



Targeted Muscle Reinnervation

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Background

- 82% majority of trauma that currently occurs in Iraq and Afghanistan involves the upper and lower extremities
 - Wearing of protective body armor
 - MRAP (Mine resistant Ambush Protected Vehicle)
 - IED (Improvised Explosive Devices)
 - Iraq – 155 artillery rounds
 - Afghanistan – nitrogen based bombs



Return to Duty Rate of Amputee Soldiers in the Current Conflicts in Afghanistan and Iraq

CPT Daniel J. Stinner, MD, MAJ Travis C. Burns, MD, LTC Kevin L. Kirk, DO, and COL James R. Ficke, MD

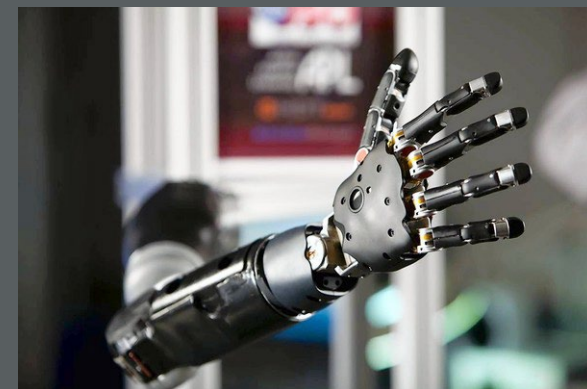
During the 1980s, 11 of 469 (2.3%) amputees returned to active duty

The number of amputees returning to duty has increased significantly, from 2.3% to 16.5%, due to advancements in combat casualty care and the establishment of centralized amputee centers



Applied Physics Lab Modular Prosthetic Limb

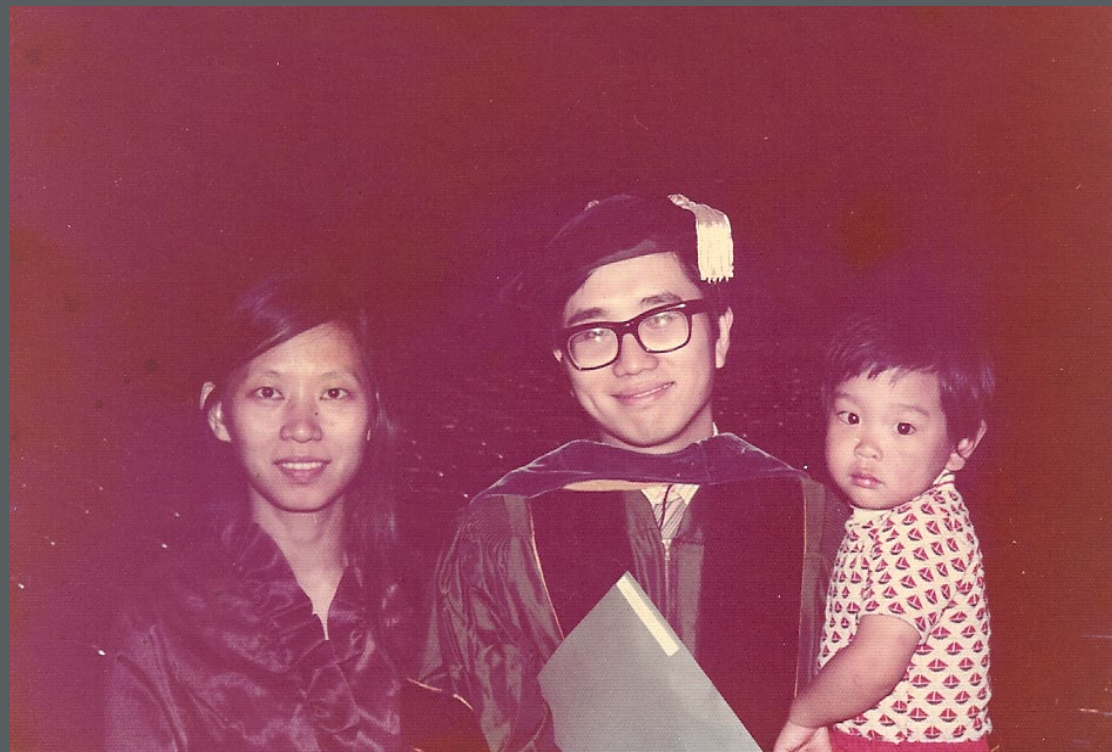
- Designed for modularity and 50% male
- The robotic arm itself weighs 9 lbs
- Capable of 17 degrees of freedom
 - Able to move each individual finger and full range of motion of the wrist
 - Able of curling 50 lbs
- Sensory feedback able to measure temperature, pressure, velocity and position



