Evoked Cortical Activity from Auditory Cortex in Anesthetized and Unanesthetized Cats

Abstract. Evoked electric responses of the auditory cortex of unanesthetized cats were studied by averaging techniques which enable us to detect responses in high-level background activity without sacrificing bandwidth. The results suggest that previous studies on evoked responses from behaving animals that are based upon ink-written electroencephalographic displays were chiefly concerned with a set of response components that differ from the classical evoked potentials in anesthetized animals.

In recent years the use of implanted electrodes has made possible the study of electric activity in the nervous system of unanesthetized behaving animals (*1*). Given the range and variety of recordable phenomena, it is not surprising that some confusion has arisen in relating recordings of electrical events in anesthetized and unanesthetized animals. During the past quarter-century an extensive literature on the so-called "classical" evoked responses from the sensory cortical areas of anesthetized preparations has accumulated. This knowledge should provide a helpful anchor when one seeks to explore the new and exciting possibilities of recording electrical events that relate to an animal's behavioral responses to sensory stimuli.

The "classical" evoked response from the auditory cortex to a click consists of a relatively stable surface-positive deflection followed by a more anesthesia-sensitive, surface-negative deflection. These two deflections are quite stable in latency but exhibit a considerable amount of amplitude variability. Given the temporal characteristics of these deflections (see Fig. 1), the customary ink-written electroencephalographic records (which have a bandwidth equivalent to a 60-cy/sec low-pass system) do not give an adequate display of these fast events (Fig. 2). In order to obtain a faithful and yet stable representation of evoked responses, the background activity can be selectively removed by the use of averaging (*2*).

The present report concerns the application of averaging to the study of evoked responses with implanted electrodes in the awake cat. In this instance, a Teflon-insulated nichrome electrode was implanted in the auditory cortex 6 months before the recording date. During recording, the cat was placed in a sound-proof chamber while clicks were delivered from a loudspeaker. Since cortical response patterns depend upon the state of the animal, we tried to put the animal into a more or less uniform state during each run. Responses were first obtained while the animal was awake.

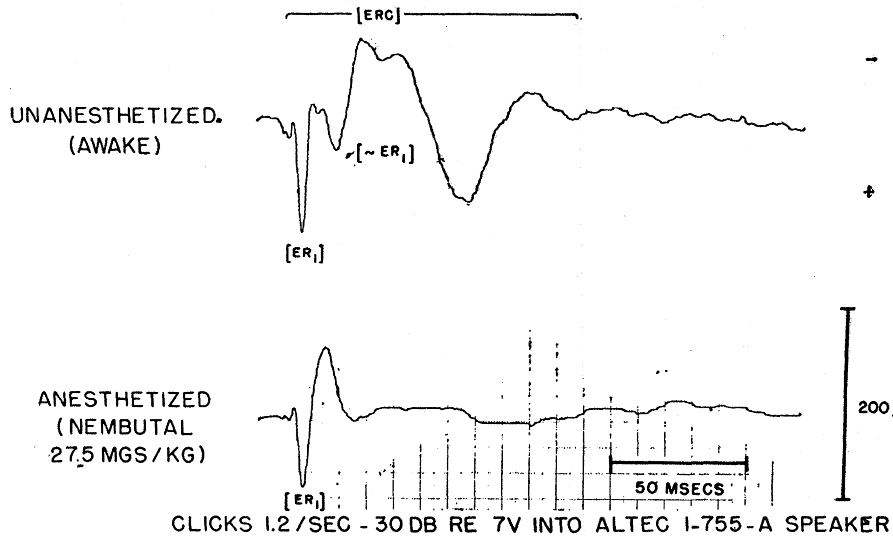

Fig. 1. Average of 256 responses from the auditory cortex of a cat in the awake state (upper trace) and in anesthetized state (lower trace). Similar results have been obtained from three other cats. The difference in the amplitude of the ER_1 component in the top and bottom traces lends itself to several interpretations. The wave form of the "slower" components of the ERC may have been affected by the low frequency cutoff of our recording system.

