

COMPONENTS OF HEARING MEASURED BY EEG AND ITS RESPONSES TO SOUNDS

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We assume that whenever a sound is presented to a subject the organization of his EEG activity will be modified in some way. There are three relatively independent changes that may occur in EEG patterns in response to sound.

a. Evoked Potentials

These are specific waves of predictable shape and delay with known patterns of distribution over the head. These include Davis's "**on effect**" and "**K formation**". In general, these specific waves are uncovered by the techniques of averaging and autocorrelation, and may be characterized more specifically by cross-correlation with a templet or may be scored without mathematics or mathematical aids, by unbiased inspection ("blind" reading). If such an evoked potential is an addition to the background activity, then can be detected by measurement of area under the EEG curve.

b. General Changes of Pattern

Whether or not a clearly-identified evoked wave-form is found, there are several other types or directions of pattern change which are likely to follow sound. These modifications include the wellstudied **suppression of alpha activity**, which is associated with a change in the state of the subject from repose towards greater alertness. In the sleep state, the change in EEG with sound may be towards either less deep or deeper sleep using the amount of theta and delta activity in the EEG as an operational definition of depth of sleep. All such changes of pattern can be measured by inspection, or by studies of frequency, energy in band pass filters, etc.

c. Increased Variance of Voltage

Not only the **type** of organization, but also the **degree** to which EEG activity is organized, can serve as an index of sensory response. From the voltage (height of wave) of the EEG trace at fixed time points before and during several stimulus presentations, the variance of voltage at each time point can be calculated. This value increases during and immediately after periods of stimulation. Such alterations of EEG activity show that stimulation elicits a modification of EEG pattern, even when the particular change is unpredictable, i.e. more pattern changes occur following stimulation, but change is present, the form of the change is different from stimulus-to-stimulus. It is as if — in the analogous EKG recording — a pattern were produced by a heart whose every beat (analogous to the EEG response) originated

in a different place. Every beat would show a different QRS complex (response) and every beat would be different from the background activity. This type of change is measurable through analysis of digitized data or measurement of velocity of movement of recording pen and by inspection of superimposed tracings.

Correlations established between any or all the above measurements, and any of the parameters of the stimulus will indicate the relative efficiency and best uses of these methods for detection of auditory information arriving in the brain. Correlations between these EEG measurements and **subject** variables (e.g., state of the organism) express to some extent the relationship of particular human subjects to auditory information, both in terms of the availability of the information, and of the subject's capacity to modify or "utilize" it. Our present crude knowledge about these correlations is summarized in table I.

Table I

Factors Affecting Detectability of EEG Response to Sound

	Stimulus							Subject			
	Tone Frequency	Tone Intensity	Rise Time	Duration	Interval between stimuli		Left, right of both ears	Mode (phones vs sound field)	State	Individual variations	CNS Disease
Random	Fixed										
Evoked Potential	NS	S	S	NS*	NS**	S***	S?	NS	S	S	S
Change of Pattern	NS	S	S	NS*	NS**	?	?	NS	S	S	S
Increased Variance	NS	S?	?	?	?	?	?	NS	S	?	?

NS = not significant

S = significant

* not significant when over 0.5 seconds for the early activity.

** not significant when over 5.0 seconds.

*** certainly significant when under 40 seconds, probably also significant, at some confidence level, at longer intervals.

It is convenient clinically, to use a vibratory or tactile stimulus as a modality differing from hearing, to check the intactness of some of the neural mechanisms underlying these responses.

Children whose "deaf" behaviour is produced or enhanced by central ner-

vous disturbances may frequently show loss or decrease of responsiveness to vibration, to clicks and or to tones and may also have local diffuse or paroxysmal disturbances of their EEG patterns. Such findings may appear singly or in various combinations. For example, the combination of good response to vibration, absent or diminished response to clicks and mild elevation of threshold for pure tones is a common pattern in children with slow language development. Their problems often seem to be reversible with growth and training.

Thresholds determined by EER-Audiometry measure information arriving at one point in one portion of the complex hearing arc. An EER threshold offers a way for assessing the subject's threshold of 'arousal' ("what was that"), but EER-Audiometry does not provide adequate information for judging whether or not the subject could identify or utilize this information.

ELEMENTS DE L'AUDITION MESURES PAR EEG ET SES REPONSES AUX SONS

Logiquement il y a seulement trois manières par qui l'activité electroencephalographique peut répondre à stimulation acoustique:

1. l'addition de l'onde spécifique,
2. la modification de l'organisation d'electroencephalogram, et
3. changement dans la variation d'ampleur du voltage.

Une méthode est décrite pour superimposer directement l'electroencephalogram pendant stimulation. Inspection visuelle de les superimpositions utilise toutes trois genres de réponse.

Nous voulons discuter des méthodes pour découvrir chaque genre de change. Nous discuterons, alors, les interactions entre les trois genres de réponse et les variables des stimulants et du sujet.

L'enveloppe de la stimulation (i.e. "le temps pour monter à l'intensité prefixé", l'intensité lui-même, et l'intervalle entre les stimulations) est le variable important. La fréquence qui est dans l'enveloppe n'est pas importante. Condition et dérangement du S.N.C. sont des variables importants du sujet.

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