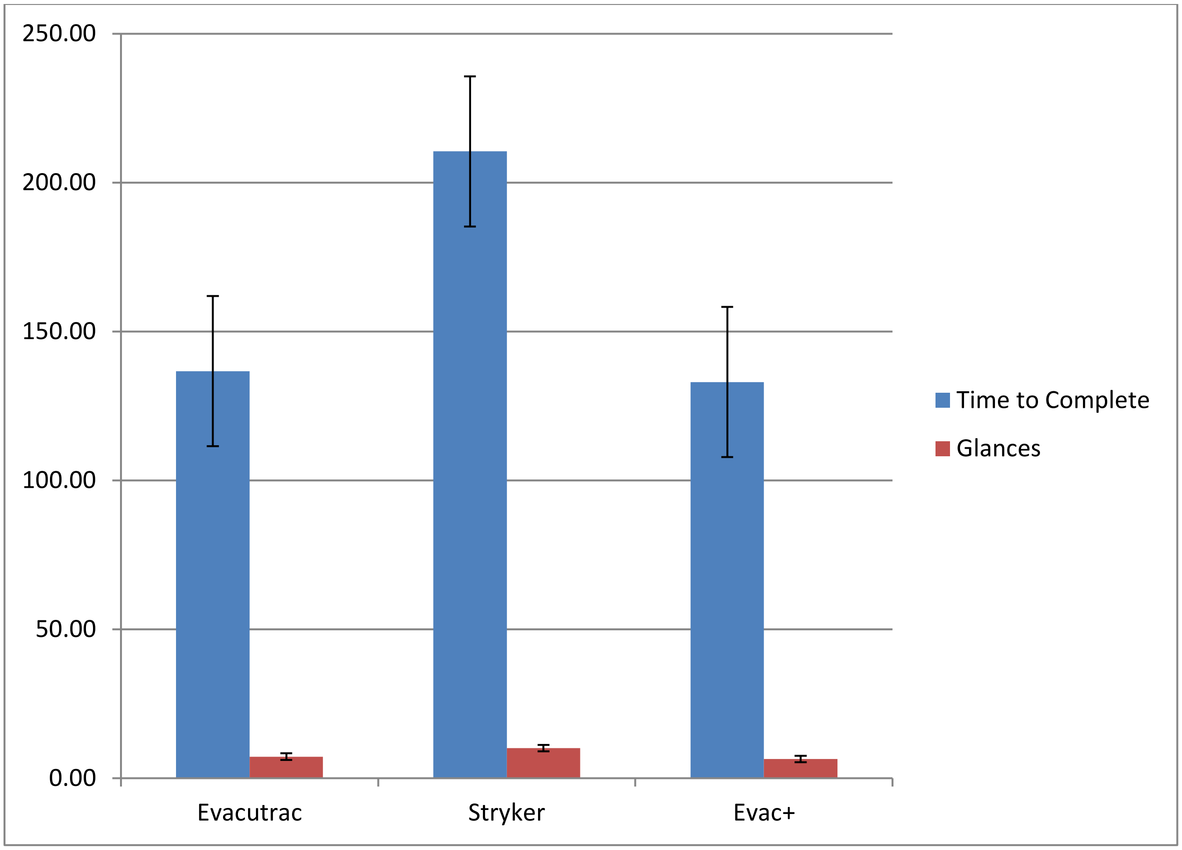


Figure 14: Phase III Time to Complete and Glances by Chair

Hypothesis Review

H1: Visual Instruction style can account for a significant portion of explained variance in the operation of emergency stair travel devices. Through the data collected in Phase I the null hypothesis was rejected. Number of instruction glances for younger adults significantly predicted time to complete: $b = .862$, $t(40) = 11.662$, $p = .000$. Number of instruction glances for middle and older adults significantly predicted time to complete: $b = .853$, $t(23) = 5.927$, $p = .000$.

H2: Improvements in instruction style can reduce time on task across device type and age group. Using the data from Phase III, the null hypothesis was rejected. See Figure 15 and Figure 16 showing the differences between chairs by phase on glances and time to complete There was a significant condition (device type) x phase interaction: $F(4, 170) = 3.869$, $p = .005$; Wilks $\Lambda = .840$, $\eta = .083$. See Table 7.

H3: There will be a performance decrement for older adults in comparison to younger adults based on the cognitive slowing of older adult information processing. This hypothesis was not supported using multivariate tests. See Table 7.

