Deliverable D: Detailed Design, Prototype 1 and BOM

Group C-5

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Introduction:

The objective of this deliverable is to finalize an idea, implement it and create a prototype based on the client's feedback on all our sketched ideas. The objective is to decide on a product that the client chose and deconstruct it's features and components that are important for the client. After determining the key components and important assumptions for the product a prototype will be created. The prototype must be sure to meet the clients requirements and improve the product by conducting various tests. After conducting all the test, we plan on making a list of all the expenses that we require to build our product with a budget of $100. After considering all this we then propose on what to do on our next client meeting and then we move on to building our product.

Client Feedback:

For this client meeting we ended up obtaining a client Irene that could test our prototype. This meant that the client meeting ended up being both meeting one and two all at once. This meant that we got both information on the client and pitched prototypes. What we learned from Irene is that when she is trying to overcome freezing, using the same method repeatedly does not work consistently and therefore variation is needed in a solution. As of now she is using a laser cane however that is working inconsistently and she is looking for a device that would work consistently. It turns out that what works best for her is either visual or tactile stimulus and not audio stimulus. As it turns out a simple beat or rhythm does not help her as much as other methods.

From the concepts we brought with us to present we suggested a vibration stimulus around either the ankle of the sole of the foot as audio stimulus has little chance of success and visual glasses were too expensive and complicated to manufacture. We were told this could work as one of the methods she has used when freezing is having her husband tap her feet. The main feedback we got was that it should not be the same pattern every time as eventually she will naturally get used to its repetition and not be able to overcome freezing.

Improved Concept:

After presenting our designs to the new client, our final design concept has been determined to be a vibration device. The main concept is to be placed within a shoe insole to simulate a walking pattern through vibrating motors. The advantage of this design is the variability of the device as it can be customized to produce a variety of vibration patterns so the client does not become accustomed to a set pattern which would cause the device to be ineffective. A second concept has also been developed, this design is a vibrating stimulus that would be mounted to the ankle and would be able to conduct the same vibration patterns as the show version. The client has been contacted as is deciding on which method she would prefer.

Critical Product Assumptions:

Because of the highly individualized nature of Parkenson's Disease, methods which could work for one individual may not work for another. Although Irene did specify which methods she currently uses and how they work, the improved design concept does not perfectly mimic any methods currently in use, and thus the following assumptions must be made.

- Assumption 1: Vibration will work as a solution for gait freezing.
- Assumption 2: Vibrating Motors will be powerful enough to feel.
- Assumption 3: Client wears shoes often enough to be effective (slippers, shoes).

Assuming that these assumptions prove accurate, the device would theoretically be a sound solution. Unfortunately, these assumptions cannot be proven until a final prototype is developed. In the development of the first prototype, assumptions 1, 2, and 3 will be assumed to be true, therefore, the first prototype will be built to test the following set of assumptions.

- Assumption 4: Device is comfortable to wear.
- Assumption 5: Motors and wiring will fit within a shoe insole.

While this is not a large list, the simplicity of the first prototype does not allow for more advanced assumptions to be tested. For future prototypes, the following assumptions should be taken into account during construction.

- Assumption 6: Device is durable enough to withstand clients weight.
- Assumption 7: Device will have enough power to last a long time.
- Assumption 8: Transmission system will work through shoes.

Prototype 1:

The first prototype of the walking stimulus device was limited in materials, and is only used for the most preliminary of testing. As a group, the decision was made to begin work on an insole walking stimulus that used a series of small vibrating motors, which would be embedded into a removable shoe insoles. Due to the limited nature of the materials for this prototype, there was no access to the actual motors or control device. With this limitation in place, the first prototype was designed to test motor placement and comfort.

The prototype 1 was divided into two smaller subsections, a prototype insole used to test comfort, and a simple test performed with materials on hand to see if the vibration of a motor could be felt through a shoe.

<u>Subsection 1: Vibration Testing:</u>

To perform the vibration testing, a group members cell phone was set to vibrate when called, and was held at the bottom of another group members shoe. Afterwards, the phone was called, and the vibration was felt through the thick sole of the shoe.

