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HEMISPHERIC CONTRIBUTION TO VERTEX AUGMENTATION/REDUCTION OF THE AUDITORY EVOKED POTENTIAL

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Since the works of Petrie et al.[24,25] and Buchsbaum and Silverman[6] the Augmenting/Reducing (A/R) construct has been postulated as a central neural mechanism related to human individual differences in the sensitivity to sensory stimulation. Buchsbaum and Silverman's neurophysiological paradigm employing the visual evoked potential (VEP)[6,32] led to postulate an "intensity control mechanism" in the central nervous system (CNS) modulating the "intensive aspect of attention". It has been considered a stable neurophysiological trait relevant to personality differences and psychophatological conditions. According to some, it should be demonstrable in all sensory modalities (von Knorring et al.[19]), in close relationship to cognitive styles (Zuckerman et al.[36]), depressive illness[3,4,5], schizophrenia[6,20,29], alcoholism[7,18], delinquency[34] among other conditions.

The assumption of a unitary or stable phenomenon behind A/R has been discussed. First, two reports (Kaskey et al.[17]; Raine et al.[26]) failed to demonstrate correlations between Reduction in visual and auditory potentials at the vertex. Several studies did not find significant Reduction at the vertex in the auditory modality, as it could have been expected on the basis of Buchsbaum and Silverman's suggestion that A/R is a property of multisensory association cortex. Second, instabilities of Augmenting/Reducing were evident in the work of Birchall and Claridge[2], who correlated arousal level, as measured by skin conductance, with VEP Augmentation or Reduction. Since the tendency of the VEP to Augment or Reduce was a function of the arousal level, they suggested that even though A/R might be considered as a stable trait, its fluctuations could reflect some state dependent process. Third, groups defined through different methods of measurement of A/R, did not overlap in the work of Connolly and Gruzelier[8]. In addition, Dustman et al.[11], reported age-dependent changes in A/R. All of these inconsistencies would indicate that the significance and neurophysiological basis of Augmenting/Reducing need further examination.

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The purpose of this study was to undertake an analysis of topographic properties of auditory Augmenting/Reducing. Hemispheric mechanisms are known to be related to different modes of information processing, cognitive styles and problem solving strategies [1,10,12,13,14,22,23,31,35]. Several reports have drawn attention to the differential hemispheric engagement in processing visual or auditory information [9], although the data are contradictory in this regard [21]. It was hypothesized that mechanisms responsible for auditory A/R might be influenced by or exert an influence upon patterns of hemispheric asymmetry, depending upon the stage of the information processing at which they operate. On the other hand, if A/R is modality specific, it could be related to topographic differences according to the sensory modality.

METHOD

Subjects — Subjects were 40 healthy right-handed unpaid volunteers (laboratory staff and medical students). All of them were male, mean age 24.5 years (range 18 — 40 years) and had no auditory impairment or history of brain disease. Drugs, tobacco and alcohol consumption were ruled out. All subjects were naive regarding the purpose of the experiment.

Procedure — Using a Grass S88 stimulator, binaural clicks were delivered through a stereo-earphone, with an interstimulus interval (ISI) of 1.5 secs, and a duration of 20msecs. Three discernible intensities were used: 63.5, 74.6 and 85 dB AL. Subjects rested on a comfortable bed in a sound attenuated, electrically shielded dark room. Stimuli were presented in blocks of 100, with an inter-block resting period of 2 or 3 minutes. They were instructed to relax and avoid movements, close their eyes and listen to the clicks, without making any attempt to count them. There were 6 blocks, two for each intensity, and the order of stimulus intensity presentation and lead selection during the recording procedure were randomized. The duration of the experimental session was 45 to 60 minutes. EEG was recorded from Cz referenced to right mastoid, and C_3 and C_4 referenced to ipsilateral mastoids, according to the 10-20 international system. Gold Grass electrode were attached to scalp with collodion impregnated gauze patches. EEG was recorded using 7P5B preamplifiers and 7DAE Grass amplifiers, with a bandwidth of 0.3 and 500 Hz. Averaging was done on line on a LINC digital computer. Each auditory evoked potential (AEP) was based on 100 artifact free sweeps with a sweep time of 400 msec.

Data analysis — By means of a cursor program, latencies and peak-to-peak amplitudes of components P_1, N_1 and P_2 were visually evaluated. P_1 was defined as the major positive deflection about 50 msec, N_1 as the negative deflection about 90 msec and P_2 as a positive one at 150 msec. Peak-to-peak amplitude of the vertex response was plotted against intensity of stimulation in the three recording places, evaluating slopes. The criterion for defining Augmenting/Reducing was the positivity or negativity of the slope across the three intensities of stimulation. All these parameters were statistically analyzed by means of «t» tests, Wilcoxon two-tailed tests and Pearson or Spearman's correlation coefficients.