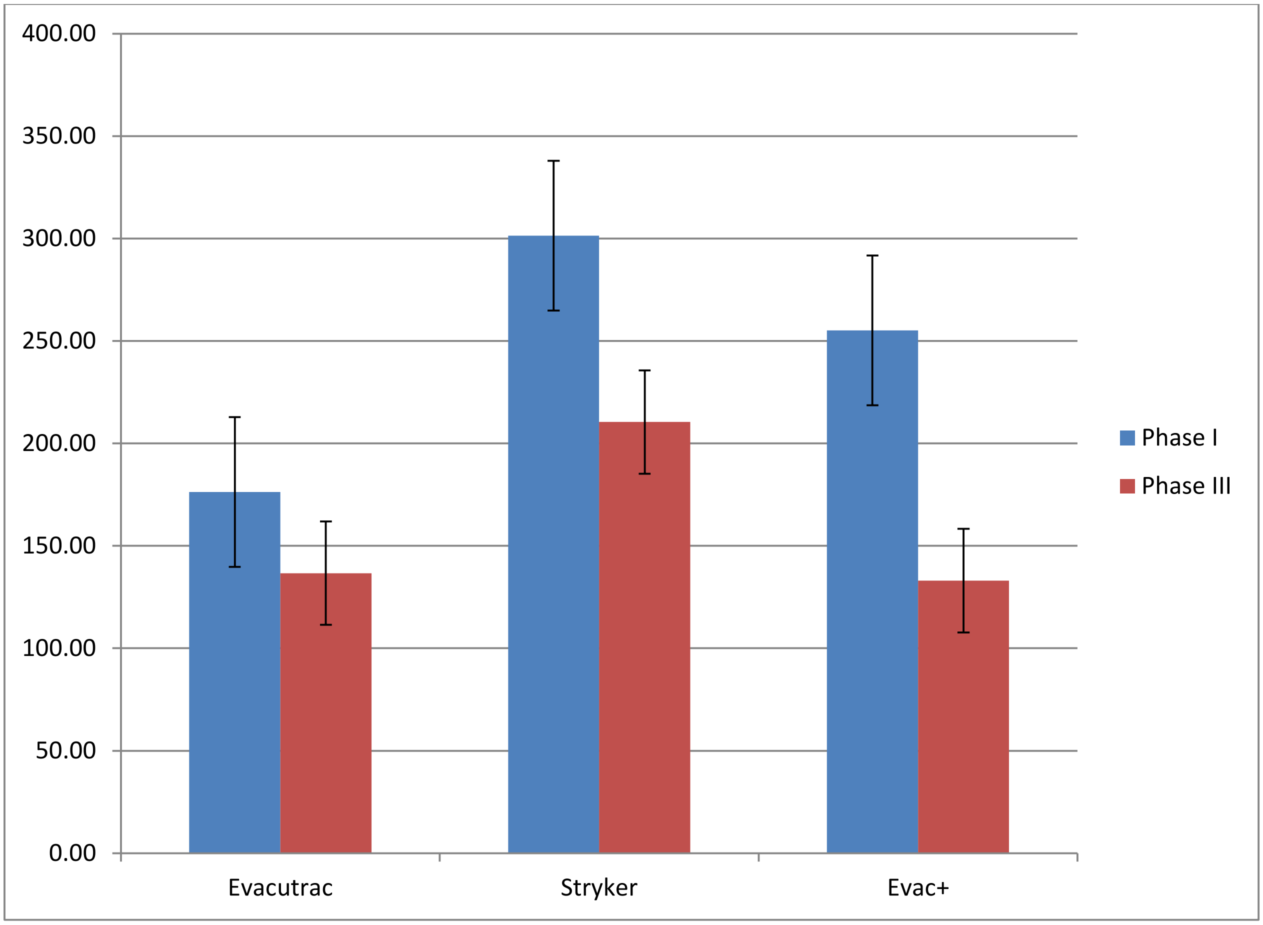


Figure 15: Time to Complete by Chair

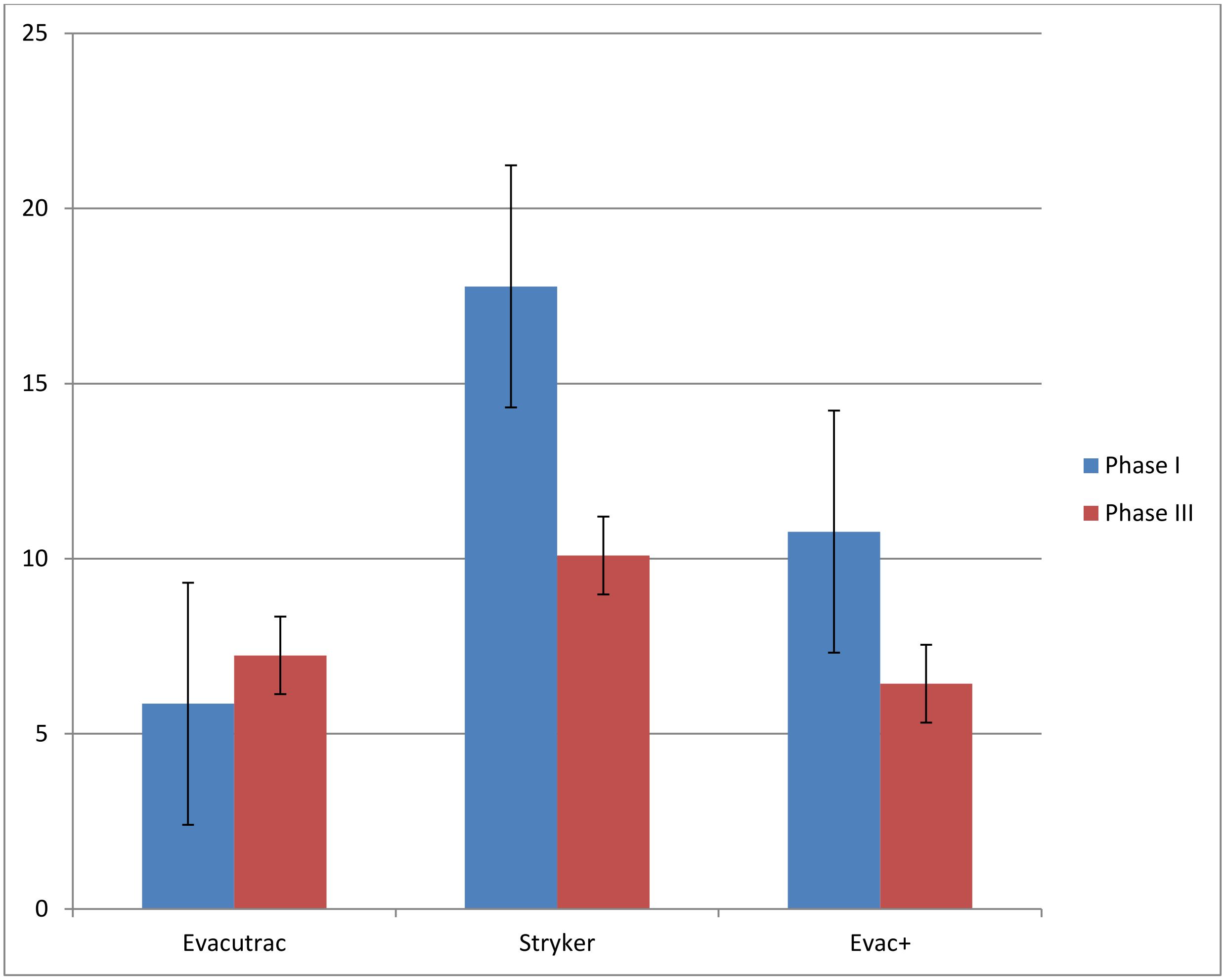


Figure 16: Glances by Chair

CHAPTER FIVE: DISCUSSION

Theoretical / Practical Implications

At the time of this writing, I was unable to find another study specifically focusing on the instructional development for emergency stair travel devices. Further, this study appears to be the first of its kind challenging the common view that everyone who operates the stairchair is pre-trained. With this novel viewpoint new research and legal questions need to be explored. How do individual differences among different types of populations (e.g., different prior knowledge, different ethnic backgrounds, and differences between genders) alter the individual's ability to assist in the stairchair operation? If individuals are not trained, who is liable in the event of a malfunction of the device due to operator error? Human Factors Psychology is in a unique place to have both the knowledge and the experimental design skills to make quantitative assessments of the performance questions and with some help from the legal profession could really break new ground in safety and evacuation.

