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EFFECTS OF STIMULATION INTENSITY, GENDER AND HANDEDNESS UPON AUDITORY EVOKED POTENTIALS

SUSANA CAMPOSANO * — *FERNANDO LOLAS* *

SUMMARY — Left handers and women show less anatomical brain asymmetry, larger corpus callosum and more bilateral representation of specific functions. Sensory and cognitive components of cortical auditory evoked potentials (AEP) have been shown to be asymmetric in right handed males and to be influenced by stimulus intensity. In this study the influence of sex, handedness and stimulus intensity upon AEP components is investigated under basal conditions of passive attention. 14 right handed males, 14 right handed females, 14 left handed males, and 14 left handed females were studied while lying awake and paying passive attention to auditory stimulation (series of 100 binaural clicks, duration 1 msec, rate 1/sec, at four intensities). Cz, C3 and C4 referenced to linked mastoids and right EOG were recorded. Analysis time was 400 msec, average evoked potentials were based on 100 clicks. Stimulus intensity and gender affect early sensory components (P1N1 and N1P2) at central leads, asymmetry is influenced only by handedness, right handers showing larger P1N1 amplitudes over the right hemisphere.

KEY WORDS: auditory evoked potential, sex difference, handedness difference.

Efectos de la intensidad de la estimulación, sexo y manualidade sobre el potencial evocado auditivo.

RESÚMEN — Los sujetos zurdos y de sexo femenino tienden a exhibir menores grados de asimetria anatómica, mayores diámetros del cuerpo calloso y mayor representación bilateral de funciones específicas. Los componentes sensoriales y cognitivos del potencial evocado auditivo (PEA) cortical han demostrado sensibilidad a la intensidad de estimulación y asimetría en sujetos masculinos. En este estudio se investiga la influencia de sexo, manualidad e intensidad de la estimulación sobre los componentes corticales del PEA. 56 sujetos voluntarios fueron sometidos a estimulación auditiva (series de 100 clicks binaurales, duración de 1 mseg, frecuencia de 1/seg, a cuatro diferentes intensidades) instruyéndoseles a prestar atención pasiva. Se registró derivaciones Cz, C3 y C4 referidas a mastoides bilateral y electrooculograma derecho, el tiempo de análisis fue de 400 mseg, los promedios fueron obtenidos sobre 100 clicks. La intensidad de la estimulación y el sexo afectan los componentes sesoriales corticales P1N1 y N1P2 en la derivación central. La asimetria sólo es influenciada por la manualidad; los Ss diestros exhiben mayores amplitudes P1N1 en el hemisferio derecho.

PALAVRAS LLAVE: potencial evocado auditivo, diferencia sexual, diferencia de manualidad.

PALAVRAS CHAVE: potencial evocado auditivo, diferença sexual, diferença manualidade.

Behavioral and physiological hemispheric asymmetry of function has been related to organism variables such as sex and handedness. Left-handers and women tend to show less anatomical asymmetry [5,8,13]. The corpus callosum is larger in both groups, in men at the splenium and in left handers at the central region [7,10,16]. Early

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Dr. Fernando Lolas — Department of Physiology and Biophysics, Faculty of Medicine, University of Chile - P.O. Box 70005 - Santiago 7 - Chile.

sensory components of cortical auditory potential (AEP) have been shown to be asymmetric in right handed males and to be influenced by stimulus intensity [4,11].

It is investigated in this study the influence of sex, handedness and stimulus intensity upon AEP components and their hemispheric asymmetry in basal conditions. Symmetrical (binaural) stimulation with low informational content (click) and passive attention conditions were used in order to avoid selecting a lateralized processing mode.

METHODS

52 unpaid volunteers without neurological or hearing impairment were recruited from the university community (14 right handed men, 14 left handed men, 14 right handed women and 14 left handed women). Handedness was assessed using some items of the Edinburgh Inventory [12]. Concordant manual preference for writing, eating with a spoon, holding a hammer to hit a nail, and throwing a ball was requested (Ss. who showed mixed preference were not included). For right handers it was also requested not to have a history of dislexia or stuttering and no left handed relatives.

Subjects lying in an acoustically and electrically isolated room were instructed to stay awake and listen to auditory stimulation. Stimulation consisted of four series of 100 binaural clicks, 1 msec in duration, rate 1/ sec, at four intensities (63, 74, 87 and 97 dB SPL). Intensity sequence was random.

Recordings were made from Cz, C3 and C4 referenced to linked mastoids with surface silver-silverchloride electrodes. Right EOG was simultaneously recorded from infra and supraorbital electrodes. Signals were amplified 20,000 times and band pass filtered between 1 and 100 Hz using Biodata PA 400 amplifiers. Averages were based on 100 clicks at each intensity, without artifact rejection; analysis time was 400 msec spanned by 640 data points.

Table 1 — Amplitude (uV) of P1N1, N1P2 and P2N2 components at CZ.