RESULTS

Figures 1 and 2 depict examples of Augmentation and Reduction of the AEP components recorded at the vertex. As can be seen in Table 1, most subjects were Augmenters in both components examined. No significant hemispheric differences in the amplitudes of P_1N_1 and N_1P_2 components, at any of the three intensities, were

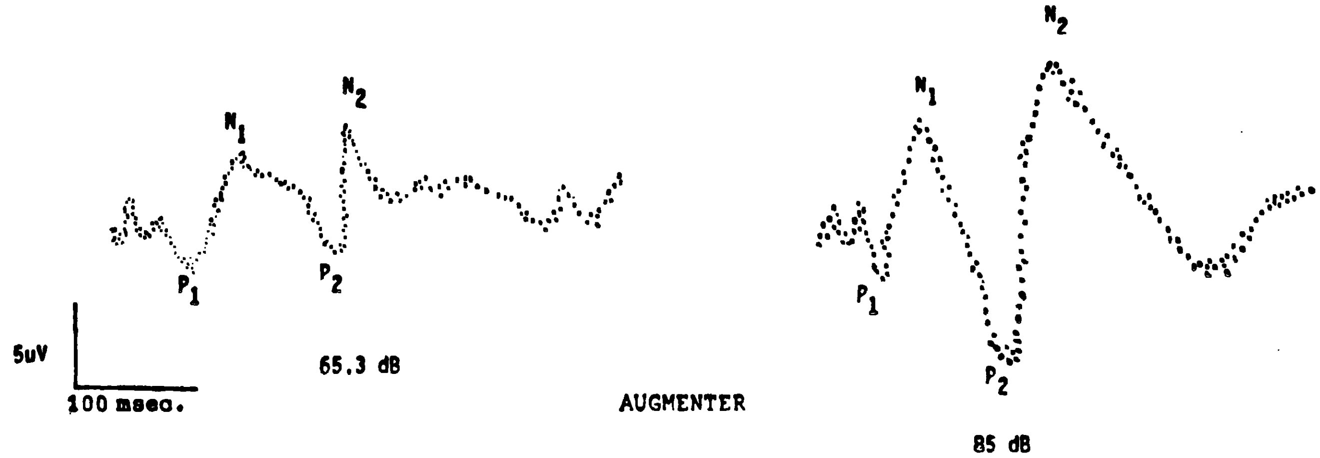

Fig. 1 — Example of an Auditory Evoked Potential (AEP) recorded at the vertex at intensities 63.5 and 85 dB AL. showing augmentation in the P_1N_1 and N_1P_2 components. Each tracing corresponds to 100 responses. Vertex negativity is upwards.

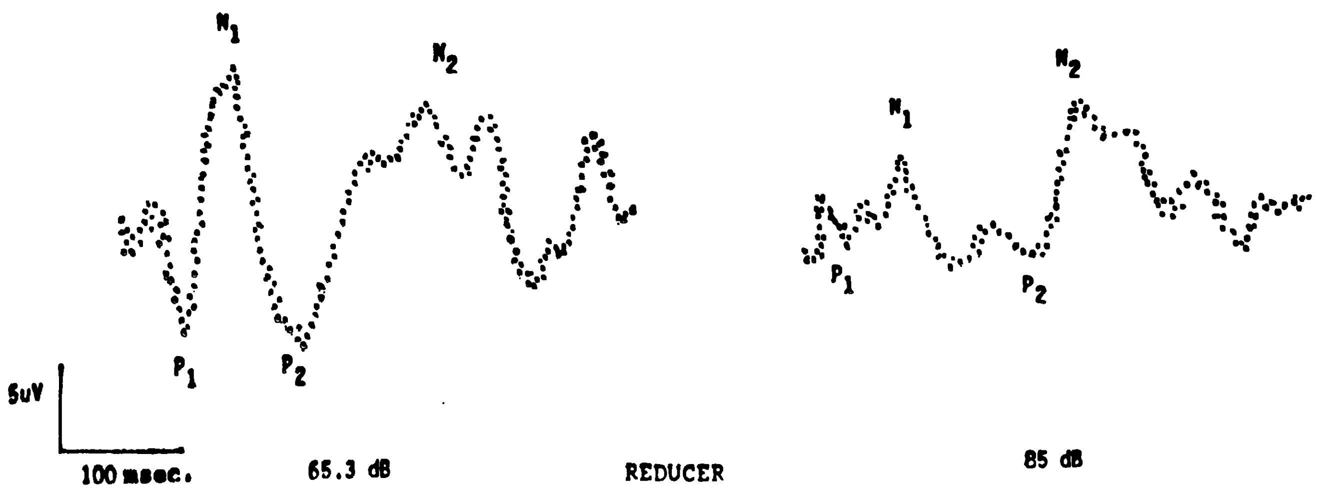

Fig. 2 — Reduction of P_1N_1 and N_1P_2 components at the AEP recorded under the same conditions depicted in figure 1.

