BIOGRAPHICAL SKETCH

EMILY A. KESHNER

Professor and Chair, Physical Therapy and Professor, Electrical and Computer Engineering

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE	Completion Date	FIELD OF STUDY
New York University	B.S.	1971	Dance Education
Columbia University	Certificate	1974	Physical Therapy
Columbia University	Ed.D.	1983	Movement Science
University of Oregon	Post-Doc Fellow	1983-84	Neuroscience
Northwestern University	Post-Doc Fellow	1985-87	Physiology

NOTE: The Biographical Sketch may not exceed five pages. Follow the formats and instructions below.

A. Personal Statement

The goal of the proposed research is to develop treatment tools for language, short-term memory and executive function impairments in aphasia that will motivate individuals with aphasia to practice conversational speech more frequently. One of the hallmarks of this research is the strong interdisciplinary team that we have organized to pursue this very functionally restricting component of stroke. My background in experimental and clinical research (physical therapy) is a strength for applying theoretical concepts about speech initiation and control to new intervention approaches. I am particularly interested in developing new methods for motivating self-initiated movement to improve functional capacity of individuals with neurological deficit. To this end, I developed one of the first virtual reality laboratories in the US with the goal of making the laboratory more of a naturalistic environment. I have published studies investigating the influences of optic flow on reaching and pointing tasks in addition to my primary interest in vestibular control of postural orientation. The current application builds on my experience with human-virtual environment interactions and my clinical knowledge of disordered sensory processing with healthy aging and neurological disorders. I will be primarily responsible for developing the gestural components of the intervention and examining whether we have facilitated use of either upper extremity during speech interactions. I have successfully administered multiple research projects and I have a history of productive collaborations with investigators from other disciplines that have resulted in publications and grant funding.

B. Positions and Honors

Professional Experience

1984 - 1985 Research Associate, Department of Neuro-otology and Experimental Audiology Kantonsspital Basel, Basel Switzerland

1987- 1989 Research Assoc., Dept. of Physiology, Northwestern University Medical School, Chicago IL

1989 - 1993 Asst. Prof., Dept. of Physical Therapy, University of Illinois at Chicago, Chicago, IL

1989 - 1993 Adjunct Asst. Prof., Dept. of Physiology, Northwestern University Medical School

1993 - 2003 Research Assoc. Prof., Dept. Phys. Med. Rehab. Northwestern Univ. Med School, Chicago, IL

1993 - 2006 Senior Clinical Research Scientist, Sensory Motor Performance Program Rehabilitation Institute of Chicago, Chicago, IL

2003 – 2006 Research Professor, Dept. of Phys. Med. and Rehabilitation, Feinberg School of Medicine, Northwestern University, Chicago, IL

2008 – 2013 Adjunct Professor, Dept. of Phys. Med. and Rehabilitation, Feinberg School of Medicine, Northwestern University, Chicago, IL

2006 – Present Professor and Chair, Dept. of Physical Therapy, College of Health Professions, Temple University, Philadelphia PA

2006 – Present Professor, Dept. of Electrical and Computer Engineering, College of Engineering, Temple University, Philadelphia PA

Honors and Awards

1993	Falk Faculty Scholar, Northwestern University
2007-2009	Affiliated Professor, University of Haifa, Israel
2008	Developments in Balance Assessment and Intervention as a Challenge for Virtual Rehabilitation Keynote Lecture, Virtual Rehabilitation 2008, Vancouver, Canada, August 25th–27th, 2008
2010	Vision and Perception of a 3D World Influences our Postural Behavior, Keynote Lecture, 3D Movement Analysis Society, San Francisco CA, July 13th, 2010
2011-2012	Associate Editor, Special Issue of IEEE Trans. in Neural Systems and Rehab. Engineering
2013	Keynote Lecture, Swiss Rehabilitation Society, Zurich Switzerland, September 12-13, 2013

