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Science as a Human Endeavour

THE DEVELOPMENT OF PROSTHETICS YOU CAN FEEL

INTRODUCTION:

When humans lose limbs of their body due to accidents, diseases, war or through other means of misfortune, attempts have long been made to create prosthetics in order to replace what has been lost. The purpose of prosthetics is to restore, to some degree, the mobility and function of those limbs for those individuals who no longer have the use of their natural limb. The creation of prosthetic limbs has a long history for humans and is in a state of constant advancement as new technologies develop. The focus of this investigation is to highlight these developments, including recent attempts to give sensory feedback with bionic prosthetics, and the impact of this new technology. This will demonstrate how new technologies have improved the efficiency and usefulness of prosthetics.

EXPLANATION OF RELEVANT SCIENCE:

Limbs are hard wired to the human body with many sensory receptors and nerves that send messages to the central nervous system (CNS) which in turn directs messages to effector muscles in those same limbs using motor neurons. The ability for a human to detect and respond to stimuli with their arms and legs plays an important role in the overall ability for an individual to carry out homeostasis. Natural limbs contain proprioceptors embedded in the muscles groups of the limb that give the individual an ongoing sense of the relative position of their limb and the strength of the effort being employed by that limb, through ongoing feedback to the CNS. Neurophysiologists call the awareness of one's movement and position of their own limbs using proprioception kinesthesia (Gonzalez, R 2018). When an able-bodied person moves their body, their brain is constantly receiving feedback and allows the body to make fine adjustments in order to avoid making errors in their movement (Cleveland Clinic 2018). When amputation of a limb occurs, the person concerned loses this critical feedback and their kinesthesia is inhibited. The result is that they cannot control their new prosthetic limb without having to watch it carefully at all times. As the prosthetist Rick Riley states, "the challenge of prosthetics is that we are putting dead things on living people" (Resnick, B 2010). Because of this the limb is no longer in communication with the brain, no longer acts as a mechanism for feedback, and any effector muscles that were present are gone. This problem is now being addressed by way of enhanced surgical procedures and the use of high end electronics to give bionic limbs sensation and reconnect induvial brains to their limbs with restored neural pathways.

CONNECTIONS TO SCIENCE AS A HUMAN ENDEAVOUR & POTENTIAL IMPACT:

The technology involved in prosthetics has gone through radical development and improvement since the earliest prosthetics were attempted. This development has taken place on several scientific fronts and required a wide range of evidence in order to improve the efficiency of prosthetics. As Nathan Stuart from The Engineer points out,

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Commented [TaKB2]: The focus for the investigation does not have to be a question but it does need to be specific enough to enable you to analyse information in depth. It must be based on a recent discovery, innovation, issue, or advancement and be linked to one of the topics in the SACE Subject Outline.

Commented [TaKB3]: Relevant biology concepts or background. This must include the use of scientific terminology. This is the second-most important part of the report, and this should be reflected in the word count allocated to it.

Commented [TaKB4]: You don't need to include a reference for information that you are expected to know as part of the Biology course.

Commented [TaKB5]: Including information about the author or publishing information can add credibility to your references.

Commented [TaKB6]: An explanation of how the focus of the investigation illustrates the interaction between science and society.
This is the most significant part of the report, so it should have the highest word count, even if it is spread throughout the report instead of as a separate section.

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"archaeologists have found examples of replacement body parts from ancient Egypt, Greece and Rome. These range from the crude – wooden peg and strap-on toes – to the primitive… attempts at limbs with hinged joints" (Stuart, N 2018). Today, we have bionic limbs that have the ability to integrate with the individual's sensory and motor neural pathways. Today, "state-of-the-art prosthetics are mechanical limbs controlled by nerve impulses and microprocessors" (Resnick, B 2010).

The technologies today owe their existence to the research and development of prosthetics of the past. In order to have a high bionic arm and hand with sensation, one must have the more basic technology of mechanics and articulation first. As a result, new technologies have built upon past developments and led to better efficiency.

