“OK Glass?” A Preliminary Exploration of Google Glass for Persons with Upper Body Motor Impairments

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ABSTRACT
Head-mounted displays such as Google Glass offer potential advantages for persons with motor impairments (MI). For example, they are always available and offer relatively hands-free interaction compared to a mobile phone. Despite this potential, there is little prior work examining the accessibility of such devices. In this poster paper, we perform a preliminary assessment of the accessibility of Google Glass for users with MI and the potential impacts of a head-mounted interactive computer. Our findings show that, while the touchpad is particularly difficult to use—impossible for three participants—advantages over a phone include that it is relatively hands free, does not require looking down at the display, and cannot be easily dropped.

Categories and Subject Descriptors
K.4.2 [**Computer and Society**]: Social Issues-Assistive technologies for persons with disabilities

Keywords
Accessibility; Google Glass; motor impairments

1. INTRODUCTION
As wearable devices increasingly enter the mainstream, head-mounted displays such as Google Glass could open new means of mobile information access for users with motor impairments (MI). Such devices are always available and offer relatively hands-free interaction. In this poster, we present a study on the accessibility of and reaction to Google Glass from five participants who use wheelchairs and have upper body MI—four diagnosed with cerebral palsy and one with a spinal cord injury.

While several studies have examined the accessibility of smartphones and other mobile devices (*e.g.*, [1,2]), very little prior attention has been paid to the design of emerging wearable devices to support mobile computing. One exception comes from McNaney *et al.* [3], who explored the applicability of Google Glass for persons with Parkinson’s disease. Through both a focus group and a 5-day field deployment with four participants, they found that initial reactions to Glass were promising, including providing an increased sense of independence and security. Participants could use the device, although speech input was problematic for two individuals and some participants found tapping on the device’s touchpad to be more difficult than swiping on it. A second exception comes from Carrington *et al.* [2], who explored the idea of input and output that employs the space around a power wheelchair. While participants in their study did not use a head-mounted display, they were introduced to the idea and several felt it would be a useful output modality, particularly if paired with a pico projector for more public information.

These previous findings [2,3] point to the potential of head-mounted displays for users with MI, yet the first study focused only on users with Parkinson’s [2] and in the second study participants did not interact with the device [3]. In this poster paper, we focus on the accessibility of one head-mounted display—Google Glass—for five participants with MI. We present initial results on the accessibility challenges of Google Glass for these individuals, as well as potential impacts of accessible head-mounted displays.

2. METHOD
We recruited five participants through United Cerebral Palsy in Lanham, MD and by word-of-mouth; see Table 1. All participants were wheelchair users with upper body MI; P3 had dysarthria. The study procedure lasted up to 60 minutes and included three parts: background questionnaire (demographics and current mobile use), tasks with Google Glass, and a semi-structured interview on the experience of using the device.

Glass provides input through a touchpad on the right arm of the device that senses taps and swipes, and through voice commands. Output is through the head-mounted display that sits in front of the right eye and a bone-conduction headphone. For the Glass tasks, the researcher first demonstrated the touchpad and voice commands. The participant then completed a series of basic tasks over about 20 minutes, such as viewing activity on the timeline, looking up the weather, and taking pictures. To complete these tasks required at a minimum 8 forward swipes, 3 backward swipes, 11 downward swipes, 12 taps, and 10 voice commands. Because of accidental taps and swipes, these numbers are a lower bound. For participants who could not reach the touchpad, the researcher performed that input. Following the tasks, participants used 5-point scales to rate the physical comfort and ease of use of the touchpad and the visual display, and ease of use of the voice commands. The session concluded with open-ended questions about the potential impacts of head-mounted displays and brief feedback on design ideas for alternative forms of input beyond the built-in touchpad. Sessions were video recorded and analyzed to

ID	Age	Gender	Diagnosed Med. Condition	Mobile Device Owned
P1	46	Male	Spinal cord injury (C5)	None currently
P2	25	Female	Cerebral palsy	Smartphone (iPhone 5)
P3	53	Male	Cerebral palsy	Brick phone
P4	25	Female	Cerebral palsy	Smartphone (HTC)
P5	22	Female	Cerebral palsy	Smartphone (iPhone 5S)

Table 1. Overview of participants.

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observe interaction successes and challenges, and to summarize open-ended responses.

3. FINDINGS

3.1 Basic Interaction

Table 2 shows participant ratings on ease of use and physical comfort for the touchpad, voice commands, and visual display.