I developed this research around three hypotheses, all which provide new information and contribute to the field at large. H1: Instructional design can have a significant impact on performance with stairchairs. This finding emphasizes the need to re-examine how instructions are created across devices. I suspect that often instructional design is looked at as an add-on, rather than being tested with actual users. This process likely stems from the view that operators will be trained; however, trained or not, operators' performance across devices can improve as a result of a focus on instructions. Human Factors professionals should be leveraged to assist in this task, which is surely more than just a pure engineering task, as it requires an understanding of human performance and cognitive processes. Instructional design is paralleled in user interface design and the development of human computer interaction, where bringing the code, appearance, and understanding are just as important from a cost perspective as the development itself.

H2: Instructions can be improved through an iterative design process that affects performance. Often there is a need to push a product out as fast as possible from a manufacturing perspective, leading to instructions that are not the easiest to understand. Improvements can still be made after production. Leveraging specialists and end users in the same room works very effectively in developing instructions, from both a top-down (developers to users) and bottom-up (user feedback) perspective. In terms of cost, focus groups are relatively inexpensive investments and provide good returns on knowledge. Focus group sessions should stop only after the majority of design solutions are repeated by different users from session to session.

H3: The age of participants did not produce significant differences in time to completion. This finding demonstrates that a vast number of people could potentially assist with assembling and preparing stairchairs. While this assistance does not equate to the ability to perform the physical tasks related to evacuation (transferring patients and taking patients down the stairs), it does demonstrate that in a circuit-type evacuation, where individuals perform specific tasks to speed up the overall process, older adults can assist to improve performance. Older adults are often not considered in evacuation operations as assistants due to their cognitive and physical limitations, but there may be a potential part of the older adult population that is not being used effectively. All of this points to the importance of instructional design.

Benefits of This Research

Complex tasks such as aviation, driving, and computer interactions have been a topic of human factors research. This research provides benefit to the field in the context of instructional design use with assistive technology in emergencies. There is currently a large push in the assistive technology realm for human factors evaluations of emergency evacuation. The first evacuation stair travel device standard by the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) was just published. This document discusses performance standards across stairchairs and seeks to ensure a level of consistency and quality for individuals with disabilities using these devices and those who are purchasing them. While not dismissing the argument that an individual should be trained to use these devices, the results from this research indicate that given effective instructional design, novice users can quickly learn how to safely and efficiently operate a stairchair. Most importantly, this research addresses the spirit of the question "How can we make our existing stairchairs that we've already purchased more efficient for a novice user in an emergency?" This very question was proposed to the researcher by the former Under Secretary of the Science and Technology Directorate of Homeland Security, Dr. Tara O'Toole. With simplified instructional design, individuals with disabilities can be evacuated more quickly, receive more help, and minimize impact to other evacuees, all of which can potentially save lives.

Study Limitations

This research, although producing some significant and interesting results, did have many constraints related to its design. The experimental environment brings with it shortcomings. Due to IRB regulations it is not possible to subject participants to the environmental stress-inducing aspects of fire evacuation, such as smoke, excessive noise, and panic. Therefore there was not enough similarity to an evacuation situation to be able to predict behavior. This is often the case with emergency research, because it is challenging to artificially create emergencies. The instructions themselves are also designed to facilitate down-the-stairs operation. Since we could not test this part of the instructions due to safety concerns, we had to exclude it. This could mean that there are other characteristics specific to the stair-descent operation and instructional design that we did not identify.

The next limitation is not having access to a larger sample, both in terms of participants and of evacuation chairs. This study was only partially funded, so financial costs had to be weighed against the expected return for the results. There are many other stairchair manufacturers, and given unlimited resources I would have purchased a larger variety of stairchair devices. However, the devices chosen for this study were some of the more common devices used in government buildings and multi-story facilities. For the purposes of the experiment the mechanical operations of each stairchair was assumed to be equivalent. The problem with this assumption is that each stairchair operates differently. For example, the Evacu-trac assembly and use could potentially be reduced to a single instruction, while the other chairs could not. An attempt to control for this was the creation of similar instructions for each device using similar design strategies and numbers of steps. This could explain the existence of post hoc significance after Phase I, but not after Phase III. Iterations of the redesigned instructions appear in the appendixes.

In terms of participant recruitment, there were numerous challenges for recruiting subjects other than young people. Through the UCF SONA system, which gives credit to undergraduate students for participating in research, we were easily able to gain access to the number of young participants we needed. However with older adults we had to recruit from the community: senior centers, community organizations, and organizations on campus. Recruitment was so challenging that members of the dissertation committee had to contribute additional funding in order to incentivize older adults to participate.

Even with financial compensation older adults had objections to participating in the research study. Some objections included poor experiment experience in previous studies, unwillingness to come to the psychology building, unwillingness to participate due to length of time required, and lack of transportation. In hindsight it would have been better to secure the cooperation of a large senior group such as one from a town or county government before engaging in the research. It was expected that older adults would participate for altruistic motives; however, the dramatic increase of participation once compensation was added cannot rule out other motives for participation.

When the study was originally designed the goal was to have a representative sample of all age groups based on U.S. Census data. It quickly became apparent that this was not going to be possible, not just because of the lack of financial incentives, but also because of the inability to recruit middle-aged adults who generally cannot take time out of their working lives to participate. This situation aligns with many other psychology studies in that researchers often rely too heavily on college students due to their being a convenient sample. It is also one of the things that makes aging research interesting yet challenging.

