REHAB CASE STUDY

USING A POWER WHEELCHAIR TO CONTROL MOBILE TECHNOLOGY

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The rise in popularity of smartphones has brought new technologies to our fingertips that many never imagined possible. Today, these devices have become a regular part of our daily life and routines. The list of tasks we can accomplish at the touch of our small screen goes well beyond making phone calls. For people with significant physical disabilities, however, use of smartphones is a challenge due to the nature of these touch-based devices. These technologies are designed for interaction using the fingers and an array of gestures such as swipes, pinches and taps. This design places people with limited hand skills at a disadvantage. More recently, interface technologies have emerged that allow integration of smartphones with the drive control system on a power wheelchair, to include joysticks, switches and other alternative controls. For users with limited motor skills, accessing smartphones through the power wheelchair has many potential advantages, to include control of both chair and phone using an existing, successful method of access.

INTERFACE TECHNOLOGIES HAVE EMERGED THAT ALLOW INTEGRATION OF SMARTPHONES WITH THE DRIVE CONTROL SYSTEM ON A POWER WHEELCHAIR, TO INCLUDE JOYSTICKS, SWITCHES AND OTHER ALTERNATIVE CONTROLS.

Despite these advantages, challenges exist. Android and Apple phones each have distinct benefits and drawbacks. Android phones offer mouse emulation, a more direct method of access. With this method, the user can navigate the screen of the phone much like one navigates a computer with a traditional mouse. While Android offers a more direct method of access for users who are capable of this type of control, significant variability exists among phones. Features and capabilities may differ between models, and in some cases, differences exist on the same model between wireless carriers. Apple provides a more consistent platform of devices that operate in a similar manner, regardless of the wireless carrier. However, access to Apple phones can only be achieved through scanning when using the drive control system for access. The drive control system operates like an array of switches, and users navigate the phone one row at a time, or one icon at a time.

The following two case studies highlight the benefits and challenges of accessing Android and Apple smartphones through the drive control system.

CASE EXAMPLE #1

Mark is a 44-year-old male with multiple sclerosis who came to our clinic with the goal of accessing a smartphone. Mark has paralysis below the shoulders and dependence on caregivers for all self-care. He is able to move his head and elevate his shoulders, with limitations in range of motion due to weakness. He has blurry vision, which is partially corrected with eyeglasses. He speaks in short phrases, with low volume, due to poor breath support. Mark operates a power wheelchair with head movements, using a Permobil Compact Lite proportional joystick positioned under his chin (see Picture 1). His posture is well-supported in the wheelchair. He independently propels the chair and operates power seat functions.

Mark lives alone and has caregiver assistance three times a day. He has a strong social network, but at evaluation, he lacked a reliable way to contact them. Mark's goals were to use a smartphone to make phone calls, send emails and text messages, and search the Internet while in his power wheelchair. Mark's need for reliable communication was critical for his independence and safety in the home and community.

Mark had no preference for any particular type of smartphone, so our goal was to determine the most direct and efficient access method. A mouth

Mark uses the Permobil Compact Lite Joystick to operate his wheelchair and control power seat functions with independence. The top of the joystick is wrapped in a paper towel for hygiene purposes. Mark has switches next to his head to activate mode, and to turn the head set connected to his phone on/off. The straw provides him independent access to a water pack.

stick was ruled out because it led to neck fatigue. We conducted a trial with an R-Net Bluetooth mouse emulator paired with an Android smartphone. Once paired, Mark used his existing joystick, located beneath his chin, to navigate the phone (see Picture 2). With his eyeglasses on, Mark was able to move the pointer around the screen and land on the desired icons. He practiced nudges, or quick taps, of the joystick left, right, up and down. He was able to complete these movements in all four directions. Nudges can be used to control left click, right click, scroll up, and scroll down.

We also explored Mark's movement capabilities to activate a separate switch for a left mouse click. He was able to use shoulder elevation to hit a switch reliably, when placed just above the left shoulder. It was important to place this switch at a location where he could simultaneously sustain activation on the switch and also move the joystick with head movements. This action allows him to perform a "click and drag" function, or swipe. This is an important gesture for many tasks on a smartphone.

