CONTRACTIONS of the facial muscles in response to taps on the face have been clinically described under a multitude of different names according to the area tapped, the muscles which respond, and the mechanism considered to be responsible. Analysis of the mechanism of the contraction is greatly impeded by the fact that the skin, muscles, and motor nerve fibres are anatomically closely connected and easily moved over the bone, thus transmitting mechanical stimuli over wide areas. Therefore the actual structure stimulated has always been somewhat obscure. Consequently, the winking response to tapping on an area around the eye has been variously classified as a skin reflex (Overend, 1896), a periosteal reflex (Bechterew, 1901; Foerster, 1936), a skin and periosteal reflex (Guillain, 1920), a perichondreal reflex (Simchowicz, 1922), or a bone reflex (Lewandowsky, 1910). Weingrow (1933) and Wartenberg (1945) called it a myotatic or muscle stretch reflex.

The last assumption is a critical point. The existence of stretch reflexes in facial muscles was denied by Sternberg (1893). Sommer (1938) failed to record any action current responses in the orbicularis oculi, orbicularis oris, and buccinator muscles on sudden stretching. Weingrow, in his study devoted purely to a clinical description of new facial reflexes, assumed, without further analysis, that the responses evoked by tapping on the orbicularis oculi and other facial muscles were myotatic reflexes. Wartenberg's similar assumption was based on purely clinical observations. He stated that with a careful tapping technique “one has the definite impression that other stimuli are reduced to a minimum and that concussion and stretching alone are effective.” Considering the extremely low thresholds for the wink reflexes evoked by various types of stimuli, such arguments have to be taken cautiously, of which fact also Wartenberg was aware.

In spite of extensive animal investigations an anatomical basis is still lacking for the stretch reflexes and for the proprioception in mimetic musculature. Muscle spindles have not been found (Baum, 1900; Hines and Tower, 1928; Bruesch, 1944), nor have any other nerve endings
suggesting a similar function. Although both the sensory and motor roots of the trigeminal nerve contribute fibres to its mesencephalic root and nucleus mediating proprioception (Corbin, 1940; Corbin and Harrison, 1940; Pearson, 1949), these fibres have not been traced to the facial muscles.

In the facial branches of the seventh nerve the presence of sensory fibres has been shown by the use of chromatolytic methods and degeneration experiments, as well as by studies of fibre count. The afferent fibres have been described as distributed solely to the region of the ear (Rhinehart, 1918; Foley and DuBois, 1943; van Buskirk, 1945), or also to other regions of the face (Davis, 1923; Wakely and Edgeworth, 1933; Bruesch, 1944). Davis described them as pressure pain fibres, Wakely and Edgeworth as muscle afferents. Bruesch suggested that the small calibre fibres traced to free terminals in the adventitia of blood vessels were associated with pain. However, clinical and experimental observations on man suggest some transmission of muscle sense through the seventh nerve (Carmichael and Woollard, 1933).

It is thus clear that more information is needed for the classification of human facial reflexes. In this study the electrophysiological mechanism and the pathway of certain of the facial reflexes is analysed.

**METHODS**

Muscle action potentials were led off by plate or needle electrodes connected to one or sometimes two differential amplifiers operating a double beam cathode ray oscillograph. When one amplifier was used the other beam of the oscilloscope was connected to an oscillator for time recording in intervals of 1 or 2 msecs. The reflexes studied were elicited by mechanical stimulation of the tissues or electrical stimulation of the nerve. The perioral and blink reflexes were elicited by the tap of a light metal rod directly on the skin, or on another short metal rod which slightly stretched the corner of the mouth or a fold of skin in the outer corner of the eye. Other mechanical stimuli were pin-pricks on the skin and light taps on the cornea with a knobbed probe. At the moment of contact with the skin, the cornea, or the other metal rod, the stimulus started the sweep of the oscilloscope which had been suppressed.

