

University
of California
San Francisco
(UCSF)



Individual Preference for Upper Extremity Prosthetics along a User-Complexity Framework: Optimizing Choice to Speed Recovery (8.05.26)

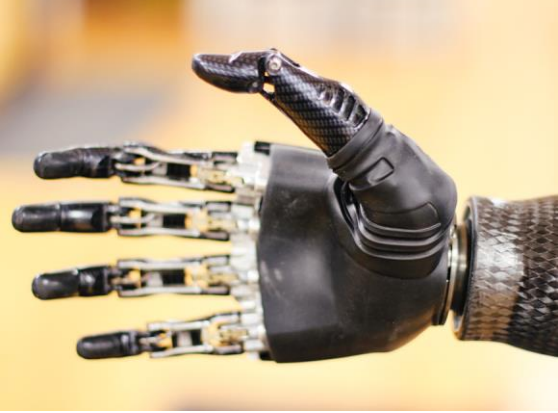
Leslie Wilson PhD, UCSF

Funding: DOD OPORP grant-4 years, 2024

Wed_1300_MHSRS_26_5836_Wilson

Disclosures

- Leslie Wilson has no conflicts to report
- Hanger Clinics where research implementation takes place provides multiple types of prosthetic devices to individuals



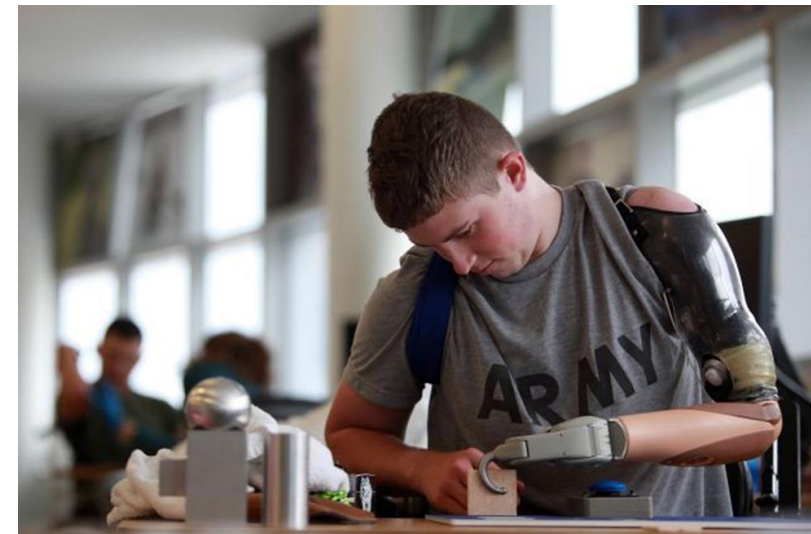
Motivation: Choose the Right Prosthetic

- Motivation:

- Extremely complex upper limb prosthetic devices are available
- While these devices can help restore function, many individuals face a mismatch between expectations and device performance
- Leads to abandonment by up to 40% of Veterans

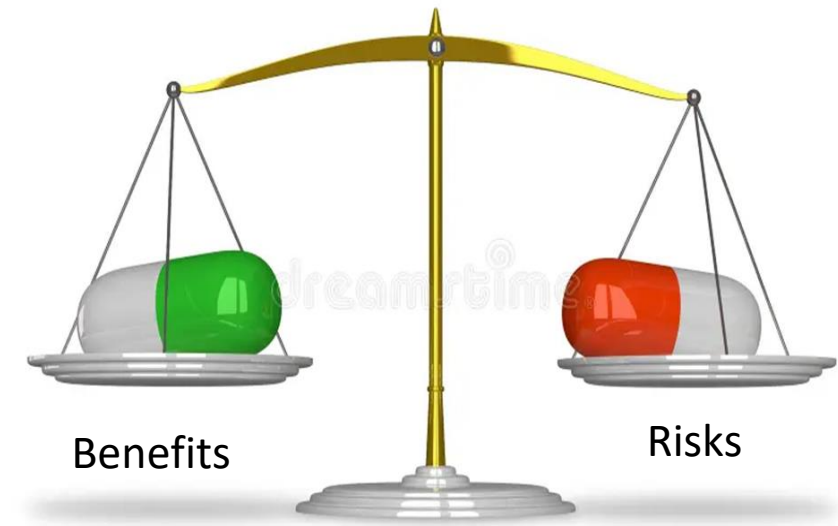
- Objectives:

- Develop and implement a **Discrete Choice Preference Tool** to determine how individuals choose an UL prosthesis
- Create a **Decision Aid** for Prosthesis Choice Across User Complexity categories
- Generate **Clinical Dashboards** of Choices, and assess its implementation in Hanger clinics nationally



What is Discrete Choice Preference?