There were also limitations in regard to experimental design. In order to recruit some of our older population we had to go on-site to senior centers. This location consideration created a discrepancy in the characteristics of the environments used for the study. Although every possible effort was taken to ensure similarities of the environment, differences cannot be ruled out.

Each of our measurements most likely contains some sort of measurement error as well. For the time to complete measurement, time was determined through using a stopwatch by a member of the research team, so there could be instances of human error related to the starting and stopping of the stopwatch. Attempts were made to deal with this by also watching videos and checking for consistency of time.

The video recordings used for the study could have had an effect on the number of instructional glances. Instructional glances were determined based on inter-rater reliability among four raters, but that is all dependent on the rater’s interpretation of the participant's eye location relative to the chair. To help accommodate this, a working definition of glance was created: any momentary eye fixation on the instructions.

For the spatial ability test scores an assumption had to be made that participants performed to the best of their ability. However, due to increased complaining by the older adult population it is possible that while the older adults finished the tests they may not have given them their best cognitive effort. There is also a possibility that some of the older adults may have actually belonged in a more traditional middle aged group which may have made the group younger as a whole, limiting significant differences.

Directions for Future Research

This research can be applied to many areas across the fields of human factors, ergonomics, human systems integration, and human performance in addition to its obvious benefits to the emergency evacuation community and the community at large. Designing for novice/older populations can help to improve user interface design and instructional design of vehicle entertainment systems. It can also be applied in the aviation field, specifically with regard to emergency safety briefings and the safety information cards that sit in front of every commercial airline passenger. It speaks to the need to develop new tools to be able to assess cognition in older adults in a quick and easy manner. Boredom and frustration were common complaints throughout the course of the study.

Outside of their direct implementations, these results can also be applied to support individuals with mental disabilities. Simplified and improved instructions can open up new job opportunities and increase worker proficiency, thereby increasing employee confidence and satisfaction. The study also showed how small, inexpensive corrections can be made to existing instructions regardless of the specified topic area. Given an opportunity of any project it would be good to continue this line of research with regard to emergency assistive technologies such as other types of stairchairs, sled devices, and other families of devices, such as those that are used to notify first responders that an older adult has fallen.

All policy change has to start somewhere. People are not going to change their minds about evacuating coworkers with disabilities overnight. Even if they do change their minds, they may choose to evacuate them in a way that is unsafe for all those who are involved. In order to facilitate change, more quantitative research and definitive statistical analyses highlighting the cost benefits of implementing change need to be presented to decision makers. It is with the help of these individuals that we will begin to make a safer work environment for the world of tomorrow.

APPENDIX A: IRB APPROVAL LETTER

University of Central Florida

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Michael W. Boyce** and Co-PIs: **Daniel Fisher, Drea K. Fekety, Janan A. Smither**

Date: **May 22, 2012**

Dear Researcher:

On 5/22/2012, the IRB approved the following minor modification to human participant research until 01/30/2013 inclusive:

Type of Review:	IRB Addendum and Modification Request Form
Modification Type:	Two Co-Investigators added to the study: Drea Fekety and Daniel Fisher
Project Title:	Assessment of Instructional Presentation for Emergency Evacuation Assistive Technology
Investigator:	Michael W Boyce
IRB Number:	SBE-12-08200
Funding Agency:	Paralyzed Veterans Association
Grant Title:	N/A
Research ID:	N/A

The Continuing Review Application must be submitted 30days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at https://iris.research.ucf.edu .

If continuing review approval is not granted before the expiration date of 01/30/2013, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., CF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 05/22/2012 02:25:16 PM EDT

Joanne Muratori

APPENDIX B: STRYKER INSTRUCTIONAL SET VERSION ONE

INSTRUCTIONS

1

1. Push seat down

2

2. Grab red bar at the same time pull up handle

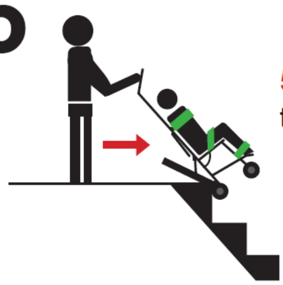
3

3. Pull up head restraint by squeezing on red bar

4

4. Pull back

5



5. I don't know we didnt try this part

6

6.?

stryker®

Rated Capacity: 1 person   Maximum weight 136 Kg (300 lbs)   Maximum chair angle 40°

APPENDIX C: STRYKER INSTRUCTIONAL SET VERSION TWO

INSTRUCTIONS

1

1. Push seat down

2

2. Grab red bar at the same time and pull up handle

3

3. Squeeze red bar to release lower trac downward.

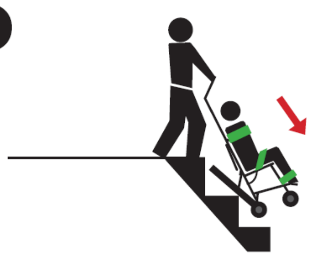
4

4. Pull back

5

5. I don't know we didnt try this part

6



6.?

stryker

Rated Capacity: 1 person   Maximum weight 136 Kg (300 lbs)   Maximum chair angle 40°

APPENDIX D: STRYKER INSTRUCTIONAL SET VERSION THREE

INSTRUCTIONS

1

1. Push seat down

2

2. Pull up red wire
at the same
time and pull up
top bar

3

3. Squeeze red
bar between tracs
to release lower trac

4

4. Transfer and buckle
all three straps

stryker®

Rated Capacity: 1 person   Maximum weight 136 Kg (300 lbs)   Maximum chair angle 40°

