
Interactive Hi-Fi Prototype and Field User Test

1. INTRODUCTION

We are evaluating the first iteration of our high-fi prototype for the **tongue-computer interface**. This prototype acts as an interface in the form of mouse to a computer and is encased in a vacuum formed housing that sits in the concave dome behind the teeth of the upper jaw. Mouse interfacing was achieved through the rewiring of mouse components. The interface is exposed to the tongue as two buttons - "Left" and "Right". These two buttons take up the entirety of the exposed interface to aid in control by the tongue.

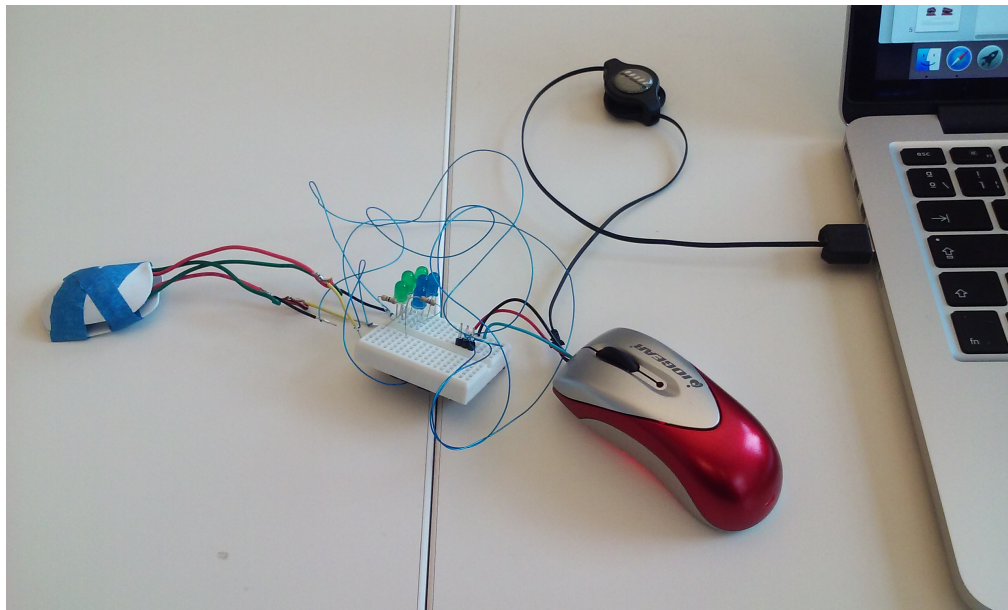


Figure 1 - Hi-fi prototype

With this prototype we seek to test users' control and comfort through a sequence of computer interfacing tasks. In designing a tongue interface we wish to make sure that the device comfortably fits in the user's mouth and the users have fine enough control to achieve their desired tasks without frustration. To this end we have created three tasks requiring varying motor difficulty. The first being a relaxed test of button control, the second being the applied task of reading and scrolling through an article, and the third being a fast-paced running game requiring coordination and fine control.

2. METHOD

Participants

While we would have liked to expand our participants population beyond Cornell Tech students, due to limited resources and time constraints the demographics of our participants do not vary much. In that sense, our 5 participants were willing volunteers who signed our consent form. Three of them were women and the other two were men.

Compensation for our participants' time was in the form of chocolate bars. Before beginning the tests, they were informed of the general purpose of the device (a device meant to be used by the tongue to connect with technology), the goal of what the final product is (so that they would try to put themselves in the shoes of a quadriplegic as much as possible), and the idea behind the 3 tasks.

Apparatus

The equipment used to test our tongue computer interface was the following: **prototype** (made out of plastic canvas with 2 switches inside of it that act as click buttons), a **mouse** (to which the prototype was connected to in order to override the functionality of the original click buttons), a **computer** (to which the mouse and prototype are connected to), a **plastic bag** (covering the device with the goal of being able to reuse the same prototype with multiple users), and **mapping software** (which overrides keyboard strokes with clicks to be able to run our tests).

Tasks

In order to better suit our goals for this prototyping session, the tasks we came up with for testing the prototype differ slightly from the first versions presented in other deliverables. In that sense the new tasks consist of:

- **Simple task:** given a screen randomly indicating what button to press, the user has to press the correct button. A counter of the right and wrong inputs is recorded. This task allows to test comfort and control.