Once we determined Mark was capable of performing mouse emulation using his existing joystick, I completed a letter of recommendation for the following modifications:

1. R-Net Bluetooth mouse emulator (which connects to the input/output module already on the chair)

2. Mount for smartphone

3. Switch and swing-away mount, located just above left shoulder

Mark purchased a Nexus 6 smartphone because it offers a large screen and it has features that are compatible with a pointing device. For example, the HOME, BACK, and MENU buttons are accessible on the screen when using a pointer. Some models of Android smartphones only offer these features through physical/capacitive buttons.

Mark navigates the screen of his smartphone using his joystick as a pointing device.

OUTCOME

Once funding was obtained and all equipment received, we installed the R-Net Bluetooth mouse emulator and paired it with Mark's phone. Initially, we used the PC Programmer software for R-Net to set up Mark's system to accept nudges of the joystick left, right, up, and down. These movements correlated with left click, right click, scroll up, and scroll down. Problems occurred with the use of nudges. An unexpected lag was introduced to the pointer movements, which we had not experienced in trials with other phones. We altered the speed of the pointer through the settings menu on the phone, but the lag continued. We were unable to determine the cause of the lag, and it is unclear if the problem related to the model of the phone, the operating software, or some other issue. We removed nudges for all functions except left mouse click as a result.

At a subsequent visit, we installed a switch above Mark's left shoulder. This switch plugs directly into

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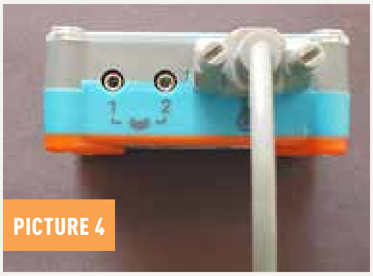
The Tecla Shield connects to the power wheelchair through the Auxiliary module. Once connected, users follow a series of steps to pair the device with a Bluetooth capable phone.



The Tecla Shield has two built in switch ports that will accept specialty switches with mono jack plugs. These switches can be used by themselves or in conjunction with the drive control system on the power chair. They can control a variety of functions when programmed through the Switch Control option on the iPhone.

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the R-Net Bluetooth mouse emulator to control a left mouse click. Mark preferred a separate switch over the use of nudges so he can perform a mouse click without having a delay in the pointer movements. Mark had some difficulty seeing the small mouse pointer. We installed an app designed to enlarge the mouse cursor, but once again, problems occurred. The larger mouse pointer did not replace the existing pointer, but rather trailed behind it. This was too confusing for him and we uninstalled the app.

Mark uses voice control through Google Now and a Bluetooth headset to complete a majority of tasks on the phone. Despite his poor breath support and low voice volume, the voice recognition software is very accurate. However, not all functions can be performed with voice control. For example, Mark cannot activate links in his browser or hang up a call with voice commands. In addition, there are some actions that cannot be performed using voice control unless the Internet is available. Therefore, the use of voice control in combination with mouse emulation gives Mark access to nearly all functions on the phone and provides redundancy if one method fails.

Mark is now able to use his smartphone to make phone calls, send text messages and emails, browse the Internet, schedule appointments, and change the channels on his TV. Mark is very happy with the use of his smartphone and reports that having a way to access it "means everything." It is critical to his safety and independence.

CASE EXAMPLE #2

Bob is a 62-year-old male with multiple sclerosis. He came to our clinic with the goal of accessing his smartphone through his power

THERE ARE ADVANTAGES AND DISADVANTAGES TO ACCESSING BOTH ANDROID AND APPLE PRODUCTS. IT IS CRITICAL TO UNDERSTAND THE CLIENT'S GOALS, THEIR CAPABILITIES, AND WHETHER THEY PREFER A SPECIFIC OPERATING SYSTEM WHEN MAKING RECOMMENDATIONS.

wheelchair drive control system. Bob has limited movement and drives his power wheelchair with an Invacare proportional RIM Head Control. He accesses an ASL fiberoptic switch to change modes using a left lateral head tilt. In the past, he explored the use of other switches located near his head, mouth, and chin, without success. Therefore, his best option for accessing a phone is by using his existing drive control system.

Bob has paralysis below the neck and dependence on caregivers for all self-care. He is able to move his head, with some limitations in range of motion due to weakness. He has limited vision and cannot see screen icons or pointers on a smartphone, even with the use of glasses. He uses a ventilator at all times for respiratory support. He speaks in phrases, with low volume and does not have sufficient articulation or volume to use voice control reliably or consistently on a smartphone. His posture is well-supported in the wheelchair. He propels the chair and operates power seat functions with independence through head movements.

