INTRODUCTION
This is an individual case study, which examined the clinical experience of specific digit and object recognition through real time responsive sensory feedback in a trans-humeral targeted muscle reinnervation amputee fit with the Johns Hopkins University Applied Physics Laboratory (JHU/APL) Modular Prosthetic Limb (MPL).

The participant presents with two distinct sensory sites on his residual limb that map to his index finger and little finger secondary to targeted muscle reinnervation (TMR) surgery.

METHOD
Subjects: The individual in this case is a 58 year old male with a trans-humeral amputation secondary to cancer who elected to receive TMR surgery (Kuiken 2009) in 2012. The TMR surgery was performed by Dr. Albert Chi of the Department of Trauma and Acute Care at Johns Hopkins Medical Institute and resulted in both motor reinnervation and distinct sensory reinnervation that could be mapped to individual digits of his missing or phantom hand.

Apparatus: We structured a blinded object identification test such that the subject determined without looking, object stiffness and location of contact with either his index or little finger. A visual obstruction was placed between the user and the hard during manipulation and headphones were used to eliminate auditory cues related to the task. The individual used the MPL system to voluntarily manipulate objects during the assessment using pattern recognition based control. Torque sensors in the index and little fingers of the MPL were mapped to force-modulated vibratextile motors (Schultz 2009) integrated into his prosthetic socket over the site of sensory reinnervation of his index and index fingers.

Procedures: The subject performed four sets of 25 repetitions of a blinded randomized index and little finger discrimination task, with five minutes rest between each set. The clinician manually pressed the prosthetic fingers during this task. After ten minutes rest, the subject trained the limb for three motion classes: hand open, hand close, and rest. The user practiced manipulating a hard and soft ball with modulated sensory feedback to both sensory sites simultaneously for ten minutes. He then performed four sets of 27 repetitions of a blinded randomized object recognition task, with five minutes rest between each set. The clinician randomly presented one of three cases: hard object, soft object, or no object.

Data Analysis: Percent accuracy was calculated across the total number of trials comparing number of correct answers over the total number of stimuli offered and normalizing the data to show confusion comparing stimulated vs. perceived responses.

RESULTS
The participant was able to distinguish between index and little finger stimulation across the four trials with 91% accuracy. He was able to distinguish between hard, soft, and no object across four trials with 95% accuracy in the blinded trials. Greater errors were associated with the index finger feedback location and detection of the more rigid object.

DISCUSSION
Accuracy fluctuated with shifts in the prosthetic socket relative to the limb as expected but repositioning of the socket resulted in restored sensory fidelity and accuracy across the trials in each case.

CONCLUSION
Tactile feedback has the potential to provide reliable and intuitive sensory feedback through a prosthetic limb when mapped logically to sensory feedback locations on a residual limb after TMR surgery.

CLINICAL APPLICATIONS
Mechanoreceptor sensory feedback directly from a prosthetic limb could lead to better and more intuitive functional outcomes.

REFERENCES
Kuiken, TA. JAMA, 301(6), 619-628, 2009.
Schultz, AE. Brain research, 1251, 121-129.