DARPA – Revolutionizing Prosthetics Program

- Benefit individuals at all levels of injury
 - Missing upper extremity
- Control Strategies
 - Surface EMG Control

WAYNE STATE
UNIVERSITY





Bruce Lee an American born martial artist, philosopher and the founder of the Jeet Kune Do martial arts system



Pete Rose best known for his years with the Cincinnati Reds is the all-time Major League leader in hits, games played, at bats and outs



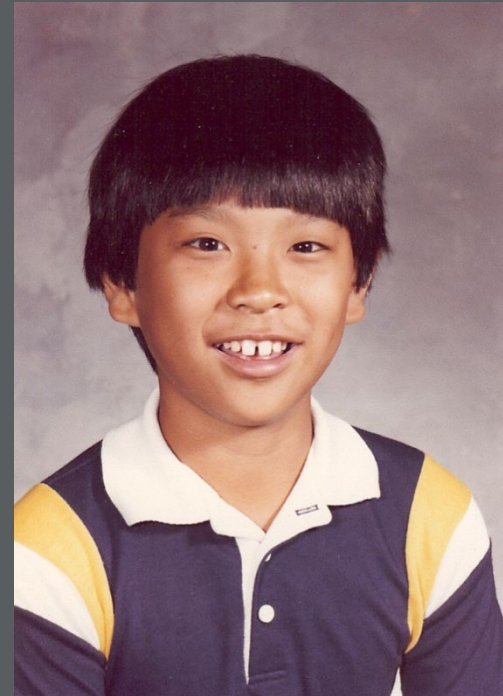
Moe Howard was one of The Three Stooges comedy team who starred in motion pictures and television



