Developing non-invasive therapeutic technology to improve motor coordination in cerebellar ataxias.

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Scientific abstract

In purposive activities a person has to control the closure of gaps between where they are now and where they want to be (e.g., the gap between their hand and a cup when reaching for it). Experiments with able-bodied individuals indicate that gap-closing follows a general pattern described by a mathematical formula. This *'movement formula*' is generated and managed in the brain to suit the task in hand. Ataxic persons have difficulty making movements that fit the normal formula. It seems their brains are inefficient at generating/managing it. Pilot work with an ataxic participant has demonstrated that moving to a '*sonic guide',* where pitch followed the '*movement formula', producing a "whoop" sound,* helped improve coordination.

We propose to analyse movement in cerebellar ataxic patients, using high-speed motion capture and force measurements, and apply what we learn to develop, with the ataxic participants, cost-effective, user-friendly devices, based on the '*sonic guide'*, together with movement measurement technology for assessing movement control. The intention is that these devices and technology could be used by therapists for treating and assessing ataxic persons, and by clinicians for diagnosis. Thus, the project could in the long term benefit any number of people suffering from ataxia.

Lay Summary

Working closely with people suffering from ataxia, we aim to produce and test user-friendly cost-effective non-invasive therapeutic devices to help them overcome their movement difficulties in everyday purposive activities, such as reaching for objects, rising from a chair, walking, stepping onto a stair, shifting weight to maintain balance, etc. In purposive activities a person has to control the closure of gaps between where they are now and where they want to be (e.g., the gap between their hand and a cup when reaching for it). Experiments with able-bodied individuals indicate that such gap-closing movements follow a general pattern that is described by a simple mathematical formula. This *'movement formula*' is generated in the brain as a pattern of electricity through nerves. By changing settings in the movement formula the brain regulates the details of the movement to suit the task in hand. Since ataxic persons have difficulty making movements that fit the normal formula, it seems that their brains are inefficient at generating the formula. But what if the movement formula could somehow be injected into their brains? This might help their movement control. We tested our idea in a pilot experiment by playing what we call a '*sonic movement guide'* to an ataxic participant with a focal cerebellar lesion. In the sonic guide, pitch glided between two tones, following the normal movement formula. This produced a "whoop" sound. After listening to and turning a handle to the "whoop" guide, the sound was turned off and the participant reached for a ball in time with the "whoop", now in his head. This much improved his reaching movements, which then closely conformed to the movement formula that the "whoop" mimicked.

During the first two years of the project we shall follow up this promising lead by working individually with ataxic participants, trying out different sonic movement guides (e.g. modulating loudness and/or pitch); also devices to sonify movement to enhance the ataxic person's perceptual feedback about their movement. The guides will be tailored to the individual participant's movement needs - walking, balancing, reaching etc - and their efficacy measured. We expect that the participants will benefit directly from the sonic guides and movement sonifiers. In the third year, we shall apply what we have learned to develop, construct and test with ataxic participants cost-effective, user-friendly devices, based on the sonic guide and movement sonifier ideas, together with movement measurement technology for assessing movement control. The intention is that these devices and technology could be used by therapists for treating and assessing ataxic persons, and by clinicians for diagnosis. In which case, the project could in the long term benefit any number of people suffering from ataxias.

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