APPENDIX E: STRYKER INSTRUCTIONAL SET VERSION FOUR

INSTRUCTIONS

1

1. Push seat down

2

2. Pull up red wire at the same time and pull up top bar

3

3. Squeeze red bar between tracs to release lower trac downward.

4

4. Transfer and buckle all three straps

stryker®

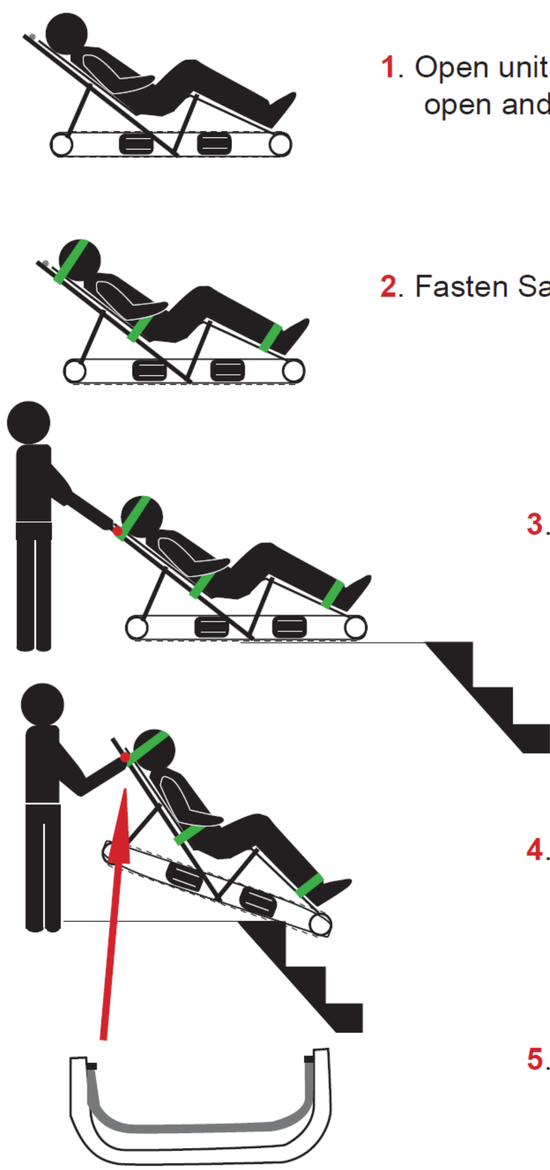
Rated Capacity: 1 person   Maximum weight 136 Kg (300 lbs)   Maximum chair angle 40°

APPENDIX F: EVACU-TRAC INSTRUCTIONAL SET VERSION ONE

INSTRUCTIONS

EVACU-TRAC

1 2 3 4 5



1. Open unit, confirm latch is open and transfer passenger

2. Fasten Safety all three straps

3. Approach stairs at a right angle

4. When front wheels drop off top step, lift handle and incline EVACU-TRAC forward

5. Squeze release bar to descend.

Release brake release bar to stop.

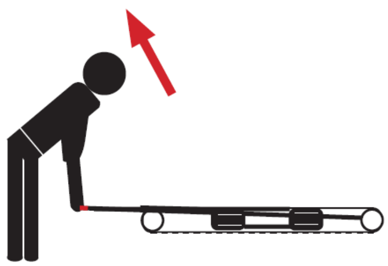
Rated Capacity: 1 person   Maximum weight 136 Kg (300 lbs)   Maximum chair angle 40°

APPENDIX G: EVACU-TRAC INSTRUCTIONAL SET VERSION TWO

INSTRUCTIONS

EVACU-TRAC

1

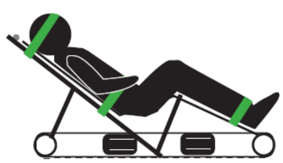


1. Lay flat, grab handle marked red and pull up

2

2. Open unit, confirm latch is open and transfer passenger

3



3. Fasten Safety all three straps, wrap waist straps all the way around to the back

4

4. Approach stairs at a right angle

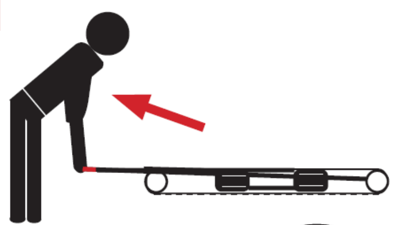
Rated Capacity: 1 person   Maximum weight 136 Kg (300 lbs)   Maximum chair angle 40°

APPENDIX H: EVACU-TRAC INSTRUCTIONAL SET VERSION THREE

INSTRUCTIONS

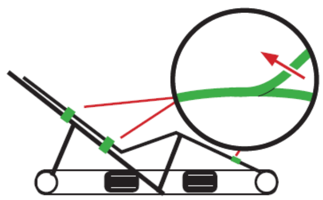
EVACU-TRAC

1



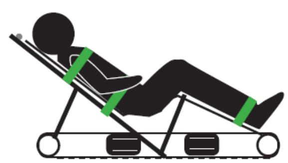
1. Lay flat, stand behind chair grab handle marked red and jerk towards you till feel click

2



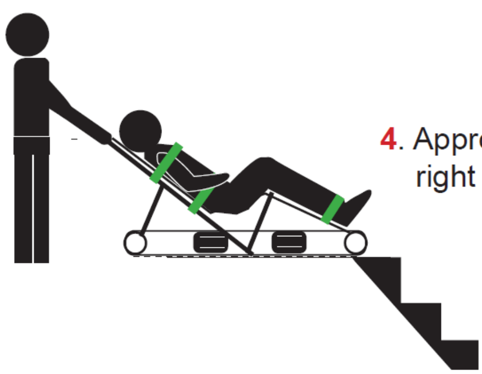
2. Undo velcro straps

3



3. Fasten safety all three straps, wrap waist straps all the way around to the back

4



4. Approach stairs at a right angle

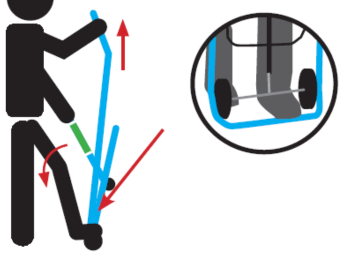
Rated Capacity: 1 person Maximum weight 136 Kg (300 lbs) Maximum chair angle 40°

APPENDIX I: EVAC+ INSTRUCTIONAL SET VERSION ONE

INSTRUCTIONS

EVACU+CHAIR

2



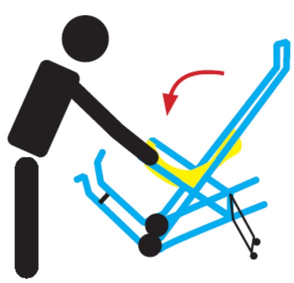
1. **Unbuckle strap first**

2. **Brace foot on bottom bar**
   Pull up handle till self-locks
   ● **Pull back rear bar marked with green sticker**

