

# FUNCTIONAL KINESTHETIC PERCEPTION OF COMPLEX BIONIC HAND MOVEMENTS

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## ABSTRACT

Clinical translation of advanced upper limb prostheses is limited because they do not provide meaningful movement sensation and require constant visual monitoring to complete even the simplest of tasks. Kinesthesia, the sense of body movement, allows us to feel the activity of our extremities without looking at them. This study moves prosthetic feedback into a new perceptual/cognitive framework by harnessing the kinesthetic illusion to provide relevant input to human amputees about complex prosthetic hand movements. In this study, illusion-inducing vibration of surgically reinnervated residual limb muscles in amputees with targeted reinnervation provided physiologically relevant kinesthetic sensation that allowed them to accurately sense and simultaneously control both virtual and mechatronic robotic hand movements in real-time without vision. On a proprioceptive motor task without vision the amputee study participants performed indistinguishably from able-bodied. Psychophysical evaluation of an active motor grip task shows that the kinesthetic feedback alone provides better system resolution than vision alone and when provided with both vision and kinesthesia together they perform optimally. The kinesthetic feedback provided a sense of authorship (agency) over movements and was implemented in clinically realistic 2-site antagonistic myoelectric prosthesis control to provide real-time sensation of hand open and hand close. The feedback system was implementable in physical devices in the context of clinical fitting constraints and the movement

percepts can be driven to operate on speed scales relevant to commercially available prosthetic hands. These results open a new path to perceptually-integrated bi-directional bionic prostheses.