Evaluating the Influence of User-Complexity on Individual Preferences for Upper Limb Prosthetic Selection: Measurement Tool Development for a Discrete Choice Experiment

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Background

Upper limb amputation (ULA) impacts daily function and quality of life. While prosthetic devices can help restore function, many individuals face a mismatch between expectations and device performance, often leading to dissatisfaction or abandonment.

Current tools inadequately capture how preferences vary by **user-complexity** defined as an individual's capabilities, functional needs, and adaptability to technology (Sarma, 2024). Individuals may prefer simplicity and comfort, while those with high complexity may prioritize advanced features despite trade-offs.

Objective: We developed, and pilot tested a choice-based conjoint (CBC) tool that incorporates user-defined complexity levels and evaluates the trade-offs individuals with ULA are willing to make when selecting a prosthetic device.

Methods

Identification and Refinement of Attributes and Levels

- Identified key prosthetic device attributes through a scoping literature review (Wilson, 2025)
- Refined attribute and level selection through one-on-one interviews with 8 individuals with ULA and 11 field experts

Conceptual Framework: User-Complexity

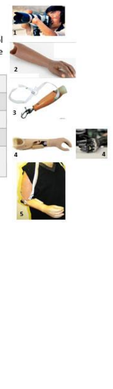
- Low: Passive Device
- Moderate: Hook and Shoulder Harness
- Moderate/High: Hybrid Harness/Myoelectric
- High: Full Myoelectric

CBC Design (Sawtooth Software)

- Employed a full-profile, balanced-overlap experimental design to simulate real-world decision-making
- Used D-efficiency scores to optimize design quality, determine final number of tasks asked, and inform sample size targets
- Final design included 14 randomized paired-choice tasks and 6 fixed-choice tasks
  - Fixed-choice tasks represented all possible pairwise comparisons between the 4 user-complexity categories

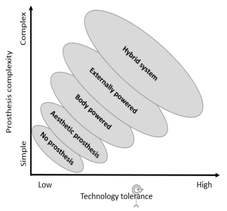
Pilot Analysis

- Recruited pilot participants through Hanger Clinic
- Analyzed attribute-level selection frequencies (times chosen/times shown) to evaluate the relative impact of benefits and risks on preferences
- Compared fixed-choice responses across the four user-complexity categories to explore preference heterogeneity



Upper limb prosthesis treatment options defined by control strategy. Intervals between levels are not equal as there are several component options within each level

1	No prosthesis
2	Functional aesthetic prosthesis
3	Body powered moving components/harness
4	Externally powered moving components
5	Hybrid system (e.g., body powered elbow + externally powered hand)



Results

Attributes and Levels Used in CBC Measurement Tool:

Risks:

1. Device Weight/Comfort Experience
2. Durability/Repair Times
3. Amount of Concentration and Energy to use Device
4. Connection of Arm to Body
5. Training and Practice Required for Successful use of Device

Benefits:

1. Functional Usefulness and Device Control
2. Life Goals for Using Two Hands, Including Device
3. Noticeability of Device

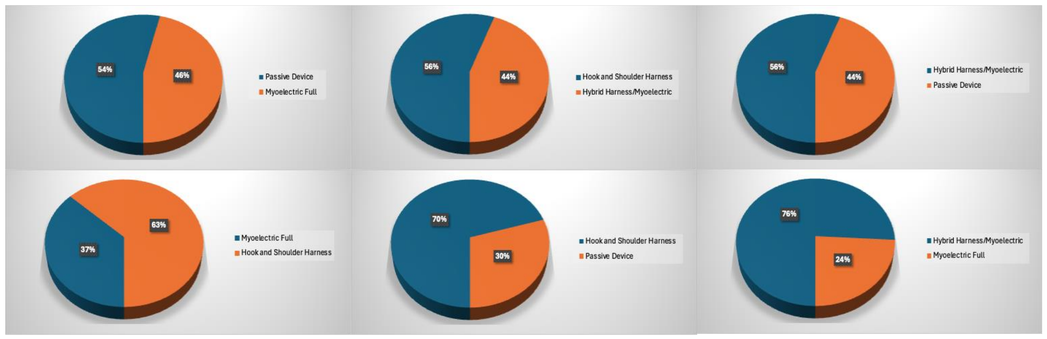
Pilot Findings: Attribute-Level Selection Frequencies