The time required to transmit the concussion from the skin to the deeper tissues, such as the muscles, is unpredictable. It varies with the speed and force of the blow. If a light metal rod is used, permitting a high velocity to the blow, this time may be less than 1.5 masec., decreasing to 0.5 masec. Tests show that 1.5-0.5 masec. is the time by which the latency for stimulation of the facial nerve branches by a tap exceeds that of the latency for electrical stimulation on the same point.

In some experiments the stimulus was a puff of air delivered through a Y-shaped tube attached to a rubber bulb which was briskly squeezed. The two shanks of the tube were of different lengths, the shorter being directed against the skin or cornea. The other, as long as the shorter one plus its distance from the target, had a contact in the opening which was broken at the instant that air impact reached it, thereby starting the sweep.

The masseter reflex was evoked by a brisk tap with a reflex hammer on a tongue spatula placed on the lower teeth.

Bipolar electrical shock stimulation of 0.5 msec. duration was also used.
RESULTS

Electrical response.—A sudden tap on any point within a wide area around the eye evokes at a very low threshold a reflex blink caused by contraction of the orbicularis oculi muscle. The contraction is accompanied by an electrical discharge coming in two groups (e.g. figs. 1A, B, D, E). In the first group the discharge consists of a well-synchronized volley starting about 12 msec. after the stimulus, and lasting 5–10 msec. The second group consists of an asynchronous discharge coming after a latent period of 25–30 msec., and usually lasting 20–30 msec. or more. Both groups are clearly related to contractions of the orbicularis oculi muscle. They are not merely the result of eye movements or electrode shifting, being readily registered by surface electrodes placed on the upper and lower eyelids (see majority of records) and by needle electrodes inserted in the muscle (fig. 1E). In the latter case the typical thin action potentials of the facial muscles may be recorded.

The result is essentially the same, whether the glabella (fig. 1A), the frontal bone (fig. 1B), the nose (fig. 1D), or the zygomatic area (fig. 1E) is tapped. In the past the reflex blink observed has been designated mainly...
according to the area tapped, e.g. the frontal reflex of Overend (1896), the supra-orbital reflex of McCarthy (1901) and Weisenburg (1903), the naso-palpebral reflex of Guillain (1920), the nose-eye reflex of Simchowicz (1922), the nose-bridge-lid reflex of Glattauer (1939). Slight differences in the impulse pattern, according to the point stimulated, may, however, be observed. If, for instance, the glabella is tapped, both responses are well developed (fig. 1A). If then on the same subject the upper part of the forehead is tapped (fig. 1B), the threshold for both responses is somewhat raised, generally slightly more for the first than for the second. The first response is therefore diminished in amplitude relative to the second. This condition is accentuated if the tap is applied to an area as far removed from the eye as the top of the head. The first response may now be missing while the second is relatively well preserved (fig. 1C). This is the cephalo-palpebral reflex of Galant (1926).

If, however, the tap is not too weak, and is not applied too far from the eye, both responses are always present, and were found in all 40 subjects tested. The variation in latency is shown in fig. 2, based on 100 measurements taken in 15 subjects. The mean latency for the first response was 12.5 msec. and for the second, which varied within wider limits, 27.2 msec. The reflexes were evoked by gently pulling a fold of skin in the outer corner of the eye outwards and backwards with a metal rod and applying a brisk tap on it with another light metal rod. The subject's eyes were kept closed. If carefully done no pain is felt, and the noise is not sufficient to elicit a reflex discharge. The usual clinical method of direct tapping on the skin gives the same results.

If the response elicited by the method described is analysed by grading the strength of the stimulus, it is found that in most subjects the threshold for both responses is much the same. Even with a very light tap it is
impossible to get constantly only one response. The result is the same if Wartenberg's (1945) similar technique for eliciting the reflex is used.

In some subjects, however, the threshold for the second response is lower than for the first. A threshold stimulus sometimes elicits both responses (fig. 3a), but often almost only the second (fig. 3b). In other subjects the threshold for the first response is lower. A gentle tap may sometimes evoke two responses (fig. 3c), but often almost only the first (fig. 3d). The independent variations in the amplitude of the two discharges show that two different reflexes are concerned while a purely clinical observation shows only one.

