The Electromyography of Vergence Movement

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In a previous report [1] a difference was described between the electromyographic pattern of version and convergence movement. The version, or saccadic, movement was shown to be associated with a sudden short discharge of larger motor units immediately followed by a regular pattern of lower amplitude. Corrective secondary bursts are often introduced upon this consistent discharge. Convergence is accompanied by a gradual increment of motor units and succeeded by a prolonged decrement. Alterations in the firing rate are slow in nature, and secondary adjustments are not seen. More recent data has shown that the two patterns are often combined in certain vergence movements and that more subtle changes are found in the motor units.

Differences of opinion have been expressed as to the findings in asymmetric convergence. One group [2] has found coactivity of the medial and lateral rectus of the stationary eye, while another [3,4] described no alterations. It is hoped that the present study will help to resolve some of the diversity of views about asymmetric convergence.

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I. Method

The subject was fixed in a headrest and a wax bite-bar to prevent head movement. A fixation light was placed 18 ft. in front, and a stimulus light was placed at intervals of 2.5 to 25 degrees to the side for version movement. Convergence was obtained by a clear Plexiglas plate placed in front of the subject with a 1 mm. diameter defect drilled in the center. The plate was illuminated from the side and was adjustable so that both sudden symmetrical and asymmetrical convergence of 2.5 to 25 degrees were produced. Gradual convergence could be produced by slowly approximating this object.

Recordings were obtained from six normal persons, 24 to 43 years of age. The recording apparatus was that previously described. The medial and lateral rectus of one eye was used at the initiation of the procedure. After obtaining pertinent data, one electrode was removed, since it was noted that the insertion of multiple electrodes produced erratic eye movements, particularly if they are maintained for over 30 minutes.

II. Results

A. Convergence.—After the introduction of the stimulus at the beginning of the lateral rectus tracing of Figure 1, there is a

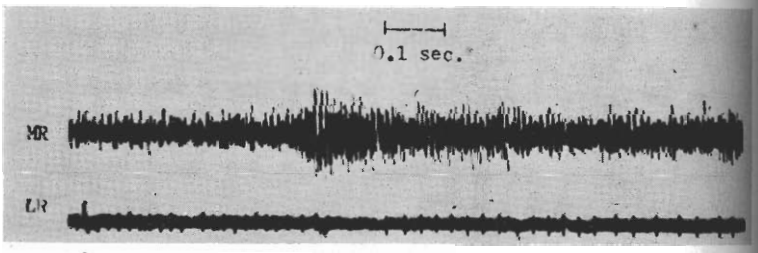


Fig. 1.—Ten degrees convergence.

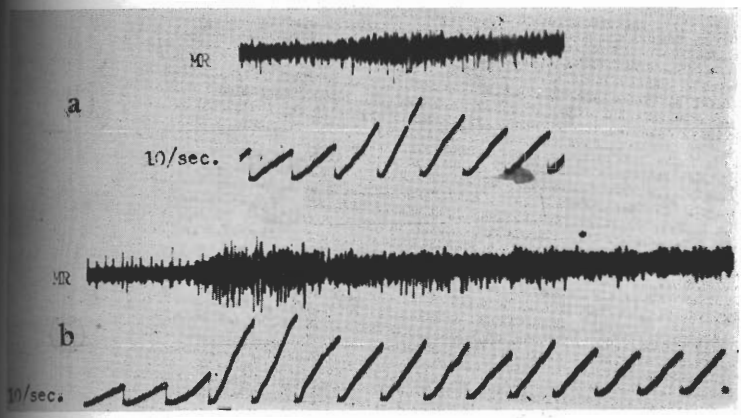


Fig. 2.—(*a*) Five degrees convergence; (*b*) twenty-five degrees convergence.

latent period of 0.4 seconds. This is followed by an increase in the activity of the medial rectus for 0.06 seconds. Maximal activity is maintained for 0.1 seconds, and then there is a gradual decline. The lateral rectus single unit pattern shows reciprocity throughout, with complete inhibition during the height of activity in the internal rectus.