- Technique used to understand how people make decisions and determine the value they place on different attributes or factors relevant to that decision.
- Forces decisions with realistic trade-offs
 - Can demonstrate to clinicians how patients prioritize various trade-offs
 - Can demonstrate a more equal patient/clinician communication around the individual's preferences
- Ability to assign preference utility (value) to different levels of each attribute



Discrete Choice Methods Mimic Real Decision Making

TWO ICE CREAM EXAMPLES

If these were your only options, which would you choose? (1 of 2)

	Option 1	Option 2
Flavor	Vanilla 	Chocolate 
How it's served	Cone 	Cup 
Number of scoops	2 	2 
Additions	Sprinkles 	No sprinkles 
Select one:	Select	☒

If these were your only options, which would you choose? (2 of 2)

	Option 1	Option 2
Flavor	Strawberry 	Chocolate 
How it's served	Cup 	Cone 
Number of scoops	1 	3 
Additions	Sprinkles 	Cherries 
Select one:	Select	Select



One Choice Option of our Preference Tool

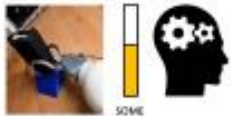
Attributes:

Function/Control

Weight/Comfort

Durability/Repair

Concentration

Option 1	Option 2
Perform power grip and some precision functions by pushing/pulling switches 	Pick up small objects with most accurate precision with surgically implanted battery-powered electrodes 
MODERATE device weight, Notice it is on 	LOW device weight, Comfort all day 
Very durable, Takes all environments, Few repairs 	Very delicate, No dirty/wet environments, Frequent repairs 
Physical effort & some concentration to use 	Little concentration to use 

Connection

Training

Life Goals

Noticeability

Natural motion connection, low infection risk & osseointegration surgery 	Tight fit, easy to get on and off, but unstable socket rotation, skin rubbing & added bulk 
LOW training or practice required 	VERY LOW training or practice required 
Perform activities that are difficult to do without 2 hands 	Accomplish daily activities more easily with 2 hands 
Blends in and those around me don't notice my limb loss and/or device. 	Doesn't matter what others think of my device as long as I like it. 
CBC_Random5 Select	CBC_Random5 Select

Conceptual Framework Developed for our Preference Tool:

USER COMPLEXITY

User-Complexity Definition: an individual’s perception of their capabilities, functional needs, and adaptability for use of different complexities of a technology

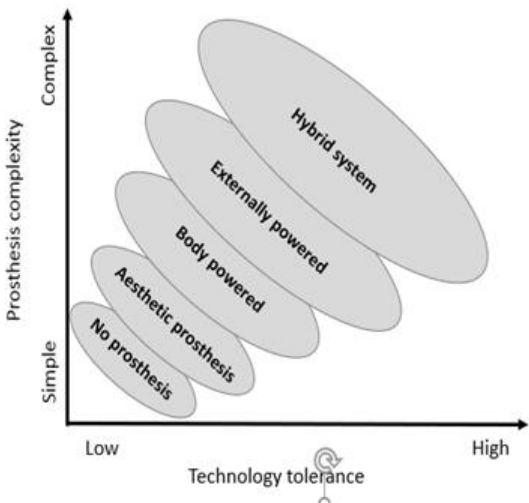
- How does individual tolerance match prosthetic design complexity?
- How do Upper Extremity Prostheses match User-Complexity Categories?

Conceptual Framework: User-Complexity Categories

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

Identification and Refinement of Attributes and Levels

- Identified key prosthetic device attributes through a scoping literature review
- Refined attribute and level selection through one-on-one interviews with 8 individuals with ULA and 11 field experts
- Conducted a pilot study to confirm final Attributes



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)



Attribute Levels by User-Complexity Prosthesis Categories

	Low: Passive	Mod: Hook/Shoulder Harness	Mod/High: Harness/Myoelectric	High: Myoelectric
Functional Usefulness and Device Control	Supports but not grip objects, doesn't move under my control 	Only, moves with physical force from shoulder 	switches 	powered electrodes 
Device Weight Comfort Experience	LOW device weight, Comfort all day 	MODERATE device weight, Notice it is on 	MODERATE device weight, Notice it is on 	HEAVY device weight, Need breaks from using it 
Durability/Repair Times	Very durable, Takes all environments, Few repairs 	Very durable, Takes all environments, Few repairs 	Moderately durable, Handle with care, Some repairs 	Very delicate, No dirty/wet environments, Frequent repairs 
Amount of Concentration and Energy to Use Device, even with Training	Little concentration to use 	Physical effort & some concentration to use 	High concentration to use 	High concentration to use 
Connection of Arm to Body	Attachment can vary from harness to socket to osseointegration with differences in stability, bulk, ease of putting on and off, and skin rubbing 	Attachment can vary from harness to socket to osseointegration with differences in stability, bulk, ease of putting on and off, and skin rubbing 	Attachment can vary from harness to socket to osseointegration with differences in stability, bulk, ease of putting on and off, and skin rubbing 	Attachment can vary from harness to socket to osseointegration with differences in stability, bulk, ease of putting on and off, and skin rubbing 
Training and Practice Required for Successful Use of Device	VERY LOW training or practice required 	LOW training or practice required 	MEDIUM training or practice required 	HIGH training or practice required 
Life Goals for Using 2 Hands, Including Device	Accomplish daily activities more easily with 2 hands 	Perform activities that are difficult to do without 2 hands 	Perform activities that are difficult to do without 2 hands 	All daily life and work tasks, plus additional attachment for sport/art/social activity 
Noticeability of Device	Doesn't matter what others think of my device as long as I like it. 	Doesn't matter what others think of my device as long as I like it. 	Doesn't matter what others think of my device as long as I like it. 	Doesn't matter what others think of my device as long as I like it. 