Service and Professional Memberships

1974-	Member, American Physical Therapy Association
1984-	Member, Society for Neuroscience
1995-	Member, International Society for Posture and Gait Research
1996-2006	Member, Barany Society
2008-	Member, International Society for Virtual Rehabilitation
1995-2010	Editorial Board Member, Gait and Posture
2003-2006	Editorial Board Member, Journal of NeuroEngineering and Rehabilitation
2006-	Associate Editor, Journal of NeuroEngineering and Rehabilitation
2008-2010	Chair, NIH - MRS study section; 2006-2008 NIH - MRS study section member
2004-	Steering Committee, International Workshop on Virtual Rehabilitation
2009-2012	President, International Society for Virtual Rehabilitation
2012-2014	President, International Society for Posture and Gait Research
2015-	Steering Committee, International Consortium for Rehabilitation Technology

C. Contribution to Science – full bibliography at:
http://www.ncbi.nlm.nih.gov/sites/myncbi/emily.keshner.1/bibliograpahy/42634515/public/?sort=date&direction=ascending

1. **Identifying the role of the vestibular system in postural control:** When Nashner (1976,1977) first described automatic postural synergies he concentrated primarily on responses in the lower limb. The head, and thus the vestibular and visual systems, were not considered to be involved in the generation of postural control reactions. As a post-doctoral fellow with Dr. Marjorie Woollacott and a Research Associate with Dr. John Allum, I performed studies that demonstrated responses at the neck and in anterior tibialis that were long latency and appropriately directionally specific for the ascending synergy in the lower limb. The rapid latencies of these responses indicated that they had to be generated by vestibulospinal and cervicocollic mechanisms and not ascending proprioceptive inputs from the limb, thereby suggesting an important role of a time synced descending vestibular synergy for postural stabilization of the upper body during external perturbations. *Publications that have resulted from this research include:*
    1. Keshner, E.A., Allum, J.H.J., and Pfaltz, C.R. (1987). Postural coactivation and adaptation in the sway stabilizing responses of normals and patients with bilateral peripheral vestibular deficit. *Experimental Brain Research*, 69: 77-92.
    2. Keshner, E.A., Woollacott, M.H., and Debu, B. (1988). Neck, trunk and limb muscle responses during postural perturbations in humans. *Experimental Brain Research*, 71: 455-466.
    3. Allum, J.H.J., Keshner, E.A., Honegger, F., and Pfaltz, C.R. (1988). Indicators of the influence a peripheral vestibular deficit has on vestibulo-spinal reflex responses controlling postural stability. *Acta Otolaryngology* (Stockh), 106: 252-263.
    4. Allum, J.H.J., Keshner, E.A., Honegger, F., and Pfaltz, C.R. (1988). Statistical identification of the extent of a peripheral vestibular deficit using vestibulo-spinal reflex responses. *Adv Oto-Rhino-Laryngology*, 42: 65-71.

2. **Characterizing the dynamics of reflex and voluntary head stability:** Prior to my work as a Post-doctoral Fellow and Research Associate with Dr. Barry Peterson, vestibulocollic mechanisms had mostly been studied in decerebrate animals in relation to eye movements**.** We produced seminal studies that characterized control dynamics of system mechanics, vestibulospinal reflexes, cervicocollic reflexes, and voluntary control in intact humans. Our studies revealed well-defined frequency bandwidths for control by each mechanism as well as the intersubject variability emergent in the control mechanisms. A hormeomorphic model was created and tested to describe the transfer functions between these control mechanisms. These data have been widely used for identifying mechanisms guiding control of head and neck stability during function movements such as locomotion. *Publications that have resulted from this research include:*
    1. Keshner, E.A. and Peterson, B.W. (1995). Mechanisms controlling human head stability: I. Head-neck dynamics during random rotations in the horizontal plane. *Journal of Neurophysiology,* 73: 2293-2301.
    2. Keshner, E.A., Cromwell, R., and Peterson, B.W. (1995). Mechanisms controlling human head stability: II. Head-neck dynamics during random rotations in the vertical plane. *Journal of Neurophysiology*, 73: 2302-2312.
    3. Keshner, E.A. and Chen, K. J. (1996). Mechanisms controlling head stabilization in the elderly during random rotations in the vertical plane. *Journal of Motor Behavior*, 28: 324-336.
    4. Keshner, E.A., Hain, T.C., and Chen, K.C. (1999). Predicting control mechanisms for human head stabilization by altering the passive mechanics. *Journal of Vestibular Research*, 9: 423-434.

