The Leve-spray

EDC Design Project
Section 20, Team 2

Bob Brickey, Chris Chen,
Zachary Kozberg, Tim Zwiebel

Professor John Lake
Professor John Anderson

Table of Contents

List of Figures

List of Tables

Executive Summary

Our goal was to enable a bilateral amputee to use aerosol hairspray with a minimum of effort and trouble. The intended user has a pair of prosthetic forearms with hooks. One pair of hooks is straight and curved and the other is canted and curved.. In trying to use an aerosol hairspray unassisted, the user has three main problems. The user has trouble holding the can without it rocking back and forth. The user has very little ability to tell where the spray is pointed, and the user cannot actuate the spray when holding the can. Use of aerosol hairspray is one daily activity that our user hopes to be able to do without the help of others. To summarize, there is one engineering problem, actuating the spray, and two user interface problems, holding the can and telling where the can is spraying.

In the design concept, a rubberized sheath provides a gripping surface for the user's hooks, while a polycarbonate lever attached directly to the sheath provides a downward force to actuate the nozzle. The polycarbonate lever also provides a large visual cue for the user to determine the direction of spray. A nylon pull-string with multiple loops for optimal pulling at certain positions around the user's head is used to pull the lever. The entire assembly is simple, easy to use, and straightforward. There is only one moving part, and maintenance and cleaning is very easy. The device is also fully capable of being mounted onto many sizes of can, providing the user flexibility in hairspray choice.

Our research for this project focused on a client interview, a user observation meeting, and some general web research. We learned about how the user's specific set of prostheses work and the limitations in the user's range of motion and ability to actuate a device. We also found some information about how the aerosol cans work.

Alternatively, the secondary designs included a hose attachment to greatly extend the range of the range of the spray, a clamping system which relied on a squeezing action to compress the can as a whole, a tracked compression device which operated in much the same way, but in tension rather than compression, and an extremely simple lever design consisting of a bolt attached to the nozzle and a pull-tab.

After user testing, many of these alternatives were abandoned due to the difficult nature of their operations. In most cases, the simplest designs typically made better alternatives, leading to our selection of the integrated lever design, or “Leve-spray.”

Further improvement on the Leve-spray could include a better machined lever portion to reduce side to side movement of the lever and a method for rotating the nozzle and the lever without having to put the device down.

Introduction

Our goal is to enable a bilateral amputee to use aerosol hairspray with a minimum of effort and trouble. The intended user has a pair of prosthetic forearms with hooks. One pair of hooks is straight and curved and the other is canted and curved.. In trying to use an aerosol hairspray unassisted, the user has three main problems. The user has trouble holding the can without it rocking back and forth. The user has very little ability to tell where the spray is pointed, and the user cannot actuate the spray when holding the can. Use of aerosol hairspray is one daily activity that our user hopes to be able to do without the help of others. To summarize, there is one engineering problem, actuating the spray, and there are two user interface problems, holding the can and telling where the can is spraying.

- To actuate the spray, the user must somehow apply force to a mechanism that will press/push the spray nozzle. The force that the user applies must be transferred into sufficient force to press/push the spray nozzle. The user must not need to apply excessive force to actuate the spray.
- To hold the can properly, the interface between the user's hooks and the can must be changed. There is too much wiggle room at this interface and not enough grip between the hooks and the can surface.
- To determine where the can is spraying, the user must have some sort of visual cue from the device.

Our device, the “Leve-spray,” is able to overcome all three problems faced by bilateral amputees in using aerosol cans. Our device is specifically built so that it fits on Suave hairspray cans, but its design can be easily transferred to cans of different sizes and spray nozzles. To solve the three problems, it has three solutions

- A lever that actuates the spray nozzle with a downwards force
- A rubber grip material that prevents the can from moving while being held by the user
- A pull-string that translates a pulling forces into a downward force on the lever

After a detailed overview of the design of our device, including its components, functions, assembly, and use, this report explains the background research that we conducted before designing the device and the progressive sequence of designs in the form of mockups and prototypes that were considered in the development of a solution. This report ends with suggestions on how to improve or further develop our device in order to improve its functionality and performance.

Design Concept

Our design, the Leve-spray, is able to overcome the difficulties that bilateral amputees face when using aerosol hairspray.

