CLASSIFYING AND QUANTIFYING UNILATERAL PROSTHESIS USE IN HOME ENVIRONMENTS TO INFORM DEVICE AND TREATMENT DESIGN

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BACKGROUND

Although there has been substantial efforts to develop new upper limb prostheses, evaluation of such systems is typically conducted through highly structured tests in clinical / laboratory settings or through survey studies. Though such evaluation techniques provide valuable data, they do not characterize how amputees make use of their prostheses in daily life.

PURPOSE

In our work, we seek to objectively classify and quantify how experienced unilateral upper-limb prosthesis-users utilize their own prosthetic devices and unaffected limbs while completing unstructured and unsupervised manipulation tasks within their own home. Our goal is to identify usage trends in naturalistic everyday activities to inform the design of new prosthetic devices and/or therapeutic interventions.

METHODS

Our analysis is based on 'first-person perspective' video recordings from head-mounted lightweight cameras, which can record for several hours at a time. The cameras are pointed towards the hands and arms of participants, who are given a short list of recommended tasks (e.g. vacuuming, brushing teeth) but mostly complete self-chosen domestic 'housework' activities during data collection periods. To date, we have collected 16 hours of video recordings from 3 participants. Two are congenital transradial amputees (one female) who use body-powered devices and one is a male with shoulder-disarticulation amputation who uses a myoelectric powered elbow, wrist rotator and multi-grasp hand. Classification of the observed manipulation strategies led to the generation of a 'Prosthesis-User Manipulation Taxonomy' which accounts for all observed actions via manipulation 'tags' split into three categories of 'Intact Hand', 'Prosthetic Device' and 'Bi-Lateral' with an additional tag for environmental features use to aid manipulation ('Affordance'). The tags consider both prehensile 'grasping' motions in addition to non-prehensile interactions, such as pushing, leaning, clamping objects against the body or hanging objects from the Terminal Device (TD).

RESULTS

Our preliminary results stem from in-depth 'tagging' of segments of the videos using the taxonomy. We have identified several thousand tag instances at an average of 33 manipulation tags per person, per minute. Though recruitment and video analysis is ongoing, initial observations are that non-prehensile manipulation with the TD occurs significantly more often than prehensile manipulation for participants with transradial amputation. This suggests that device design efforts may benefit from focus on non-prehensile features (such as grip pads on the outside of a TD). Conversely, the participant with shoulder disarticulation completed few non-prehensile motions (which rely on arm mobility) but did utilize his multi-grasp TD to perform more prehensile grasps.