Study Design for Preference Tool Development



- **Sample:** 271 Adults with upper limb loss at or above wrist
- **Recruitment:** Hanger Clinics Nationally: Including the 42-78% of veterans seeing private prosthetists, (paid \$25 when completed)
- **Survey Administration:** Sawtooth On-line software
 - DCE Design: randomized, full-profile, balanced overlap choice pairs
 - 14 Random Pairs and 6 fixed scenarios represent user-complexity levels
- **Analysis:**
 - Random Parameters logistic regression
 - Sub-Analysis comparisons
 - Frequencies across 6 fixed choice management options
 - Latent Class Analysis to identify Prosthesis User-Complexity Groups

RESULTS



Demographics & Clinical Characteristics

Demographic Information		Participants (N = 271)
Age, mean (SD)		56 (16.8)
Gender, n (%)		
Male		165 (60.9)
Female		106 (39.1)
Race/Ethnicity, n (%)		
American Indian/Alaska Native		1 (0.4)
Asian/Pacific Islander		13 (4.8)
Black or African American		17 (6.3)
Latino/Hispanic		13 (4.8)
White/Caucasian		219 (80.8)
Multiple Ethnicity		8 (3.0)
Marital Status, n (%)		
Married or Partnered		175 (64.6)
Single		59 (21.8)
Divorced		20 (7.4)
Widowed		17 (6.3)
Education Level, n (%)		
Less than Some High School		3 (1.1)
High School Diploma or Equivalent		34 (12.5)
Some College		68 (25.1)
College Degree		96 (35.4)
Graduate Degree		70 (25.8)
Employment Status ^a , n (%)		
Full-Time		92 (33.9)
Part-Time		22 (8.1)
Self-Employed		20 (7.4)
Unemployed		17 (6.3)
Home-maker		3 (1.1)
Student		6 (2.2)
Volunteer		5 (1.8)
Retired		97 (35.8)
Unable to Work due to Disability		40 (14.8)
Annual Household Income, n (%)		
Less than \$25,000		34 (12.5)
\$25,000 - \$49,999		53 (19.6)
\$50,000 - \$99,999		87 (32.1)
\$100,000 or More		97 (35.8)
Type of Insurance ^a , n (%)		
Medicare		120 (44.3)
Medicaid (or MediCal)		37 (13.7)
VA/TRICARE		16 (5.9)
Employer or Self-Insured Private Plan		147 (54.2)
Other Government Insurance (e.g. CalPERS, Workers Comp)		25 (9.2)
Uninsured		5 (1.8)
Does Insurance Cover Prosthetic Devices, n (%)		
Yes, all		103 (38.0)
Yes, some		123 (45.4)
No		23 (8.5)
Unsure		22 (8.1)
^a Individuals may have chosen more than one option; thus counts may exceed sample size		

Clinical Characteristics	Participants (N = 271)
Side Dominance, n (%)	
Right-Handed	208 (76.8)
Left-Handed	53 (19.6)
Ambidextrous	10 (3.7)
Health Conditions, n (%) ^a	
Asthma, Emphysema, or Chronic Bronchitis	34 (12.5)
Arthritis or Rheumatism	74 (27.3)
Cancer, Diagnosed in the Past 3 Years	22 (8.1)
Diabetes	33 (12.2)
Digestive Problems (Ulcer, Colitis, or Gallbladder Disease)	29 (10.7)
Heart Trouble (Angina, Congestive Heart Failure, or Coronary Artery Disease)	23 (8.5)
HIV Illness or AIDS	8 (3.0)
Kidney Disease	12 (4.4)
Liver Problems (Cirrhosis)	8 (3.0)
Stroke	17 (6.3)
Current Health Status, n (%)	
Excellent	54 (19.9)
Very Good	112 (41.3)
Good	88 (32.5)
Fair	14 (5.2)
Poor	3 (1.1)
Upper Limb Status, n (%)	
Upper Limb Amputation Only	212 (78.2)
Upper Limb Difference Only	37 (13.7)
Both Upper Limb Amputation & Difference	22 (8.1)
Affected Limb(s), n (%)	
Right Arm	108 (39.9)
Left Arm	131 (48.3)
Both Arms	32 (11.8)
Age at Limb Amputation/Difference ^b , mean (SD)	23.7 (22.2)
Level of Limb Loss Amputation/Difference ^c , n (%)	
Above the Shoulder	3 (1.1)
At the Shoulder	6 (2.2)
Above the Elbow	46 (17.0)
At the Elbow	8 (3.0)
Below the Elbow	162 (59.8)
At the Wrist	46 (17.0)
Main Reason for Upper Limb Amputation/Difference ^d , n (%)	
Congenital	81 (29.9)
Accident	123 (45.4)
Cancer	17 (6.3)
Diabetes or Loss of Circulation	0
Infection	15 (5.5)
US Military Trauma	6 (2.2)
Other	29 (10.7)

^a Individuals may indicate having multiple health conditions or none at all

^b Average of the two ages for individuals with bilateral amputations were used in this calculation

^c Individuals with bilateral amputations were counted only for the more severe level of amputation

^d Individuals with bilateral amputations indicated same reason for both arms and thus only counted once

Prosthetic Characteristics & Standardized Measures Scores

Standardized Measures (Raw Scores)	Participants (N = 271)
PROMIS Physical Function, mean (SD)	27.4 (9.2)
PROMIS Pain Interference, mean (SD)	14.6 (7.8)
Patient Trust in Prosthetist, mean (SD)	18.8 (4.9)
Satisfaction in Device Training, mean (SD)	7.3 (3.0)
Social Support Scale, mean (SD)	12.7 (3.6)
OPUS: Health Quality of Life Index, mean (SD)	67.7 (17.6)
OPUS: Satisfaction with Device, mean (SD)	35.8 (11.9)

full possible score range: 0 to 44	higher score = better physical function	
full possible score range: 8 to 40	lower score = better (less pain interference)	
full possible score range: 5 to 25	higher score = more trust	
full possible score range: 0 to 12	higher score = more satisfied	
full possible score range: 0 to 16	higher score = higher social support	
full possible score range: 0 to 92	higher score = better outcome	
full possible score range: 11 to 55	higher score = better outcome	