3.1.1 Touchpad Input

The accessibility of the touchpad depended on each individual's abilities, with these differences reflected in Table 2's subjective ratings. P2 encountered the fewest issues, having trouble with only 7 of 61 touchpad interactions. Her most common challenges were accidentally tapping instead of swiping, and the device not responding when she swiped. P4 was also able to use the touchpad, though had difficulty in 34 of 93 interactions. By far the most common issue for P4, in 47% of problematic interactions, was that the touchpad did not respond to her input, likely because of the angle of her finger. She also had persistent trouble correctly locating the touchpad, despite intervention from the researcher. In contrast, P1 and P5 could not physically reach the touchpad at all. For P5, the location of the touchpad on the right of the device was particularly problematic because she had limited movement in her right hand; she may have been able to use it had it been on the left. Finally, P3 could reach the touchpad but physically moved the device when trying to tap and swipe, making it so he could not read the display. After a few attempts, he asked the researcher to perform the gestures.

3.1.2 Voice Commands

Of the participants only P3, who had dysarthria (slurred speech), had difficulty with the voice commands—for him the device only successfully recognized the word 'Google.' P1 and P4 expressed surprise at how well Glass recognized their voices and P4 commented that the voice recognition with her current smartphone does not always work. P2 suggested that Glass should be fully accessible by voice, and wanted voice commands like 'Go Back' or 'Home Screen' instead of swiping or tapping multiple times on the touchpad. These findings are in contrast to McNaney *et al*. [3], whose participants experienced more issues with voice input perhaps partly because they used Glass in a field setting.

3.1.3 Visual Display

All participants were able to read text on the display when prompted. However, P1, P3, and P5 said that looking at it strained their eyes, and P3, P4, and P5 needed the display to be frequently adjusted. P4 had problems sitting up and keeping her head upright, which affected her ability to look at the display. During the session, she asked to be strapped to her wheelchair so that she could sit up and see the display better. Participants did not complain about the font size or size of the display.

3.2 Potential Impacts of Glass

Comparing Glass to a mobile phone, three participants mentioned the touchpad on Glass as a disadvantage. Advantages, however, included, not having to look down at the display (P2, P4), keeping the hands free (P2, P4) and reducing the risk of dropping and damaging the device (P1). For example, P1 said:

> "*That someone who has limited mobility could wear a technological device without fear of dropping or damaging it that seems a lot more useful than a notepad or a laptop in my aspect, in my living situation.*"

P2 expressed the physical ease of not having to hold her phone:

> *"My hands are free. It didn't require me to pick up anything as opposed to having to pick up this [phone] and you know look down on it and you know I was looking up so I didn't have my head down."*

We also asked about the ability to pay attention to surroundings while using Glass, and impacts on personal safety and independence. Three participants said that voice commands on Glass would enable independence especially in situations where they have to ask for help to type text. Only P1 expressed safety concerns about wearing the device (*e.g*., mugging).

At the end of the session we briefly introduced theoretical alternatives to the touchpad for controlling Glass: mid-air gestures, wearable physical buttons, and a portable touchpad. While the responses were generally positive, each participant had different yet specific places where they would like the touchpad to be located, like the armrest, joystick or tray (which mirrors Carrington *et al*.'s [2] findings). Participants also spoke about using body and facial movements and customized voice commands as other alternatives to the touchpad.

ID	Visual Display		Touchpad Gestures		Voice Commands
	Comfort	Ease	Comfort	Ease	Ease
P1	2	2	5	5	1
P2	1	1	1	1	1
P3	4	4	5	1	4
P4	1	2	1	2	1
P5	3	3	5	5	2

Table 2. Ease of use and physical comfort ratings for aspects of Glass interaction (1=very easy to 5=very difficult).

4. DISCUSSION AND CONCLUSION

For our five participants, Google Glass presented exciting possibilities for mobile information access but also serious accessibility challenges. The always-available, head-mounted display could allow for easy access to information on the go, without the physical requirement to hold a mobile phone. At the same time, more than half of the participants couldn't use the touchpad input. For one participant, this issue could have been mitigated had the touchpad been on the left side of the head; for others, expanded voice control or input elsewhere on the body or wheelchair (as with some of the ideas in [2]), is needed. These initial findings are the first step in a larger research project. We intend to design and evaluate more accessible alternative input methods for controlling head-mounted displays, such as mid-air gestures and wearable, tangible inputs. Ultimately, our goal is to design and assess the extent to which accessible head-mounted displays can improve independence and mobile information access for users with MI.

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6. REFERENCES

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