Component	Augmenters	Reducers
P_1N_1	27 (67.5%)	13 (32.5%)
N_1P_2	31 (77.5%)	9 (22.5%)

Table 1 — Augmenting/Reducing frequency of the AEP at the vertex in a sample of male Ss (N = 40).

found (t test) (Table 2). The amplitudes at the vertex were greater than those from the hemispheric leads. Slopes of the amplitude-intensity function for the whole group of subjects, showed a non significant tendency to be higher on the left, for both components of the AEP (Table 3). A Pearson correlation coefficient was calculated between the slopes of components P_1N_1 and N_1P_2 separately in the three leads; all were positive and significant ($c_z = 0.57$, $c_3 = 0.59$, $c_4 = 0.72$; $p < 0.01$). In order to study hemispheric contribution to vertex recording, the subjects were classified according to the slopes of the amplitude-intensity function of each component at the

Components	Leads								
	c_z			c_4			c_3		
	65.3dB	76.4dB	85dB	65.3dB	76.4dB	85dB	65.3	76.4dB	85dB
P_1N_1	4.3±2.4	4.6±2.1	4.9±2.3	3.5±2	3.5±2	3.7±1.6	3.3±1.4	3.6±1.7	3.8±1.6
N_1P_2	5.9±3	6.8±3	7.5±3.2	4.8±2.6	5.2±2.2	5.3±2.2	4.6±2	5±2	5.6±2

Table 2 — Peak to peak amplitudes of the AEP components for the three intensities or stimulation (65.5, 75.6 and 85 dB AL) in the three leads (N = 40).

Lead	Components	
	P_1N_1	N_1P_2
Left	1.87 ± 5.9	4.58 ± 8.6
Right	0.91 ± 5.3	1.99 ± 7.6
t	0.77, ns	1.75, ns

Table 3 — Hemispheric differences in the amplitude-intensity slope for two components of the AEP (N = 40).

vertex. Each one of the four groups depicted in Table 4, represents the combination of the Augmenting or Reducing tendency in both components (e.g. AA: P_1N_1 Augmenter, N_1P_2 Augmenter and so on). When both P_1N_1 were Augmenters (AA) at the vertex, there was a greater Augmenting tendency in the left hemisphere, significant for the N_1P_2 component. But when both P_1N_1 and N_1P_2 components showed Reduction at the vertex (RR), the right hemisphere had the greater Reducer slopes, significant for P_1N_1. Subjects who had different slopes in the two components (RA or AR), did not show hemispheric differences in A/R. The two groups (AA an RR) were consistent in that, for both, the left hemisphere was more involved in augmentation and less involved in reducing, and the right hemisphere was more involved in reducing and less involved in augmenting (Table 4).

Group	P_1N_1		N_1P_2	
	C_3	C_4	C_3	C_4
AA (N = 23)	3.73 ± 6.5	2.69 ± 3.3 NS	8.07 ± 6.3	4.8 ± 6.2**
RR (N = 5)	—1.8 ± 3.6	—8.8 ± 5.8*	—5.8 ± 1.3	—10.3 ± 7.7 NS
AR (N = 4)	2.89 ± 6.2	3.65 ± 4.9 NS	—1.06 ± 4.99	—0.67 ± 6.3 NS
RA (N = 8)	—1.02 ± 4.93	1.2 ± 2 NS	3.95 ± 3.5	3.02 ± 3.4 NS

Table 4 — Hemispheric differences in the amplitude-intensity function slope for two components of the AEP according to groups defined at the vertex: AA, augmenter at P_1N_1 and N_1P_2; RR, reducer at P_1N_1 and N_1P_2; AR, augmenter at P_1N_1 and reducer at N_1P_2; RA, reducer at P_1N_1 and augmenter at N_1P_2. Right-left difference significant at $p > 0.01$ (*) and $p > 0.01$ (**) for Wilcoxon two tail test.

