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Feedback control of the limbs position during voluntary rhythmic oscillation. (English)

Zbl 1125.92010
Biol. Cybern. 97, No. 2, 123-136 (2007).

Summary: The mechanisms that control the limbs position during rhythmic voluntary oscillations were investigated in ten subjects, who were asked to synchronise the lower peak of their hand or foot rhythmic oscillations to a metronome beat. The efficacy of the "position control" was estimated by measuring the degree of synchronisation between the metronome signal and the requested limb position and how it was affected by changing both the oscillation frequency (between 0.4 and 3.0 Hz) and the limbs inertial properties. With the limbs unloaded, the lower peak of both the hand and foot oscillations lagged the metronome beat of a slight amount that remained constant over the whole frequency range (mean phase delay $-13.2°$ for the hand and $-4.7°$ for the foot). The constancy was obtained by phase-advancing, at each frequency increment, the electromyogram (EMG) activation with respect of the clock beat of the amount necessary to compensate for the simultaneous increase of the lag between the EMG and the movement, produced by the limb mechanical impedance. After loading of either limb, the increase of the oscillation frequency induced larger EMG-movement delays and the anticipatory compensation became insufficient, so that the movement progressively phase-lagged the clock beat.

The above results have been accurately simulated by a neural network connected to a pendulum model that shared the same mechanical properties of the moving limb. The network compares a central command (the intended position) to the actual position of the effector and acts as a closed-loop proportional, integrative and derivative controller. It is proposed that the synchronisation of rhythmic oscillations of either the hand or the foot is sustained by a feed-back control that conforms the position of each limb to that encoded in the central voluntary command.

MSC:

92C20 Neural biology
93B52 Feedback control

Software:

GraphPad Prism; Prism

Full Text: DOI

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