Components

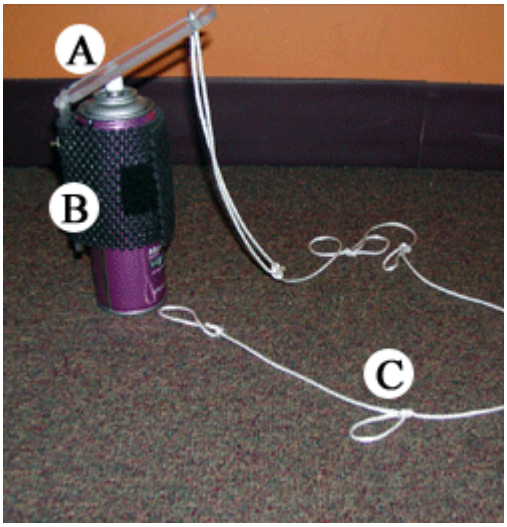

Figure 1: Labeled picture of the Leve-spray

- *Lever (A).* The lever is made of polycarbonate. It is about two inches long. One end fits inside the rubber gripping sheath and the other flips out over the can. There is a hole for the pull-string at the end of the lever.

- *Rubber gripping sheath (B).* This is made of a rubber mesh often used to line bookshelves to prevent books from slipping. In this application, it is cut down to two-thirds the height of a aerosol can. The piece is long enough to wrap around a can and have a slight overlap. Multiple strips of Velcro are used to secure this in place.

- *Pull-string with multiple loops (C).* The pull-string is made of a thick nylon string that has multiple loops in it. It is connected to the end of the lever.

Function

Each of the components of the Leve-spray play a role in solving the three problems in this project.

Table 1: Problems, the components, and how they solve the problems

Problem	***Component***	***Solutions***
Actuating the can	Lever Pull-string	The lever is the mechanism that presses downwards on the spray nozzle to actuate the spray. The pull-string translates a pulling force into a downwards force on the lever end.
Holding the can	Rubber gripping sheath	The rubber is a surface with much more friction than the metal can, allowing the user to grip the device securely without slipping.
Directing the spray	Lever	The lever is a large visual cue that gives the user an approximation of where the spray is directed. The direction of the lever is the direction of the spray.

Assembly

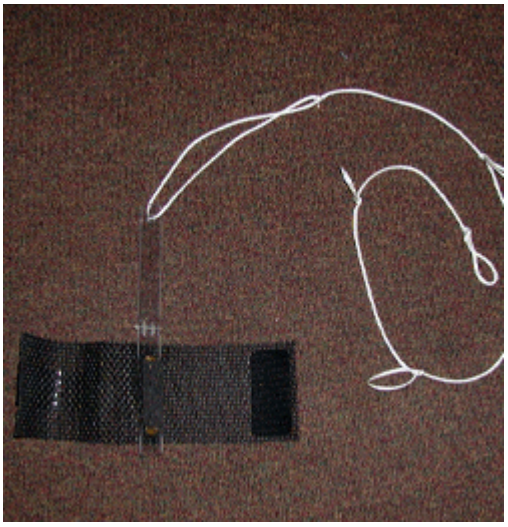

Figure 2: Leve-spray detached from a can and laid flat

The rubber gripping sheath is the component that holds everything together. It is 3.75 inches in length and 1 foot in width. Velcro strips on the ends of the sheath allow the sheath to be wrapped around cans of multiple sizes. The next component, the lever, is bolted to the

The lever is the mechanical component of the device. It consists of two polycarbonate pieces, each about 5 inches in length and 0.75 inches in width. They are connected with a plastic bolt through holes on the connected ends of the two pieces. Two polycarbonate fitted portions and a solid rubber piece provide a non-slip interface with the can surface. The top portion of the lever is the portion that comes into contact with the spray nozzle. There is a round hold drilled through the end of it, through which the pull-string is tied.

The pull string is four feet long with about 6 inches between each loop.

