FACIAL ASSOCIATED MOVEMENTS.

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IN medical literature there are several reports of various associated movements connected with the cranial nerves. We have had the opportunity of examining 400 individuals at the National Hospital, Queen Square, and purpose in this paper to record various types of movement associated with contraction of the extrinsic eye and eyelid muscles.

Perhaps the earliest and best-known example is met with in the 'jaw-winking reflex,' carefully described by Marcus Gunn and others. In 1908, Kinnier Wilson drew attention to an associated movement of the ear and eye muscles. On extreme lateral ocular deviation a bending back of the pinna was observed in twenty out of fifty subjects; this movement, he stated, occurred in both ears, but was more marked in the homolateral pinna. He suggested that it was due to a contraction of the *transversus auriculæ* muscle, which thus tended to enlarge the external auditory meatus. The associated eye-ear movement was, therefore, a device whereby the senses of sight and hearing were simultaneously brought to bear upon a given object. Other simple associated facial movements were quoted in the same paper, such as the familiar upward ocular deviation evoked by wide opening of the mouth. Stannus, working in Nyasaland, found the presence of the oculo-aural associated movement in 66 per cent. of 100 Bantu negroes. He recorded the movement of the contralateral ear to be of greater frequency than of the homolateral ear. We are indebted to Dr. Wilson for drawing our attention to this report.

In our series of cases we noted six types of associated movements, which may occur singly or combined. Each of these types will be considered in detail.

ASSOCIATED MOVEMENTS.

1. On extreme lateral deviation of the eyes there may be noticed a movement of the helix of the pinna. The helix is rotated backwards and inwards towards the mastoid, the point of maximum movement occurring at the midpoint of the helix. This movement occurs only when full lateral deviation has taken place. The character of the ear movement is slow and deliberate; it is well sustained as long as deviation

is continued, and is released when the eyes are returned to their normal position. It is important to note that there is no movement of the ear as a whole. This is essentially the same movement as described by Kinnier Wilson. The range of movement differs in various individuals. Although in the majority of instances this phenomenon is bilateral, several cases in our series exhibited a movement of one ear only. It may also be noted that deviation to one side may cause greater ear movement than deviation to the other.

In the bilateral cases it has been our experience to find more

FIG. 1.—The oculo-aural movement. Note the position of the pointer attached to the left ear:

- (a) when eyes are directed straight forwards.
- (b) when eyes are deviated to the right.

frequently a wider range of movement in the contralateral than in the homolateral ear. This relationship between the eyes and ears was observed in fifty out of 400 cases. It is noteworthy that it is more readily elicited in males than females. In no case was the subject able to reproduce voluntarily the rotation of the pinna, nor were the subjects cognizant of the purpose of the investigation.

For the sake of brevity we shall, following Stannus, refer to this phenomenon as the 'oculo-aural' movement.

In four cases suffering from disseminated sclerosis and exhibiting marked nystagmus of the eyes we were able to demonstrate a nystagmus of the ear. The retraction movement of the ear was rapid, and synchronized with the quick outward phase of the eye movement, while the slow

recoil accompanied the slow phase of the eye movement. In these cases it was the homolateral pinna which alone showed the nystagmus. Fatigue was produced earlier in the ear than in the eye muscles.

2. In many cases our attention was attracted to a movement of the eyebrows associated with ocular deviation, which we shall speak of as the 'oculofrontalis' movement.

This consists of elevation of the homolateral eyebrow with depression of the contralateral brow upon outward ocular deviation, most movement occurring in the outer extremity of each eyebrow. The raising of the eyebrow takes place gradually as the eye becomes more and more deviated, and is highest on full deviation. Here, again, the patients were unaware of the object of the investigation, and failed to produce the movement voluntarily.

Several cases of disseminated sclerosis presented rhythmic nystag-

FIG. 2.—The oculonasal movement. Note the dilatation of the nostrils occurring when the eyes are deviated laterally (b), compared with the size when the eyes are directed forwards (a).

moid movement of the lateral half of the homolateral eyebrow when the eye was turned outward. A large proportion of these cases exhibited no ocular nystagmus; thus it is justifiable to assume that this nystagmoid movement may prove of considerable diagnostic value.

