Creating More Intuitive Prostheses Using an Objective Detection Response Task to Measure Cognitive Load

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Controlling a prosthetic hand is cognitively demanding and up to 44% of upper-limb amputees abandon their prosthesis. There is a need for prosthetic control strategies that are more intuitive. To develop a quantitative method of measuring cognitive load, a dual-task paradigm was employed in which participants completed a secondary Detection Response Task (DRT) while performing a primary task involving transferring fragile objects. The DRT required participants to respond to vibratory stimuli by pushing a button; a longer response time indicates greater cognitive load associated with the primary task. DRT response time had a high correlation ($r=0.83$) with a standardized subjective measure of cognitive load, the NASA Task Load Index (TLX), suggesting that the DRT can objectively quantify cognitive load during prosthesis use. DRT was applied to explore the cognitive impact of different prosthetic control algorithms. The hypothesis was that cognitive load could be disentangled from performance, anticipating discernible variances in DRT response times despite optimal performance. To test this, prosthesis users completed the DRT while performing a Target Touching Task under an algorithm trained on four different amounts of training data. As the amount of training data increased, there was a significant increase ($p<0.05$) in cognitive load measured from the NASA-TLX survey and DRT times, but no significant increase in performance. This shows that cognitive load is an effective measurement for assessing quality of prosthetic control, even when performance metrics remain unchanged. Altogether, this work highlights that a DRT can objectively assess the cognitive load of prostheses and can be used to design more intuitive prostheses that improve user experience and adoption rates.

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