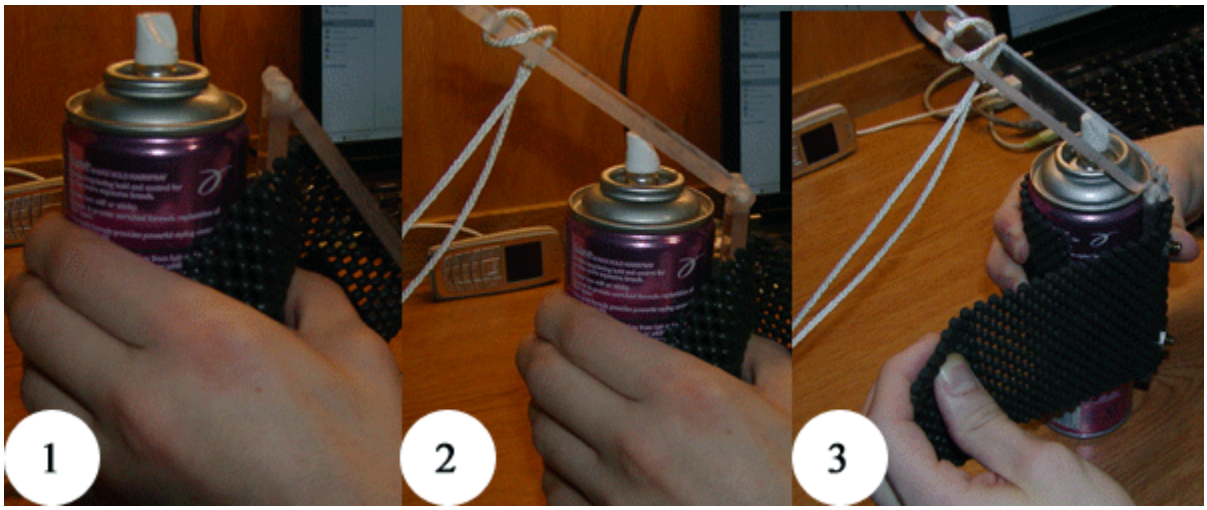

Figure 3: Steps for the installation of the Leve-spray

The Leve-spray can be installed in three steps. First, place the lever against the surface of a can. Second, align the lever with the spray nozzle, making sure that it points in the direction of spray. Last, wrap the rubber gripping sheath around the can and fasten the Velcro.

Replacement of the Leve-spray only requires the additional step of undoing the Velcro before installing it on a new can.

Use

To use the lever-sheath, the user must:

1. Grip the can around the rubber grip sheath and pick up the can
2. Grab one of the loops on the pull-string
3. Maneuver the can into spraying position
4. Pull the pull-string

Figure 4: Gripping the rubber grip sheath

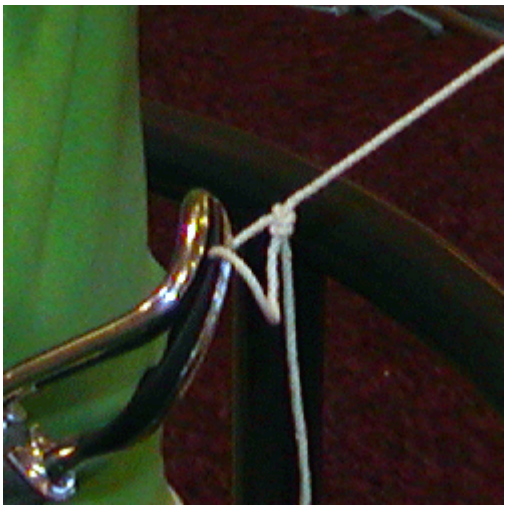

Figure 5: Grabbing the loops on the pull-string

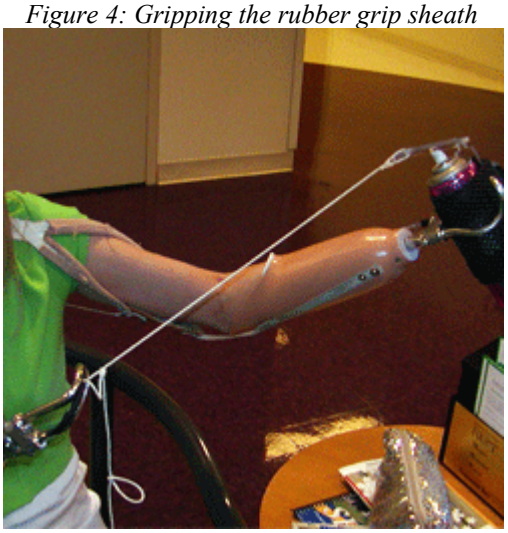

Figure 6: Moving the can into spraying position

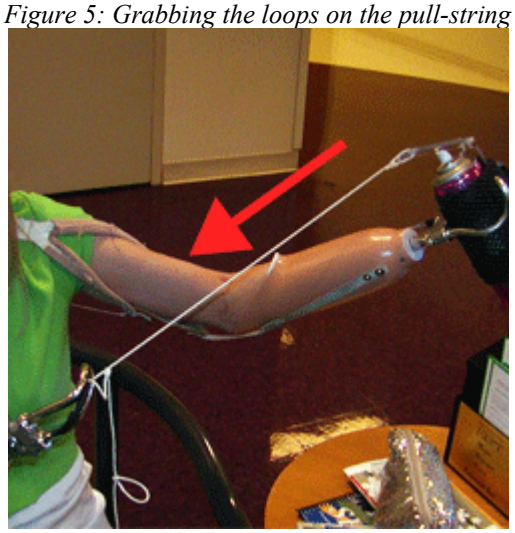

Figure 7: Pulling the pull-string

Background Research

Methods

We obtained information for our background research from three sources: a user observation session, a client meeting and interview, and web research.