3. **Context dependent control of head-neck-trunk stabilization:** As a Research Assistant/Associate Professor, I branched off from the previous studies to examine the significance of redundancy in the head and neck. The human musculoskeletal system has redundant degrees of freedom and more muscles than necessary to perform a majority of functional behaviors. Using the head and neck as a multisegmental, multimuscle inverted pendulum model of the human body, we developed a SIMM model of the head and neck in cats and humans to examine the kinematics changes in muscle activation patterns and head-neck-trunk coordination during defined reflex and voluntary stabilizing tasks in multiple planes of motion. A significant outcome was the finding that variability in muscle activation patters existed across animals within species, but each animal or human produced a consistent preferred activation pattern, thereby demonstrating a strong influence of individual developmental experiences on motor programming. *Publications that have resulted from this research include:*
    1. Keshner, E.A., Baker, J.F., Banovetz, J., Peterson, B.W. (1992). Patterns of neck muscle activation in cats during reflex and voluntary head movements. *Exp Brain Res*, 88: 361-374.
    2. Keshner, E.A., Campbell, D., Katz, R., Peterson, B.W. (1989). Neck muscle activation patterns in humans during isometric head stabilization. *Experimental Brain Research*, 75: 335-344.
    3. Statler K.D. and Keshner E.A. (2002). Effects of inertial load and cervical spine orientation on a head tracking task in the alert cat. *Experimental Brain Research*, 148:202-210.
    4. Keshner E.A. (2003). Head-trunk coordination during linear anterior-posterior translations. *Journal of Neurophysiology*, 89: 1891-1901.

4. **Non-linear dynamics of head-neck stabilization mechanisms:** Control mechanisms in decerebrate animals had been modeled linearly and suggested that head-neck stabilization was the result of a linear summation of primitive reflexes. My studies with intact humans and animals, however, revealed sufficient variability and contextual dependence to suggest that these behaviors were not a simple linear summation but a result of more complex processing of several control mechanisms and pathways. I developed the Virtual Environment and Postural Orientation Laboratory at Northwestern University to create a controlled naturalistic environment with multiple paths for controlled sensory disturbances. To support my hypothesis of non-additive control mechanisms, my colleagues and I employed non-linear analyses of neck muscle EMG and head velocity data during combined visual and whole body mechanical disturbances. Our results revealed that in a functional context, we do not weight sensory inputs so as to respond only to the most relevant (i.e., movement of the base of support producing loss of balance). Instead, individuals will reorganize their behaviors to accommodate each of the sensory demands (i.e., a simultaneous rotation of the visual world). These data demonstrated that sensory reweighting, a prevalent hypothesis in postural control, is not a linear process and can not be sufficiently tested by removing inputs or constraining

degrees of freedom during postural behavior. Current cellular studies in parietal lobe of monkeys (Angelaki lab) are supporting our conclusions. *Publications that have resulted from this research include:*

1. Gurses, S, Dhaher, Y, Hain, TC, Keshner, E.A. (2005). Perturbation parameters associated with nonlinear responses of the head at small amplitudes. *Chaos*, 023905, 15*.*
2. Keshner EA and Dhaher, Y (2008). Characterizing head motion in 3 planes during combined visual and base of support disturbances in healthy and visually sensitive subjects. *Gait and Posture,* 28: 127-134.
3. Gurses S, Kenyon RV, Keshner EA (2011). Examination of time-varying kinematic responses to support surface disturbances. *Biomedical Signal Processing and Control*, 6: 85 – 93.
4. Slaboda JC, Lauer R, Keshner EA. (2011) Time series analysis of postural responses to combined visual pitch and support surface tilt. *Neuroscience Letters*, 91:138-142.