COMMENTS

Our main result concerns hemispheric contribution to vertex auditory evoked potential A/R. An Augmenting pattern in the AEP at the vertex was related to a greater left hemisphere involvement, but in Reducers the right hemisphere was more related to changes at the vertex. These hemispheric differences are evident only when the dynamic range of auditory reactivity is explored. No hemispheric differences appeared in absolute amplitudes at each intensity of stimulation. Although both cerebral hemispheres respond to clicks with no AEP amplitude differences, they seem to react differently to changes in the intensity of auditory stimulation. Even if the present findings cannot be directly related to current concepts of hemispheric asymmetry, they are compatible with the notion that attention allocation mechanisms might be involved in differential hemispheric activity, since N_1P_2 amplitude has been linked to selective attention [15,27]. This does not imply that enduring characteristics of each hemisphere are irrelevant, it rather suggests that they might be called into operation through a central mechanism allocating attention to different processing or cognitive modes, depending upon situational and demand factors. Results presented by Schwartz and Kirsner [30] lend further support to this contention.

According to the information processing theory, Moscovitch [22] states that the form or code in which a stimulus is represented is determined by the transformation it undergoes through successive stages of processing. In a first stage, the information is classified in terms of sensory, low-level precategorical properties. Stimulus are represented as literally as possible. A subsequent encoding mechanism classifies the stimulus in higher-order categories. The peripheral mechanisms that extract physical features of the stimulus are common to both hemispheres, but the central mechanisms engaged in categorical processing are different in the two hemispheres, each one reflecting the peculiar way in which these are specialized. In that higherorder or categorical processing hemispheric asymmetries appear. Since there is enough evidence that both cerebral hemispheres can process the same kind of stimuli, their physical precategorical properties cannot account for their subsequent processing by one or the other hemisphere. Attentional factors may have here a critical role as control mechanisms enabling the individual to select the hemispheric processing mode he will preferentially use in each particular situation. If we consider the Augmenting/Reducing phenomenon as an individual difference in the "intensive aspect of attention" [32], we can interpret our findings as reflecting an "attentional bias" to prefer one hemispheric over the other. This could be influenced by subject characteristics interacting with modality of stimulation and situational variables.

A modality specific effect cannot be ruled out on the basis of data presented, since as Davis and Wada [9] and others have demonstrated a greater involvement of the left hemisphere in the processing of the auditory information can be found in a sample of subjects unselected for psychological characteristics. Only the conjoint exploration of visual and auditory hemispheric reactance under comparable circunstances in a well-defined population can help settle this issue. Experiments now under way attempt to assess the relative contribution of stimulus modality, electrode placement and psychological make-up to the topography of A/R. Individual differences in cerebral asymmetry patterns of Augmenting/Reducing might be important in two respects. First, crossmodal studies might be inconsistent because of disregarding this factor. Second, in the search for electrophysiological correlates of hemispheric utilization in relation to specific tasks, individual differences in the reactivity to sensory stimulation and in the balance between hemispheres must be taken into consideration.

SUMMARY

Starting off from the notion that the cerebral hemispheres differ in their processing mode, this paper reports on stimulus intensity modulation of auditory evoked potentials recorded from hemispheric leads (C_3 and C_4 referenced to ipsilateral mastoid processes) in a sample of 40 male Ss between 18 to 40 years of age. The experimental set up involved the recording of series of 100 trials to binaural clicks of 63.5, 74.6 and 85 dB AL. Ss who were augmenters at the vertex showed positive Amplitude-Intensity function slopes over the left hemisphere; when Ss were Reducers at the vertex, the slopes were negative on the right hemisphere. These results are interpreted in terms of attention deployment or allocation to one or the other hemispheric processing mode. This might constitute a trait-like enduring subject characteristic whose relation to traditional psychometric variables needs further exploration. The modality especificity of this phenomenon is also discussed.

RESUMEN

Aumento/redução do potencial evocado auditivo no vértex: contribuição hemisférica.

El presente artículo describe la modulación de la intensidad de estimulación en potenciales evocados auditivos relacionada con las diferencias cerebrales hemisféricas en el procesamiento de la información en una muestra de 40 Ss hombres de 18 a 40 años de edad. El diseño experimental consistió en el registro de series de 100 respuestas electrocorticales a clicks binaurales de 63,5, 74,6 y 85 dB AL. Los Ss "aumentadores" en el vertex presentaron pendientes positivas de las funciones de amplitud-intensidad en el hemisferio izquierdo; cuando los Ss fueron "reductores" en el vertex, las pendientes fueron negativas en el hemisferio derecho. Los resultados son interpretados en términos de factores atencionales que dirigen el procesamiento hacia uno u otro hemisferio cerebral. Esto podría constituir un rasgo característico y estable para cada sujeto, cuya relación con variables psicométricas clásicas requiere ser explorada. También se discute la especificidad del fenómeno en términos de modalidad sensorial.

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