INTRODUCTION

The mirror neuron system has been attributed with increased premotor and primary motor cortex activation upon an individual’s viewing of another’s actions (Cattaneo and Rizzolatti, 2009). A popular interpretation of this observation is that these brain areas are active while performing and witnessing an action due to a shared cortical representation for both events (Rizzolatti and Sinigaglia, 2010). Recent work has shown that this effect is weakened when an individual witnesses a human movement performed by a virtual robotic actor (Shimada, 2010; Tai et al., 2004). This result suggests that the mirror neuron system may be preferentially engaged by limb movements which are similar in appearance to that of the viewer. The aim of this study is to investigate whether or not these findings could be replicated in intact individuals and amputee prosthesis users imitating tool use movements made by actors with similar and dissimilar arm types.

METHOD

Subjects: Ten right handed intact subjects were recruited for this study (4 female, 6 male, aged 24.8±3.3 years). Six upper extremity amputee prosthesis users were also recruited (2 female, 4 male, aged 44.3±9.9 years). All amputations were due to trauma and were either at the trans-radial (5) or elbow disarticulation level (1). Prosthetic device types used by the subjects were body-powered (2), myoelectric (3), and hybrid (1).

Procedures: All subjects viewed video demonstrations of common tools being used by both intact actors and amputee actors wearing a prosthetic device. In each case, subjects were then asked to pantomime the movement seen in the video. Intact subjects were asked to use their right arm while amputees were asked to use their affected arm. Therefore, there were 4 experimental groups: intact subjects imitating an intact actor (Int-Int), intact subjects imitating a prosthesis user (Int-Pro), prosthesis users imitating an intact actor (Pro-Int), and prosthesis users imitating a prosthesis user (Pro-Pro).

While performing the cued pantomime movements, subjects wore a 58-channel electroencephalography (EEG) cap that recorded brain activations via scalp potential activity.

Data Analysis: Continuous EEG data were filtered, epoched, linear detrended, baseline corrected, and averaged for each condition using Neuroscan software (Compumedics Neuroscan, Charlotte, NC). Finally, t-tests were performed to compare the effects of video demonstration type (Int-Int vs. Int-Pro, Pro-Int vs. Pro-Pro) and subject arm type (Int-Int vs. Pro-Int, Pro-Int vs. Pro-Pro).

RESULTS

Intact subjects showed no effect of watching the intact or prosthetic arm, showing equivalent left parietofrontal activity during planning and execution. The prosthesis users who imitated intact demonstrations showed greater bilateral parietal and occipital positivity during movement planning and execution than the intact group (p<0.001). However, when prosthesis users imitated prosthesis demonstrations, typical left parietofrontal activation during planning was found.

DISCUSSION

We suggest that when prosthesis users imitate intact subjects, the greater bilateral/occipital positivity during planning and execution reflects the unique visuospatial processing involved in performing tool-use movements with their prosthetic arm, which does not match that of the intact demonstrator. The finding that prosthesis users imitating other prosthesis users did not show this effect suggests that prosthesis users plan normally when they are able to imitate other prosthesis users.

CONCLUSION

This result has significant implications on amputee rehabilitation and subsequent prosthesis training, as standard therapy involves practicing with an intact physical therapist. This arm type mismatch could necessitate abnormal planning mechanisms in amputees learning to use their prosthetic device.

REFERENCES