



Commentary

Response to commentary of Shirani and Okuda regarding "Unilateral arm rehabilitation for persons with multiple sclerosis using serious games in a virtual reality approach: Bilateral treatment effect?"

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We thank Shirani and Okuda (2019) for this insightful commentary on our article regarding the use of virtual reality serious games approaches to upper limb rehabilitation for persons with multiple sclerosis (MS). Their focus on future directions in this line of research is consistent with concepts that we are currently investigating regarding upper limb dysfunction in persons with MS.

A growing number of MS experts are pointing out the importance of neurological reserve and the role it may play in slowing or limiting the progression of MS-related disability both in pediatric and adult onset MS. In particular preservation of lateralized pattern of movement associated brain activations appears to be important for preserved arm function (Rocca et al., 2009; Zhong et al., 2017). As suggested by Shirani and Okuda this construct applied to handedness implies differences in resilience of pre-existing neural networks in the two hemispheres with greater neural reserve capacity favoring the clinically functional prognosis for the dominant vs non dominant arm. While a tendency of the dominant arm to remain more functional has been shown in research on Parkinson's Disorder and post stroke (see Shirani and Okuda's commentary) as yet this hypothesis was not supported for persons with MS. Shirani et al. (2019) found no difference in fine motor function between hands tested with finger tapping in a large number of right and left handed persons with MS over different disability levels. Similarly, a study by Solaro et al. (2019) applying the Nine Hole Peg Test to a large number of right handed persons with MS found no differences in hand function between right and left hands over the diverse disability levels (Solaro et al., 2019).

Regarding handedness and potential implications for neurorehabilitation through virtual reality-based games, some support for suggested training of the left (non dominant) hand in early stages of the disease comes from findings of Zhong et al. (2017) that found stronger functional connectivity across the two hemispheres but in particular within the right hemispheres of persons with MS (right handed persons) that had better motor preservation suggesting the maintenance of right lateralized functional connectivity may contribute to preserved motor function along the lifespan of persons with MS.

The advantage of virtual reality-based approaches for persons in the early stages is obvious, it is a training approach that can be accessible to most persons, training can be adapted to the person's interests and ability level, it can be carried out at home and at any time of the day. There are indications that virtual reality approaches in the form of serious games are efficacious in improving arm and hand function in persons in the moderate to severe stages of MS (Jonsdottir et al., 2018 and, 2019) and so it might be a promising approach for the maintenance of abilities bilaterally over the whole lifespan of having MS.

In the early stages of MS most persons experience problems with balance, mobility and fatigue that impact on their daily life and so tend to be prioritized in their training. In this context motivation might be a potential issue to address in any approach for upper limb training as a prevention for future problems. Nonetheless, given the importance of neurological reserve in preserving function in persons with MS, the effect of virtual reality based games used exclusively for the non dominant hand on neurological reserve in the early stages of MS should be investigated.

We again thank Shirani and Okuda for their excellent commentary and agree that it is important that future studies combine behavioral and neural structures analysis to assess effects of a treatment aimed to preserve arm and hand function in persons with MS.

Declaration of Competing Interest

The authors disclose no conflicts of interests related to this work.

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