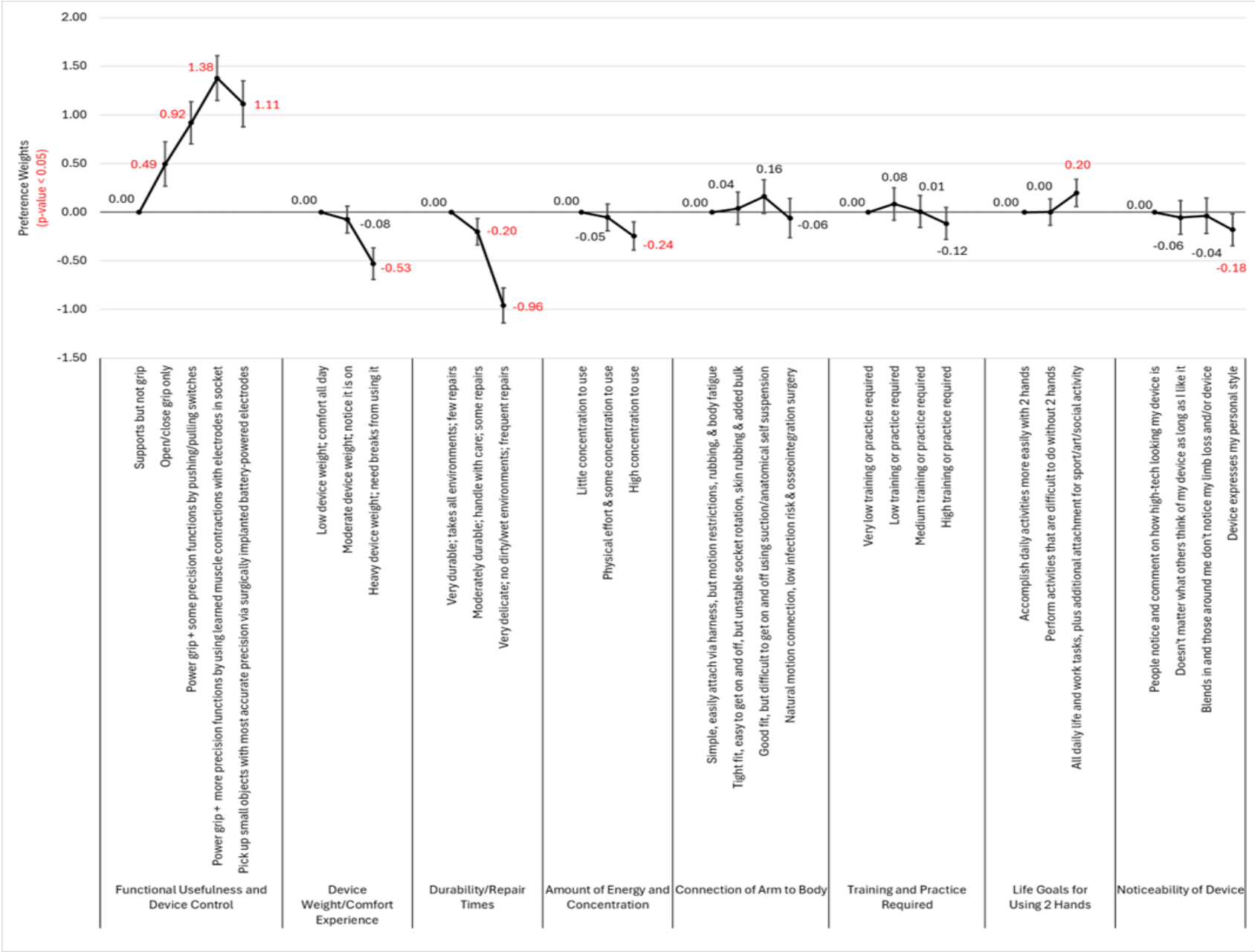
Prosthetic Characteristics	Participants (N = 271)
Prosthetic Device Knowledge, n (%)	
None	1 (0.4)
Very Little Knowledge	25 (9.2)
Moderate Knowledge	122 (45.0)
Very Knowledgeable	85 (31.4)
Extremely Knowledgeable	38 (14.0)
Number of Owned Prosthetic Devices in Lifetime, mean (SD)	7.1 (7.8)
Number of Owned Prosthetic Devices Currently Used, mean (SD)	1.7 (1.3)
Use of Prosthetic Device in Days per Week, mean (SD)	4.8 (2.7)
Use of Prosthetic Device in Hours per Day, n (%)	
Less than 1 Hour per Day	25 (9.2)
1 - 4 Hours per Day	45 (16.6)
5 - 8 Hours per Day	50 (18.5)
9 -12 Hours per Day	46 (17.0)
13 - 24 Hours Per Day	72 (26.6)
Do Not Wear Prosthesis	33 (12.2)
Prosthesis Used Most Often ^a , n (%)	
No Prosthesis	34 (12.5)
Aesthetic (Cosmetic)	39 (14.4)
Body-Powered Harness	101 (37.3)
Non-Electrically Powered	20 (7.4)
Electrically-Powered	97 (35.8)
Hybrid	4 (1.5)
Activity-Specific	21 (7.7)
Suspension System/Method for Keeping Prosthesis On ^a , n (%)	
Shoulder Harness	128 (47.2)
Suction or Skin Fit	109 (40.2)
Roll-On Liner/Gel	28 (10.3)
Suspension Sleeve	19 (7.0)
None	28 (10.3)
Osseointegration	1 (0.4)
Other	29 (10.7)
Main Reason for Use of Prosthetic Device, n (%)	
Helps Perform General Activities of Daily Living	136 (50.2)
Helps with Mobility at Work	10 (3.7)
Makes my Amputation Less Noticeable	49 (18.1)
Helps Perform Recreational Activities	21 (7.7)
Other	55 (20.3)
Main Factor Limiting Use of Prosthetic Device, n (%)	
Too Heavy or Uncomfortable	66 (24.4)
Skin Becomes too Irritated	22 (8.1)
Too Noticeable in Public	8 (3.0)
Does not Provide Enough Usefulness	70 (25.8)
Phantom or Overuse Pain is too much	9 (3.3)
Makes me too Tired to Use	2 (0.7)
Too Expensive	11 (4.1)
Other	83 (30.6)
Socket or Attachment Type Used Most Often, n (%)	
Hard Socket	124 (45.8)
Flexible with Silicone Liner	94 (34.7)
Flexible with Non-Silicone Liner	9 (3.3)
Osseointegration	0
No Prosthesis or Artificial Limb	20 (7.4)
Other	24 (8.9)
Comfort Score of Socket Fit ^b , mean (SD)	6.4 (2.8)
Level of Prosthetic Device User Experience ^b , mean (SD)	7.2 (2.9)
Satisfaction with Prosthetic Device ^b , mean (SD)	6.2 (3.0)

