Arm motor rehabilitation in chronic stroke: Effects of two training environments

Sandeep K. Subramanian, Christiane B. Lourenco, Heidi Sveistrup, Mindy F. Levin

Abstract: **The effects of training in a 3D virtual environment (VE) as compared to a similar physical environment (PE) were compared in 32 subjects (n=16 per group) with chronic post-stroke hemiparesis. The PE group improved elbow extension as measured by the elbow subscale of the Reaching Performance Scale. The VE group had increased range of shoulder horizontal adduction and decreased range of trunk rotation after training. Results suggest that both environments are useful tools for upper limb motor rehabilitation post-stroke.**

Keywords- *Rehabilitation, Feedback, Virtual Reality, Upper limb*

I. INTRODUCTION

Virtual reality (VR) provides a platform to design specific environments (VEs) involving individually tailored activities combining intensity, variability, specificity and salience of practice identified as pertinent to enhance experience-dependant neural plasticity [1]. VR applications help shape motor output by providing optimal learning conditions combining extrinsic sensory feedback from the environment with intrinsic sensory feedback from the moving limb [2]. Knowledge of results (KR) and performance (KP) feedback can be incorporated in VEs [2]. Intensive practice in VEs with feedback is beneficial for arm motor recovery. However, it is unclear if training in a 3D VE with feedback results in similar or better outcomes compared to a similar physical environment (PE). Our objective was to compare training effects in 3D VE to a similar PE in chronic stroke subjects.

II. METHODS

Thirty two subjects with chronic post-stroke hemiparesis were randomized to a PE (n=16, 60±11 yrs) or VE group (n=16, 62±9.7 yrs). Participants had a stroke 3±1.9 yrs (PE) to 3.7±2.2 yrs (VE) previously. The VE simulated a supermarket with 6 consumer products on 2 shelves (Fig. 1B) and had similar dimensions to a PE (described in [2]). The VE scene was rear-projected on a 2m long x 1.5m high screen and viewed with polarized glasses to create a stereoscopic effect. Subjects made 72 pointing movements per session for 12 sessions (3 times/wk, 4 wks.). Both groups received the same auditory feedback on movement accuracy and speed (KR) and trunk motion (KP) after every trial. Subjects in VE also had visual feedback about the number of successful reaches (Fig. 1B). Clinical and kinematic evaluations were done pre- and post-training. Assessments included Fugl-Meyer Scale, Reaching Performance Scale, RPSS (impairment) and Wolf Motor Function Test and Motor Activity Log, MAL (activity/participation). Kinematics (Optotrak 3020, 6 markers, 100Hz) of pointing movements to 1 test and 1 transfer target included motor performance (error, peak velocity and trajectory straightness) and movement pattern (elbow, shoulder and trunk) variables. Outcomes were evaluated with ANOVA.

Figure 1: Representation of the physical (A) and virtual (B) environments

III. RESULTS

Similar changes occurred in both groups on specific outcome measures. An effect of time was seen for participation with better MAL scores post training ($F_{1,30} = 6.187$, $p<0.03$) in both groups. Both groups increased range of shoulder flexion for the transfer target ($F_{1,30} = 6.281$, $p<0.02$) and tended to increase velocity after training ($F_{1,30} = 3.602$, $p<0.07$). Group specific changes were also observed. In PE, elbow extension improved (RPSS, $F_{1,30} = 6.761$, $p<0.02$). VE increased shoulder horizontal adduction range (test: $F_{1,30} = 4.453$, $p<0.05$) and decreased trunk rotation (transfer: $F_{1,30} = 4.88$, $p<0.05$) with no other effects.

IV. CONCLUSION

Both groups improved on different outcomes depending upon the environment in which they trained. The fact that both groups received a similar amount of feedback (KR and KP after every trial) and the same intensity of training may explain why improvements were seen in both groups. Our results suggest that both environments are useful for arm motor rehabilitation post-stroke and factors other than feedback provided by the environment such as the participants' levels of motivation and self efficacy may be important.

REFERENCES

[1] J. A. Kleim and T. A. Jones, "Principles of experience-dependent neural plasticity: implications for rehabilitation after brain damage," J Speech Lang Hear. Res., vol. 51, no. 1, p. S225-S239, Feb.2008

[2] S. Subramanian, L. A. Knaut, C. Beaudoin, B. J. McFadyen, A. G. Feldman, and M. F. Levin, "Virtual reality environments for post-stroke arm rehabilitation," *J Neuroeng. Rehabil*, vol. 4, p. 20, 2007.