Making Assistive Technology and Rehabilitation Engineering a Sure Bet

The Wolverine System: A Stabilization System for Ataxic Hands

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ABSTRACT

Ataxia is a dysfunction of the nervous system that makes gross muscle movement difficult. For our client ataxia manifests itself in uncontrollable tremors in his left hand and arm that make tasks such as typing and eating difficult. Our team was charged with the challenge of enabling a left hand dominant man with left-handed ataxia to type more easily. The system consists of a glove and wrist stand, combining both pressure and bracing to limit the shaking. On the top of the glove an air bladder and metal strips work cohesively to exert pressure on the fingers. A platform that secures the gloves with Velcro prevents involuntary motion from the wrist and arm. The end combination resulted in a system that would limit the shaking of the hand, wrist and fingers (see Figure 1).

KEYWORDS

Ataxia, Stabilization glove, Wrist stand

INTRODUCTION

Ataxia inhibits the ability of people to perform daily activities that others may take for granted. Simple tasks such as typing and eating become a trial. The client's ataxia causes shaking in his left arm, hand and wrist. This shaking makes fine motor movements, such as bringing a spoon to his mouth or pressing the correct key on a keyboard, nearly impossible. Hampered in these regards the client's quality of life is negatively impacted.

Currently in the market, very few items specifically target the client's issue. Analysis of a variety of products including weighted utensils for eating, gyroscopes and computer controlled hand guides for doctors in surgery, proved all to be inadequate or unfeasible as resources for the project. Our team realized that there is a market for a device to meet our client's needs in a more inexpensive, comfortable and relatively aesthetically presentable device to aid in eating and typing.

The design is focused on the improvement of the user's typing. To aid the user, the device consists of a system composed of a glove and wrist stand. This system assists the user by:

- Stabilizing the wrist and limiting involuntary tremors by using Velcro attached between the glove and a wooden platform
- Using brass strips within the fingers of the glove to oppose the involuntary movement of the fingers

- Exerting pressure on the extensor tendons with an air pocket to reduce involuntary movements of the hand.

The following report provides details about the user, requirements for the design, the design concept and its function as a solution to the proposed problem. The limitations of the design will also be outlined as well as possible solutions our team has brainstormed.

USERS AND REQUIREMENTS

The main stakeholder of The Wolverine System is our user Grover Cleveland Hunt Jr.

- He is an 83 year old male
- He has been afflicted with ataxia since suffering a stroke in 2008
- Due to severe shaking in his left arm and hand he is unable to type properly

G.C. has attempted various methods to deal with the tremors before he sought our help. By supporting his left hand with his stable right hand he was able to perform most tasks that only require one hand, which includes eating and shaving. He was not able to come up with any alternative method to type effectively other than to backspace often.

After meeting with the client Anne Marie Ryan and the user G.C. Hunt, we were able to devise the following list of requirements based on the user's needs and preferences:

Stability

- Device must increase typing accuracy to around 80% so that what he types is legible.
- Device must stabilize the left wrist enough so that the hand is held steady on the keyboard.

Ease of Use

- Device must be able to be attached independently by the user.

Comfort

- Device must be able to be worn for 1-2 hour periods.
- Device must not collect sweat and become uncomfortably moist.

Portability

- Device must not weigh more than five pounds.

Aesthetics

- Device must be simple and discreet to please the user.
    - Color should be black.

- Device must fit within the confines of the user's home office space.

We took all of these requirements into consideration when formulating our design and used them to guide the design process.

DESIGN CONCEPT

The design is a system comprised of two pieces that work in conjunction with one another—a glove and a wrist stand. Each part addresses a need of our user. The purpose of the glove is to stabilize the user's fingers so that he is more likely to hit the correct key. It is a fingerless glove that leaves his fingertips free to type, however it incorporates opposing tension that is created by brass strips and pressure that is exerted by an attached air pocket. The wrist stand is fairly simple in design, just made from a piece of wood that serves a similar purpose to a mainstream keyboard wrist support. However, it was tailored to our user by adding Velcro to the side where his left wrist will rest. This corresponds to a piece of Velcro on the bottom of the glove and will hold the user's wrist in place while he types.

DESIGN RATIONALE

The design is a combination of several different components we discovered during user testing that each made a small impact on the user's shaking. Every piece was tested in isolation and once we saw which made an impact we tried combining them in different ways to come up with the most effective design.

During the first user testing we tried a multitude of ideas ranging from compression of tendons to finger tension and from typing devices to eating devices. After that round of testing we had decided to move forward with a design that was a combination of several of those isolated ideas that help us to meet our requirements.

For the glove we combined:

- A compressed air pocket
- A flexible metal skeleton for the fingers
- A tight, fingerless glove

During our initial mockup testing we realized that user's lack of consistent typing skills was hampering the test for accuracy. So in our second round of testing we had the user type letters individually, which kept him focused on the typing rather than other aspects such as grammar. It was difficult to prove the effectiveness of our device when the user was told to type full sentences. However, when the user was told to type letters individually he was able to type eleven out of sixteen letters for an accuracy of 68%. This was an enormous increase from his accuracy at our initial testing, which we tested about 15%. In all observations we were able to see a decrease in the shaking when our device was put on.