User Observation

We held an observation session with Erica Vanzui on January 23, 2006 at the Rehabilitation Institute of Chicago. We asked questions and watched her interact with spray cans while unassisted. We were able to learn almost everything we needed to about the problem and the constraints on the solution that we would develop. Erica explained how her prosthetic hooks are opened and closed and demonstrated their use.

Client Meeting

A client meeting took place on January 17, 2006 with Mike Hirsh, an employee at the Rehabilitation Institute of Chicago. He introduced the problem to our group, showing videos and answering questions that gave insight into the scope of the problem and the range of motion that our user is capable of.

Web Research

We were able to obtain a large amount of general information about prosthetics and aerosol spray cans. The site that proved the most useful was a "How Stuff Works" article concerning aerosol spray cans that explained the general concept behind the cans and how much could be modified to achieve our design goals.

Findings

Prosthetics

There are distinct limitations to the prosthetics of the user that were not anticipated.

- *Cost*. Extensive modification of existing prosthetics unlikely, as they are custom made.
- *Range of Motion.* The user has full range of motion around her head, but has difficulty opening the hooks on her prosthetics.
- *Wrist*. The user has very little control of her wrists with only one hand; two hands are required: one for holding something and one for moving the wrist.

- *Direction of Actuation.* The hooks are at rest when closed and exerting full force. The user must apply tension in order to open her hooks.

We learned a lot about Erica's specific set of prosthetics

- *Curved hook.* This is a traditionally curved hook, capable of grabbing many things, attached to her left arm. The user favors this hand for holding the aerosol can. This grip is not perfect for holding a can however, without a grip of some sort, the can slips and moves while held.

- *Canted hook.* This is a slightly slanted curved hook. It allows the user to perform tasks such as writing. The user demonstrated that she is able to hold a can in these hooks almost as stably as the curved hooks.

- *Wrist*. The left wrist has no mechanism for wrist manipulation. The right wrist has buttons that allow the user to apply tension via her shoulders to manipulate her wrists. There are separate buttons for rotation and bending.

- *Mechanics.* Erica is able to apply tension through wires by moving the position of her shoulders. This allows her to open her hooks, which are closed at rest, and for her to rotate and bend her right wrist.

Spray Cans

There are variations in the types of aerosol cans available on the market today.

- *Size*. Many sizes of cans are available, from small travel sizes to large industrial sizes used for household application of pesticides and cleaners.

- *Tips*. Cans have different variations on the tips and buttons for actuating the aerosol spray, varying from a large button to a small, traditional tip with atomizer. Tips are also available on the aftermarket, primarily intended for spray-painting.

- *Direction of actuation.* Cans with traditional tips actuate with surprisingly little lateral force while not working with vertical force. Other cans with large buttons, such as those found on shaving cream, require downward force.

Implications for Alternatives

Actuation

While spray cans are usually thought to activate with a completely downward force, it

turns out that it is easier to actuate an aerosol can with diagonal force. The user has no possibility of actuating the aerosol can herself safely and consistently without assistance.

Aiming

The user has no ability to tell where the spray nozzle is pointed precisely in many positions, including but not limited to behind her head. This is due to the fact that the user cannot tell the direction of the nozzle with tactile sensation.

Gripping Ability

The user is capable of holding a spray can with her prosthetics, however the can is not totally secure when held on its own. The can sometimes slips, changing the angle of spray. The user is capable of applying approximately three pounds of force.

Range of Motion

The client meeting and user observation showed that the user has a larger range of motion than previously expected. She can easily reach all the way around her head, including the back side. It is unnecessary to design around improving the client's own range of motion because it is already more than adequate for the task of using hairspray.

Alternatives

Concepts

In determining different design possibilities for our device, we focused on the following questions in a brainstorm session.

