Cortically-Evoked Pinna Movement in the Cat. (22103)

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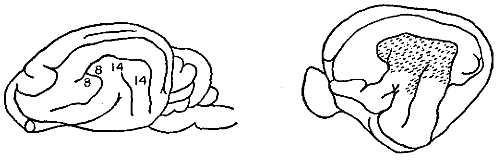
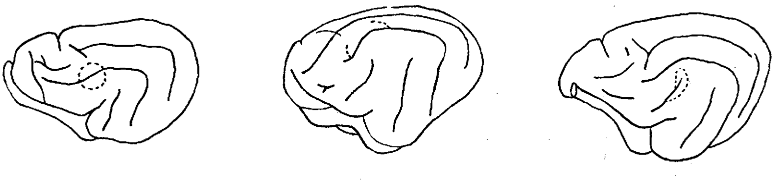
Ferrier's(1) observation that stimulation in the cat ectosylvian region evoked ear movement, led him to postulate that this region constituted the auditory area. Bremer(2) considered that such topographic overlap of sensory and motor representations of various body parts has functional significance in indicating a mechanism subserving simple cortical reflexes. Although Ferrier's postulated auditory area has been amply confirmed by histologic and neurophysiologic studies, there are data indicating that acoustic stimulation also evokes cortical potentials in areas outside the ectosylvian gyrus. Mickle and Ades(3) and Bremer(4) observed such evoked potentials in a region roughly corresponding with somatic sensory II. We noted another region of activation more medially situated in the suprasylvian gyrus(5). Maps indicating cortical area for pinna movement reveal some discrepancies in localization (Fig. 1)(1,6,7, 8,9). Actual data are scanty; *e.g.*, Woolsey and Walzl(8) merely state that the suprasylvian area enclosed by broken lines "is the 'motor' area for the pinna" (their Fig. 10) and, similarly, Claes(9) gives no data supporting her "area for auricular movements." Ward and Clark(10) reported, as infrequent finding, that stimulation of anterior end of middle suprasylvian gyrus produced movement of the contralateral ear.

In studies of suprasylvian auditory response area our observations indicate a sensory-motor overlap, which reconcile, to some degree, discrepant findings in earlier reports.

Methods. Observations were made on 10 adult cats anesthetized with Dial-urethane, 50 mg/kg, or Nembutal, 35-50 mg/kg intraperitoneally, and on 2 modified "encéphale isolé" preparations. In the latter, operative procedures were carried out under ether anesthesia and the animal allowed to regain consciousness under artificial respiration after transection of the cord at C3 and infiltration of operative sites with procaine. The C3 level, rather than the bulbospinal level of Bremer, was chosen since a major portion of innervation of the pinna is derived from C1



FERRIER (1876)   MANN (1896)



CLAES (1938)   WOOLSEY & WALZL (1942)   GAROL (1942)

FIG. 1. "Motor area" for pinna movement as reported by other authors (reproductions of original diagrams).

and C2 segments. Various degrees of exposure of one or both hemispheres were made and stimulation carried out with bipolar platinum electrodes (inter-electrode distance 0.5-1 mm) leading from a Grass square wave stimulator. Optimal parameters of stimulation were determined and observations of pinna movements were recorded cinematographically. In some experiments in which the areas of acoustically-evoked potentials were defined, the electrocorticogram was recorded by a Grass Model III electroencephalograph, using wick electrodes.

Results. Exploration of lateral surface of cortex, made accessible by wide exposure, revealed that pinna movements were evoked from 2 small discrete areas, one in the ectosylvian gyrus (ES), lying within Auditory I area, and the other in the suprasylvian gyrus (SS) roughly corresponding with suprasylvian auditory receptive area mentioned above (Fig. 2). Since wide exposure of a hemisphere virtually destroys the ipselateral pinna, smaller exposures were made and care taken to preserve muscle and fascial attachments of the pinna as much as possible. It was then noted that the 2 responses differed significantly *i.e.,* ES response was always bilateral, whereas SS response was always unilateral, involving the contralateral pinna.

