

Paralysis and the Human Tongue

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For anyone living with paralysis, new developments in assistive technology can bring great hope. Paralysis is defined as the loss of muscle function which can be temporary or permanent, and can be complete or partial and occur on one or both sides of the body. It may also affect just one area, or be widespread. Paralysis of the lower half of the body, including both legs, is called Paraplegia and paralysis of both the arms and legs is Quadriplegia. Common causes are stroke and accidents which affect the spinal cord, but other conditions such as multiple sclerosis, muscular dystrophy, Bell's palsy and tumors can cause a slow deterioration which may lead to paralysis.

There are currently many forms of assistive technologies which aid those with paralysis and other forms of debilitating conditions in performing everyday tasks. The most common, and least expensive, is the Sip/Puff or Suck/Blow System which allows it's user to suck or blow into a plastic tube in order to move their wheelchair independently. The downfall of this system is that it only allows for four separate commands. Another method is electromyography which generally uses the movement of facial muscles to send signals to a computer which distinguishes each movement as a separate command, and performs the desired operation. This method, along with the "head tilt" cannot be used in patients who have lost control of their facial muscles or cannot move their head or neck. A third method is a brain-computer interface which requires an invasive and expensive surgery to implant a sensor into the grey matter of the brain. This devise detects brain impulses and passes them through an algorithm to generate a command; this complex algorithm can make the system very slow.

The tongue, although an unlikely candidate, has been of interest to scientists since the 1960's as a way for quadriplegic patients to gain independence. The tongue is directly connected to the brain through the hypoglossal cranial nerve so is usually not affected in those who have been in accidents which have caused injury to the spinal cord. Tongue movements are also quick and accurate and do not require a great deal of concentration, so the tongue does not fatigue easily. A current method using the tongue, called the *Think-a-Move*, which is relatively new and expensive at just under \$6,000, and has proven to have more diversity than the Suck/Blow System. It uses a tiny microphone pointed inward toward the ear canal which can detect changes in air pressure inside the oral cavity due to various tongue movements. This

system's downfall, similar to the Suck/Blow, is that it is limited to only eight to ten commands.

The latest and most promising development done by Georgia Institute of Technology's Dr. Maysam Ghovanloo, has brought much hope and excitement to those living with paralysis. The electrical engineer has designed a prototype of his *Tongue Drive* system. This technology implements a 3mm magnetic tracer attached to the end of the tongue whose movements are detected by sensors either inside the mouth or on an external headset. Movements are then transmitted wirelessly to a computer (similar to a PDA) which can be on the user's clothing or attached to the wheelchair. The signals are then processed and used to control the wheelchair's movements much like that of a joystick. It is believed that the system will potentially be able to be trained to recognize an infinite amount of commands, which could eventually allow them to control the majority of their surroundings. When the system is turned on it simply prompts the user to establish six commands – left, right, forward, backward, single-click, and double-click. In trials this system showed a response time of less than one second, almost 100% accuracy, and proved to be 150 bits per minute which is faster than the bandwidth of most brain-computer interface systems. The obstacles facing the *Tongue Drive* system today are that its initial trials used participants who were able bodied citizens not faced with paralysis. Dr. Ghovanloo believes that even patients with paralysis should yield similar results as long as they have full use of their tongue. Other obstacles for the team are that the prototype has a bulky mouthpiece and headgear, that they need to boost the wireless battery's charge, and find a way to keep the cost low.

In the future the *Tongue Drive* system plans to use the teeth as a keyboard and cheeks as computer consoles to increase the amount of commands possible for its users, but it may be years before they can implement this technology. Plans are for this system to be brought to market within the next 18 months and keep initial costs under \$10,000.

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