The first response further differs from the second in that it is unilateral, whereas the second response is bilateral. If, for instance, activity is recorded from the upper lids of both eyes simultaneously, and a gentle, sudden stretch is given to the muscle on the right side (the lower recording in fig. 3e), a double discharge with a fully developed first response will be evoked on that side. On the left side, however, only the second response is found (upper recording in fig. 3e). If the stimulus is now moved to the left side, the first response will appear only on that side (fig. 3f, upper tracing) without any electromyographical trace of it from the lid of the

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**Fig. 3.—Records from 3 subjects: (1) A and B; (2) C and D; (3) E and F.**

- **A–D,** Threshold stimulus (tapping) tends to produce only the second (B), or only the first (D), response. **E and F,** Upper tracing in each figure from the left, and lower tracing from the right, eyelid. A tap on the right side (E) produces a right-sided, and on the left side (F) a left-sided, first response, and bilateral second response.
right eye from which only a second asynchronous response is recorded (fig. 3r, lower tracing). If stronger stimuli are used, the first reflex will be bilateral, probably due to transmission of concussion to the other side.

Although in most subjects the second reflex is already bilateral at threshold strength, sometimes a "local sign" of the reflex is exhibited. In some subjects the reflex at threshold strength is somewhat stronger on the side stimulated, and may occasionally be unilateral, sometimes appearing as fascicular twitchings in the lower lid. However, as soon as the stimulus is raised a little above threshold, the response is distinctly bilateral. If a strong stimulus is used the second reflex may no longer remain localized to the orbicularis oculi muscle. The discharge becomes more widespread and is recorded from adjacent or even more remote muscles in individuals with a lively response.

Other facial muscles, such as the orbicularis oris (fig. 1r) or the chin muscles, readily respond on tapping or stretching at a somewhat higher threshold with a unilateral reflex discharge of the same type as the first response in the orbicularis oculi muscle. After a latent period of 13–15 msec. a well-synchronized volley appears. In some normal subjects the same stimuli evoked even a second asynchronous reflex discharge (fig. 1r) which did not seem to be part of a generalized wink reflex. The threshold was, however, higher than that for the first response. The reflexes of the perioral muscles will be dealt with more fully in a later paper (Ekbom, Jernelius, and Kugelberg, 1952).

**Afferent pathway.**—Trigeminal rhizotomy abolishes both responses. In 7 patients who had been subjected to complete (2 cases) or almost complete sensory and motor rhizotomy, this was unequivocal as regards the orbicularis oculi reflexes. Case 2 is an example of this. A weak or moderately weak tap on a fold of skin in the outer corner of the eye on the side operated upon produces no response whatever (fig. 4A). A stronger stimulus will produce delayed reflex response, elicited from the opposite side by the spread of concussion, but no early discharge, since this is unilateral (fig. 4b). On the non-operated side a very weak tap evokes the normal double response (fig. 4c).

Tractotomy does not affect the first response, as seen in 4 patients examined. The threshold for the second reflex was raised, but the reflex was not abolished. Apparently, however, in no case was the tractotomy complete. The perception of pain was much reduced, but pain was felt in isolated spots several centimetres apart.

Direct proof that the afferent path for the reflexes examined is in the trigeminal nerve could be secured by electrical stimulation of the trigeminal root in a patient with tic douloureux during operation per-
Fig. 4.—Records from the eyelid following trigeminal rhizotomy. A and B, operated side. A weak tap (A) evokes no response and a stronger tap (B) only a second response. C, normal side. A weak tap evokes a double response.

Fig. 5.—Electrical stimulation. A, stimulation of the trigeminal root evokes the usual double response. B and C, stimulation of the infra-orbital nerve through the skin evokes (B) only the first response, and (C), after shifting the position of the electrode slightly, only the second response.
formed by Dr. Norlén. Since the blink reflexes are rapidly lost during general anaesthesia, the operation had to be performed under local. The dura was opened and the temporal lobe lifted up to expose the middle fossa. The cavum meckelii was then opened, whereupon the trigeminal root could easily be stimulated bipolarly. The typical double response was obtained at a current strength of about 1 mA. (Fig. 5A).