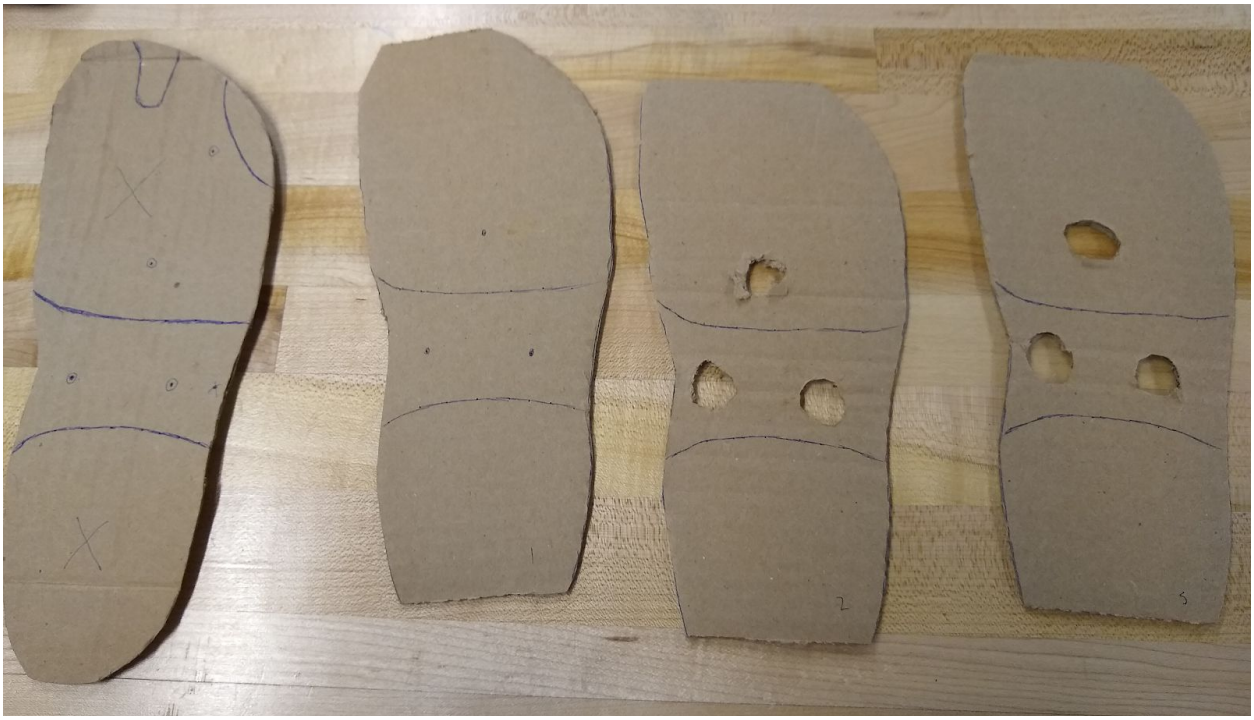
While a phone vibrating motor is not a perfect analogue to the motors which will be used in the final product, this test demonstrates that even small amounts of vibration can be felt through a thick shoe. The motors selected for use in future prototypes are stronger than a phones vibrating motors, and there will be more of them working to send vibrations through much less material.

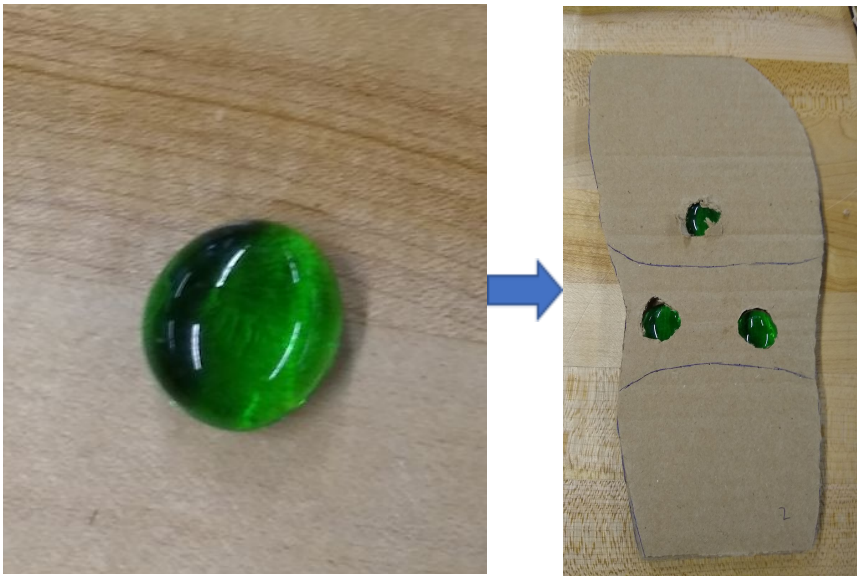
Subsection 2: Comfort Test:

To test the comfort of a shoe insole with built in motors, a simple prototype was constructed of cardboard and tape, as well as some small glass gems. Firstly, to determine the comfort of the insole, the placement of the motors must be determined. For maximum comfort, the motors would have to be placed in an area of the insole that was under the smallest amount of load, which would also help with the durability of the motors.

To determine the area of the foot under the most load, a piece of cardboard was cut to the shape of a shoe insole, and placed inside of a group members shoe. After about 2 minutes of pacing and standing on the insole, the cardboard had crumpled in specific areas where the most load was applied. These areas were marked in preparation for further construction.