3

3. **Push small wheel forward with foot to extend out**

4



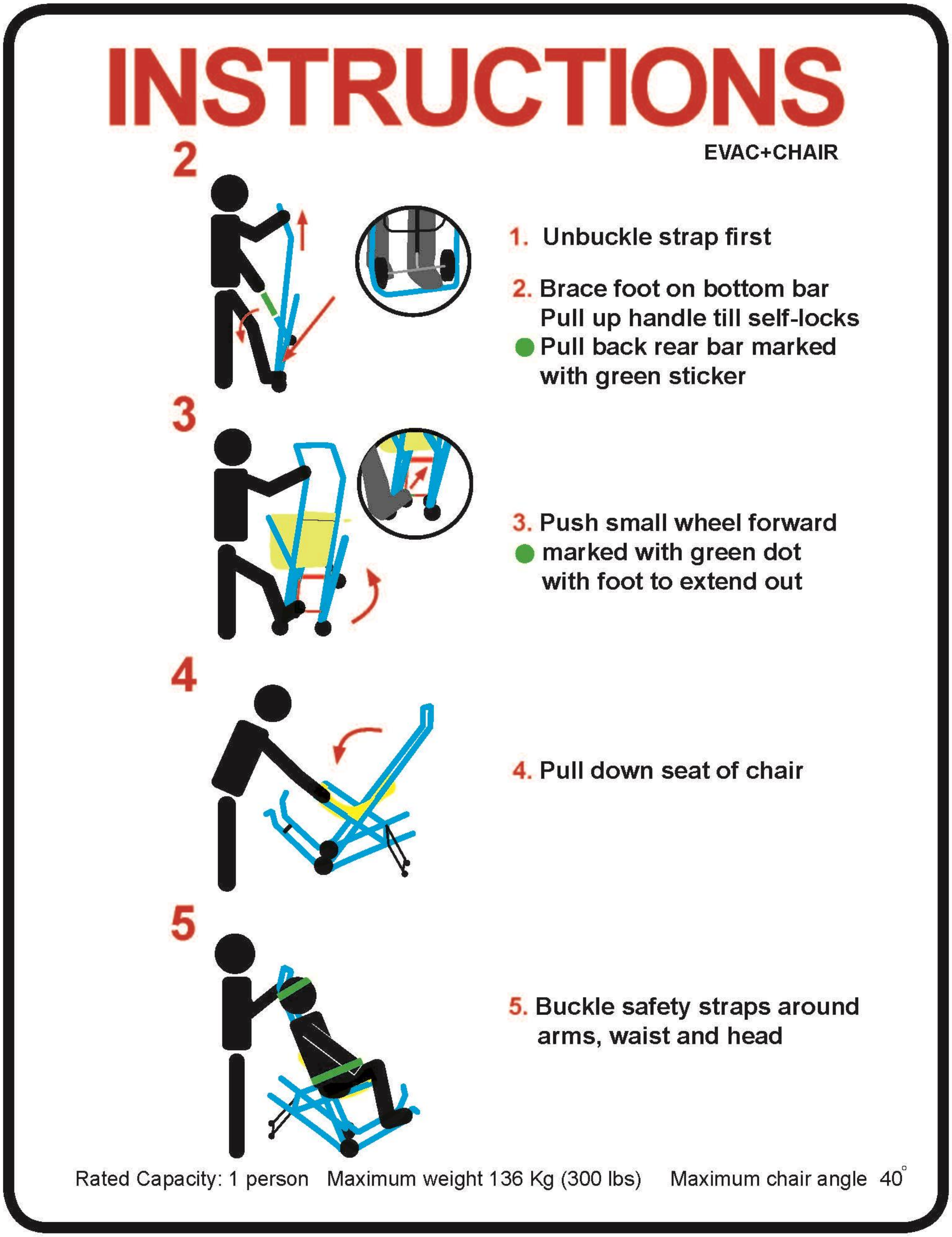
4. **Pull down seat of chair**

5

5. **Buckle safety straps around arms, waist and head**

Rated Capacity: 1 person Maximum weight 136 Kg (300 lbs) Maximum chair angle 40°

APPENDIX J: EVAC+ INSTRUCTIONAL SET VERSION TWO

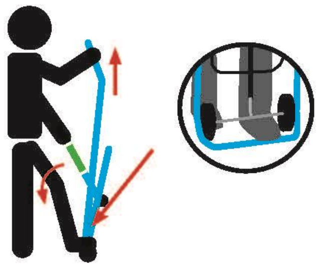

INSTRUCTIONS
EVAC+CHAIR
2
3
4
5
1. Unbuckle strap first
2. Brace foot on bottom bar
Pull up handle till self-locks
Pull back rear bar marked
with green sticker
3. Push small wheel forward
marked with green dot
with foot to extend out
4. Pull down seat of chair
5. Buckle safety straps around
arms, waist and head
Rated Capacity: 1 person Maximum weight 136 Kg (300 lbs) Maximum chair angle 40°

APPENDIX K: EVAC+ INSTRUCTIONAL SET VERSION THREE

INSTRUCTIONS

EVAC+CHAIR

2

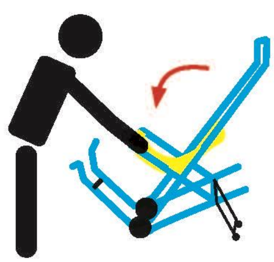


1. Unbuckle strap first
2. Brace foot on bottom bar
   Pull up handle with grip till
   self-locks

3

3. Push small wheel forward
   ● marked with red dot
   with foot to extend out

4



4. Pull down seat of chair

5

5. Buckle safety straps around
   waist and head

Rated Capacity: 1 person   Maximum weight 136 Kg (300 lbs)   Maximum chair angle 40°

APPENDIX L: CONSENT FORM

Assessment of Instructional Presentation for Emergency Evacuation Assistive Technology

Informed Consent

Principal Investigator: Michael Boyce

Co-Investigators: Janan Smither, Ph.D.; Daniel Fisher; Melissa Thye; Kody Schmidt; Adam Gold; Amanda Pagano; Erica Valiente; Sarah Stull; Christina Morsi

Investigational Site: UCF Psychology Building, Room 306.

