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Cognitive Load and Compensatory Movement in Learning to use a Multi-Function Hand

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BACKGROUND
Recent technology provides increased dexterity in multi-function hands with the potential to reduce compensatory body movements. However, it is challenging to learn how to operate a hand that has up to 36 grips. While the cognitive load required to use these hands is unknown, it is clear that if the cognitive load is too high, the user may stop using the multi-functional hand or may not take full advantage of its advanced features.

AIM
The aim of this project was to compare cognitive load and compensatory movement in using a multi-function hand versus a conventional myo hand.

METHOD
An experienced prosthesis user was assessed using his conventional myo hand and an unfamiliar iLimb Ultra hand, with two-site control and the same wrist for both prostheses. He was trained to use power grip, lateral grip and pinch grip and then completed the SHAP test while wearing the Tobii Pro 2 eye-tracking glasses. ***Pupil diameter*** (normal range: 2-4mm during normal light) was used to indicate the amount of cognitive load.[1] The ***number of eye fixations*** on the prosthesis indicate the need of visual feedback during operation. *Dartfish motion capture* was used to track the ***maximum angles*** for **shoulder abduction** and **elbow flexion**.

RESULTS
Larger pupils were found in the use of I-limb ultra (2.6-5.6mm) than in the use of conventional myo hand (2.4-3.5mm) during the SHAP abstract light tests. The pupils dilated most often during changing grips, e.g. switching to pinch grip for the tripod task (from 2.7 to 5.6mm). After training of using power grip and pinch grip repeatedly, the maximum pupil diameter decreased from 5.6 to 3.3mm. The number of eye fixations on the I-limb ultra (295 fixations) were also higher than on the conventional myo-hand (139 fixations). Smaller **shoulder abduction** and elbow flexion were observed in the use of I-limb ultra (**16.6**°, 36.1°) than in the use of conventional myo hand (**57°**, 52.7°).

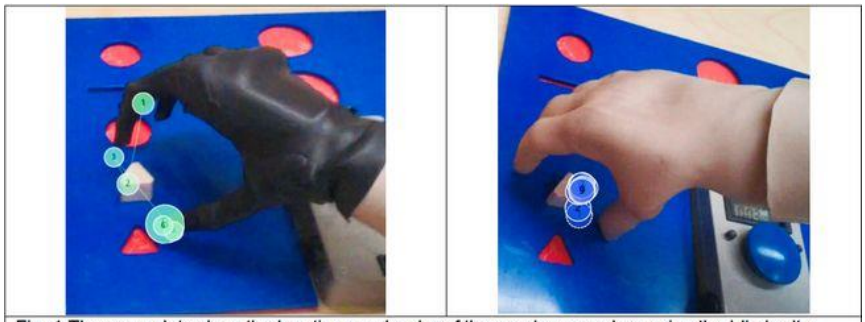

Fig. 1.The gaze plots show the locations and order of the user's gaze when using the I-limb ultra and the conventional myo hand. When using the I-limb ultra, the user looked at the **index finger** ➔ **the tripod wood object** ➔ **the thumb** before grasping (green circles). When using his own conventional myo hand, he looked mainly at the tripod wood object (blue circles).

DISCUSSION AND CONCLUSION
Although it is cognitively demanding to learn to use **a multi-function hand,** it is possible to decrease this demand with adequate prosthetic training. Our results suggest that using a multi-function hand enables reduction of body compensatory movement, however at the cost of a higher cognitive load. Further research with more prosthesis users and other multi-function hands is needed to confirm the study findings.

REFERENCES
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