4th grade



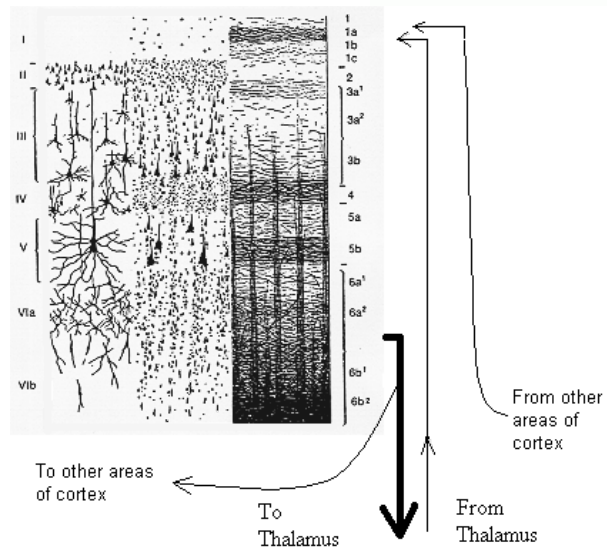
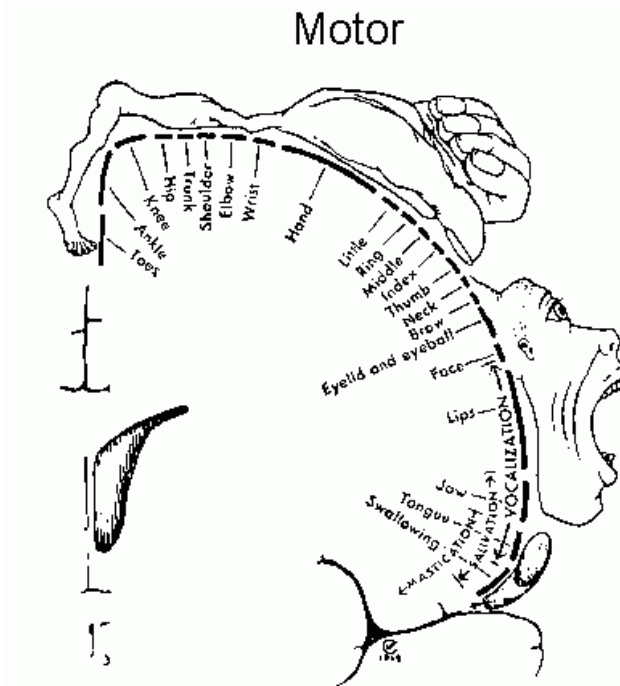
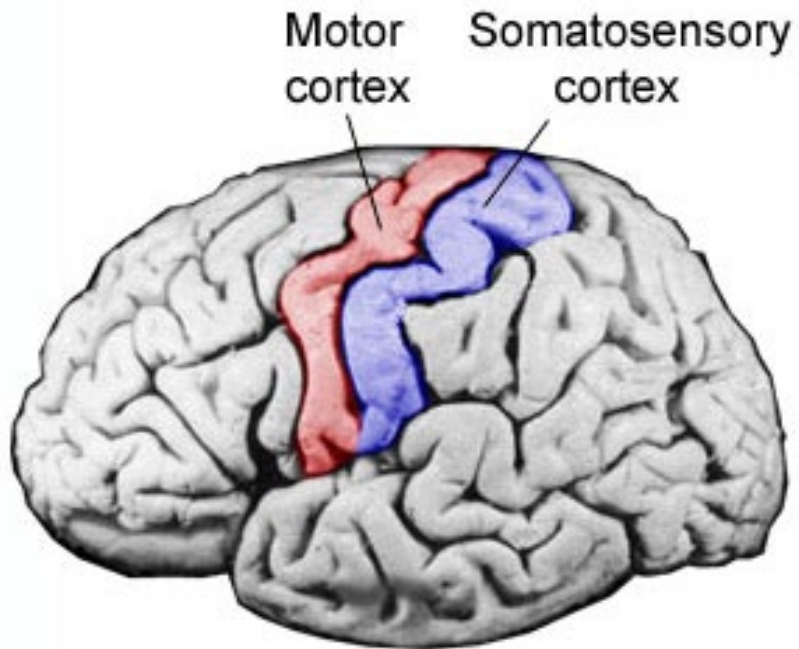
5th grade



6th grade



Jennifer Chi
born
September 30, 1973





“Breakthrough”

Aired December 21, 2012

- Benefit individuals at all levels of injury
 - Spinal Cord injury
- Control Strategies
 - Cortical Control





“Breakthrough”

