Reprint Series
13 January 1978, Volume 199, pp. 207-208

SCIENCE

Pontine Reticular Formation Neurons and Motor Activity

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Activity in cat pontine reticular formation (PRF) cells is not, as Cohen suggests, "predominantly related to eye movement." We tested for eye movement relations in every cell we encountered, polygraphically recording and visually observing eye movements while monitoring unit discharge. We also tested for unit activity correlated with eye blinks elicited by corneal stimulation in all cells. A number of cells related to eye movement were observed, but histological analysis localized these cells to the region of the abducens nucleus, in agreement with previous studies in the cat (*1*). The gigantocellular tegmental field (FTG) units that we identified as head movement cells, the most common cell type, all showed intense discharge without any eye movement. Conversely, rapid eye movements (REM) and maintained eye positions in both the horizon-tal and vertical planes without accompanying unit discharge were observed in each of these cells. Since head movements tend to be associated with eye movements these cells do show a general correlation with eye movements. Cells specifically related to eye movement may exist in the PRF (2), but clearly they are not the predominant cell type in the FTG area, which comprises most of the PRF.

Several other findings illustrate the lack of relationship between unit activity in most FTG cells and eye movement., (i) During adaptation to head restraint, FTG unit firing decrement correlated closely with decrease in neck electromyogram *(3, 4),* not electrooculogram (EQG). (ii) Most cells habituated to rapid head acceleration in conjunction with changes in neck muscle tone. However, EOG response to such stimulation does not habituate, (iii) Operant conditioning of increased firing rate in those FTG cells which appeared to discharge in relation to head movement was accompanied by repetitive head movements. In no case did we observe a conditioned increase in unit firing correlated only with increased eye movements. (iv) During REM sleep many of these cells discharge in long intense bursts. This firing does not result from increased numbers of eye movements (5, 6). (v) Many FTG cells were found to be entirely unrelated to head or eye movement. We have observed cells which discharge in close relationship to directionally specific tongue movements. Other cells exhibited activity related to facial musculature and to specific postures *(4).* It would be difficult to reconcile such findings with the claim that FTG cells relate predominantly to eye movement.

In monkeys, eye movement cells are not uniformly distributed throughout the PRF, but tend to be restricted to dorsomedial regions *(7).* Similarly, neurons related to vestibular nystagmus in the cat are not distributed throughout the PRF, but rather are sharply localized to dorsomedial regions, especially the area caudal to the abducens nucleus (2). While some connections exist *(8),* horseradish peroxidase studies have not revealed a major projection from the FTG region to the oculomotor nuclei (9).

Stimulation in the PRF produces com-

0036-8075/78/0113-0207$00.50/0

plex head and body movements in the unrestrained cat and monkey. Only in restrained animals does the stimulation effect appear to be restricted to eye movement *(10)*. Lesions in this area produce gross deficits in posture and head movements, as well as disturbing eye movements (77).

Eye and head movements are normally coordinated and therefore it should not be surprising that eye movement relations have been found in cells related to head and other movements. Indeed, as *Bizzi et al. (12)* have pointed out, neck muscles are activated prior to eye muscles in coordinated movements. Neck muscle activation can also be detected in head-restrained animals. Most studies of eye movement relations in PRF cells have been performed in head-restrained animals. Therefore, correlations between activity in head movement cells and EOG in these preparations might speciously suggest that these cells were triggering eye movements. Conclusions from studies that examine the relationship of unit discharge to only one isolated behavior must be cautiously interpreted and cannot confirm general conclusions about the cells' functional role.

We have now examined a large portion of the medial brainstem reticular formation in unrestrained, behaving cats in a variety of behavioral situations and find cells related to specific movements throughout this area. The correlations between PRF activity and habituation and conditioning processes (*13*), pain and escape behavior *(14),* treadmill stepping (15), REM sleep *(3, 6,* 76), and eye movements can be viewed as a consequence of the involvement of these movements in a variety of behaviors.

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28 October 1977