3. Pursuing our investigation further, we observed an associated movement of the tongue. If the mouth is allowed to hang open, and the eyes strongly deviated to one or other side, in many cases the point of the tongue turns over to the homolateral side. This movement is synchronous with the eye movement, and is quite well sustained, the tongue returning to its normal position along with the eyes.

On questioning each patient whether he knew if the tongue was moving, he always replied in the negative. It is fair, therefore, to assume that this deviation of the tongue is an associated movement, and not a voluntary effort, although one must admit such a tongue movement is possible voluntarily. In no patient were we able to

demonstrate a nystagmus of the tongue, as in the case of the frontalis and the ear.

We suggest the term 'oculolingual' movement for this phenomenon.

4. An 'oculonaral' movement was observed in only one patient, who was under treatment for *tabes dorsalis*. In this man lateral deviation of the eyes resulted in wide dilatation of both nostrils, irrespective of the side to which the eyes were turned. This movement was deliberate,

FIG. 3.—The oculomandibular movement. The point of the chin is protruded and deviated to the left, when the eyes are turned to the right.

equal in both nostrils, well sustained, and occurred only on extreme lateral deviation. It was independent of respiration.

5. In one case of arteriopathic cerebral hemiplegia an associated 'oculomandibular' movement was noted. When the jaw was allowed to drop and the eyes rapidly turned from side to side, the point of the chin became protruded and deviated in the opposite direction to the eyes. This movement commenced only after the eyes had been deviated in either direction in rapid succession for some time; once established, however, it persisted until the eyes were brought to rest.

6. To illustrate an associated 'orbiculostapedial' movement we are able, through the kindness of Dr. Duncan, to quote the following case :—

M. S., a girl of nineteen, was admitted to the Cassel Hospital for Functional Nervous Disorders for conversion-neurosis. She was a music student, training to be a professional singer. She exhibited a strong blepharospasm of the right eyelid, which had persisted, with occasional

intervals, for nearly a year. At times the left eyelid was similarly affected. When the blepharospasm was present on the right side she complained of buzzing in the homolateral ear while singing or listening to a high note. This occurred in the other ear when the other eyelid became affected, and disappeared when the blepharospasm was cured.

Dr. Wilson informs us he has seen an analogous case, in which homolateral tinnitus occurred with each paroxysm of an idiopathic facial spasm involving the orbicularis palpebrarum.

MUSCLES AND NERVES INVOLVED.

Before we pass to a discussion of these various phenomena, it is advisable to attempt an analysis of the muscles concerned in each.

Deviation of the eyes involves a coordinated contraction and relaxation of the muscles attached to the eyeball, especially the internal and external recti of both sides; these muscles are innervated by the third and sixth cranial nerves respectively.

The movements of the helix of the ear must be the result of a contraction of some intrinsic muscle; the transversus auriculæ muscle alone can explain this. This small band of muscle derives its nerve supply from a fine twig of the seventh cranial nerve.

The cause of the raising of the eyebrow is due to a contraction of the frontalis muscle, and not to the possible mechanical factor of the globe of the eye raising the upper lid. This fact was evident, as the brow was frequently seen to wrinkle, and on palpation a definite contraction of the frontalis muscle was felt. The lowering of the opposite eyebrow may be explained by regarding it as an instance of active relaxation, associated with active relaxation of the external rectus of the same side. The seventh cranial nerve supplies the frontalis.

The deviation of the tongue is clearly due to the contraction of the intrinsic muscles of one side, which are supplied by the twelfth nerve.

The nostril movement is caused by bilateral contraction of the dilatores naris, which are supplied by the seventh cranial nerve of each side.

The oculomandibular movement is due to the action of the homolateral external pterygoid; this muscle is innervated by the motor division of the fifth cranial nerve.

The subjective auditory sensations present in the cases quoted may result from a contraction of the stapedius, which is supplied by the seventh nerve.

DISCUSSION.

These associated movements appear to be independent of pathological states. We have found them to occur in many forms of nervous disease, organic and functional, and also in cases free from any cranial nerve involvement. It is perhaps noteworthy that no case suffering

from an ocular palsy exhibited these movements. We thus definitely state that the essential element of these associated movements is not the result of a pathological state.