> Will the user be able to hold the device and actuate it at the same time?
> There are two possibilities for a solution to the problems: a one-handed solution that can be activated and operated with a single hook and a two-handed solution that would be held with one hand and activated with the other. A one-handed solution would have to utilize the opening action of the user's hooks to activate the device. A two-handed solution has more possible design options.
>
> How will the spray be delivered?
> The spray originates at the tip of the can nozzle. One way to modify where the spray originates would be to attach a wand or hose with separate tips to spray away from the can. Another way would be to attach the can to the end of a device that would be actuated at the other end.
>
> How will the user actuate the spray?
> For a one handed-solution, the actuation method is limited to the opening action of the hooks holding the can. For a two handed solution, the user could manipulate levers, buttons, strings, and other mechanical devices.

We developed a generation of diverse mockups to test various answers to these questions.

Table 2: Overview of Mockups

Name	***Grip***	***Actuation***	***Description***	***Picture***
Track Trigger	One-handed, can held in sleeve supported by user's hooks.	Opening of user's hooks	Opening of user's hooks presses down on a metal bar	 *Figure 8: Track trigger mockup*

Name	*Grip*	*Actuation*	*Description*	*Picture*
Foam-core Lever	One-handed, device attached to the user's forearm	Movement of user's wrist	Large foam-core receptacle with a spine and a lever	 *Figure 9: Foam-core lever mockup*
Clamp		Pressing the trigger	Bar clamp with a duct tape mounted can	 *Figure 10: Clamp mockup*
Hose	No-handed, can mounted to flat surface.	Pushing the end of the hose attached to the nozzle	Spray goes through the hose and out through the tip	 *Figure 11: Hose mockup*

Name	*Grip*	*Actuation*	*Description*	*Picture*
Lever	Two-handed, can held in user's hooks with a rubber grip	Pull-string	Balsa wood lever	 *Figure 12: Lever mockup*
Bolt		Pull-string	Long metal bolt glued to a nozzle tip	No picture available

We were able to bring most of these mockups to the first user testing.

First User Testing

We met with Erica at the Rehabilitation Institute of Chicago for our first user testing with our mockups. Afterwards, we came to the following conclusions:

- A one-handed device would be too difficult to build. Erica does not have enough dexterity with her hooks to easily actuate them while moving her arms behind her head. In addition, the method for attaching the device to the hooks would likely be too weak if the hook had to provide both the holding and pressing actions.
- The Clamp and Foam-core Lever mockups were too hard to mount on Erica's forearm. Bulk and weight were large design problems with both of these alternatives; it seems a smaller, lighter design is superior.
- Erica prefers simple designs, such as the Bolt.

For more detailed information about user testing, refer to Appendix B.

After the user testing, we were able to come to these conclusions about our mockups:

Table 3: Mockup Evaluations

Name	***Strengths***	***Weaknesses***
Track Trigger	• One-handed design • Simple actuation method	• User had difficulty using the one handed mechanism • Requires a great deal of force
Foam-core Lever	• One-handed design	• Connection to user's forearm didn't work • Hard to actuate
Clamp	• Pre-existing mechanism	• Heavy • Oversized • Hard to for the user to hold • Have to modify actuation method
Hose	• User doesn't have to hold the can • Lower weight • Potentially easier aiming	• Leaks • Delay in spray • Potential of clogging • Device falls off can from time to time
Lever	• Simple mechanism	• Too fragile with balsa wood
Bolt	• Simple • Lightweight • Easily actuated • Bolt direction can be used to determine spray direction • Pull-string directed towards user, preventing extra strain	• Forced to connect nozzle permanently to bolt

The Track Trigger, Foam-core Lever, and Clamp designs did not work as well as expected. In particular, the user did not like the fact that the Foam-core Lever and the Clamp would have to be mounted on her arm every time she wanted to use the device. We decided that we would not continue developing the designs.

At this point, we were really interested in the Bolt and Hose designs. However, the Bolt mockup had several problems: the bolt had to be permanently connected to a nozzle, the bolt could be used to break the nozzle tip, and the bolt could be actuated too easily. In addition, the the bolt could be used to apply enough leverage to break the tip on the aerosol can. The Hose mockup showed a lot of promise, but there were a lot of engineering problems to solve in connecting the hose to the tip and the nozzle.

We also were able to develop a new mockup based on our experiences with the Lever, Foam-core Lever and Bolt designs.

Table 4: Lever-cap Mockup Information

Name	***Grip***	***Actuation***	***Description***	***Picture***
Lever-cap	One-handed, can in user's hooks	Pull-string pulls the lever downwards onto the nozzle	Modified aerosol can cap with a lever and a rotation bar	 *Figure 13: Lever-cap prototype*

The Lever-cap combined of the functionality of the lever-based mockups. It is a pull-string and lever based mechanism installed into a modified aerosol can cap. The direction of the lever, like with the Bolt mockup, indicated the direction of the spray. The pull-string, also like the Bolt-mockup, would be pulled towards the user, preventing excess strain when already holding an aerosol cap farther out. A bar attached permanently to the nozzle tip allowed the user to rotate the spray without letting go of the can.