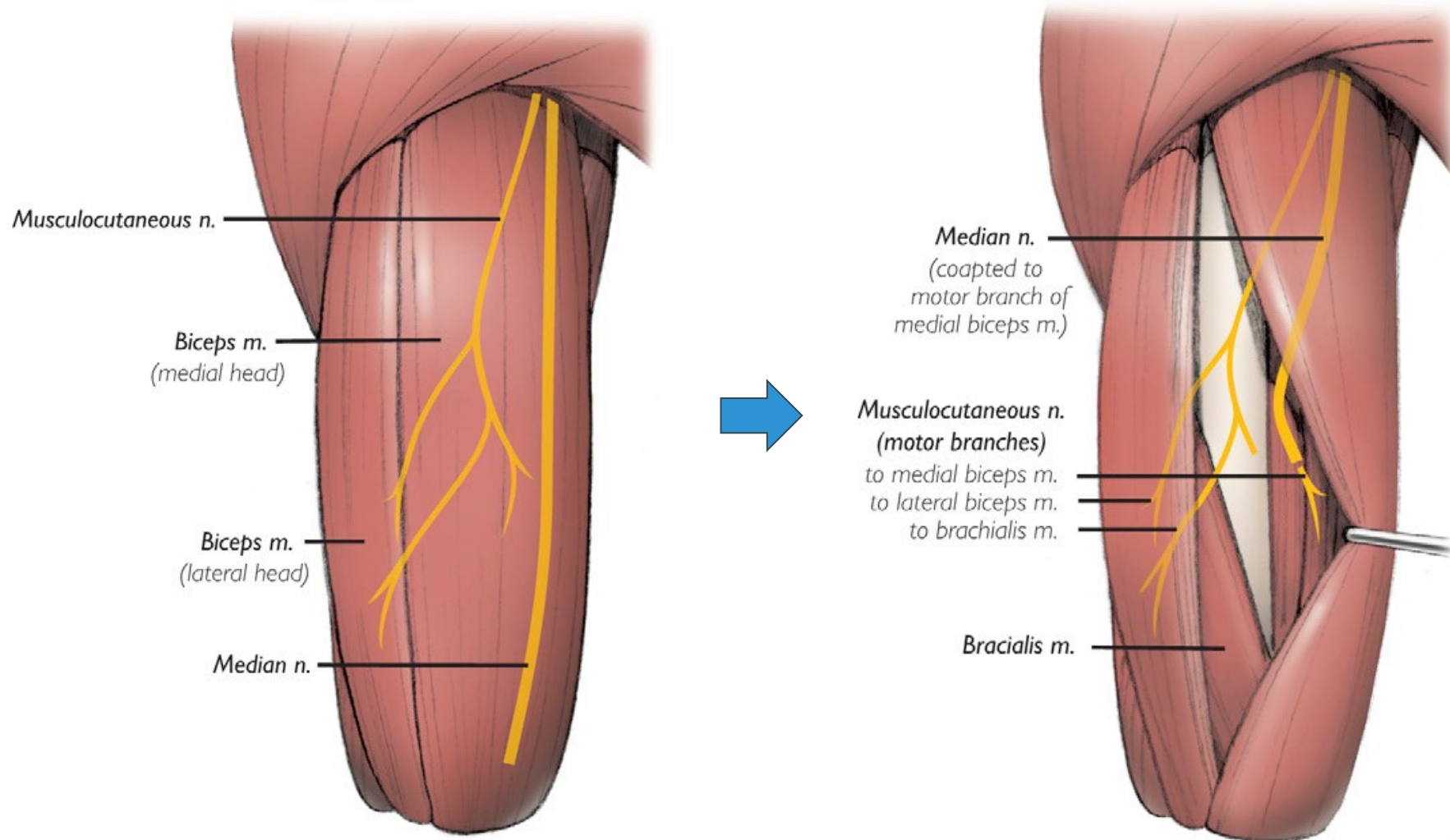
Aired December 21, 2012



DARPA – Revolutionizing Prosthetics Program

- Benefit individuals at all levels of injury
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Targeted Muscle Reinnervation



Pre and Post TMR – Above Elbow Commercially Available Prosthetics

Residual

Musculocutaneous -> Lateral biceps
Proximal Radial -> Long head Triceps

Transfers

Median -> Medial head Biceps
Distal Radial -> Lateral Triceps
Ulnar -> Brachialis