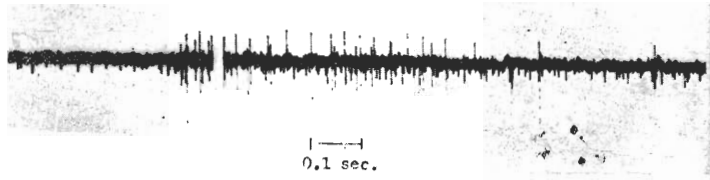
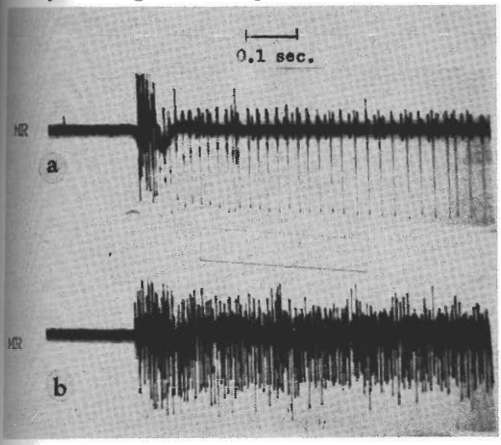


Fig. 3.—Five degrees convergence.

Figure 2 illustrates the gradual alterations of myography in convergence by integration at 10 per second. In a large movement there is increasing activity for over 0.2 seconds and then a gradual decline for 0.8 seconds. In smaller movements differences are noted for a shorter time but usually require at least 0.4 seconds before stability is reached. Single motor unit (Fig. 3) discharge follows the general pattern with increasing frequency of firing at the onset followed by a more gradual decrease.

Fig. 4.—(*a*) Twenty-five degree saccadic; (*b*) twenty-five degree convergence.



Upon comparison of the motor unit activity between saccadic and convergence activity (Fig. 4), it is noted that convergence has more motor units present and at least some of the units are different, with use of amplitude as the distinguishing criteria.

B. Divergence.—The electromyography of divergence was found to consist of two types. The first form (Fig. 5) demonstrates coactivity of the medial and lateral rectus. The medial rectus shows slightly diminishing activity up to a saccadic burst and then the presence of a uniform firing pattern. The lateral rectus recording has the spindle-shaped pattern that was seen in the recordings of the medial rectus for convergence, and the first increase in activity occurs with the beginning of the saccadic burst in the medial rectus.

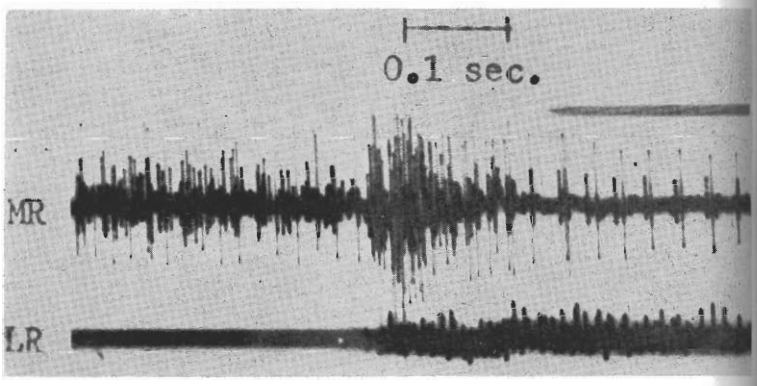
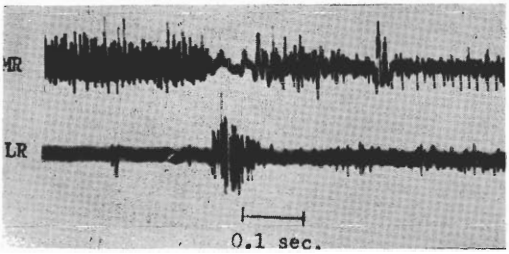


Fig. 5.—Divergence from 20 degrees.