First Design Review

The first design review took place on February 21, 2006. We presented the Hose mockup and a potential future design of a Hose prototype. We found that there were too many engineering problems and uncertainties associated with design. While the payoff on completing such a design would be good, the time needed to work out the details would be too great, and there was no guarantee that a Hose based device would even work.

We also learned that a pull-string based prototype should have either multiple loops or knots in the string to allow the user multiple distances to pull from.

More detailed information about design reviews can be found in Appendix E.

After the first design review, we focused on developing our Lever-cap mockup into a prototype. We presented this prototype at the second design review.

Second Design Review

The second design review took place on February 28, 2006. We presented our lever-cap prototype. We learned that we have to use stronger materials for everything. Between the second

design review and the second user testing, a significant change took place in our design concept: we abandoned the cap concept in favor of a lever mounted directly on the grip itself. The main reason for switching the design so radically was in order to accommodate a far larger segment of can sizes; for the previous design, different caps would have needed to be made for each new can size. The new design can fit any size of can without modification, sacrificing the ability to turn to nozzle at will. From user testing, we determined that one-size-fits-all was more important than ease of rotation, so we modified our design accordingly.

Second User Testing

A second round of user testing was necessary and took place at the Rehabilitation Institute of Chicago on March 3, 2006. We learned that multiple loops of flatter material was needed for the pull string and that the device was too bulky and not constructed well.

Our second iteration of the same design was much improved, with closer attention paid to durability. While the design at this point does have some flaws, it has improved far beyond the initial design concept. The main issues at this point are cosmetic; very few changes need to be made prior to prototype status.

Table 5: Leve-spray Information

Name	***Grip***	***Actuation***	***Description***	***Picture***
Leve-spray	One-handed, can in user's hooks	Pull-string pulls the lever downwards onto the nozzle	Lever integrated directly into the grip, rather than the can cap.	 *Figure 14: Leve-spray*

Next Steps

Our design works well, as demonstrated in user testing. The user felt that the device was easy to use and hold.

We feel that work can be done in the following areas in order to improve our design:

Side-to-Side Lever Movement

At this point, when a force is applied perpendicular to the lever, the lever deflects slightly in the direction of the force. This is due to the elasticity of the rubberized sheath. One possible way to counteract this movement would be to add an additional layer of the sheath which does not stretch. This would stabilize the lever while still maintaining the gripping ability of the sheath.

Rotation of the Nozzle

One shortcoming of the current design is its inability to turn the nozzle without first setting the can down. It would be a plus if a way could be designed to turn both the nozzle and lever in the direction the user wanted without manually repositioning the can.

Appendix A: Project Definition

Project Name: Hairspray Application System for Bilateral Amputees

Client: Mike Hirsh

Team Members: Bob Brickey, Christopher Chen, Zach Kozberg, Tim Zwiebel

Date: February 13, 2006

Version: Three

Mission Statement: To design a device for a bilateral amputee to effectively use hairspray safely and with minimum impact on everyday activities.

Constraints

- Must weigh no more than three times unmodified spray can
- Cannot interfere with safety of user
- Must cost no more than $50

Users and stakeholders

- Erica Vanzui
- Bilateral amputees
- Rehabilitation Institute of Chicago
- People with the use of only one arm
- People with the use of only a few fingers on one or both hands
- People who have reduced control over their arms and hands

Requirements	Specifications

• Safety
  • User can tell where he or she is spraying
  • User has a safe grip on the device while spraying
  • Spray range is limited
  • User can easily stop spraying at any time
  • Device will disengage if dropped
	• Secure fastenings will be used to prevent the device from slipping or falling from the user's grip
	• The device will cease spraying when the user drops the device
	• Device will be made of material with toughness and fracture toughness so that it will not shatter when dropped
	• Protective support/cushioning to prevent the aerosol can from being damaged when dropped
	• Coating around the device to minimize

	injury if the device is dropped onto the user's feet or another part of the user's body • Visual cues will allow the user to know which direction the spray is directed
• Ease of Use	• User can use the device in the normal 1-3 minutes time it takes to apply hairspray • Preparing the device for use takes minimal effort and time (less than a minute) with two prosthetics • User has the ability to control the duration of the spray, including a constant spray and short bursts of spray with little to no effort • User will be able to remove the device when finished applying hairspray in less than minute
• Maintenance	• Replacement of cans or remount of device on new can must be possible within five minutes time by the user • Device will require minimal cleaning, if any is required due to residue from hairspray • User has the ability to adjust the positions of the controls on the device to best fit his or her needs

