Development of exergames for the training and evaluation of coordination and dynamic stability in cerebellar ataxia

Cornelia Schatton[1,2], Jan-Marco Moritz, Adrian Simon Bauer, Martin Giese[1,2], Matthis Synofzik[3,4], Winfried Ilg[1,2]

[1]Department of Cognitive Neurology, Hertie Institute for Clinical Brain Research, [2]Centre for Integrative Neuroscience (CIN), [3]Department of Neurodegeneration, Hertie Institute for Clinical Brain Research and Centre of Neurology, [4]German Research Centre for Neurodegenerative Diseases (DZNE), University of Tübingen, Germany

Background: Despite of the importance of the cerebellum for motor control and motor learning, recent studies have shown that training based on physiotherapy or exergames can lead to substantial motor improvements in degenerative cerebellar ataxia[1]. Specifically, we have shown that training based on commercial exergames can improve dynamic stability and joint coordination[2]. However, the use of commercial games presents several short comings, especially with respect to adaptations of training complexity. Here, we developed 2 exergames for individualized training and evaluation of ataxia-related control mechanisms in whole-body movements.

Methods: The concept focuses on exercising ataxia-related control mechanisms like predictive control in joint coordination and dynamic stability in various tasks; e.g. predictive control is exercised on internal events like anticipatory body adjustments and on external events like anticipation of a ball trajectory. For the development of motor challenges with increasing complexity we integrate knowledge about the influence of gradual learning cueing of sequences and feedback conditions which had been retrieved from motor learning studies with cerebellar patients[1].

Results: We have implemented 2 exergames based on the Kinect™v2 to train ataxia-specific control mechanisms in different environments.

1) *a choice stepping reaction time task*[3]. The player controls an avatar which has to step as fast as possible on highlighted target squares lightening up randomly around him. Game complexity is parameterized mainly by the amount and order of targets. At higher levels subjects perform specified target sequences and control a tetris-like game by target hitting. Exercise includes elements like dynamic stability and trunk-leg coordination which are known to be specifically dysfunctional in ataxia.
2) I*n air ball* one has to keep a ball or other simulated objects in the air by hitting with all extremities. Complexity is parameterized by object characteristics (velocity), restrained work space and the amount of objects. At higher levels, targets have to be hit with the balls and a virtual partner joins the game.

Pilot patient trials indicated that these games indeed addressed ataxia-related motor impairments. Moreover, they showed that game complexity can be adjusted to individual motor impairments and improvements, enabling training benefits over a longer period. The embedded analyses focus on predictive control, dynamic stability and joint coordination.

Conclusions: Exergames are a novel method for a wide range of rehabilitation strategies and neurological conditions. We here show that customized exergames can be individually and continuously tailored according to each subjects' individual disease severity and training progress.

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