After the areas of highest load were determined (The areas marked with a faint X in the rightmost picture), The placement of three sample motors was determined, and templates of the insole were constructed with extra cardboard. Holes were then cut into the extra cardboard to allow the placement of the small glass gems which, while not a perfect analogue for the vibrating motors given their rounded tops, will serve as adequate material for initial testing.





After the holes were cut and the gems were secured with duct tape, the entire insole was assembled, and inserted into a shoe. A group member then paced back and forth for about 5 minutes, testing to see the comfort of the insole, as well as if the motor analogues could be felt in an uncomfortable position.

The test was determined to be a success, as the placement of the glass gems did not prove uncomfortable. Additionally, the additional layers of cardboard slowly adjusted to better fit the shape of the foot and shoe. Unfortunately, the cardboard insole was thicker towards the toes, and it made for some discomfort, but since there were no motors or wires in the toes, that can be easily shaped for a better fit in future prototypes.

Comparison to Target Specifications:

While this prototype was able to test the feasibility and general comfort of the device, the limited material made it difficult or impossible to test a number of the target specifications, and some cannot be tested without the aid of a Parkinson's patient. This prototype served mostly to

prove the device could be made comfortable, but a table of target specifications is still listed below.

Target Specifications		**Target Specifications**		**Prototype Specifications**
Metric		**Units**	**Value**	**Value**
1	Volume of the device	cm^3	<50	~160*
2	Time it takes for the user to start walking once device is activated	s	<8	Requires client
3	Weight of the device	g	<250	Requires further prototyping
4	Time it takes the user to put on the device	min	<12	**
5	Strength of parts	J	<3.5	Requires further prototyping
6	Material cost	CDN$	<80	~$66.89 ***
7	Efficiency over time	Scale 1-5	5	Requires client

*This is the estimated volume of a single insole, which, when inserted into a shoe, will take up no additional space on the user's person, functionally reducing the volume to 0 cm^3

** Once the device is placed in a shoe, the device will take no additional time to put on.

*** The price is estimated in the Bill of Materials section later in this report.

Plans For Next Client Meeting.

For our next client meeting we want to be able to present a prototype with a functional vibrating device such that we can test the stimulating effects. This vibrating device will not necessarily have a protective casing as our main goal will be to see its functionality. Something that we hope to have functioning at the time of the next client meeting is either an app or remote to control the vibration's streanght and patterns. Although the prototype will not have the casing for the final product. The reason why we do not necessarily intend to present variation is that due to our product having an arduino we can code to provide extra features. Our main objective of this client meeting will be to show them a functional vibrating device that can then be used and implemented in shoe insoles.

Bill of Materials:

Part #	Part Name	Unit Cost	Quantity	Total Cost
1	Arduino	$17	1	$17
2	Button Cell Batteries	$0.80	2	$1.60
3	Vibrating Motors	$0.70	8	$5.60
4	Shoe Insoles	$16.00	1	$16.00
5	Wireless Transmitter	$3.00	2	$6.00
6	Wireless Receiver	$4.00	2	$8.00
7	Wires	$0.50	10	$5
			Total Before Tax:	$59.20
			Total Cost:	$66.89

Justification for choice of parts.

The main goal of our product is for the vibrations to have an effect as a stimulus. This is the main reason why we have eight vibrating motors as the want to optimise their effects. An arduino is needed if we are to make the device work from an app and that is why the need for a transmitter and receiver which should be wireless. The reason that we end up having duplicates of products is that there needs to be a stimulus for each foot. The shoe insole says one however that is only because you buy them in pairs. Wires are the to make sure power is given to the motors from the button cell batteries. The choice for the button cell batteries is simply due to size as that was one or our target specifications is size and weight of the device.

Conclusion:

After analysing our design ideas and client needs, we were able to develop a prototype that satisfied all the conditions for the client. This prototype went under several tests for durability and comfort which is necessary since our product was a shoe insole. The expected cost of our product is also reasonable and is approximately $67. The rest of the money could be used for damage cost as a failsafe in case our product experience some malfunction and we need extra components. All in all, our products meets the target specifications and it meets the clients needs so therefore we intend on creating a working prototype and present it to our client to test if it is an effective aid for a patient with Parkinson's.

Purchase Links:

Coin Cell Battery:

https://www.amazon.ca/LiCB-CR2032-Lithium-Battery-10-pack/dp/B0792HY7YQ/ref=sr_1_6?crid=1QOFKRMOQC6VC&keywords=3+volt+coin+battery&qid=1580409992&sprefix=3+volt+coin+%2Caps%2C263&sr=8-6

Vibrating motors

https://www.amazon.com/gp/product/B07Q1ZV4MJ/ref=vp_c_A1ENPAH2G5QY16?ie=UTF8&m=A1TBJFOKESMIUW