Actual movement of the ear varied somewhat from animal to animal, the most consistent pattern from SS stimulation consisting of an initial pricking up and cupping of the contralateral ear. If the stimulus was continued, this was followed by a "laying back" of the ear; *i.e.,* ear was retracted so that it lay in the plane of the dorsal convexity of the skull. With ES stimulation, the most common response was a pricking up of both ears, without cupping.

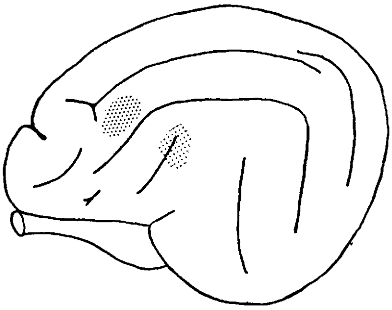


FIG. 2. Cortical areas from which pinna movements are evoked by electrical stimulation.

Both areas were approximately equal in size, and under conditions of these experiments covered approximately 20-30 sq mm in a given animal. No consistent differences in pattern of pinna movement could be determined by stimulation of different points within the responsive areas, even with closely spaced electrodes and threshold stimulus intensities.

The most effective parameters of stimulation for SS were 40-60/sec, pulse duration 5-10 msec, and 4-6 volts output. Pulse durations briefer than 2 msec rarely evoked responses. The required duration of stimulus was a few seconds. Changing parameters of frequency and pulse duration produced no significant changes in pattern of ear movement, if the stimuli were effective at all. With suprathreshold stimulation the required stimulus duration decreased, and initial pricking up of ears tended to disappear, movement consisting mostly of retraction. Antecedent stimulation frequently facilitated the responses from SS, so that with a series of stimulations, latency might be shortened to a small fraction of a second. In this way, a previously ineffective stimulus frequency of 5 or 10/sec might now become effective and evoke pinna twitches which followed the stimulus frequency. No marked extinction phenomena were noted.

ES required similar parameters of frequency and pulse duration, but in general had somewhat higher threshold than SS. In a number of experiments with good SS responses, no pinna movements could be elicited from any portion of the ectosylvian gyrus. The converse was not observed. When present, ES responses required somewhat higher voltages (6-10 v) and longer stimulus durations. No gross facilitation by antecedent stimulation was demonstrated for ES responses, which were also more susceptible to anesthesia, disappearing earlier than SS with increasing depth of narcosis.

Prolonged stimulation of SS frequently resulted in after-discharge manifested by twitches of contralateral pinna. These seizures sometimes spread to involve contralateral face, but frequently remained limited to the pinna. Such post-stimulus effects were never observed after ES stimulation, despite use of strong and prolonged stimulation. Local application of strychnine to SS was followed by spontaneous twitches of contralateral ear, twitches being coincident with strychnine spikes as recorded electrocorticographically. Although less consistently obtained, strychninization of ES evoked bilateral ear twitches of lesser magnitude.

Ablation of ectosylvian or cruciate gyri did not influence responses obtained from SS stimulation, nor did ablation of SS abolish responses evoked by stimulation of ES.

SS responses were easily obtained from the modified encéphale isolé preparations, the fundamental pattern being similar to that observed in anesthetized animals.

Frequently, but not consistently, stimulation of SS evoked conjugate deviation of eyes to the opposite side, in addition to contralateral pinna movement. Such eye movements were not observed with ES stimulation, although reported to occur by Ferrier.

Discussion. There are 15 muscles which move the external ear of the cat; *i.e.*, change its orientation in space, and an additional 6 which change orientation of its parts to each other; *e.g.*, "cupping"(11). With such a complex of muscles, a considerable range of variability of movement pattern is conceivable. However, movements which have meaning to the human observer are limited to a few gross patterns such as pricking up of ears, as though "alerted," and laying back of ears, as though enraged. Behavioral interpretations of observed ear movements evoked by electrical stimulation face obvious difficulties. Nevertheless, the demonstration of unilateral responses from one cortical region as opposed to bilateral responses from another, represent two significantly different patterns of motor response.