Glove

The glove was used as a tool used to encompass multiple parts of our device into a single unit. The type of glove that was used in the prototype was chosen because it fulfilled the comfort requirements. It was

a plain work glove, elastic and reinforced with leather. When the user was told to rate the glove on comfort he gave it a 4.5 out of 6 (see Figure 2).

Figure 1. Final Prototype showing the glove and platform attached with a keyboard as a reference.

Tensile Skeleton

The point of this aspect of the device was to create tension for the up and down movement of his fingers. After tests during the User Observation we deduced that despite the shaking his hand still had full strength. Therefore we felt comfortable creating a device that made him work to move his fingers. Since he had to do more work, we noticed, he was focused on hitting the keys and did it more accurately.

The brass metal strips were chosen for their degree of flexibility. After testing several types and thicknesses we determined that .013 cm was the optimal thickness. Initially spring metal was our optimal material, but then we discovered brass strips which provide more stability and hold their initial shape for longer. Each strip will bend approximately 2 inches when 2 pounds of force is applied eight inches from a fixed point along the strip. The ½ inch wide strips were also the right width to lie over a finger without obstructing movement. The length of each of the strips was determined by calculating the length from the tip of each of the user's fingers to his wrist.

Compressed Air Pocket

This is the part that gave the most obvious improvement. Since this pocket compressed his extensor tendons, it too made the movement of his fingers more difficult. And since they could not move as easily, we noticed during testing, they could not shake as much either. This is a similar idea to Anne Marie Ryan's Styrofoam design. During the client meeting, she took time to discuss how having that piece on his hand improved the shaking. We took that idea and decided to go with compressed air to make it more comfortable and even more effective. So this piece of the device made the greatest improvement in the reduced shaking of the fingers.

Wrist Stand

Use of this wrist stand also showed great improvement during User Testing. A major problem that the user had was that he could not even keep his hand still on the correct area of the keyboard. This created

a problem immediately, because if he was not anywhere near the keys, there was no chance of him hitting the right ones. As soon as we strapped his wrist down, we saw immediate improvement. Though he was still not hitting all of the right keys, he was hitting keys in the right area which was massive progress.

Velcro was chosen as the method for the attachment of the glove to the stand because it was the easiest way for the user to get his hand on and off the device without assistance (see Figure 3).

Figure 2. The prototype glove.

DESIGN LIMITATIONS

The final product design does not completely fulfill the requirements given by the user because of complications faced in the design process. One of the most difficult challenges encountered while trying to create a device to improve the user's typing was his inability to type accurately – even with his unaffected right hand. This problem indicates that the user's ataxia may not be the only issue that needs to be resolved in order for typing accuracy to be improved.

One option that our group considered was a larger keyboard with more spacing between the keys. During User Testing we tried this idea out by having him hit "keys" on a paper keyboard we had drawn out to size. This worked well, however due to time constraints and the user's unhappiness with the idea, it never came to fruition. It is something to consider for the future, though. While this testing proved somewhat effective in allowing the user to type more accurately, his typing was still not perfect.

Future Options to Consider:

- Larger keyboard
- Voice recognition software
- User interface involving just a mouse

CONCLUSION

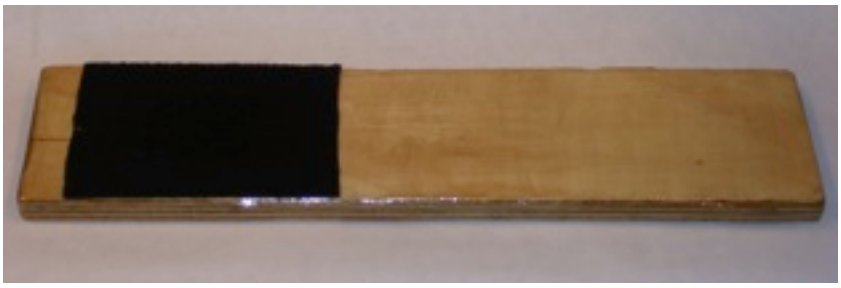

Figure 3. The prototype wrist platform

The user required that our group create a device that was able to prevent his tremors while fulfilling criteria that include: aesthetics, stability, ease of use, comfort and portability. To fulfill these criteria we created a system of components that together make up the design. The glove we created has many unique features that address different user requirements as well as some unstated requirements. Some of these features include:

- Pressured air bag against extensor tendons
- Copper metal strips along back of fingers
- Exposed finger tips, by removing tip of glove
- Elastic Straps with velcro adjustments
- Comfortable foundation in glove

By attaching the glove to the stand we were able to also prevent involuntary wrist movement. Each component and feature of the design was proven effective through multiple rounds of user testing. The design meets the requirements set forth by the user while also statistically increasing his typing accuracy to 68%. Much of this success is due to the two-part system, which allowed us to more effectively isolate the different manifestations of the user's shaking.

The user's typing ability will be greatly increased through the use of our system given the fact that he will be able to type when his hands are steady. In our testing we sometimes noticed that some of the difficulty he experienced while typing was related more to his focus than his physical abilities. We had the best results when we convinced him to slow down and focus on each letter instead of rushing through sentences.

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