Appendix B: User Observation and Testing

User Observation

We met with our user, Erica Vanzui, at the RIC in Chicago, Illinois, on Monday, January 23, 2006. During the course of the meeting, we were able to ask questions and observe her perform various activities, some of which led to important design realizations:

- She is able to reach behind her head while retaining the ability to open/close prosthetics.
- She can hold the aerosol can quite firmly, with little instability.
- She would prefer a system attached to the can, rather than her prosthetics.

In addition, we were able to obtain more detailed pictures of her prosthetics which better our understanding of how they work and their design limitations, including:

- Only ~= 2 pounds of tensile force for everyday activities.
- Only left hand is curved, and while she can hold the can in either hand, the left is far more stable.
- Wrist action is rather limited on both arms, she is limited to manipulating wrist movement on one hand with her other hand.

First User Testing

Our first session of user testing took place at the Rehabilitation Institute of Chicago on February 16, 2006 at 3:30PM. This session helped us determine which alternatives were fit for further refining and testing, specifically in how the user would hold the can and device and actuate the can. The user was able to interact with several of our mock-ups and express her opinions about what worked and what did not work.

This meeting allowed our team to determine:

- Which designs had the most potential
- Which was the most effective lever-type mechanism in our designs
- An approximate effective tether length for pull-strings
- Adding a grip around the can is favored by the user

In order to achieve the first objective, team members first demonstrated the action necessary to actuate the lever with the pull-string and then allowed the user to try for herself. We noted which design was the most intuitive and easy to use by both the user's actions and her verbal responses. For the second objective, the user tried holding the can and holding the pull-string, afterwards estimating a comfortable length with her arms. We noted this length and afterwards began to test lengths in the vicinity of the one that she specified. The third objective was achieved purely through the user's overwhelming response that a grip on the can would be the ideal solution for holding the can and the device.

Erica's favorite mock-ups from the first round were the hose and the bolt.

Second User Testing

The second user testing occurred on March 3, 2006.

General Comments about the Design

- Looked rather flimsy in action. The "base"piece and the lever piece weren't secure against the can and moved around during use.
- Bulge at the back cause the user slight difficulty rotating the can
- User holds the device between her legs while sitting down to rotate the can
- User will be seated when using the device
- The device will be located on the user's vanity in her room
- Erica prefers the mesh grip to the solid grip.
- Erica had to hold her arm all the way out to use the spray. See pictures
- Erica would sort of hold the spray over her head, close her eyes, and then hope that the spray lands properly.
- Erica's wrist joint was loose today, this could be a problem for her on bad days. It prevented her from demonstrating the device properly.

Improvements to be made:

Pull-string

- Erica thinks that a flatter material, such as a ribbon, would make it easier to use.
- Erica prefers the loops versus the knots because of their security
- It might get tangled in the user's hook assembly. A stiffer material could prevent this from happening as well as be easier to use.
- The connection between the pull string and the lever does not seem very secure.
- Pulling hard on the pull string could break the lever
- Loops closer to the can as well would help Erica with actuating the spray closer to her head

Lever

- Need a better material
- Needs to connect better to the grip

Suggestions

- Make the spray rotatable
- Modify the actual grip so that there are two positions, one on the can and one sort of as an attachment to the can. This could allow her to hold it closer to her head without straining her arms as much
- Make the lever action smaller and more easily actuated.
- Make it reliable enough so that she can orient the can at any angle and get a spray. Don't disconnect the lever completely from the other portion as it is now, where the lever can flop around at any angle.

Appendix C: First User Testing Questions

Test clamp mock-up

- Can she support the weight?
- Can she actuate the spray (squeeze the trigger)?
- Can she maneuver it to direct the spray?
- Problems?
- Her thoughts/ideas?

Test hose mock-up

- Can she support the weight?
- Can she actuate the spray (bend the base of the hose)?
- Can she maneuver it to direct the spray?
- Problems?
- Her thoughts/ideas?

Test lever mock-up

- Can she support the weight?
- Can she actuate the spray (move the lever)?
- Can she maneuver it to direct the spray?
- Problems?
- Her thoughts/ideas?

Test bold mock-up

- Can she support the weight?
- Can she actuate the spray (pull cord)?
- Can she maneuver it to direct the spray?
- Problems?
- Her thoughts/ideas?