Functions

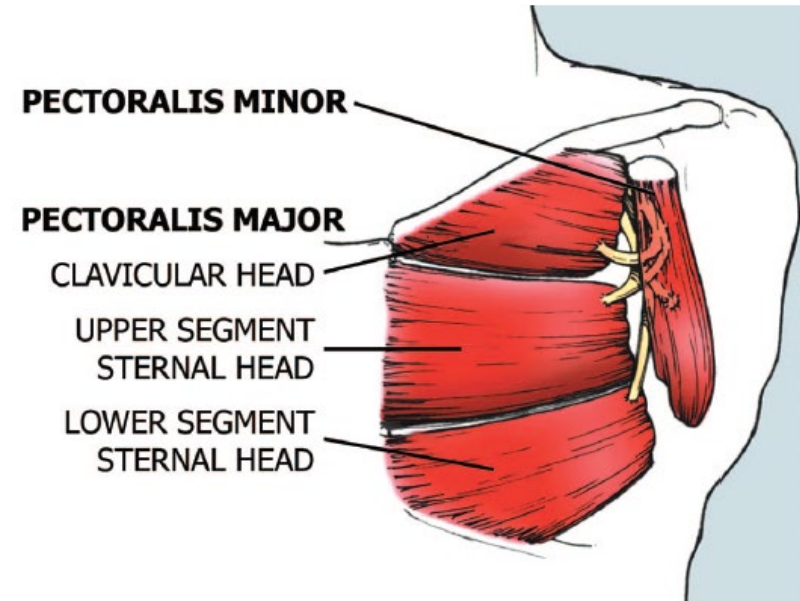
Elbow flexion
Elbow extension

Functions

Hand Close
Hand Open
Wrist/Hand



Pre and Post TMR – Shoulder Commercially Available Prosthetics



Targeted Muscle Reinnervation Advanced Algorithms

Figure 1. Normal Anatomy and Examples of Targeted Muscle Reinnervation (TMR)

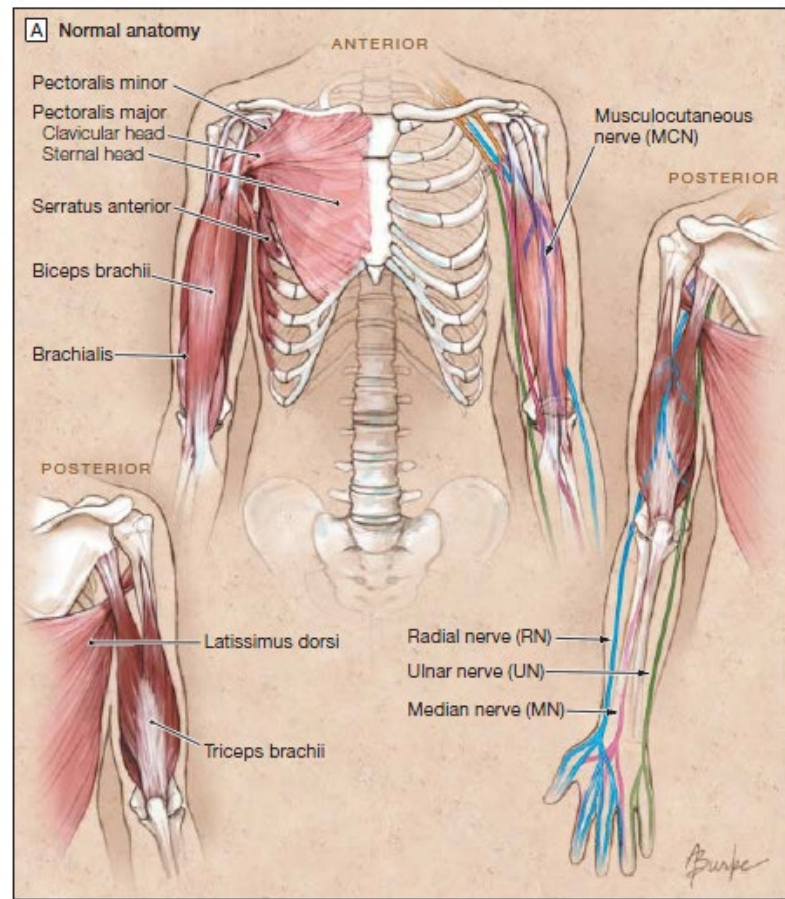


Table.