Nembutal was then administered intraperitoneally, and an hour later a second run was made under comparable stimulus conditions. During each run the electric activity from the implanted electrode referred to a frontal lead was recorded on magnetic tape. The bandwidth of the entire recording system covered the range from 1.5 cy/sec to 5 kcy. The recorded data were processed on the ARC-1 computer (*2*). Further details on the relation of average responses to individual responses are given in (*3*). The results of averaging are shown in Fig. 1.

Even a cursory examination of these findings points to the need for clarifying the term "evoked cortical response," if one attempts to cover records from both anesthetized and awake animals. In awake cats, the pattern of activity time-locked to the stimulus has at least several components. Under these circumstances it might be more appropriate to designate this pattern as an evoked response complex (ERC). A comparison of the top and bottom traces in Fig. 1 indicates that the one clearly common element is the early surface positive deflection of the classical evoked response. Even the later surface negative component is sufficiently modified, so that it can no longer be isolated in the ERC. Thus it might be convenient to designate the common element as the ER_1 and to withhold identification of later components until they have been examined more closely. Beyond this our state of knowledge warrants little more than a gross label of that part of ERC that is not ER_1 as $\sim ER_1$.

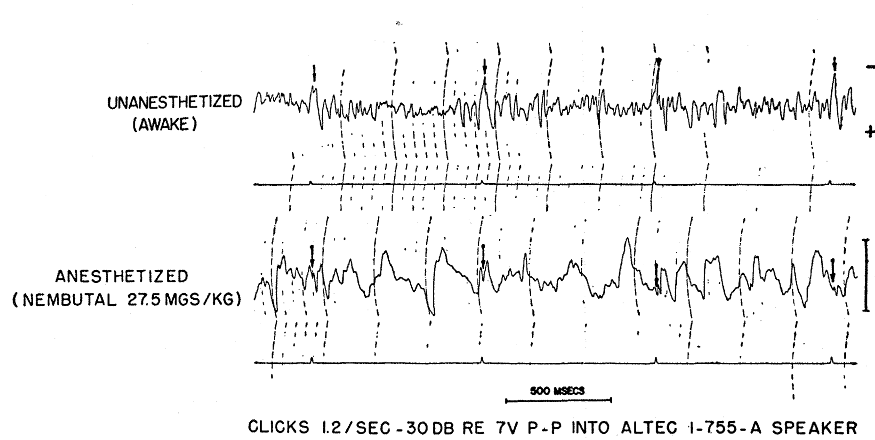

Fig. 2. Ink-written electroencephalographic records that belong to the same set of taped data from which the average responses in Fig. 1 were computed. The time markers under each record indicate the occurrence of clicks; the arrows identify the response components that are visually most easily detectable. Upward deflection indicates negativity of auditory cortex referred to frontal bone.

Most of the studies of electric responses to sensory stimuli in behaving animals have been based on ink-written electroencephalographic records. They have thus dealt predominantly with that part of the ERC that we suggest be labeled $\sim ER_1$. An examination of Fig. 2 bears out this point. The arrows in the upper trace point to what are apparently the $\sim ER_1$ components; the arrows in the lower trace indicate the ER_1.

These results do not in any way invalidate existing studies on the electric correlates of conditioning. Our data emphasize that the behavior of ER_1, as well as that of other components of the ERC, can be studied as a function of stimulus parameters and organismic states, provided the ERC is adequately displayed (*4*).

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4. This work was supported in part by the U.S. Army Signal Corps, the Air Force Office of Scientific Research, and the Office of Naval Research, and in part by research grant B-1344 from the National Institute of Neurological Diseases and Blindness, U.S. Public Health Service.
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Clay Mineral Composition of Sediments in Some Desert Lakes in Nevada, California, and Oregon

Abstract. X-ray analyses of some Recent desert lacustrine sediments in Nevada, California, and Oregon show that illite and montmorillonite are the most abundant clay minerals and that chlorite and kaolinite are present in subordinate amounts in the sediments of many of the lakes. These clay suites are derived from source rocks.