^a Individuals were asked to select 1 to 2 options, thus counts may exceed sample size

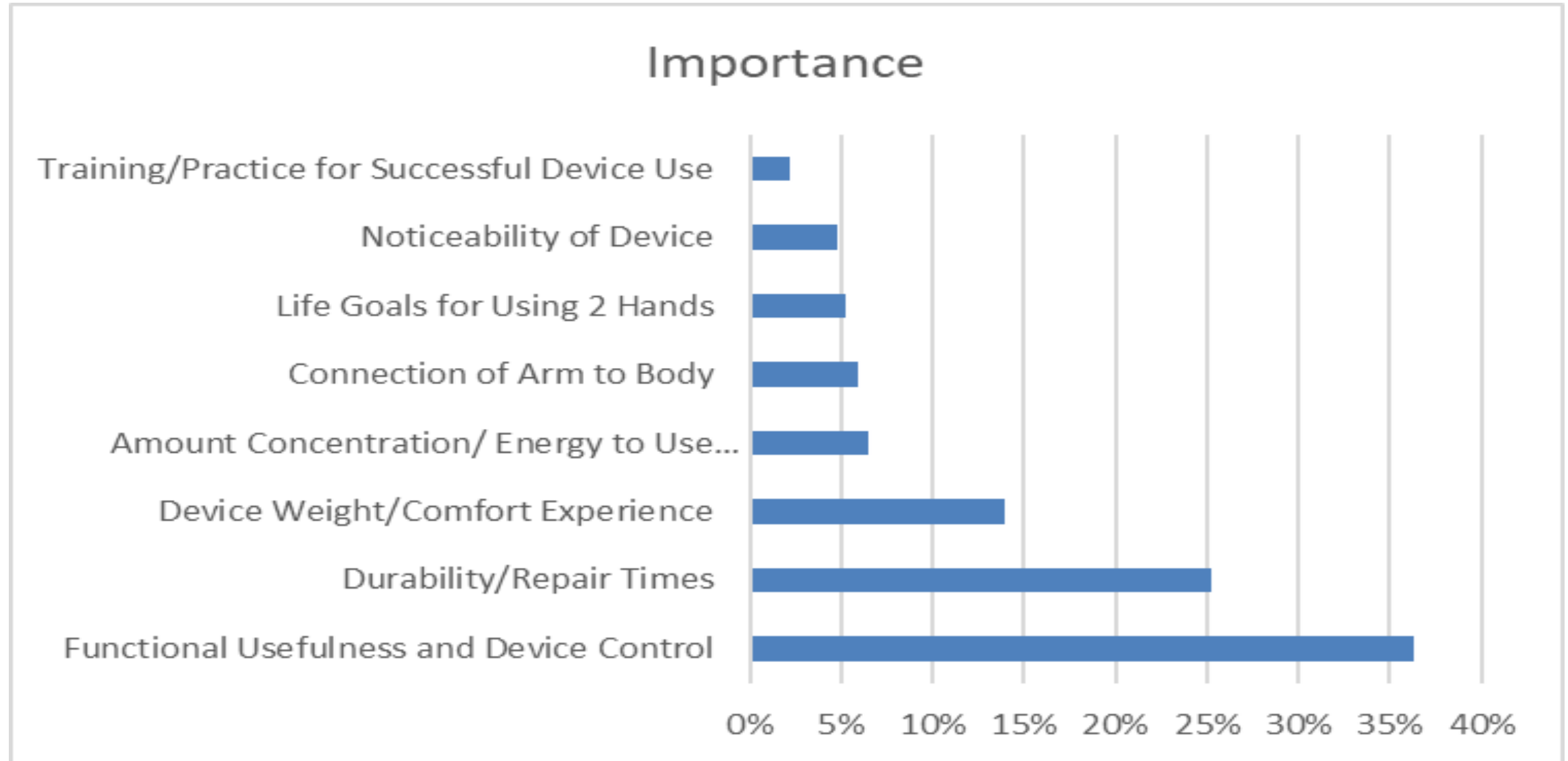
^b Scores are based on an 11-point Likert scale ranging from 0 to 10