It is difficult to determine, from reports of other investigators, whether any differentiation between bilateral and contralateral pinna movements has been made. It appears that other observers considered that ear movements represented an exploratory or alerting reaction to sound. Behaviorly, at least two types of auditory alerting must be considered. In one there is a generalized alerting; *i.e.*, both ears prick up and the animal becomes generally attentive without specific reference to the source of stimulus. This seems a response mediated by the ES area. In the other type, the animal becomes attentive to the particular region in space from which acoustic stimulus arises. One or both ears may respond, with the ear ipselateral to the stimulus source turning laterally or cupping, and head and eyes perhaps turning to that side.

Our studies of suprasylvian potentials evoked by acoustic stimulation indicate that these responses are largely evoked by stimulation of contralateral ear. Since this same area, when stimulated electrically, evokes pinna movement restricted to the opposite ear and, frequently, conjugate deviation of eyes to opposite side, it is suggested that this suprasylvian area mediates a cortical reflex concerned with "directed alerting"; *i.e.*, with an alerting reaction focussed toward the side from which acoustic stimulus originates.

Only part of the cortical efferent discharge evoked by afferent volley is directed towards motoneurones of brain stem or spinal cord, and a study of sensory-motor overlap gives information on only one aspect of function of such a region. Ability to localize sound in space has been attributed to asymmetrical activation of ectosylvian auditory area of the two hemispheres(12). The data here presented suggest that the suprasylvian region may also play a role in the mechanism of sound localization.

Summary. 1. Pinna movements in the cat are evoked by electrical stimulation of two discrete cortical areas. One, in the ectosylvian gyrus (ES) evokes movements of both ears; the other in the anterior suprasylvian area (SS) is of lower threshold, and evokes movement of the contralateral ear alone. 2. Both areas are topographically situated in regions in which acoustic stimulation evokes electrical responses. 3. The 2 areas of sen-

sory-motor overlap are considered to mediate 2 different cortical reflexes, the ES response of generalized alerting to unlocalized sound, and SS response one of oriented alerting to localized sound.

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Mechanical Fragility of Human Neutrophilic Erythrophagocytes. (22104)

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It has been suggested that the erythrophagocyte may be a fragile cell(1) but controlled studies have not appeared in the literature. Studies presented here were designed to obtain quantitative data on this point as part of a study of properties of the erythrophagocyte and the nature of erythrophagocytosis. Erythrophagocytosis can be produced *in vitro*(2) by incubating phagocytic leucocytes with red cells sensitized by antibodies or other surface altering substances(3,4). A method for producing erythrophagocytes in high percentages in a uniform manner using iso-agglutinins was developed and used.

Definitions and method. For purposes of this experiment the erythrophagocyte is defined as any white blood cell which has ingested one or more red cells, red cell ghosts, or large fragments of either. Finely vacuolated cytoplasm in a leucocyte was not considered evidence for erythrophagia. White cells found erythrophagocytic under suitable conditions included neutrophiles, eosinophiles, and monocytes. This is in agreement with previous work(5,6). Of this group of cells only the neutrophile was present in appreciable percentages in the blood used, hence, our data applies to the neutrophilic erythrophagocyte. Cell survival time refers to *in vitro* period of morphologic integrity as indicated by presence of cell membrane or well defined cytoplasmic border seen by phase microscopy, chamber examination using special diluent, or on differential smear. Blood from normal, type A and O Rh negative white adult donors was used as source of red cells and anti-sera repectively. In plasma from type O donor, the anti-A titer was at least 1:512. The same red cell and anti-sera donors were used throughout. Anti-sera showed no agglutinating or lysing properties against the leucocytes used. White blood cells were obtained from normal type O adults and adult patients with elevated leucocyte counts and high neutrophile percentages. Blood was drawn in 5 cc samples to which 0.01 cc heparin (50 mg/cc) had been added. Erythrophagocytic activity does not appear to be altered by presence of anticoagulants (4,5). Blood from each donor was centrifuged 3 minutes at 2500 rpm promptly after drawing. The buffy coat from the leucocyte donor was removed with red cells and plasma to yield a mixture containing approximately 60% cells and 40% plasma by volume. Cells