Researchers at the University of Central Florida (UCF) study many topics. To do this we need the help of people who agree to take part in a research study. You are being invited to take part in a research study which will include about 200 people. You have been asked to take part in this research study because you can help contribute to emergency evacuation safety and disaster preparedness for persons with mobility impairments. You must be 18 years of age or older to be included in this research study. The persons doing this research are Michael Boyce and Dr. Janan Smither.

What you should know about a research study:

- Someone will explain this research study to you.
- A research study is something you volunteer for.
- Whether or not you take part is up to you.

- You should take part in this study only because you want to.
- You can choose not to take part in the research study.
- You can agree to take part now and later change your mind at any point in time.
- Whatever you decide it will not be held against you.
- Feel free to ask all the questions you want before you decide.

Purpose of the research study: The purpose of this study is to assess human-technology interactions with evacuation stairchair devices, which are designed to quickly evacuate persons with disabilities down flights of stairs in an emergency.

What you will be asked to do in the study: After you read this form, confirm that you are 18-years or older, and agree to participate in this study, you will be given a brief vision test designed to measure whether your visual acuity qualifies as 20/40 (corrected or uncorrected). Following this, you will be given an assistive technology product designed for emergency evacuations of persons with disabilities. These devices are commonly referred to as “stair-chairs”. You will be asked to assemble the device, as best you can and as quickly as possible, so that a person with a disability would be able to use it in the event of an emergency situation. We will ask you to prepare this device according to the directions provided with the equipment. In addition to this, we ask that you describe your thought process aloud as you are completing the assembly process. We will be recording your time-on-task during this session in an effort to compare performance among different individuals. This assembly process will require the you to do a small amount of heavy lifting to correctly prepare the device.

Once the assembly session is completed, there will be a debriefing session which will allow you to report any positive or negative feedback regarding your interaction with the device.

Location: This study will take place in the UCF Psychology Building, Room 306.

Time required: Each participant will require no more than 90 minutes in total. For the requirements of this study to be complete, each participant will only have to sign up for one, 90 minute session.

Audio or video taping:

A digital video camera will be used to record each participant's session, and you will be visually recorded on these tapes. The videos produced from these digital recordings will be stored on a secure computer, available for access only by the research investigators you meet today. The purpose of the video recordings is so that the researchers can more specifically measure your performance with the stair-chair devices. These video recordings will be purged from our system and destroyed upon official completion of the study.

Risks:

The risks involved with physical work in this study are expected to be similar to that of operating yard equipment (e.g. pulling an empty wheelbarrow) or assembling/unfolding lawn chairs. This is a minimal risk study and we do not anticipate any risks which are not covered by our safety measures.

Benefits:

As a participant in this research, there will be a cash disbursement to you at any time you decide to end the experiment or at the completion of the experiment. Additionally participants become more aware and prepared for evacuation procedures and emergency safety. Your contributions to our study today will assist a greater field of knowledge being researched within the scope of emergency evacuations and disaster preparedness for persons with disabilities.

Compensation or payment:

You will be paid for involvement in this study when you no long wish to continue or at the completion of the experiment. Participants will be paid 10 dollars for completion of the experiment. If the participant no longer wants to participate prior to completetion of the experiment the researcher will compensate the participant based on time completion: 1.50 US dollar per 15 minutes of the experiment with a 10 US dollar cap.

Confidentiality: We will limit your personal data collected in this study to people who have a need to review this information—i.e only the above named researchers. Your identity will be kept confidential. Your information will be assigned a code. Your information will be combined with information from other people who took part in this study. When the researcher writes about this study to share what was learned with other researchers, he or she will write about this combined information.

Study contact for questions about the study or to report a problem: If you have questions, concerns, or complaints, or think the research has hurt you, you may contact the primary investigator Michael Boyce, by phone at (203) 668-9452 or by email at mboyce@knights.ucf.edu. You may also contact Dr. Janan Smither, the co-investigator, at (407) 823-5859 or email her at janan.smither@ucf.edu.

IRB contact about your rights in the study or to report a complaint: Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF IRB). This research has been reviewed and approved by the IRB. For information about the rights of people who take part in research, please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901. You may also talk to them for any of the following:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You want to get information or provide input about this research.

APPENDIX M: SCRIPT FOR EMERGENCY EVACUATION INSTRUCTIONS STUDY

Example Script Used for the Study

Script for Emergency Evacuation Instructions Study

1. Preliminary Paperwork

- After you bring the participant to 306, have them read through the Informed Consent document (they do not need to sign it), and ask them if they have any questions:

  "The first form I have for you is our Informed Consent. If you could, please read through it and let me know if you have any questions regarding the study."

- Administer the visual acuity test via the OPTEC machine.

  "The next thing we will be doing is measuring your visual acuity. If you have prescription glasses or contacts please wear them for this test and the rest of the experiment."

  - Be sure the OPTEC is on, set to BOTH EYES, FAR, and make sure the dial is on Slide #1 in the FAR position: **"When you press your forehead up against the machine, a series of letters will be presented to you. There will be letters in the left, middle, and right side of the viewfinder. If you don't see three columns of letters please let me know."**
    - If the participant doesn't see three columns, the machine could be malfunctioning. First, check to if you can see three columns through the viewfinder. If you don't see three columns restart the machine and try again.

- Next say **"Please read the lowest row that you are comfortable reading from the middle column."** They should be able to read the "O Z N R" row (or anything below this row) in the "BOTH EYES" column of #1 "ACUITY" - FAR. Refer to the OPTEC accompanying sheets if you get confused. Circle the line they get correct and switch the setting to - NEAR.

- Next say **"Please do that one more time, again read the lowest row in the middle column that you are comfortable reading."** They should also be able to read the "O D S K" row in the 'BOTH EYES" column of #3 "ACUITY – NEAR"

- Administer the colorblindness test via the OPTEC machine. On the OPTEC, press the FAR/NEAR button to switch the slide back to FAR. Then press the FORWARD button to switch to Slide #2 for the colorblindness test.

