Phantom Motor Execution facilitated by Machine Learning and Augmented Reality alleviates Phantom Limb Pain

M. Ortiz-Catalan1,2,6, R. Guðmundsdóttir1,6, M Kristoffersen1,6, A. Zepeda-Echavarria1,6, K. Caine-Winterberger2, K. Kulbacka-Ortiz2, C. Widehammar1, K. Eriksson3, A. Stockselius4, C. Ragnö4, Z. Pihlar5, H. Burger5, and L. Hermansson1

1Department of Electrical Engineering, Chalmers University of Technology, Gothenburg, Sweden; 2Centre for Advanced Reconstruction of Extremities, Sahlgrenska University Hospital, Mölndal, Sweden; 3Faculty of Medicine and Health, Örebro University, Örebro, Sweden; 4BräckeDiakoni Rehabcenter Sfären, Solna, Sweden; 5University Rehabilitation Institute, Ljubljana, Slovenia and 6Integrum AB, Mölndal, Sweden

Background: Phantom limb pain (PLP) is a debilitating condition for which no effective treatment has been found. We hypothesized that re-engagement of central and peripheral circuitry involved in motor execution could reduce PLP via competitive plasticity and reversal of cortical reorganization. We named the working mechanism as phantom motor execution (PME)

Objectives: Here we present the results of a single-group clinical trial investigating the use of PME in patients with chronic intractable phantom limb pain.

Methods: Fourteen patients with upper limb amputation and chronic intractable PLP. Three clinics in Sweden and one in Slovenia. Twelve sessions of PME using machine learning, augmented and virtual reality, and serious gaming. Changes in intensity, frequency, duration, quality, and intrusion of phantom limb pain assessed using the numeric rating scale, the pain rating index, the weighted pain distribution scale, and a study-specific frequency scale before each session and at follow-up interviews 1, 3, and 6 months.

Results: PLP decreased by: 47% (SD 39; absolute mean change 1·0 [0·8]; p=0·001) for weighted pain distribution; 32% (38; absolute mean change 1·6 [1·8]; p=0·007) for the numeric rating scale; 51% (33; absolute mean change 9·6 [8·1]; p=0·0001) for the pain rating index. Intrusion of PLP in activities of daily living and sleep reduced by 43% (SD 37; absolute mean change 2·4 [2·3]; p=0·004) and 61% (39; absolute mean change 2·3 [1·8]; p=0·001), respectively. Two of four patients on medication reduced intake by 81% (1300 mg reduction, gabapentin) and 33% (75 mg reduction, pregabalin). Improvements retained 6 months after the last treatment.

Conclusions: Promotion of phantom motor execution aided by machine learning, augmented and virtual reality, and gaming, is a non-invasive, non-pharmacological, and engaging treatment with no identified side-effects at present. Further work is necessary to identify functional and structural brain changes caused by pain and by the intervention itself.