Stimulation of the infra-orbital nerve with surface electrodes or needle electrodes inserted in the vicinity of the infra-orbital foramen produces, at threshold strength, sometimes only a first response, sometimes a double response, or more commonly only a second response (fig. 5B and C). The result depends largely on the position of the stimulating electrodes, and careful adjustment is necessary if only the first response is to be evoked. The threshold for eliciting both reflexes is lower than that required for producing a sensation of pain.

Adequate stimulus.—A light prick with a sharp needle or a faint puff of air applied to the skin elicits a very strong second reflex without any trace of the first (fig. 6C). Stimulation of the conjunctiva or cornea elicits only the second response (fig. 6D). Evidently stimulation of receptors for light touch and pain is not adequate for eliciting the first reflex. Greater distortion of the skin or underlying tissues is apparently required. To produce the first response by local distortion the stimulus should be applied over or near the orbicularis muscle. If, for instance, the skin is very
lightly tapped with a blunt pin attached to a flexible wire, a fairly localized distortion is evoked. If the tapping is applied over the muscle, both responses are elicited (fig. 6A), but if applied on a spot a few centimetres away (fig. 6B), only the second reflex appears, with little change in amplitude. Stretch is a very effective method for eliciting the first response. Sudden, slight traction applied to a broad strip of adhesive tape attached to the skin below the eye renders it possible constantly to obtain only the first response, manifested by a faint twitch of the eyelids on the side stimulated. One therefore has the impression that stretching of the orbicularis oculi muscle is the stimulus adequate for evoking the early reflex response although the threshold is exceedingly low.

There is no doubt that pain is an adequate stimulus for eliciting the second reflex. However, a stimulus such as a faint puff of air is also very effective (fig. 6C), although then it is not felt as pain but rather as a touch with a slight tickling quality.

Discussion

Two different types of reflexes are easily produced in the facial muscles by tapping the face. In the orbicularis oculi muscle both are evoked at about the same low threshold. This renders a purely clinical interpretation of the response almost impossible. Wartenberg (1945), by using a careful tapping technique which he assumed reduced to a minimum all stimuli other than that of muscle stretch, evoked a reflex which he described as a blink on the side stimulated, and as a weaker blink on the opposite side. The electromyogram clearly shows, however, that it is not a question of one single reflex, as suggested by Wartenberg, but of two different reflexes on the side stimulated and of one late reflex on the contralateral side, provided a very weak stimulus is used. A stronger tap will give rise to spread of concussion to the opposite side and evoke a double response in both orbicularis oculi muscles. In some individuals a very weak tap will give rise to the first response proper, and a blink is then observed only on the side stimulated. All clinical studies of the blink reflex with a technique based on tapping on an area around the eye have been of a reflex blink composed of at least two different reflexes. To investigate the components separately more refined techniques than those used in purely clinical observations must be employed, although the fact that the first component is unilateral and the second bilateral may be of some help. Other late reflex responses must also be taken into consideration, such as those produced by visual stimuli or when the patient is startled by an unexpected touch or noise.

The first orbicularis reflex is apparently evoked by muscle stretch although this is difficult to demonstrate with certainty owing to anatomical...
factors. The reflex is elicited by stimulation of large, low-threshold fibres, considerably larger, at any rate, than those subserving pain. The reflex discharge is usually a well-synchronized volley similar to that obtained when the facial nerve is stimulated by electric shock. Stretch reflexes in other parts of the body are also accompanied by a discharge of this type (Hoffmann, 1922; Magladery and McDougal, 1950). The reflex elicited by a weak tap over the muscle is restricted to the muscle proper, and thus possesses the restricted distribution of the myotatic reflex (Liddell and Sherrington, 1925). Stronger tapping gives rise to spread of concussion which hampers further investigation of the distribution of the reflex.

