THE USE OF MOBILE EYE TRACKING TO ASSESS COGNITIVE LOAD IN LOWER LIMB AMPUTEES: A PILOT STUDY

Sabina Manz (1,2), Strahinja Dosen (2), Jose Gonzalez-Vargas (1)

1. Ottobock SE & Co. KGaA, Duderstadt, Germany;
2. Department of Health Science and Technology, Aalborg University, Aalborg, Denmark

Introduction

Lower limb amputation can have significant impact on the patients' quality of life and physical abilities [1], and has also been shown to have social [2] and cognitive effects [3]. The literature reports that the use of a prosthetic device is associated with increased cognitive load [3]. The limited research which exists has demonstrated that more advanced prosthetic knee joints (e.g., microprocessor-controlled knees, MPK) have been able to reduce the cognitive burden on the users compared to non-microprocessor-controlled knees (NMPK) [4]. However, current methods (e.g., EEG) are cumbersome and can only be used in controlled settings. Recently, eye trackers have become of interest with respect to assessing cognitive load in amputees. One pilot study looked at the transitions from stairs to level ground and vice versa and found that amputees spend more time focusing on the transition area compared to the able-bodied population [5].

The use of eye trackers, however, is fairly new in this field and its relevance for the assessment of cognitive load is still unknown. Therefore, the purpose of this study was to investigate the use of gaze data obtained from a mobile eye tracker in patients with lower limb amputation to estimate the cognitive load in different motor tasks.

Methods

A mobile eye tracker (Tobii Pro Glasses 3, Stockholm, Sweden) was used to record the gaze location in a patient with unilateral transfemoral amputation and an able-bodied participant. The participants were asked to wear the eye tracker, similar to regular glasses, while performing different activities of daily living. The experiment was performed in a laboratory environment that allowed stair and ramp ascent/descent, walking on different terrains, and tight turns. A preliminary qualitative analysis of the gaze data obtained during stair ascent was performed. For this evaluation, the gaze data was mapped to a screenshot of the stairs.

Results

The qualitative gaze analysis can be seen in Figure 1. The left and right image show the results for the able-bodied participant and the subject with transfemoral amputation, respectively. On the left, the visual sampling is spread out equally across the stairs, whereas on the right, the sampling is concentrated in the areas of visual interest to safely ascend the stairs when using a prosthesis. In the latter case, there are clearly visible "hot spots" associated to the steps taken with the prosthetic leg (i.e., 2nd and 4th stair).

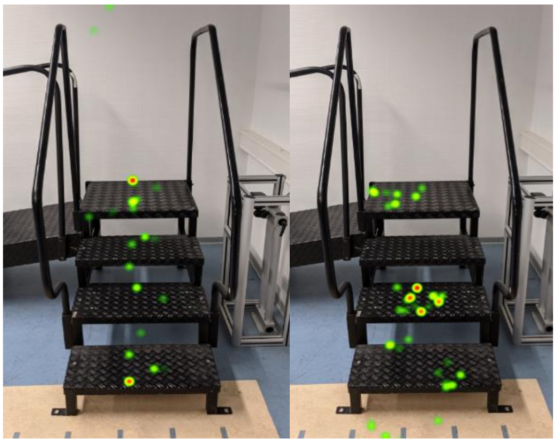

Figure 1: Gaze locations during stair ascent, accumulated from two trials for an able-bodied participant (left) and a participant with transfemoral amputation (right). The colors indicate the duration of each fixation, i.e., the redder the spot, the longer the fixation.

Discussion

The preliminary analysis showed clear differences in the gaze patterns of the able-bodied participant compared to the subject with transfemoral amputation. The next step in this research is to perform a more extensive data collection that will include more participants, wearing different prosthetic devices, and a larger set of tasks (e.g., dual-tasking). This will show whether eye tracking could be used to assess the cognitive burden while using a prosthesis. Furthermore, it is of interest to investigate whether eye tracking can determine the assumed differences in the cognitive burden between different types of devices, for instance, NMPK versus MPK systems.

References

1. Jordan et al, Prosthet Orthot Int, 36:430-434, 2012.
2. Burger et al, Prosthet Orthot Int, 21:35-39, 1997.
3. Miller et al, Arch Phys Med Rehab, 82:1031-1037, 2001.
4. Möller et al, Prosthet Orthot Int, 43:257-265, 2019.
5. Li et al, IEEE Engineering in Medicine and Biology Society - Annual Intern. Conference, 3163–3166, 2019.

Acknowledgements

This work is supported by the Marie Skłodowska-Curie Actions (MSCA) Innovative Training Networks (ITN) H2020-MSCA-ITN-2019 - 860850 – SimBionics.