5. **Using perception of optic flow for postural relearning:** My work with virtual reality environments distinctly revealed that visual flow has as significant an impact on postural control as does proprioceptive and vestibular feedback. The conflict between visual and vestibular feedback in the virtual environment suggested that a higher order processing of these inputs was involved in shaping postural orientation behaviors. On moving my laboratory to Temple University, I have employed the directionally conflicting impact of the psychophysical phenomenon known as vection (physical motion initiated by visual flow) combined with the automatic postural behaviors that are elicited by base of support motion to define how parameters of optic flow could be used for relearning of appropriate postural responses. We have shown that visual flow is so compelling that we are able to modify the direction and amplitude of postural sway even during simultaneous cognitive tasks, particularly in individuals with increased visual sensitivity as is found in those with neurological disorders and even healthy aging. We have started to investigate whether motor learning results from experience in the virtual environments that can be transferred to the physical world. Our goal is to define specific parameters of visual flow that, when combined with postural disturbances and other augmented sensory inputs, can be prescribed as treatment interventions for instability. *Publications that have resulted from this research include:*
    1. Keshner, E.A., Kenyon, R.V, Langston, J. (2004). Postural responses exhibit intra-modal dependencies with discordant visual and support surface motion. *J Vestib Res*, 14: 307-319.
    2. Dvorkin A, Kenyon RV, and Keshner EA (2009). Effects of roll visual motion on online control of arm movement: Reaching within a dynamic virtual environment. *Exp Brain Res*, 193: 95-107.
    3. Slaboda JC, Lauer R, Keshner EA (2013). Postural responses of adults with cerebral palsy to combined base of support and visual field rotation. *IEEE Transactions Neural Systems and Rehabilitation Engineering* (TNSRE), 21:218-224. doi: 10.1109/TNSRE.2013.2246583.
    4. Levin MF, Weiss PL, Keshner EA (2014). Emergence of VR as a tool for upper limb rehabilitation. *Physical Therapy*, 95 (3), 415-425.

D. Research Support

<u>Ongoing Research Support</u>

RIF127D23 (Wright, WG PI) 10/01/13-9/30/15
DOD Army Rapid Innovation Fund
Virtual Environment TBI Screen (VETS): A field-deployable diagnostic screening system.
This project will clinically validate a technically advanced, yet portable system that can be used to provide a field assessment of postural imbalance and visual-vestibular function in TBI patients.
Role: Co-investigator
Overlap: There is none.

R21DC012245-01 (Martin N, PI) 12/01/2012-11/30/2015
NIH/NIDCD
Promoting Functional Communication in Aphasia with Virtual Clinicians
The major goals of this project are to develop software for and test the feasibility of a communication system that uses virtual clinicians to promote better functional communication of individuals with aphasia.
Role: CO-Investigator
Overlap: No overlap.

1R01HD069769-01A1 (Lauer, R. PI) 4/01/2012 - 5/31/2016
NIH/NICHHD
Balance and Posture in Adults with Cerebral Palsy
The objective of this proposal is to determine the impact of visual field motion on the ability to sustain balance and posture in the adult with Cerebral Palsy as compared to age matched peers of typical development.
Role: Co-Investigator
Overlap: There is no overlap.

Recently Completed Research Support

1R13DC012999-01 (Keshner EA, PI) 12/1/2012-11/30/2013
NIH/NIDCD
Combined Cognitive Neuroscience/International Virtual Rehabilitation Conferences
A conference exploring transfer of technology to rehabilitative interventions and dissemination of new research findings across disciplines will make treatments more effective more rapidly.
Role: PI
Overlap: There is no overlap.

1313890 (Wright W.G., PI) 1/15/2013-12/31/2013
NSF
Combined Cognitive Neuroscience/International Virtual Rehabilitation Conferences: Student Support
To support student travel, registration and presentation awards at these combined conferences.
Role: Co-PI
Overlap: There is no overlap.