Published in final edited form as:

Ann N Y Acad Sci. 2001 October ; 942: 479–481.

Efferent-mediated Binaural Interactions between the Vestibular End-Organs in the Chinchilla

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In nonmammalian species, the efferent vestibular system (EVS) conveys vestibular input to contralateral vestibular end-organs.^{1,2} Recently we reported that a vestibular input to the EVS results in symmetric, excitatory (type III) rotational responses in afferents.³ Canal-plugging experiments imply that the responses reflect the bilateral efferent innervation of each labyrinth.⁴ To study the role of the contralateral labyrinth, we have stimulated it with galvanic currents.

METHODS

Afferent activity was recorded from the left superior vestibular nerve in precollicularly decerebrated chinchillas. The right ear was stimulated by cathodal (excitatory) and anodal (inhibitory) currents (50–250 μ A) delivered through electrodes implanted on the round window and in the floor of the middle ear. Even though 100- μ A currents were near the threshold for efferent-mediated crossed effects, this current magnitude was chosen as a standard stimulus because higher currents could result in reflexive movements and/or direct spread to the opposite (left) labyrinth.

RESULTS AND DISCUSSION

Over 70% of the units (35/48) were excited by cathodal and anodal currents. The response was seen during the 5-s per stimulus period and lasted 10–20 s post stimulus (Fig. 1A,B). Excitatory responses were similar in canal and otolith units and, on average, were small. Responses averaged for 100- μ A anodal and cathodal currents had mean values ($\pm$ SE) of 1.5 ± 0.3 and 4.9 ± 1.5 spikes/s, for per-stimulus and 10-s post-stimulus periods, respectively. Of the two polarities, anodal currents usually produced smaller responses. The response increased with stimulus intensity (Fig. 1B). Per-stimulus responses were positively related to the discharge regularity of the unit (CV*). This relation was clearer in the first 2.5 s of the per-stimulus period (Fig. 1C) than in the second 2.5 s.

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Figure 2 is a heuristic model of efferent pathways. It shows direct vestibular input to the efferent nucleus (e) from the labyrinth (lab), as well as indirect input from the vestibular nuclei. Group e projects to both labyrinths. The excitation seen in response to contralateral cathodal currents can be explained by the direct innervation of the labyrinth by the contralateral e group. Excitatory responses to anodal currents may be the result of disinhibition involving crossed inhibitory pathways. From calculations based on the equivalence of afferent response to galvanic currents and rotations, the response magnitude to 100- μ A currents is consistent with the EVS-mediated rotational type III responses.³ The smaller excitation in response to anodal currents can be explained by the silencing of peripheral and central neurons when contralateral vestibular afferents are inhibited.

In conclusion, the results of the present study, together with past results on efferent-mediated rotation responses,³ suggest that EVS-mediated responses to vestibular stimuli depend on binaural afferent inputs.

Acknowledgments

This work was supported by NIH grants RO1 DC 03946 and T32-DC 00058-01.

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FIGURE 1.

(A) Discharge (*left ordinate*) of an irregular unit (standardized coefficient of variation, $CV^* = 0.42$) in response to anodal (*solid curve*) and cathodal (*dashed curve*) 100-μA currents delivered to the contralateral ear. **Bar histogram:** Averaged response to the two current polarities (*right ordinate*). (B) Averaged responses of a regular unit ($CV^* = 0.04$) to 100- and 200-μA contralateral currents. (C) Relation between response magnitude and discharge regularity. Each point represents a separate unit. The response was calculated as the average

response during the first 2.5 s of 100- μ A anodal and cathodal stimulation. Thick horizontal lines in **A** and **B** indicate 5-s current presentation.