Control of prosthetics through EMG patterns associated to phantom limb voluntary gestures is possible in transhumeral amputees without surgical reinnervation

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BACKGROUND

There is a need to extend the control possibilities of upper limb amputees over their prosthetics, especially with newly available polydigital hands. While decoding phantom hand and wrist movements from EMG electrodes placed on the forearm of transradial amputees has been commonly studied [1], little extension of this approach to transhumeral amputees has been done. Nonetheless recent studies showed correlations between distal phantom hand voluntary movements and muscle activity in the residual upper arm in transhumeral amputees [2], i.e., of muscles that initially had no physical effect on the concerned hand joints.

AIM

The purpose is to evaluate the extension of this concept to transhumeral patients (who did not undergo reinnervation surgery [3]) by classifying the muscle activities in their residual upper limb naturally generated when mobilizing their phantom limb.

METHOD

We asked three transhumeral patients (24 to 62 years old) to perform a control task during which they had to mobilize their phantom limb to activate associated buttons on a graphical user interface. To this aim, twelve EMG electrodes were placed over their residual limb and a state-of-the art classifier (LDA with a classical set of features) was trained over two demonstrations of each of their possible phantom movements including at least the elbow flexion and extension, the wrist pronosupination and the hand closing and opening. The patients were then asked to randomly control some buttons on a GUI which were associated to a movement class and control by the raw classifier output. Tests were performed over 5 randomized repetitions of each possible movement.

RESULTS

Patients, without being trained neither to this task nor to mobilize their phantom limb, were able to control the interface through classification of their phantom limb related myoelectric patterns with a rather important success rate (over 80% when considering basic sets of 6 hand, wrist and elbow movements) as shown in Fig.1. In addition to the six listed movements, two patients were also able to control some finger movements (thumb, major and little finger, for which the classifier was also trained) which were successfully recognized by the controller with, however, a slightly reduced efficiency (see Fig. 1).

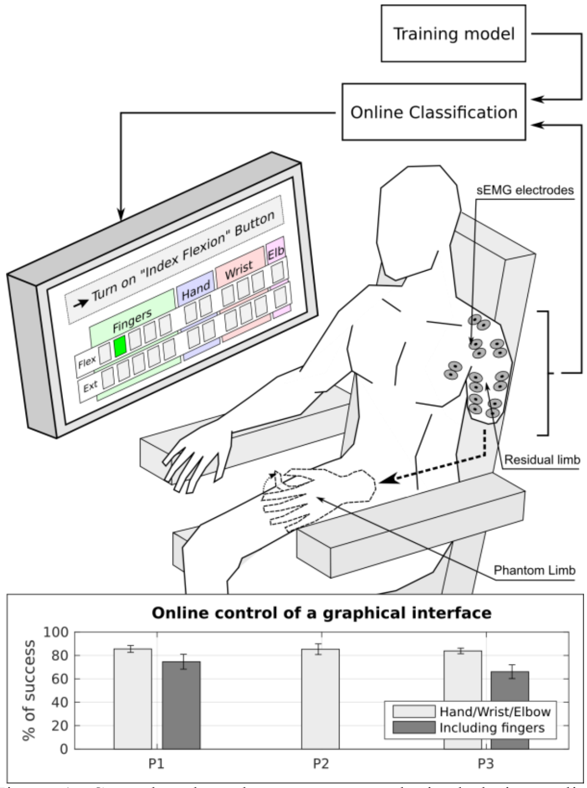

Figure 1. Control task and success rates obtained during online control of a graphical interface for each participant, averaged among the six elbow/wrist/hand phantom movements (light grey) and including 6 extra phantom fingers movements (thumb, major and little finger, in dark grey).

DISCUSSION & CONCLUSION

While remaining preliminary (with a need to perform experiments with larger populations and study the possible effects of training and long-term phantom mobilization), these results will have several impacts. Beyond changing the way the phantom limb is apprehended by both patients and clinicians, such results could pave the road towards a new control approach for the 85 % of transhumeral amputated patients with a voluntary controllable phantom limb. This could ease and extend their control abilities of functional upper limb prosthetics with multiple active joints without undergoing muscular reinnervation surgery.

REFERENCES

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