Bob lives with his wife and has caregiver assistance for approximately 22 hours per day. At times, he is alone in the home while his wife runs errands nearby. He also takes his dogs for a walk each day in the area surrounding their townhome. When Bob is alone, his wife sets up a call between her cell phone and his existing iPhone. He remains in conversation with her throughout the duration for safety. If Bob's ventilation tubing becomes accidentally disconnected, his wife has less than 15 minutes to reconnect it. Unfortunately, the calls they set up occasionally get dropped. Bob has no way to call her back or answer a call. Their goal was to find a reliable way for him to initiate and answer calls while alone.

Bob does not have adequate vision or strength to access a phone directly using a mouth stick. He cannot see the icons or pointer on the screen, and therefore using his existing RIM Head Control as a mouse emulator was ruled out. We set up a trial with an interface device that allowed Bob to use a single switch to scan on his iPhone. Apple phones do not allow access via mouse emulation, but do offer a variety of options for scanning using the Switch Control option built into the operating system. We programmed the system so Bob could use automatic scan to navigate the iPhone as the icons were read aloud. When the system scanned to a desired target, Bob would press his head against a switch to select items.

Once we determined Bob was capable of automatic scanning using a switch, I completed a letter of recommendation for the following modifications:

1. Tecla Shield Bluetooth Interface Device (which connects to the Auxiliary module already on the chair)

2. Mount for the smartphone

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OUTCOME

Once funding was obtained and all equipment received, we installed the Tecla Shield and paired it with Bob's iPhone (see Picture 3). Using the Switch Control option, we programmed it to accept depression of the RIM Head Control as a switch input. When Bob pressed his head against the pad, the action was set to select items on the screen. We tried to program the iPhone to accept head turns to the right and left, so we could add two switch functions (going to the HOME screen; activating SIRI). Unfortunately, the Switch Control option could not consistently differentiate Bob's head turns from neck extension. In general, proportional joysticks can be programmed to operate as separate switches, but Bob did not have sufficient range to activate the RIM Head Control in this manner. As a result, his head control could only serve as a single switch.

Next, we turned on the scanning features of the iPhone using the Switch Control option. We activated speech feedback so that items on the screen are read aloud as they scan, and we slowed down the rate of scan to help Bob process the auditory information successfully. Bob found automatic scanning confusing because the scan program moves through various items on screen that are irrelevant to him and it is not possible to customize the scan pattern. We simplified the set-up of his phone as much as possible by putting the Phone app on a page by itself and setting up a short list of "Favorite" people he needs to call, organized in order of importance.

Bob practiced using the scanning features to initiate and answer calls, but ran into several challenges. The range of deflection he had to achieve on the RIM Head Control was significant (and more than required for driving). He often made a timely switch hit, but did not consistently activate the icons on screen as a result. This led to frustration and fatigue. Additionally, when he was unable to make an activation in a timely manner, he would occasionally access other icons or apps on the phone accidentally. Getting out of the undesired apps required him to listen carefully to a series of prompts and hit his switch in a timely manner to correct these errors. This was time consuming and frustrating as well. Had we been able to successfully program head turns to activate the home screen or Siri, this problem could have been eliminated. Unfortunately, the interaction between this particular drive control system and the Switch Control option on the iPhone was not ideal.

After putting forth a good deal of effort and practice, Bob abandoned the use of this interface device and gave up on his goal to initiate and answer phone calls with independence. We considered using other specialty switches as an access method because the Tecla Shield has built-in ports (see Picture 4). However, Bob did not want any additional devices mounted near his head, and also had a long history of searching for other switch sites without success. In hindsight, it is clear that the trial we conducted beforehand was not sufficient to give us an accurate picture of how the drive control system would interact with the iPhone. We did not have the necessary equipment to conduct an exact trial, and simulation with specialty switches provided a different experience.

Integrated control of smartphones through the drive control system can provide independent access for people with significant physical disabilities who otherwise could not use them. There are advantages and disadvantages to accessing both Android and Apple products. It is critical to understand the client's goals, their capabilities, and whether they prefer a specific operating system when making recommendations. Conducting trials with the intended devices will also significantly improve outcomes. Nevertheless, limitations in the function and use of smartphones through integrated control may still occur due to the nature of these touch-based devices.

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