The clay mineral composition of the less-than-2-μ-fraction of nineteen Recent desert lacustrine sediments from Nevada, California, and Oregon yields data to extend an earlier study of the clay minerals in playas of the Mojave Desert, California (*1*). The sediments of the lakes studied have a wide range in chemical character, from weakly saline to very saline, in which deposits of calcium and sodium salts (sulfates, halides, carbonates, borates, and others) are found. A wide variety of composition is found in the source rocks surrounding the basins, and sediment derived from the same kind of source rocks are deposited in lakes with different chemical environments. By comparing the clay composition of the detritus coming from the source rocks with the clay suite of the lake sediment, conclusions concerning the diagenesis of clay minerals in the continental saline environment can be made.

Table 1. Relative abundance of clay minerals expressed in parts in ten of the less than 2-μ fraction. The symbol (d) indicates that the clay mineral is partially degraded. Amorphous material abundance: A, abundant; M, moderately abundant; T, present in minor or trace amounts.

Location	Illite	Montmorillonite	Chlorite	Kaolinite	Amorphous material
		Nevada			
Columbus Marsh	4	2	1	3	M
Fish Lake Marsh	5	3	1(d)	1	T
Silver Peak Marsh	3(d)	6	1(d)		M
Rhodes Marsh	4(d)	4	1(d)	1	T
Teels Marsh	4	3	3		T
Carson Sink	4(d)	3	2	1	T
4-8 Mile Flat	5(d)	2	2	1	T
Pyramid Lake	5(d)	3	1	1	M
Smoke Creek Desert	4(d)	4	1	1	T
Winnemucca Lake	5(d)	3	1	1	T
Black Rock Desert	5(d)	3	1	1	T
		California			
Borax Lake	6(d)	4			T
Deep Spring Lake	8	1	1(d)		T
Middle Alkali Lake	4(d)	6			M
Mono Lake	5	2	2	1	M
		Oregon			
Abert Lake	3(d)	7			A
Silver Lake	2(d)	8			A
Summer Lake	3	7			M
Harney Lake	3(d)	6	1		M

The relative abundance of clay minerals, determined by x-ray methods, in the sediments studied is given in Table 1. Illite and montmorillonite are the most abundant clay minerals found, and chlorite and kaolinite are present in minor amounts in many samples. The illite and chlorite of many samples are slightly degraded, and the degradation is produced in the source rocks predominantly by weathering. No clearly significant variation can be seen between the clay suite of the lacustrine sediments and the clay minerals derived from the source rocks.

The data support the earlier conclusion (*1*) that the sodium and calcium continental saline environment does not produce diagenetic changes in clay mineral composition. This conclusion does not apply to those saline environments where magnesium and potassium activity is high. The clay data obtained from a study of the Saltair core from Great Salt Lake, Utah (*2*), and from cores in several basins in California also suggest that the clay minerals usually are not effected by diagenetic processes in continental (sodium and calcium) saline lakes (*3*). Several lakes contain sediment rich in material amorphous to x-rays, and the lakes which contain the sediment most amorphous to x-rays are found in areas where Recent vulcanism is extensive. The montmorillonite content of most of the samples likewise is related directly or indirectly to ash. The The entire region of the study has been an area of active volcanoes through much of Tertiary time, and source rocks of the basin sediment are rich in volcanic products. Although the evidence is inconclusive, it is believed that montmorillonite is forming from glass in several of the basins studied, almost certainly in Abert Lake and Silver Lake, Oregon.

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1. J. B. Droste, *Science* **130**, 100 (1959). The study of clay minerals associated with evaporite sediments has been supported by National Science Foundation grants, Nos. G-5659 and G-11350. This support and the encouragement and council of Ward C. Smith of the U.S. Geological Survey are gratefully acknowledged.
2. A. J. Eardley and V. Goosdetsky, *Bull. Geol. Soc. Am.* **71**, 1323 (1960).
3. The study of cores from Danby, Cadiz, Bristol, Owens, China, Searles, and Panamint basins in California has almost been completed.

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