The second form (Fig. 6) is marked by inhibition of the medial rectus (0.1 second) with the reappearance of an irregular pattern (0.25 second) followed by a steady-firing state of fixation. Accompanying the inhibition of the internus, there is a saccade in the lateral and an irregular pattern that reciprocates with the medial until a stable state is reached.

Fig. 6.—Twenty-five degree divergence.



Divergence also has the secondary bursts of saccadic movement. Figure 7 illustrates the motor unit pattern, as well as the secondary adjustments that occur in a serial fashion.

C. Asymmetric Convergence.—Sudden asymmetrical convergence is characterized by a saccadic burst in yoke muscles followed by a convergence pattern in the medial recti. This is shown in Figure 8 for the adducting eye. The supposedly stationary eye shows similar changes, except that the saccade occurs in the lateral rectus and is then followed by a convergence pattern in the medial rectus.

If the subject is required to follow a slowly moving target that approaches one eye from straight ahead, no alteration in the electromyography is noted until the object approaches the near point of convergence when coactivity begins (Fig. 9). The lateral rectus trace indicates the single motor unit pattern as it increases concomitant with the medial rectus (6 cm.). Further activity is seen as the break point of convergence is approached (3 cm.). Divergence occurs in one of the two forms previously described. A recording from a medial rectus (Fig. 10)

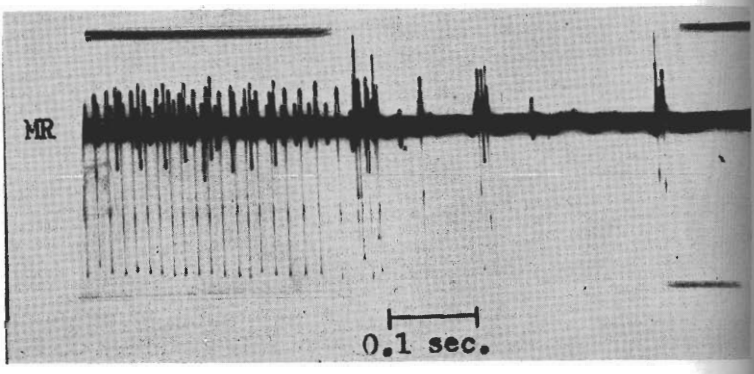


Fig. 7.—Ten degree divergence.

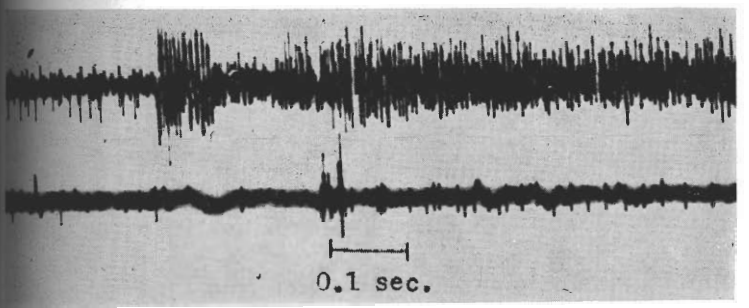


Fig. 8.—Asymmetric convergence.

indicates that no alteration in single motor units is noted until a distance of 6 cm. and further activity occurs up to divergence. seem to require corrective adjustments. The motor units that are involved in the movement show similar changes in their rate of

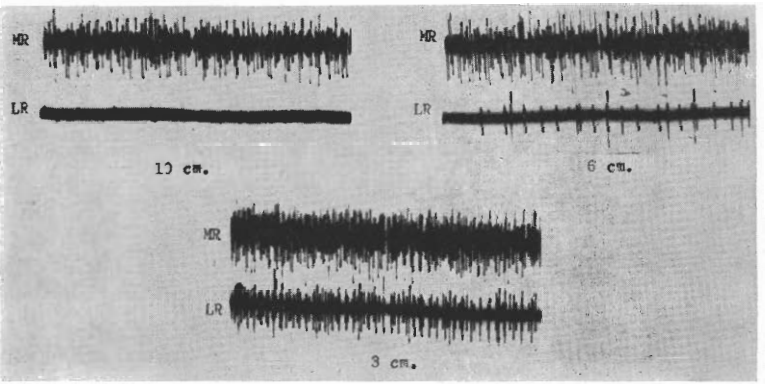


Fig. 9.—Asymmetric convergence.