Preference Scores

- 1. 2nd highest Functional Use is most preferred: $\beta=1.38$, Most Complex is next preferred $\beta=1.11$
- 2. Least Durable is least preferred $\beta=-0.96$
- 3. Heavy device is neg. preferred about half as much as durability $\beta= -0.53$



Percent Each Attribute Contributes to Prosthesis Choice

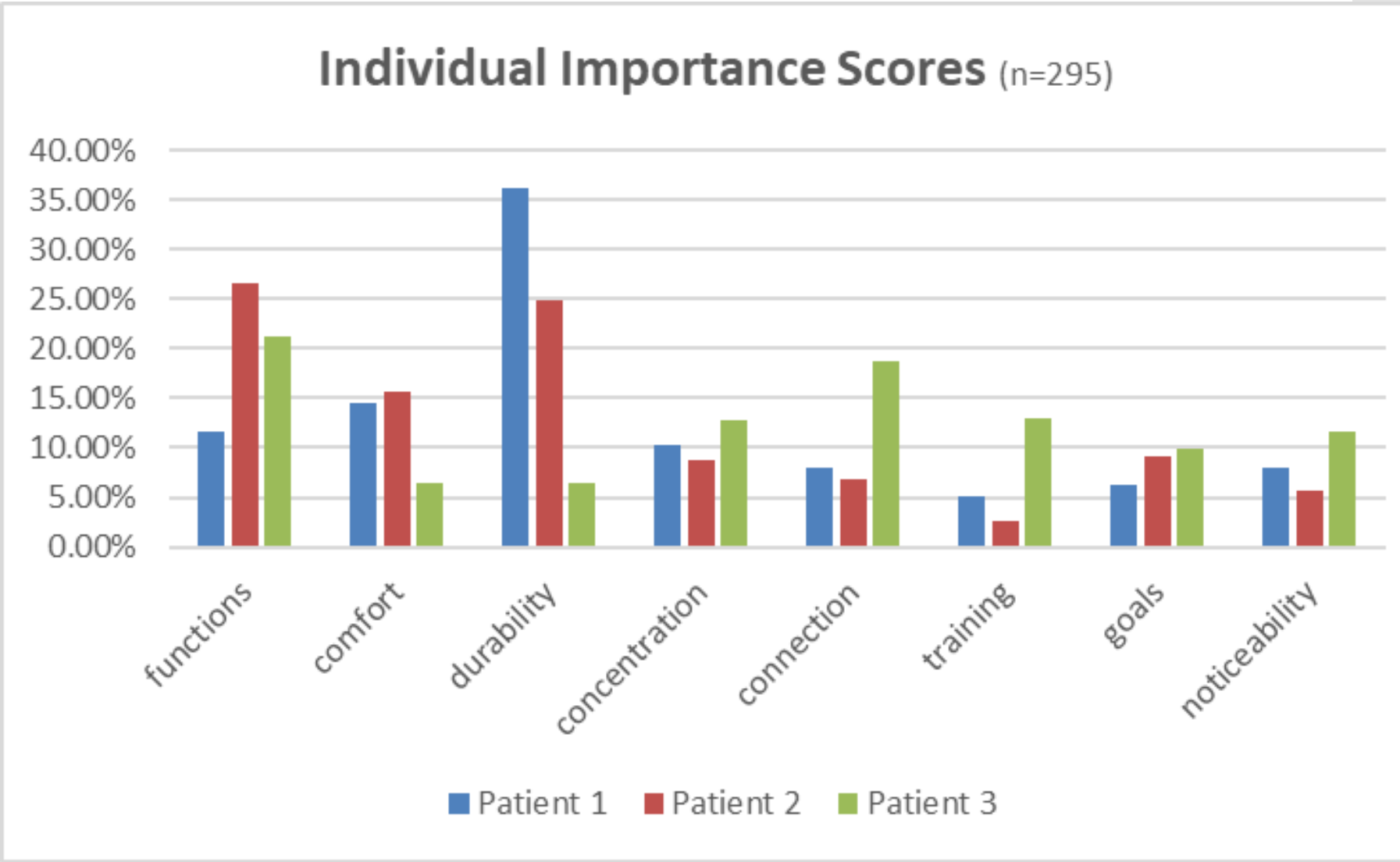


Each Individual has Different Importance Scores based on which Attributes are Most Important to their Prosthesis Choice

Patient 1 shows that prosthetic durability is most important, providing 36% of the importance to choosing a prosthetic, Comfort is next (14%) and Function is third (11%)

Patient 2 shows that function is most important to his/her choice of prosthetic (27%) while durability is 2nd (24%) and comfort 3rd (16%)

Patient 3 shows that function is most important (22%), followed by device connection (18%), & amount of training (13%) & concentration needed (12%).