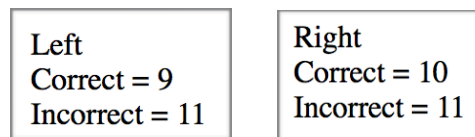
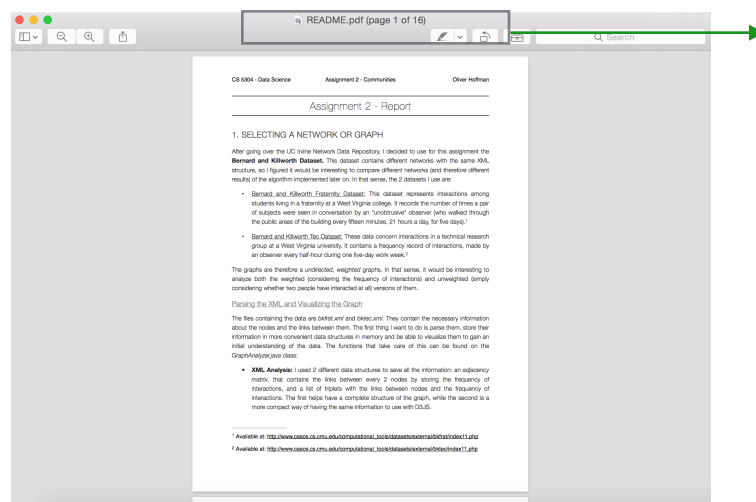


Figure 2 - Image of the simple task

- **Moderate task:** given a document of several pages long, the user is asked to scroll from the top of the document to the end and back up using the right and left clicks (which have been mapped to the up and down arrows in the keyboard). This task allows us to test ease of use in a very common, daily task.



Document's title and pages

Figure3 - Image of the moderate task

- **Complex task:** the user is asked to play a video game using only the tongue interface. The game consists on a block that keeps moving forward which needs to “jump” to evade obstacles. The user will perform the jump operation by clicking either left or right. This task allows us to test control of the device in a dynamic environment.

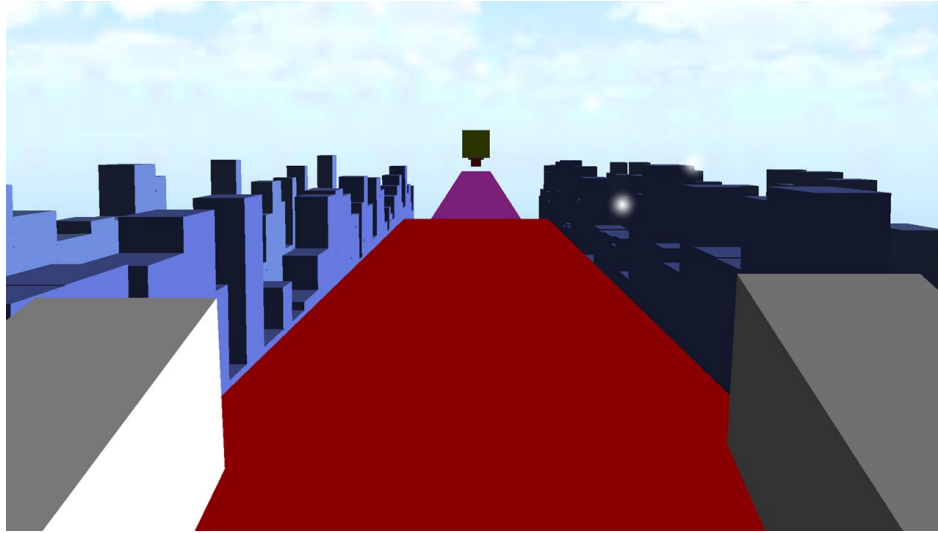


Figure 4 - Image of the complex task

Procedure

The way that tasks were conducted was:

- Users were asked to sit down in front of a computer prepared for the tests.
- They were then given a plastic bag to cover the device in.
- They were explained the purpose and procedure of every task.
- They were given a few seconds to put the device inside their mouths and get used to it.
- They were asked to carry out each task.
- They were asked for feedback as an input of qualitative analysis for our study.
- Quantitative results were recorded in the log.

3. TEST MEASURES

Task # 1 - Press correct button indicated on screen

The rationale behind this task was to test how accurate the user can be when clicking a specific button. In that sense, **we measure the number of correct and incorrect** inputs. This quantitative measure can serve as a base for comparison in future iterations of the prototype when testing for accuracy of input. We also asked the users for qualitative feedback in terms of sensation and opinion of the task carried out.

Task # 2 - Scroll from the top to the bottom of a document

The rationale behind this task was to gain a qualitative impression of the feeling of the device in a common task users already used to doing in another way. The scrolling of documents was very simple for us to do, since all that was needed was to map the up and down arrow keys to the left and right clicks. After performing the task, users were asked for a **general impression** of the task, if they found any difficulties, if they felt in control all the time, and if they had any other feedback to provide.

Task # 3 - Play a videogame

The rationale behind this task was to gain a better understanding of the amount of control a user can have when using the tongue interface in complex, dynamic environments. Because of this, users were asked to play a simple video game which only required them to click every time they wanted a block to jump and evade obstacles. **We measure the score of the game session** as the quantitative variable. Users were asked to play the video game 3 times, and the highest and lowest scores were recorded.