More information regarding the reflex may be obtained by comparing it with the well-defined masseter reflex which is a myotatic reflex. The afferent limb of this reflex consists mainly of large myelinated fibres with the perikarya in the trigeminal mesencephalic nucleus (Corbin, 1940; Corbin and Harrison, 1940). The perikarya sends collaterals to the trigeminal motor nucleus (Szentágothai, 1948), thus giving anatomic support to the assumption of a monosynaptic reflex arc which is a characteristic of the spinal stretch reflexes of the cat (Lloyd, 1943). The mean latency for the first orbicularis oculi reflex in 5 subjects was 12 msec., 4·5 msec. longer than that for the masseter reflex which was 7·5 msec. In 3 cadavers the mean length of the efferent arc from the facial nucleus to the upper lid was 25·4 cm., or 15·7 cm. longer than that from the trigeminal motor nucleus to the masseter muscle. The conduction rate of the facial branches of the seventh nerve, measured by stimulating one of the branches at two points 7·5 cm. apart, was found to be 45 metres per second. The conduction rate of the trigeminal motor nerve fibres may be assumed to be the same as that in the proximal part of the facial nerve. In the difference of 4·5 msec. in reflex time, 3·5 msec. may be accounted for by the longer efferent pathway of the orbicularis oculi reflex. To this should be added the difference in conduction time for the afferent path. The pathway from the upper lid over the first trigeminal branch to the pons (10·2 cm.) was 1·2 cm. longer than that from the masseter muscle to the pons. The unknown pathway of the first orbicularis oculi reflex from the root entrance to the facial nucleus may be assumed to be somewhat longer, roughly 2 cm., than the pathway of the masseter reflex from the root entrance to the trigeminal motor nucleus. A 3·2 cm. difference, calculated after a conduction velocity of 70 metres per second (Magladery and McDougal, 1950), would add 0·4 msec. more. This leaves 0·6 msec. which corresponds to the delay of a single synapse (Lorente de Nó, 1938). The calculations, based on the measurement of mechanically induced reflexes with muscle action potentials as index instead of nerve action potentials, should not be stressed too far. From a comparison with the simple stretch
reflex, however, it is clear that the first orbicularis reflex discharge is transmitted through a simple arc. It is, according to existing evidence, compatible with a myotatic reflex.

The second orbicularis reflex, compared with the first, shows quite another picture in almost every respect. The electrically induced response in the muscle is a fairly long-lasting asynchronous discharge. The reflex is bilateral and not restricted to the orbicularis oculi muscle proper, showing widespread responses at stimulus strength above threshold. The reflex time is much longer and more variable. A slower conduction velocity of the fibres of the afferent arc cannot explain the longer reflex time of the second reflex since stimulation experiments show that the fibres are of large calibre and the afferent arc is too short for any minor difference in conduction speed to play any considerable role. The central pathway might be longer, since some part of the reflex is evidently directed over the spinal tract of the trigeminal nerve, but the main difference in time is certainly due to the intercalation of the greater number of synapses. The general characteristics of the second response are the same as those of the conjunctival or corneal reflexes but the latency is shorter (fig. 6d).

**SUMMARY**

Reflex discharges in facial muscles evoked by mechanical stimulation have been investigated chiefly in the orbicularis oculi muscles. Two different types of reflexes with separate latencies are noted. Stimulation or section of the trigeminal root shows that the afferent paths of both reflexes are to be found in the trigeminal nerve.

(1) The first response is a well-synchronized volley with a latency of about 12 msec. The reflex is unilateral. From a comparison with the masseter reflex it is clear that the reflex discharge is transmitted through a simple arc. It is, according to existing evidence, compatible with a myotatic reflex.

(2) The second response is a long-lasting asynchronous discharge with a variable latency, roughly 21–40 msec. The reflex is bilateral, having no restricted distribution, but shows widespread responses on stronger stimulation. The reflex arc is multisynaptic, and at least some part of it passes over the spinal tract of the trigeminal nerve. Adequate stimuli are pain and probably touch.

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