The occurrence of facial nystagmus is probably of widely different import. Here it may be conjectured that one is dealing with a lesion analogous to that which is responsible for nystagmus of the eye.

The mechanics and causation of these associated movements may be viewed from the anatomical, developmental, and phylogenetic aspects.

1. *Anatomical*.—It will be gathered from a preceding paragraph that the third, fourth, fifth, sixth, seventh, and twelfth cranial nerves participate in these movements. The nuclei of these nerves are widely separated topographically; thus one is tempted to look for either a communicating system of fibres making a reflex arc, or for some higher controlling centre.

It is known that the dorsal longitudinal bundle connects the various cranial motor nuclei together, and may be the means by which an overflow stimulus passes from one nucleus to another. The suggestion that the associated movements occurring in the ear, nose, jaw, and tongue may result from an overflow of the stimuli supplied to the oculomotor nuclei is too simple; it does not explain why a part only of the facial nerve is affected, for surely, if an overflow of stimulus did occur, it would affect either the nucleus as a whole or those nerve-cells most in use.

The possibility of these movements being of a reflex character is worthy of consideration. Might not either the active movement of the eyeball or its alteration in position cause an afferent impulse to pass back to the various cranial nerve nuclei, evoking a motor response sufficient to cause contraction of the muscles observed? This hypothesis fails to explain the selective nature of the motor response, its slow character, and its absence in the majority of individuals. It would appear, therefore, that these phenomena are not reflex in character, but are rather of the nature of 'associated' movements. This last supposition demands the existence of a higher controlling centre. The experimental investigations of Horsley and Ferrier throw some light on this subject. These observers found that, on stimulating the anterior corpora quadrigemina, retraction of the ear occurred, with deviation of the eyes.

2. *Developmental*.—According to Cunningham, there are two series of elementary structures concerned in the formation of the muscles of the head and face—the cephalic myotomes, and the muscular structure of the branchial arches. The first, second, and third cephalic myotomes give rise to the ocular muscles, while the muscles of the tongue arise from the seventh, eighth, ninth, and tenth myotomes. The muscles of

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mastication originate in the first branchial arch, and the platysma and facial muscles arise from the second arch. We thus see that, as far as the muscles are concerned, there is no common origin. The nerves supplying these various muscles are apparently distinctly segmental; the third, fourth, and sixth nerves are typically segmental in character, while it is said that the hypoglossal nerve is the segmental nerve for the three or four myotomes from which the tongue arises. The facial nerve is related to the second branchial cleft, and the trigeminal nerve to the first branchial cleft. We put forward the suggestion, however, that the cranial nuclei concerned may have a common mesoblastic origin, though we have been unable to find any proof of this in the literature.

3. *Phylogenetic*.—A prolonged series of observations carried out at the London Zoological Gardens revealed the presence of these associated movements in animals. It was apparent that the presence or absence of the association depended upon many extraneous anatomical and environmental factors. Chief among these may be mentioned, firstly, the prehensibility of the fore-limbs; secondly, the amount of voluntary ocular movement; and, lastly, the dependence of the animal upon auditory stimuli.

The presence of binocular vision in animals is determined by the prehensibility of the fore-paws. Thus animals whose fore-feet are exclusively ambulatory in function, such as horses, sheep, etc., have imperfect binocular vision. Animals which employ the fore-paws for climbing or for grasping and catching food and conveying it to their mouths possess the faculty of binocular vision. Hence carnivora and monkeys show this feature, their eyes being set close together and well in front of the head. Such animals, however, do not all show associated eye-ear movements. In the carnivora, especially lions, tigers, leopards, jaguars, and pumas, the range of voluntary eye movement is extremely small, these animals using the muscles of the head and neck to look in different directions. Such animals do not show an associated oculo-aural movement.

Most animals, and in particular those which are naturally hunted by larger animals or are themselves carnivorous, are dependent far more upon their hearing than upon their sight. The external ears of such animals are highly complex organs, capable of a great variety of movement; not only can they be rapidly moved in any direction, but they are capable of movement independently of each other. The most complex ear movements are found in animals whose usual mode of life is a solitary one, such as lions or tigers, while the ear movements are less specialized in animals that live in colonies. Generally speaking, the animals which show the highest grade of ear movement, with but little range of voluntary eye movement, do not exhibit the oculo-aural movement.