4. RESULTS

User 1

- **Task 1:** The user did 18 clicks and surprisingly, got 8 correct and 11 incorrect. He explained that it was difficult to see exactly what he was doing and that we should make it more intuitive. He suggested using some ridge that would help the user identify more easily the button being clicked.
- **Task 2:** The user was able to scroll down the document easily, though he did make some mistakes a couple of times and went up when he wanted to go down and down when he wanted to go up. Overall however he said that it felt good and was able to complete the task.
- **Task 3:** It is surprising how the most complex task was the one he found easiest to achieve. He got a score of 861 in the game (best case) and 150 (worst case). He also said that it felt really easy to use! Finally, he did mention that the device should stay fixed inside the mouth, since sometimes it moved too much.

User 2

- **Task 1:** The user did 12 clicks and got 11 right! She explained that it was really easy to use and easy to identify the buttons in the mouth.
- **Task 2:** She was able to scroll down and up the document successfully without any effort. She did mention however that the device needs to stay more fixed inside the mouth. She also said that it was very comfortable and easy to click.
- **Task 3:** The user said she was not very good at video games, and only got a score of 71 in the worst case and 112 in the best. Once again, she mentioned she always felt in control of the device and that it was quite intuitive and good.

User 3

- **Task 1:** The user did 21 clicks and he 20 right! He explained that the left button was a little easier but that overall he felt he had control and the device was comfortable.
- **Task 2:** He was able to scroll down and up a document with no problems. He made a couple of mistakes but overall he experience was not affected.
- **Task 3:** He was able to control the movements in the game just fine and had fun! He got a score of 450 in the best case and 400 in the worst.

User 4

- **Task 1:** The user clicked 11 times and got 9 right. She explained that it felt really good and comfortable but that the right button was harder to click.
- **Task 2:** The user had some problems scrolling down and up at first but when she got used to the device she was able to use it properly. She said it was comfortable and worked quite well.
- **Task 3:** The user played the game and was able to get a best score of 170 and worst score of 75. She said that it was very easy to play with the tongue.

User 5

- **Task 1:** The user clicked 16 times and got 10 right. He said the device was very interesting, and that he saw how its use could be expanded beyond quadriplegics. He proposed for example using some kind of tape on the roof of the mouth instead of a full device.
- **Task 2:** The user scrolled up and down just fine and said that he thought it was easy and comfortable.
- **Task 3:** He played the game just fine and got a best score of 240 and worst score of 110. He said it was very intuitive and easy to play.

5. DISCUSSION

After running the tasks with the different participants of our study, we have come to the conclusion that the tasks performed were all quite simple for users to do. This gave us great insight into understanding what we are doing right and wrong.

- Things done **right**: the first time users used the device, they had a "Woah!" expression, meaning the device is something that surprises them because it is something that actually works well. They were able to perform all operations easily and the device fitted comfortably inside their mouths. The measurements used in the tasks also seemed good, giving us the impression that users are able to control the device just fine based on the video game scores and the correct/incorrect counters from task 1.

- Things done **wrong**: we underestimated the need for a wireless interface in our prototype. This is something most users pointed out: “When it becomes wireless it will work so much better...”. Moreover, the device fits inside the mouth but is not attached to anything, giving an impression that it might fall off anytime. Since we have already achieved a good level of comfort shape-wise, the next logical step would be to expand this comfort to fitting the device inside the mouth.

Based on the results received, we are now ready to take our prototype to the next level by incorporating a joystick-like functionality in order to actually be able to move the mouse around. This will give us an even better impression of the tasks that the final users are expected to perform. Moreover, the use of plastic bags to cover the prototype was well-received among users, meaning that in future scenarios we should continue using it.

As mentioned above, a wireless interface would probably help the users perform the operations more comfortably and get a much better feeling of what the final version would be like, therefore improving the feedback we would receive. In that sense, it should be considered as a necessary implementation in the next few iterations of our product.

Finally, in terms of recommendations for a larger study in future iterations, it would be interesting to get an idea of what the reaction to the interface would be when used by quadriplegics. In that sense, we are planning on running the next user test with people from this community, having also a larger user base. The use of plastic bags helps keep the prototype hygienic and cheap, and should be something definitely used in the future.

6. APPENDICES

This section includes the general script used when testing the device with users:

Script

- Hello, thank you so much for helping us out! The idea behind our project is to help quadriplegics access technology in a more independent manner through a tongue-computer interface. In this version of the prototype we want to see how people can easily click buttons with their tongue and perform a few tasks. For this purpose we developed this small device that can be wrapped in a plastic bag to keep things a hygienic as possible. The tasks you need to perform are the following:
 - **Task 1:** the screen shows the button you need to click on and will count the number of times you get it right and wrong. You can stop after the count of both correct and incorrect clicks sums 15. What do you think of your results? How did the device feel inside your mouth?
 - **Task 2:** now you need to scroll the document from the top to the bottom and all the way back to the top using the buttons in the interface. Left goes up and right goes down. How did it feel? Do you think you were in control all the time? Any other feedback for us?
 - **Task 3:** now is time to do something fun! You are going to play a video game 3 times and see how far you can get. You can click any of the 2 buttons to jump! What score did you get? Was it simple to use the device? Any other feedback for us?
- Thank you so much for everything! Here is your chocolate.