4 Latent Classes:

Each class corresponds to a User-complexity Technology and a potential Prosthetic choice to discuss :

- C1: Mod to Mod/High
- C2: Low
- C3 Mod/High to High
- C4: Mod/High

3 Individuals: probability of belonging to each class:

Persons	PROBABILITIES (AS PERCENTAGE)			
	Class.1	Class.2	Class.3	Class.4
1	0.25%	26.29%	73.44%	0.02%
2	0.03%	51.10%	6.24%	42.62%
3	0.00%	0.01%	96.84%	3.15%

Attribute (N=271)	Class 1 (12%)		Class 2 (27%)		Class 3 (50%)		Class 4 (11%)	
	β - coefficient	SE	β - coefficient	SE	β - coefficient	SE	β - coefficient	SE
Functional Usefulness and Device Control								
Supports but not grip (<i>Reference</i>)	-	-	-	-	-	-	-	-
Open/close grip only	1.314	0.430	0.763	0.214	0.080	0.148	0.548	0.343
Power grip + some precision functions by pushing/pulling switches	1.633	0.492	0.008	0.211	1.072	0.145	1.029	0.359
Power grip + more precision functions by using learned muscle contractions with electrodes in socket	1.617	0.444	0.209	0.217	1.446	0.149	1.812	0.342
Pick up small objects with most accurate precision via surgically implanted battery-powered electrodes	1.532	0.444	0.346	0.206	1.382	0.143	0.244	0.374
Device Weight/Comfort Experience								
Low device weight; comfort all day (<i>Reference</i>)	-	-	-	-	-	-	-	-
Moderate device weight; notice it is on	0.145	0.289	-0.010	0.141	-0.198	0.088	0.213	0.283
Heavy device weight; need breaks from using it	-0.056	0.284	-0.469	0.138	-0.668	0.098	0.401	0.247
Durability/Repair Times								
Very durable; takes all environments; few repairs (<i>Reference</i>)	-	-	-	-	-	-	-	-
Moderately durable; handle with care; some repairs	-1.471	0.328	-0.174	0.119	-0.003	0.091	0.303	0.223
Very delicate; no dirty/wet environments; frequent repairs	-3.948	0.531	-0.662	0.133	-0.454	0.097	0.002	0.220
Amount of Concentration and Energy to Use Device								
Little concentration to use (<i>Reference</i>)	-	-	-	-	-	-	-	-
Physical effort & some concentration to use	0.123	0.282	-0.117	0.130	0.032	0.092	-0.220	0.251
High concentration to use	-0.564	0.301	-0.327	0.141	-0.089	0.092	0.082	0.262
Connection of Arm to Body								
Simple, easily attach via harness, but motion restrictions, rubbing, & body fatigue (<i>Reference</i>)	-	-	-	-	-	-	-	-
Tight fit, easy to get on and off, but unstable socket rotation, skin rubbing & added bulk	-0.430	0.322	-0.535	0.165	0.409	0.133	0.004	0.297
Good fit, but difficult to get on and off using suction/anatomical self suspension	-0.592	0.332	-0.529	0.169	0.581	0.135	-0.032	0.262
Natural motion connection, low infection risk & osseointegration surgery	-0.156	0.309	-1.040	0.222	0.720	0.134	-1.002	0.415
Training and Practice Required for Successful Use of Device								
Very low training or practice required (<i>Reference</i>)	-	-	-	-	-	-	-	-
Low training or practice required	0.716	0.360	-0.158	0.155	-0.135	0.118	1.421	0.368
Medium training or practice required	-0.053	0.306	-0.176	0.158	-0.112	0.111	1.127	0.393
High training or practice required	0.171	0.310	-0.326	0.137	-0.202	0.107	1.131	0.402
Life Goals for Using 2 Hands								
Accomplish daily activities more easily with 2 hands (<i>Reference</i>)	-	-	-	-	-	-	-	-
Perform activities that are difficult to do without 2 hands	-0.777	0.316	0.043	0.120	-0.025	0.090	0.478	0.244
All daily life and work tasks, plus additional attachment for sport/art/social activity	-0.387	0.292	0.127	0.141	0.241	0.092	0.279	0.283
Noticeability of Device								
People notice and comment on how high-tech looking my device is (<i>Reference</i>)	-	-	-	-	-	-	-	-
Doesn't matter what others think of my device as long as I like it	-0.235	0.354	0.472	0.158	-0.127	0.113	-1.125	0.352
Blends in and those around me don't notice my limb loss and/or device	-0.253	0.321	0.427	0.188	-0.065	0.115	-1.061	0.325
Device expresses my personal style	-0.235	0.334	0.133	0.158	-0.253	0.113	-0.880	0.348
USER-COMPLEXITY TECHNOLOGY CHOICE	Mod to Mod/High		Low		Mod/High to High		Mod/High	
PROSTHETIC CHOICE	Hybrid/Myoelectric		Body Powered		Osseointegration Hybrid Myoelectric		No Osseo, Wants training, doesn't mind weight or delicate	

Prosthesis Choice Descriptions

Best Match

Passive to Body-Powered

Indicated preference for passive device that provides support and natural appearance without active grip, to body-powered device controlled by shoulder harness with strong grip function.

Best Match

Osseointegration, Hybrid to Simpler Myoelectric

Potential willingness to consider bone-anchored attachment. Indicated preference for hybrid device combining body movements with muscle signals or switches or simpler myoelectric control systems.

Best Match

Hybrid to Simpler Myoelectric

Indicated preference for devices that combine body movements with muscle signals or switches for control or simpler electric systems controlled by muscle signals/switches alone.

Best Match

Fully Myoelectric

Indicated preference for electric motor-powered device controlled by muscle signal electrodes on or in arm muscles, with socket attachment rather than bone anchoring.