- Functional usefulness and device control mattered most: The highest-function level (allowing precise grip via implanted electrodes) was selected 62.1% of the time, the most frequently chosen level across all attributes.
- Durability and device weight/comfort were strong drivers: Highly durable devices (56.0%) and lightweight, all-day comfortable options (53.4%) were frequently preferred, reflecting user priorities for reliability and wearability.
- Preferences varied across attributes: While some features showed clear preferences, others—such as concentration, training, and noticeability—had more evenly split selections, highlighting the heterogeneity in user priorities and trade-off decisions.

Fixed-Question Response Comparisons

- Hook/shoulder harness devices (moderate-complexity) were chosen:
  - 70% of the time over passive devices (low-complexity)
  - 56% of the time over hybrid devices (moderate/high-complexity)
  - 63% of the time over full myoelectric devices (high complexity)
- Full myoelectric devices (high-complexity) were least preferred across all comparisons, with only:
  - 46% selecting over low-complexity
  - 37% selecting over moderate-complexity
  - 26% selecting over moderate/high-complexity

Attribute	Level	Freq Chosen (%)
Function	Supports but not grip	31.02
	Open/close grip only	42.38
	Power grip + some precision functions by pushing/pulling switches	57.43
	Power grip + more precision functions by using learned muscle contractions with electrodes in socket	57.10
	Pick up small objects with most accurate precision via surgically implanted battery-powered electrodes	62.13
Comfort	Low device weight; comfort all day	53.36
	Moderate device weight; notice it is on	54.96
	Heavy device weight; need breaks from using it	41.63
Durability	Very durable; takes all environments; few repairs	56.02
	Moderately durable; handle with care; some repairs	52.58
	Very delicate; no dirty/wet environments; frequent repairs	41.32
Concentration	Little concentration to use	49.70
	Physical effort & some concentration to use	50.99
	High concentration to use	49.30
Connection	Natural motion connection, low infection risk & osseointegration surgery	44.56
	Good fit, but difficult to get on and off using suction/anatomical self suspension	56.84
	Tight fit, easy to get on and off, but unstable socket rotation, skin rubbing & added bulk	50.26
	Simple, easily attach via harness, but motion restrictions, rubbing, & body fatigue	48.28
Training	Very low training or practice required	50.66
	Low training or practice required	53.56
	Medium training or practice required	48.28
	High training or practice required	47.48
Goals	Accomplish daily activities more easily with 2 hands	47.92
	Perform activities that are difficult to do without 2 hands	49.01
	All daily life and work tasks, plus additional attachment for sport/art/social activity	53.08
Noticeability	People notice and comment on how high-tech looking my device is	51.45
	Doesn't matter what others think of my device as long as I like it	49.34
	Blends in and those around me don't notice my limb loss and/or device	48.01
	Device expresses my personal style	51.19



Conclusion

The CBC tool effectively captured individualized trade-offs in upper limb prosthetic selection. Selection frequencies generally aligned with expected patterns, with participants typically choosing more favorable levels of attributes, reinforcing the tool's ability to reflect real-world decision-making. Pilot findings revealed that preferences do not uniformly favor the highest level of device complexity. While higher functional capability is an important driver of choice, many users prioritized a balance between function, comfort, durability, and the burden of training or maintenance. This often led to preferences for devices in the moderate to moderate/high complexity range (e.g., body-powered or hybrid systems), rather than fully passive or fully myoelectric options. These insights highlight the heterogeneity in user preferences and underscore the need for personalized prosthetic guidance and shared decision-making to better align devices with user needs and goals.

To date, 295 individuals with ULA have completed the CBC tool and will analyzed to further explore how user complexity and preference heterogeneity influence device selection.