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Modulation of somatosensory evoked potentials during coordination between posture and movement

Bozhidar Dimitrov *, Tatyana Gavrilenko, Gantcho N. Gantchev

Institute of Physiology, Bulgarian Academy of Sciences, Acad. G. Bontchev St., bl. 23, 1113 Sofia, Bulgaria

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Abstract

Somatosensory evoked potentials (SEPs) elicited during execution of voluntary movements undergo modification in their amplitude ('gating'). We have studied SEP changes during a motor task that includes anticipatory postural adjustment and focal movement. Upright standing subjects were performing fast forward elevation of one arm. The electrical stimulus was presented over the ipsilateral posterior tibial nerve within two different time frames: (1) preceding the EMG activity of femoral biceps muscle, known to be first in occurrence in such task; (2) during this EMG activity, yet before the EMG occurrence in anterior deltoid muscle – prime mover for the forward arm elevation. The following significant changes in SEPs preceding focal movements as compared with control SEPs during quiet stance were found: The early component P42-N50 showed a marked decrease, regardless of its time relation to the anticipatory activity in the leg. Component N50-P60 increased in amplitude, more so when elicited within an earlier time frame. Thus, diminution of amplitude as an expression of gating, was found to exist already before the occurrence of anticipatory postural adjustment activity and to persist during the ensuing focal movement.

Keywords: Somatosensory evoked potential; Anticipatory postural adjustment; Voluntary movement; Gating; Posture; Balance

1. Introduction

Somatosensory evoked potentials diminish in amplitude during the course of voluntary movement (Coquery et al., 1972; Lee and White, 1974; Papakostopoulos et al., 1975; Starr and Cohen, 1985; Cheron and Borenstein, 1987; Burke and Gandevia, 1988; Jones et al., 1989, etc.). Different names have been assigned (e.g. inhibition, suppression, diminution, alteration, modulation) and subtle mechanisms of either occlusion or collision were suggested for a phenomenon widely accepted as 'gating'. A selective filtering of that part of upcoming afferent information, which is rendered to be of comparatively lower priority in regard to the appropriate execution of voluntary act was proposed to occur somewhere between cuneate nucleus (Ghez and Pisa, 1972) and VPL thalamic nucleus (Skinner and Yingling, 1977). It is of interest to point out that a gating effect was present even before the actual displacement of the moving limb (Cohen and Starr, 1987; Chapman et al., 1988). We decided to employ a complex motor task comprising postural coordination during focal movement. Following Belenkiy, Gurfinkel and Paltsev's report in 1967, many studies have proven the existence of anticipatory postural adjustment expressed in activation of leg postural muscles that

* Corresponding author. Tel.: (0359) 2-713-3703; Fax: (0359) 2-719-109; e-mail: bozholan@iph.bio.acad.bg.

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precedes an arm movement, be it self-paced or performed in a reaction time (RT) mode. This 'associated postural adjustment' (Cordo and Nashner, 1982) is presumed to be automatically released by a central command, in advance of the focal movement. Thus, during a task including forward arm elevation while standing freely, the first ever activity to occur was shown to be from biceps femoris muscle (BF), invariably followed by the burst in the prime mover of the arm – anterior deltoid muscle (AD). Our aim was to check how somatosensory evoked potentials would be influenced when elicited at different time intervals during the period of associated postural adjustment (Dimitrov et al., 1989).

2. Methods

Eight subjects were studied in two subsequent sessions. They were standing upright with hands hanging freely and, upon the occurrence of a click delivered by the experimenter, were instructed to execute a forward arm elevation of the dominant right hand in a RT mode. RT measures were performed for the first 40 training trials and thus the individual adjustment of the stimulus delay for each subject in every session was secured. This delay ranged between 98 and 140 ms and was manually set following the training session (Fig. 1). The posterior tibial nerve was stimulated behind the medial malleolus of the ipsilateral (right) leg with an intensity just capable to produce a visible toe twitch. The stimulus was generated from a DISA stimulator by automatic triggering from the click. Electrodes were placed

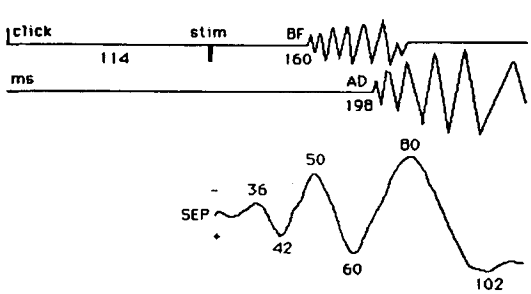

Fig. 1. Schematic description of time sequence of events (ms) during the anticipatory postural adjustment period and the ensuing somatosensory evoked potential components in a reaction-type task of focal movement – arm elevation during upright standing.

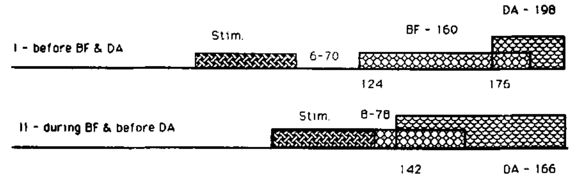

Fig. 2. Relationships between time frames (ms) of electrical stimulus deliverance and occurrences of activities in biceps femoris (BF, equilibrium stabilizer) and anterior deltoid (DA, prime mover).

upon the bellies of BF and AD muscles and on scalp positions C_z, D_z (middistance between C_z and F_z) and E_z (middistance between C_z and P_z), referred to linked earlobes. The EEG was recorded on an ALVAR TR8 machine, set at bandpass 1.6–1000 Hz and fed into a MINC 23 (DEC) microcomputer at a rate of 2 KHz. Trial-by-trial rejection/acceptance was done in dialogue mode off-line and the criterion of correct EMG burst sequences was decisive in accepting the particular trial for averaging up to 250 repetitions. The two separate sessions were performed always in the same order, i.e. firstly the stimulus preceded both the activity in BF and AD (see also Fig. 2) and secondly it was delivered before AD but during the BF activation. Student's paired *t*-test was used for comparisons between SEPs elicited in control sessions and SEPs elicited in movement sessions.

3. Results

A schematic description of the time sequence in the first series is presented in Fig. 1. Upon the presentation of a click from the experimenter, the stimulus was automatically delivered following mean delay of 114 ms, being always succeeded by the EMG in biceps femoris (mean 160 ms, range 124 to 190 ms) and later on by the EMG in anterior deltoid muscle (mean 198 ms, range 176 to 222 ms; equivalent to reaction time). Thus, the SEP components N36-P42 and P42-N50 developed before the BF burst, the component N50-P60 developed before the AD burst and the components P60-N80 and N80-P102 developed during the AD activation. The mean BF precedence over AD was 38 ms (range 6 to 70 ms) and the respective delays of BF and AD from the stimulus were 46 and 84 ms (Fig. 2). In the