

EFFECTS OF EXTERNAL LOADS ON HUMAN HEAD MOVEMENT CONTROL SYSTEMS

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Rapid and precise head movement is a natural physiological activity of man which is closely related to his perception and reaction to his environment. Gaze directed head movements are much slower and smoother than the accompanying eye movements. In numerous experiments researchers have studied the direct effects of inertial-elastic load on head movements and found adapted changes in neurologically controlled compensation for the added load. Recently Nam et.al.(1984) showed that with the added viscosity the head trajectories were slowed down and the movement lasted longer in spite of adapted compensation. Numerous potential applications of head-directed control systems to manned and unmanned aircraft flight control, fire control, target acquisition, and reconnaissance have been proposed.

The purpose of this investigation is to elucidate the central and reflexive control strategies underlying movements. The authors studies the effects of external loads on human head movement control systems. In this article, we presents some experimental results on dynamic changes with the addition of aviation helmet(SPH4) and lead weights(6 kg). We have measured intended time-optimal movements, their dynamics and electromyographic activity of neck muscles in normal movements, and also in movements made with external weights applied to the head. We observed that, when the external loads were added, the subject went through complex adapting processes and the head movement trajectory and its derivatives reached steady conditions only after transient "adapting" period. The steady "adapted" state was reached after 15-20 seconds(i.e. 5-6 movements).

Head movement trajectories were initiated 250(21) and 272(20) milliseconds after the target displacement in normal and added inertia movement, respectively. The large mechanical load of the head produced dynamic lag solely as a consequence of the neuromuscular and load inertia delaying mechanics. When subjects had a supplementary position feedback, they were able to achieve a more accurate final head position. In adapting states, subject showed large overshoots or undershoots in initial states and after 3-4 movements accuracy of movement was achieved. This implies that neck muscles generated the correct forces to drive the head to an accurate steady state position within that time. With the added inertia, adaptation to the new load also took place rapidly. More variations within a particular subject's performance were seen in consecutive trials and the subject took a longer time to achieve accurate movements.

Main Sequence plots were obtained for a single trained subject (Army Helicopter pilot (OMC)) performing head movements ranging from 10 to 50 degrees. As might well be expected, the data shows that movements of all magnitude measured are reduced in velocity and acceleration and take longer time to complete when performed with an aviation helmet and added inertia. When a subject attempted to make a time-optimal movements in response to a constant target displacement, the resulting movement exhibited a variability.

With the addition of an inertial load, changes in EMG reveal a corresponding change in control strategy. Control strategy seems to scale the width of the first agonist pulse (P1) and the height and width of the second agonist pulse (P3) according to the magnitude of the desired time-optimal movement. The main change observed in EMG with added inertial load is the reduction in height (or complete suppression of P3) as was in the case of viscous load. Added inertia increases the kinetic energy in a moving mass which must be dissipated in order to stop the head. The clearly evident fourth pulse in the added inertia records can be interpreted in this respect as an additional damping pulse required to dissipate kinetic energy beyond the capacity of third pulse (P3).

Horizontal rotation experiments with added loads showed the adaptation of the nervous control signal to the added loads. Studies (e.g. bang-bang model) to explain the height and width of first agonist pulse as a function of movement dynamics is strong evidence that EMG envelopes reflect an underlying controller signal. It is suggested that the future design or development of head-directed hardware systems consider the effects of the increased rotational inertia of various headgear configurations on head movement control system.

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