III. Comment

Convergence movement has many features that distinguish it myographically from saccadic eye movement. The onset has a more gradual increment, and after the initial rise there is changing activity for almost a second. The activity is of a regular fashion with slow changes which do not discharge. In addition, there are more units present in convergence motion and at least some of the units are different. Once fixation is obtained in convergence, a different pattern is also still present.

The first form of divergence shows features of both convergence and saccadic movement. There is coactivity of the medial

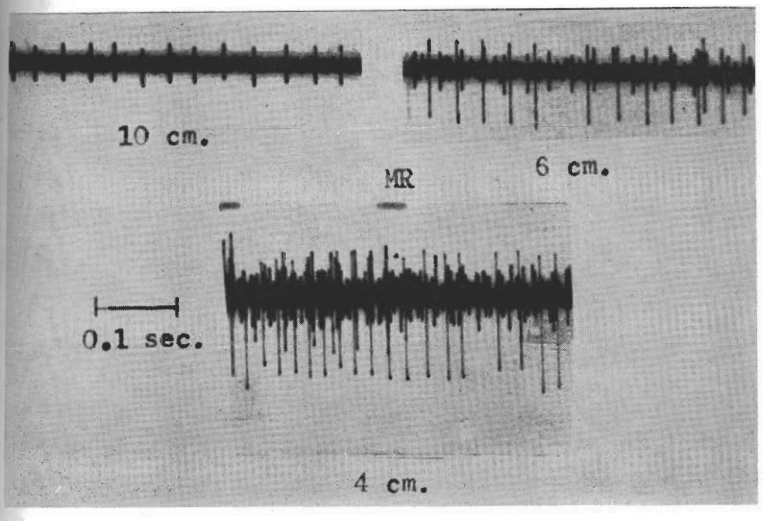


Fig. 10. — Asymmetric convergence.

and lateral rectus, with a saccade occurring in the medial; concomitantly the spindle pattern is seen in the lateral rectus. The second form of divergence consists almost entirely of saccadic elements with bursts being seen in both medial and lateral recti, and often what are apparently corrective adjustments are observed. There is no doubt that divergence is active. It is possible that the two forms of divergence may be on a sampling basis, since only a small area of an ocular muscle is surveyed at one given interval with an electrode and one form of activity may be missed.

Sudden asymmetric convergence has been described [5,6] as consisting of a version movement to the side of the object, followed by convergence of both eyes. The electromyographic pattern shows similar findings with the convergence pattern following after the saccadic pattern. The delay between the convergence and version pattern is about equal to the latent period for the movement.

If a subject slowly approximates an object approaching directly in front of one eye, there is no increase in coactivity of horizontal antagonists until the near point of convergence is approached. From this point until divergence an increase of simultaneous activity is seen. Single motor units are useful in this observation, since changes in fixation as small as 2 degrees 30 minutes can be discerned.[1]

In view of coactivity as a normal variant of divergence, it would seem that this phenomenon is the beginning of divergence under the conditions of a slowly advancing stimulus. As support for this hypothesis is the finding of coactivity in normal subjects at the near point of symmetric convergence. Furthermore, in subjects with a remote near point of convergence, this simultaneous increase is seen at a greater distance for both symmetric and asymmetric convergence.

IV. Conclusions

1. Convergence utilizes more motor units than saccadic movement of the same magnitude.

2. Part of the motor units are different in the two patterns.

3. Divergence activity resembles saccadic movement, and the pattern is different from convergent motion.

4. Sudden asymmetric convergence is accompanied by a saccadic burst in agonists, followed by a convergent pattern in both medial recti.

5. No increase in coactivity of horizontal antagonists is noted with slow asymmetric convergence on an approaching target until the near point of convergence is approached.

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