  - Next say **"This next test will test for colorblindness. On this slide you will see 6 circles labelled A through F. In each circle, there will be colored dots that form the shape of a number. If you do not have colorblindness, these numbers should be plainly clear to you. I want you to tell me what the number is for each circle, and if you are unable to see one of them just say 'blank'."**

  - Refer to the OPTEC scoring sheets for correct answers. Participants should be able to correctly answer all 6 circles, including the last one (F) which is blank. It should be obvious from their results whether the participant displays colorblindness.

- Bring the participant back to the center table and administer the Bennett Mechanical Ability test. **"This multiple-choice test will measure your understanding of mechanical forces in**

practical applications. Read through the instructions on the first few pages and let me know if you have any questions before beginning."

- Make sure the participant's number (refer to code sheet) is clearly printed on the Name line at the top of the document.

- When they are finished with the Mechanical Ability Test, administer the Spatial Orientation and Visualization tests and give these instructions. Have your stopwatch ready before giving them the test.

"The next series of tests will measure your ability to interpret different configurations of visual objects. The total amount of time you will be given to complete this packet is about 45 minutes, but it is unlikely that you will need this full length of time. There are instructions and practice problems printed before each of the 5 tests in this packet. Read through the instructions and practice problems, and do not skip to further sections without permission."

- Make sure the participant's number (refer to code sheet) is clearly printed on the Name line at the top of the document.

- Pay attention to when the participant gets to "stop"s in the instructions. You will need to cue the participant to begin each portion of the test as per the documents instructions. When you tell the participant to begin, start the stopwatch and make sure that the participant does not go over the allotted time for any given section.

- When the participant has completed the 5 tests, gather their paperwork and begin reading instructions for the main stair-chair assembly portion of the session (see below).

<u>2. Setup for Experimental Equipment</u>

- <u>Video Cameras</u>: There are two video cameras in use for the experiment, a Toshiba HD cam and a Samsung standard definition camera. Make sure both of these devices are plugged in and have sufficient storage space for the video recordings required.

- <u>Stopwatch</u>: Have the stopwatch cleared and ready to time the participant's performance when they are told to start.

- <u>Evacuation Chair</u>: Designated evacuation chair will be listed on the coding sheet. Be sure to retrieve the appropriate evacuation chair prior to the participant arriving and placing it in the cabinet (Stryker instructions face out and wheels resting on the ground; EvacuTrac with blue seat facing outward and large wheels resting on the ground)

- <u>Observation Notebook</u>: There will be two experimenters for each experimental session. *If two people are not available for testing, the participant needs to be rescheduled.* One experimenter's job is to record observations related to the chair assembly. The individual performing the observation should be looking for the following activities (Pershing, 2007; Robson, 2002):

  - <u>Actions</u>: Specific, individual actions performed by participants during the course of the observation that may be recognized - what is the person doing?

  - <u>Actor Goals</u>: The explicit objectives given by participants related to their final target outcomes - what objectives do they mention?

- ○ Chronology: The order in which the observed activities and actions take place during the larger observation - what order are things done?

- ○ Emotion Expression: Expressed utterances of emotion or feelings related to activities, actions, goals, events, other participants, etc. - what expressions do they have?

3. Stair-Chair Assembly

- Read the following instructions to the participant, in preparation for the assembly session: **"You will now be asked to interact with a stair-chair as if you were in a real emergency situation. Your task is to locate the chair inside the grey cabinet beside you [point to the cabinet], take it out, and place it directly on the yellow X on the floor.**

"You will then assemble the stair-chair as quickly as possible, using the visual instructions attached to the device. It is up to you to find these instructions on the device and interpret them correctly. You will be timed during this assembly session, so time is of the essence.

"Because you are pretending this is an actual emergency situation where lives may be at risk, you need to prepare this device in a way that allows a person to sit in the chair and be strapped in securely for an evacuation.

"While you're assembling the chair, we want you to verbalize your thought processes. Any and all ideas that come to mind while interacting with it should be said out loud. This will help us understand what is going through your mind as you try to assemble the chair.

"It is your job to verbally let us know when you have assembled the chair so that it's ready for me to sit in it. Say the word "SIT" when you have reached this point. If you say "SIT", but the chair is incorrectly assembled, we will ask you to continue until it's correct. I will sit in the chair once you have correctly assembled it and said "SIT". Once I am seated, you will then secure me in the seat with the safety straps attached to the device.

"Your session will be completed and the timer stopped when you have successfully assembled the chair, strapped me in to it, and you say the word "DONE" aloud. If you say "DONE", but it is not finished, we will tell you to continue. Do you have any questions?"

○ Remember to stop recording from both cameras once the session is over.
○ Remember to write down the time from the stopwatch before continuing with post-test paperwork.

4. Post-Test

- Administer the NASA-TLX on Drea's computer via Dropbox ("Evacuation Dissertation Research"--> "NASA-TLX Results"--> "NASA-TLX.exe"). Enter the participant's number and let them fill out the surveys. Give them clarification if needed. The program will save the data into an Excel spreadsheet on its own.

○ **"For Part 1 of the NASA-TLX, you will be asked to indicate your answer on the scale for each of the items. Keep in mind that this test is specifically focused on your interaction with the stair-chair device, and no other part of this test."**

○ **For Part 2, you will see a pairing of some of the items from Part 1, and you will choose whichever one was most influential or most significant during the assembly of the chair."**

    - Participants will often ask what “Temporal Demand” means. It refers to “How hurried or rushed was the pace of the task?”

    - Participants will also sometimes get confused on the “Performance” item on the list. Tell them that it’s asking “How successful were you in accomplishing what you were asked to do?”
        - This item’s scale is also backwards on the screen (“Success” on left; “Failure” on right).

- Administer the “Evacuation Instructions Experiment Post-Test Form” via Google Docs. In the document, go to the “Form” tab up top, then click “Go to live form”. The instructions on this survey will be self-sufficient.

- Have the participant read through the Debriefing form and allow them to ask any questions they have about the study and its objectives. Make sure they are aware that they can contact Michael for the results of the study once it’s completed. Allow the participant to keep the Debriefing form if they would like to.

- Have the participant fill out the exit survey for SONA (Psychology Research Experience Evaluation Form for Participants). Direct the participant to the front desk to turn in the form once they are completed. The participant will also be dismissed at this time.

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