Galvanic vestibular stimulation: new uses for an old tool

Brian L. Day

MRC Human Movement and Balance Unit, Institute of Neurology, Queen Square, London, WC1N 3BG, UK

Although known about for 100 years or so, galvanic vestibular stimulation attracted relatively little interest until some 15 years ago. This is partly because oculo-motor control has dominated human vestibular research, and those physiologists interested in the vestibular control of eye movements understandably paid little attention to it. They were quite content spinning and accelerating people to produce natural patterns of vestibular input. However, this ‘natural’ approach has not been so useful for those wishing to study the vestibular contribution to whole-body control. The intractable problem has been how to stimulate the vestibular system naturally without exciting other sensory systems and without interfering with the whole-body function under investigation. Galvanic stimulation is not a natural stimulus but has the advantage that it does not suffer from these serious complications. It may therefore still have an important role to play as a tool for studying human vestibular function, particularly in the field of whole-body control. In this issue of *The Journal of Physiology*, Fitzpatrick *et al.* (1999) use the technique to study vestibular influences on walking.

The stimulation technique is very simple. The only apparatus required comprises a 9 V battery, a switch and a means of controlling the current. A small current (around 1·0 mA) passed between the mastoid processes for a second or two will cause a person to sway if they are standing with their eyes closed. The simplicity of the technique, however, belies the complexity of the body response it evokes. Lund & Broberg (1983) discovered a key principle when they showed that the direction of the evoked movement was always in the direction of the anodal ear. No matter how much a person changed their posture by twisting their body and/or neck about a vertical axis, the current always made them sway towards the anode. Thus, the electrically evoked vestibular input is capable of perturbing a complex motor process, one that is able to take into account the relative positions of all body segments from the head to the feet.

Recent work on galvanic stimulation suggests that the evoked vestibular input is capable of influencing more than one whole-body control process. A motor process concerned with whole-body balance is probably responsible for the response galvanic stimulation produces in people trying to stand still (Day *et al.* 1997). However, if a person performs a voluntary movement of the upper body the stimulus produces an additional effect by modifying the movement itself (Séverac Cauquil & Day, 1998). This implies that the vestibular input also gains access to those motor processes that control voluntary movement. Fitzpatrick *et al.* (1999) now show that an additional central process may be affected by the stimulus.

In this novel study Fitzpatrick *et al.* investigated the effect of galvanic stimulation on the path taken during a blind walk to a previously seen target. They observed a large effect during the early stages of the walk. The path tended to deviate towards the anode, away from the usual straight-line path obtained without stimulation. They went on to study how the same stimulus alters the perception of the path taken. To do this they pushed the blindfolded subject in a wheelchair along a curved path and at the end asked the subject to indicate where they had started. For the wheelchair ride with galvanic stimulation, the estimated start position contained a constant error that was not present without stimulation. The error was in the opposite direction to the deviation observed during the blind walk. Therefore, it is possible that the path deviation during the walk was a consequence of the altered perception of the path taken. There are, of course, other possible explanations for the disturbed walk. For example, it could have been caused indirectly by the known effects of the stimulus on balance and/or movement control processes. Further work would be required to resolve this. Even so, the perceptual effect on its own suggests a disturbance to some other central process, possibly one concerned with whole-body navigation.

A number of other questions arise from this work. For example, it is not evident why people stop deviating towards the anode after the first few steps, or why the perceptual illusion occurs in the horizontal plane (yaw) whereas the motor effect of galvanic stimulation occurs in vertical planes (roll/pitch) in people standing still. These questions may be difficult to answer until we have a more precise understanding of the dynamics of the evoked firing patterns and the classes of vestibular afferent that are recruited by the stimulus in man. The ocular response to galvanic stimulation (e.g. Zink *et al.* 1997) may help here since a great deal is known about the different eye movements that can be evoked by afferent signals from the semicircular canals and otoliths.

This simple tool therefore seems to have some potential for probing a number of central processes. Arguably, any process that is able to extract meaning from head acceleration signals is a candidate for perturbation by galvanic vestibular stimulation. It is difficult to predict how useful a tool galvanic stimulation will turn out to be. However, it is encouraging that physiologists have started to pay closer attention to this unnatural means of stimulating the vestibular system.

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