Peripheral nerve actions (radial, median, and ulnar) of upper limb.

Radial	Median
Elbow Extension	Pronation
Supination	Radial wrist flexion
Radial Wrist Extension	Midline wrist flexion
Ulnar Wrist Extension	Finger flexion at DIPs and MPs (digits 2 & 3)
Midline Wrist Extension	Finger flexion at PIPs
Index finger extension	Thumb flexion (distal)
Little Finger Extension	Thumb opposition
Thumb Extension	Thumb abduction
Finger Extension	Finger abduction
	Finger adduction

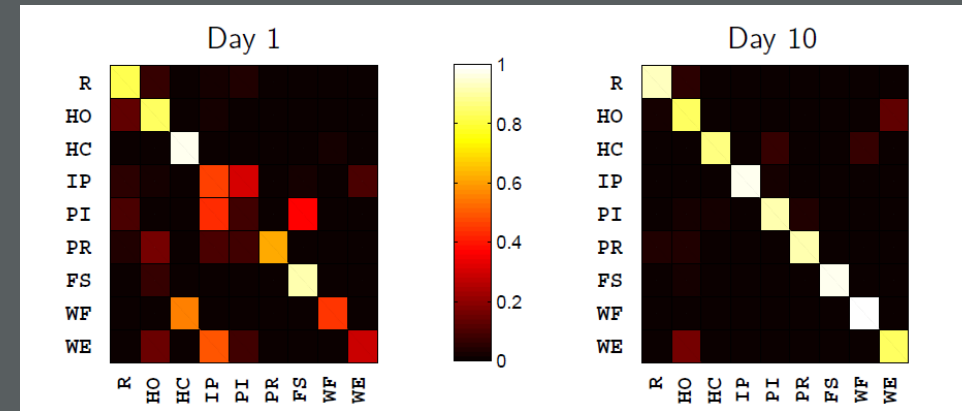
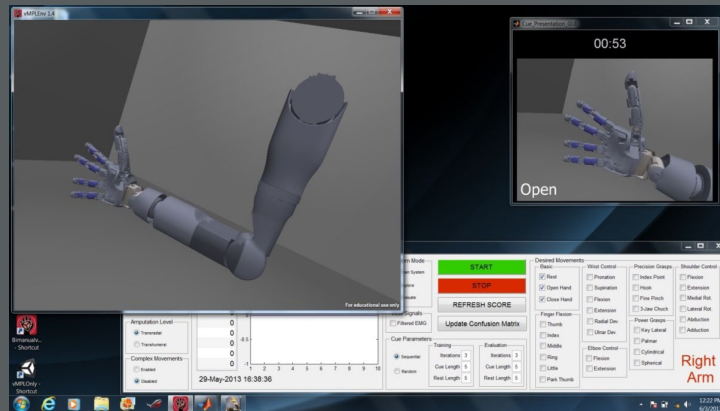
Ulnar

Ulnar wrist flexion
 Finger flexion at DIP (digits 4 & 5)
 Thumb flexion (proximal)
 Thumb abduction
 Little finger opposition
 Little finger abduction
 MP flexion (digits 3 & 4)

A Training Strategy for Learning Pattern Recognition Control for Myoelectric Prostheses