Among the primates the oculo-aural movement occurs in varying degrees. The higher apes, such as the orang-outang and chimpanzee, possess a very slight degree of voluntary ear movement, but a wide range of eye movement, together with a highly prehensile pair of forelimbs. These monkeys present a well-marked oculo-aural movement.

The mandrills, baboons, spider monkeys, capuchins, drills, woolly monkeys, geladas and Japanese apes all show a lesser degree of associated movement; at the same time, the power of voluntary ear movement in these animals increases as the range of eye movement wanes. The association occurs more markedly in the adult animals than in the young ones. Both the male and female show the movement, though it is less noticeable among the males, as the ears tend to be concealed by long tufts of hair.

Various other associated facial movements have been noticed amongst the animals. Thus the gelada monkey, when its attention is suddenly seized, elevates its eyebrows, and at the same time both ears are drawn back—not so much by a general withdrawal of the whole ear as by a bending back of each pinna. A similar retraction of the ears has been noted to accompany opening of the mouth in several animals. Thus, when the domestic cow lows or when the lion roars, both ears are simultaneously dressed back.

Voluntary movement of the nostrils occurs in most animals, being most marked in the elephant, the tapir, and the ant-eater. No association, however, has been observed between the movements of the eyes and of the snout in any animal.

The cooperation of the external ocular muscles with the appreciation of sound is best studied in the reptiles, some of which have a wide range of ocular movement and no external ear. In the chameleon, for example, the eyelids are circular, having a small central aperture; these lids are capable of a wide range of voluntary movement, the two eyes working independently. If a high note is blown on a Galton's whistle behind a chameleon, the animal immediately turns the lids back in the direction of the sound, so that the central apertures become directed towards the whistle. At first there is no head movement at all, but if the high note is repeated several times, the chameleon finally turns its head in the characteristic sluggish manner of reptiles, and then slowly advances towards the sound.

The oculofrontalis movement of man is reproduced identically in some animals, particularly those with long, shaggy coats and prominent eyebrows. The movement is probably a mechanism whereby the eyebrows are retracted from the field of vision so as not to obscure the outlook.

The origin of these oculo-facial associated movements, therefore, appears to be vestigial. It is probable that they are relics of a more

highly specialized movement whereby the senses of sight, smell, hearing, and taste are rapidly focussed upon an object.

There is a certain amount of evidence to suggest an association between voluntary contraction of the orbicularis palpebrarum and contraction of the stapedius muscle. The well-known phenomenon may be cited in which screwing up the eyelids is accompanied by a whistling, roaring, or 'scrunching' noise in the ears. This has been explained in various ways, and, in particular, has been attributed to an associated contraction of the stapedius muscle. Although the exact function of the stapedius muscle with regard to high tones is still under dispute, one of its actions certainly consists in damping down loud and unpleasant tones. This action may possibly explain the familiar screwing up of the eyes when a shrill and loud noise is heard, the object being perhaps to contract the stapedii and so damp down some of the tympanic vibrations.

Another common associated movement may be explained by this theory of stapedius action. When listening for a very quiet noise, the subject naturally deviates the eyes to one or other side. Is this in order to contract the stapedii and so pick up and intensify subdued tones? Experiments, using a Galton's whistle or wire, with a view to detecting alterations in the appreciation of high notes, when the eyes are closed or open or deviated laterally, have met with negative results in our hands.

SUMMARY.

A description has been given of several associated facial movements.

The origin of the movements has been discussed from various standpoints.

It is probable that they are relics of a more specialized mechanism in animals, used both for protective and utilitarian purposes.

Nystagmus, both of the frontalis muscle and of the ear, is of pathological significance, and may be of diagnostic value.

We desire to express our indebtedness to Dr. Vevers, of the Zoological Society, who placed every facility at our disposal for the observation of the animals in his charge. Our thanks are also due to the physicians of the National Hospital, Queen Square, for permitting us to carry out this investigation on patients under their care.

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