Individualized Clinical Dashboard

Patient information & Reason for Visit

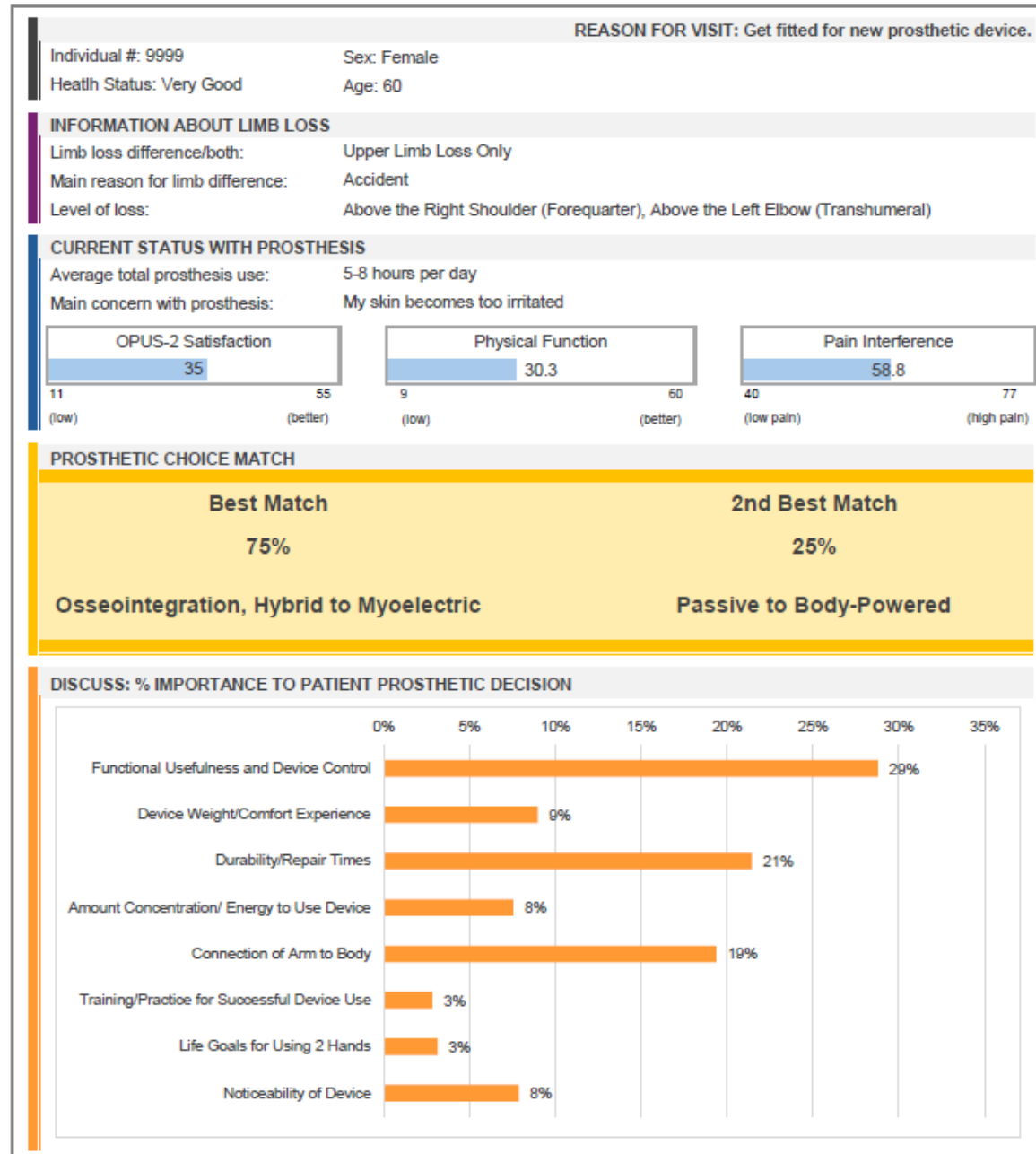
Limb Loss Information

Current Status with Prosthesis:

- Opus Satisfaction, Physical Function & Pain Interference

Best Match recommendations with percentages

Top Factors & percent Importance to Prosthesis Choice



Simplified Printed Patient Preference Report to Share with Patient

Key Components:

- Main reason for visit and patient main concern
- Best match recommendations with confidence percentages
 - Primary (e.g., 75% match)
 - Secondary (e.g., 25% match)
- Top 3 Preference Importance chart showing what attributes matter most to their prosthesis choice
 - Functional usefulness and device control
 - Weight/comfort experience
 - Durability/repair times
 - Energy/concentration requirements
 - Connection to body, training needs, life goals, noticeability

Prosthesis Choice Report for:	
Janet Jones	
Main Reason for Visit:	
Get fitted for new prosthetic device.	
You Mentioned:	
My skin becomes too irritated	

→ Your Best Match Recommendations

Best Match Osseointegration, Hybrid to Myoelectric This type connects directly to your bone and uses muscle signals to control the device.	75%
Second Best Match Passive to Body-Powered This type supports objects but does not actively grip. It is controlled by your body movements.	25%

What Matters Most to You
Here is what is most important to you when choosing a prosthetic device:

	0%	5%	10%	15%	20%	25%	30%	35%
Functional Usefulness and Device Control								
Durability/Repair Times								
Connection of Arm to Body								



Goals of Dashboard

- Guide patients in evaluating the factors associated with each choice
- Provide patients with information on prosthesis options
- Enhance communication between prosthetist and patient
- Improve efficiency and elicit shared-decision making.



ACKNOWLEDGEMENTS:

Shane Wurdeman PhD, Hanger Institute

Todd Castleberry, Hanger Institute

Kristin Nav

Ruben Vargas, UCSF

Danea Horn, UCSF