An important example of this is the great leaps that have been made in computing and processing. This has allowed for data collection through electronic sensors and the ability to process this data fast enough to make it useful in wiring to the human muscles and nerves. Also, as recent as 2014, an international team of scientists who had developed the first bionic hand with touch sensation were limited to a fixed laboratory for their creation. The reason for this was that the sensory and computing equipment behind the hand was far too large to carry or to be moved out of the lab (Walsh, F 2018). This is a major practical hurdle that has only recently been overcome through development of new computing technology for collecting and analyzing electrical impulse information. Recent findings show that, "with increasing miniaturization of electric motors and advances in computing power this is becoming less of a challenge" (Stuart, N 2018).

Another crucial development that is making bionic prosthetic limbs possible is the increasingly sophisticated technology being employed to give sensation to hands and feet. In 2014 Dustin Tyler and his research team in Ohio gave amputees back a sense of touch and pressure through the bionic hand (Thomson, H 2016). But even in the few years since this breakthrough continued development of sensor technology has gone beyond force and pressure to giving amputees a sense of texture. Their finger with an electronic sensor was hooked up to a patient's arm by way of electrodes and the patient could distinguish between different textured surfaces 96% of the time (Thomson, H 2016). The development of these sensors provide great potential for being even faster than human sensory neurons: "sensation coming from a bionic source does not have to be speed-limited by the diffusion of ions in solution, as are sensory nerves…" (Templeton, G 2015). In other words, development of this technology could prove to be more efficient than human sensation. All of this significantly means that patients now have much more accurate control over their fine motor skills and are less likely to make mistakes in movement with their prosthetic limb.

The other important development is less invasive and more fine-tuned surgical procedures that allow scientists to connect sensory electrodes to antagonistic muscle groups in the limb. As MIT Technology Review points out, "most muscles that control limb movement occur…in pairs… one muscle stretches when the other contracts, and both send sensor information back to the brain" (Trafton, A 2017). Surgical techniques have only recently been developed that allow us to connect electrodes to muscle groups at the amputation site so that the muscles and nerves surrounding a prosthesis can sense and transmit

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proprioceptive information about the artificial limb (Grant, B 2017). This development has only been made possible by building on previously more invasive surgical techniques. As Siobhan Treacy describes, "the sensors translate mechanical stretch into electrical signals that can be interpreted by the brain" (Treacy, S 2018). The result is a restored relationship between the artificial limb and the patient's brain, giving the life-like feelings.

One of the most important impacts of this technology is that we can now give amputees a more realistic limb which they can use as part of their own body. Currently, patients reject their artificial limbs at a rate of about 20 percent (Trafton, A 2017), but the hope is that the better technology will decrease this number and give them better reason to keep and use it to improve quality of life. The ultimate goal of the advancements is to "improve the relationship between the mind and the prosthesis" (Cleveland Clinic 2018). If this can be achieved the social, emotional, and functional barriers for those with prosthetics can be greatly reduced. There is an incredible potential for this technology to "improve the lives of thousands of wounded veterans" and also greatly impact emergent military applications (Templeton, G 2015).

Commented [TaKB10]: A discussion of the potential impact or application of the focus of the investigation, e.g. further development, effect on quality of life, environmental implications, economic impact, intrinsic interest.
NOTE: this discussion can be mixed in with the discussed SHE concept(s) in this section or it can more separate at the end of this section as I have done here.

Although there are many potential possible impacts of this technology, there is a great need for further development in ensuring the cost is more accessible to amputees. This is currently a massive barrier. As a recent study shows often bionic legs with currently technology can cost up to 15 times more than a conventional prosthetic limb – which are already expensive (Thomson, P 2012). This problem has recently led to wave of development to make the technology more accessible. One such example is the Bristol-based Open Robotics company which is trying to develop affordable robotic systems (Fanning, P et al. 2018).

Conclusion:

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Prosthetic limbs have been limited in the past due to the fact that they have always been disconnected from the nervous system of the individual. This has left amputees with limited ability and functionality, and without any sensation of where their limb is and any ability to interact with as with natural limbs. The development of technologies related prosthetic limb construction, computer processing, sensation technology and surgical techniques have led to crucial improvements that have built on previous methods and capabilities. The new technologies have led to bionic limbs that can be integrated with the human nervous system and give direct feedback to the brain which the patient is aware of. This has led to finer motor control of the limb itself. All of these are steps that have built on previous technology and have given amputees the potential of improved quality of life.

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The word count includes in-text referencing but does not include the reference list at the end of the document.

Reference List:

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