Michael A. Powell, BS, Nitish V. Thakor, PhD

JPO Journal of Prosthetics & Orthotics:
January 2013

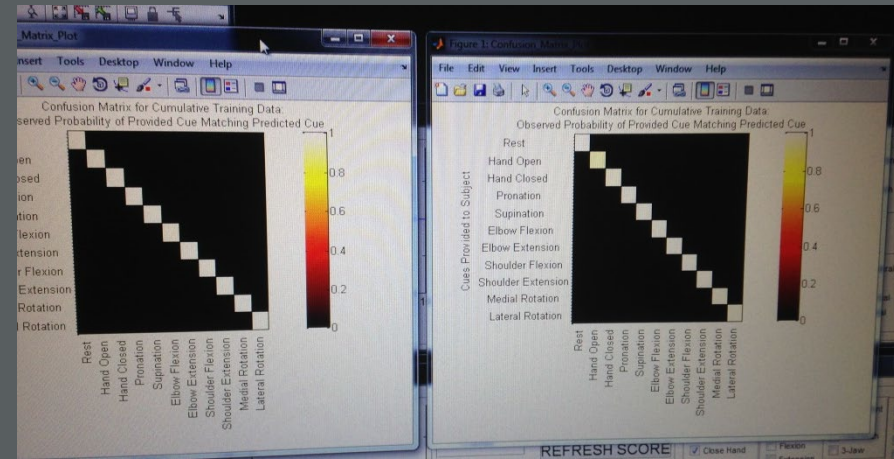


- Virtual Interactive Environment Real-time control and feedback
 - Confusion Matrix Performance Feedback
 - Able to classify multiple grips and finger control

Air Guitar Hero

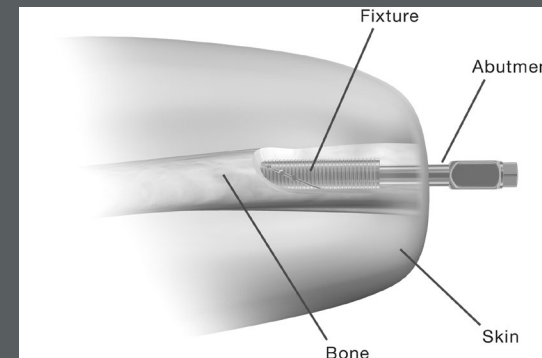
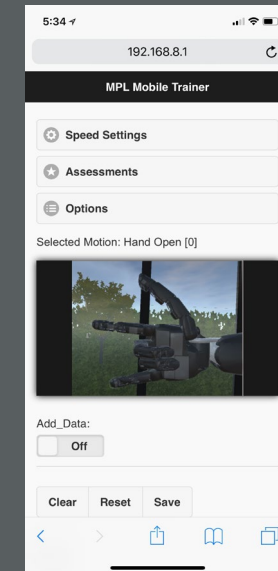
- Pattern Recognition
- Intuitive individual finger control
- Accurate prediction of position and duration in real time

Bilateral MPL Shoulder Fitting



Osseointegration / October 2015

- First patient in the US to have an upper extremity OI implant
- Bluetooth Myobands streaming EMG wirelessly
- Utilizes Mobile APP for control and classifications



Amazing Grace



Charles, Betty &
Samantha Matheny



DEKA Demonstration

- Limitations
 - Requires stationary control
 - Cognitive burden
 - Bilateral operation
 - Requires foot manipulation

OHSU / DEKA Arm





Preemptive Treatment of Phantom and Residual Limb Pain with Targeted Muscle Reinnervation at the Time of Major Limb Amputation



- Patients who underwent TMR had less PLP and residual limb pain compared with untreated amputee controls,
- TMR cohort was 1 out of 10 compared to 5 (PLP) and 4 (residual) out of 10 in the control population ($p = 0.003$ and $p < 0.001$, respectively).
- Targeted muscle reinnervation was associated with 3.03 (PLP) and 3.92 (residual) times higher odds of decreasing pain severity compared with general amputee participants.

Virtual Rehabilitation

- Virtual Tasks
 - Performance Evaluation
 - Box and Blocks
 - Clothespin
 - Positional
 - Weight
 - Gaming
 - Strengthening Exercises

OHSU VR Clinic

- 50+ patients served
 - Amputees
 - Brachial Plexus injury
 - Spinal Cord
 - Stroke
- VR sessions
 - Sign Wave
 - Camera base
 - Ready take home
 - EMG based activity
 - Take home in progress
 - Wireless Bluetooth amplifier
- 1 hour sessions
 - Engagement
 - Durations
 - Enjoyment



Questions?