Her general thoughts/ideas?

What designs worked/didn't work well?

Appendix D: Second User Testing Questions

Which is the better grip?

Which is the better pull-string?

How important is the ability to turn the nozzle without setting the can down?

Will it be necessary for you to change cans without additional aid?

Appendix E: Design Review Summary

First Design Review

The first design review took place on February 21, 2006. At this point in the design process, we had several designs that we were interested in exploring. Seeing as this design review was limited to only fifteen minutes, we decided to put forth our most promising, but also most complicated, design, the "hose" mock-up. This design review session went well, and pointed out several uncertainties with the "hose" design at this stage of the process:

- How much force would it require to break the tip?
- How much force is required to actuate the system? Vertically? Horizontally?
- Which direction of force is easier for the user use?
- How will the user hold the hose?
- Will the twisting of the hose shift the direction of the spray tip on the end of the tube?
- How will the device keep the can stable on the bathroom counter?

We received several good suggestions on where we could go with this design.

- Using a wedge to convert vertical force into a horizontal force on the adapter
- Using a braided wire sheath to protect the tubing
- Using a crossbar to allow vertical force to cause horizontal movement of the adapter
- Using a bright color to allow the user to see where the spray would go

After this design review, we concluded that the "hose" design, although innovative, had too many engineering difficulties to be fully pursued at this stage of the design process. We decided to narrow down our options and choose a reliable and simple but expandable design, the "lever" design.

Second Design Review

The second design review took place on February 28, 2006. We presented a working model of our "lever" design. The feedback we received about this design centered around three components of the design: the rubber grip sheath, the pull-string, and the lever.

Rubber grip sheath

- The material used isn't conducive for cleaning. In a bathroom environment, the device might be subject to spray or splatter from water, soap, lotion, shaving cream, etc.
- The bulges in the sheath and the overlap of the sheath might cause the user to be unable to grip the can or even lose control of the can while holding it.
- How thick does the sheath need to be?

Pull-string

- Is there a reason why the pull-string has only one loop? Why is the string the length it is?
- Should the pull-string be made of the nylon rope that is on the current design? Will stiffer or less slippery materials produce better results?
- Using multiple knots in the pull-string might allow the same functionality as multiple loops, without the user needing to fully release the pull-string
- Braiding the nylon rope or some other kind of rope could increase the width of the pull-string and possibly make it easier to use

Lever

- Could you build more of the cap out of the same material as the lever?
- Is there an optimal length for the lever?
- Where should the fulcrum be on the design?
- Rotation currently depends on attaching a metal bar to the lever and the side of the cap. Is there a way to make the rotation more reliable? The connection seems flimsy.
- Is there a way to make this design work on all cans?

Conclusions

- We need to consider using different material while also testing the current material to see just how cleanable it is.
- We need to bring in multiple prototypes of different sheath designs with and without a bulge to the user testing in order to find out what the user's preference is.
- We need to build multiple versions of pull strings with different materials and designs to the user testing to find out what the user's preference is.
- We need to experiment a little with the design of the lever portion of the device to figure out the best method for attaching the lever and allowing rotation of the spray tip.
- Overall, there is a general need for user testing to help decide exactly where our design will end up.

Appendix F: First Design Review Questions

What do you think of the actuation method?

Do you think the design is intuitive?

Is the design effective in meeting design constraints?

Do you see any safety concerns that were overlooked during the presentation?

Are there any places where you see that additional feature would be useful in improving the design?

Do you notice any notable shortcomings of the designs that you feel need to be addressed?

Can the user effectively use the design?

Does the user have enough dexterity to use the design?

Appendix G: Second Design Review Questions

Overall Design

Please rate our design from 1-10 in the following categories. If possible, please provide rationale for ratings on the back of this sheet:

- *Functionality*
- *Usability*
- *Safety*

Rubber-grip Sheath

On a scale from 1-10, how well do you think the user will be able to hold onto the can via the rubber-grip sheath? ____

Explain your response.

Can you think of any ways to design the rubber-grip sheath so that Erica can install it herself?

Pull-string

Do you think the length of pull-string on our current prototype is appropriate? If not, please provide some suggestions.

Do you think there should be a different material used for the pull-string? If so, what would it be?

Lever

The lever on the current prototype is made out of polycarbonate. What other materials are suitable for the lever?

Are there any ways to avoid mechanical failure of the lever?

Rotation bar

Do you think the rotation bar is large enough for the user to turn effectively?