	P1N1							
	63 dB		74 dB		87 dB		97 dB	
Right Handers	X	(SD)	X	(SD)	X	(SD)	X	(SD)
Men (N=14)	3.97	(1.69)	4.27	(2.41)	5.30	(2.60)	5.15	(2.10)
Women (N=14)	4.26	(1.12)	5.09	(2.47)	4.18	(1.93)	5.18	(2.15)
Left Handers								
Men (N=14)	3.02	(1.58)	4.18	(1.92)	4.47	(1.79)	5.08	(2.16)
Women (N=14)	3.54	(1.39)	3.86	(1.50)	3.71	(2.27)	5.51	(2.30)
	N1P2							
	63 dB		74 dB		87 dB		97 dB	
Right Handers	X	(SD)	X	(SD)	X	(SD)	X	(SD)
Men (N=14)	5.86	(2.64)	7.36	(2.53)	8.38	(3.27)	8.41	(3.25)
Women (N=14)	7.43	(2.11)	7.50	(2.09)	8.04	(2.90)	8.57	(3.10)
Left Handers								
Men (N=14)	4.17	(1.52)	6.35	(1.98)	6.60	(2.28)	7.84	(2.15)
Women (N=14)	6.57	(2.36)	6.50	(2.73)	7.78	(3.35)	9.61	(3.19)
	P2N2							
	63 dB		74 dB		87 dB		97 dB	
Right Handers	X	(SD)	X	(SD)	X	(SD)	X	(SD)
Men (N=14)	8.06	(2.91)	7.28	(1.99)	8.26	(2.23)	7.33	(2.56)
Women (N=14)	8.06	(3.96)	9.68	(3.59)	10.25	(4.26)	10.05	(4.55)
Left Handers								
Men (N=14)	5.22	(2.03)	7.40	(3.39)	6.26	(4.24)	7.27	(4.24)
Women (N=14)	6.94	(2.12)	6.33	(1.71)	8.40	(2.97)	9.31	(2.98)

Latency of P1, N1, P2 and N2 components and peak to peak ampliutdes of P1N1, N1P2 and P2N2 complexes were measured using a cursor program. If the maximal excursion at the EOG exceeded maximal peak to peak amplitude at Cz, averages were rejected. Components were identified according to maximal deflection in the following time windows: P1, 40-80 ms; N1, 60-120 ms; P2, 100-190 ms; N2, 150-300 ms.

An asymmetry coefficient for the proportional activation of the left hemisphere (Left Proportional Amplitude Coefficient, LPAC) was obtained as follows: LPAC=Amplitude at C3/Ampl. at C3 + Ampl. at C4.

Amplitude and latency averages are shown in Tables 1 and 2. Analysis of variance (ANOVA, Balanced) was performed for Cz latencies and amplitudes and for LPAC, factors being sex, handedness and intensity. C3 and C4 amplitude and latency differences were analyzed using nonparametric procedures (Wilcoxon Sign Rank Test).

Table 2 — Latency (msec) of P1, N1, P2, and N2 components at CZ.

	P1							
	63 dB		74 dB		87 dB		97 dB	
Right Handers	X	(SD)	X	(SD)	X	(SD)	X	(SD)
Men (N=14)	54.2	(7.1)	53.5	(9.2)	54.6	(9.2)	52.1	(3.9)
Women (N=14)	55.6	(6.3)	58.4	(9.0)	56.4	(4.9)	52.5	(5.5)
Left Handers								
Men (N=14)	55.8	(6.5)	55.9	(4.3)	55.2	(4.1)	54.9	(4.5)
Women (N=14)	56.9	(7.6)	57.7	(10.8)	56.1	(8.7)	56.9	(8.0)
	N1							
	63 dB		74 dB		87 dB		97 dB	
Right Handers	X	(SD)	X	(SD)	X	(SD)	X	(SD)
Men (N=14)	83.9	(7.4)	80.4	(9.8)	80.4	(8.9)	79.1	(9.3)
Women (N=14)	84.8	(8.9)	85.2	(12.0)	85.0	(11.3)	81.2	(10.8)
Left Handers								
Men (N=14)	88.6	(10.6)	88.5	(12.3)	83.6	(11.1)	82.4	(12.9)
Women (N=14)	89.0	(12.7)	80.1	(10.7)	79.2	(7.5)	80.9	(12.4)
	P2							
	63 dB		74 dB		87 dB		97 dB	
Right Handers	X	(SD)	X	(SD)	X	(SD)	X	(SD)
Men (N=14)	144.5	(10.2)	146.1	(12.6)	145.0	(13.9)	144.0	(10.5)
Women (N=14)	141.6	(15.7)	147.4	(11.3)	146.4	(11.3)	141.2	(10.1)
Left Handers								
Men (N=14)	155.5	(16.7)	153.4	(19.6)	148.9	(17.2)	147.7	(16.2)
Women (N=14)	142.6	(12.9)	142.0	(16.5)	145.0	(10.8)	143.7	(16.3)
	N2							
	63 dB		74 dB		87 dB		97 dB	
Right Handers	X	(SD)	X	(SD)	X	(SD)	X	(SD)
Men (N=14)	225.5	(15.5)	217.5	(20.8)	229.7	(23.3)	223.1	(20.1)
Women (N=14)	220.2	(29.0)	240.1	(28.0)	223.1	(22.5)	231.2	(26.3)
Left Handers								
Men (N=14)	221.2	(27.4)	234.3	(28.0)	223.5	(32.7)	240.3	(27.8)
Women (N=14)	214.1	(24.1)	222.3	(32.9)	223.9	(28.6)	229.4	(37.2)

RESULTS

A tendency to larger amplitudes in women and right handers can be appreciated in Figure 1. Amplitude and latency averages and standard deviations are shown in Tables 1 and 2.

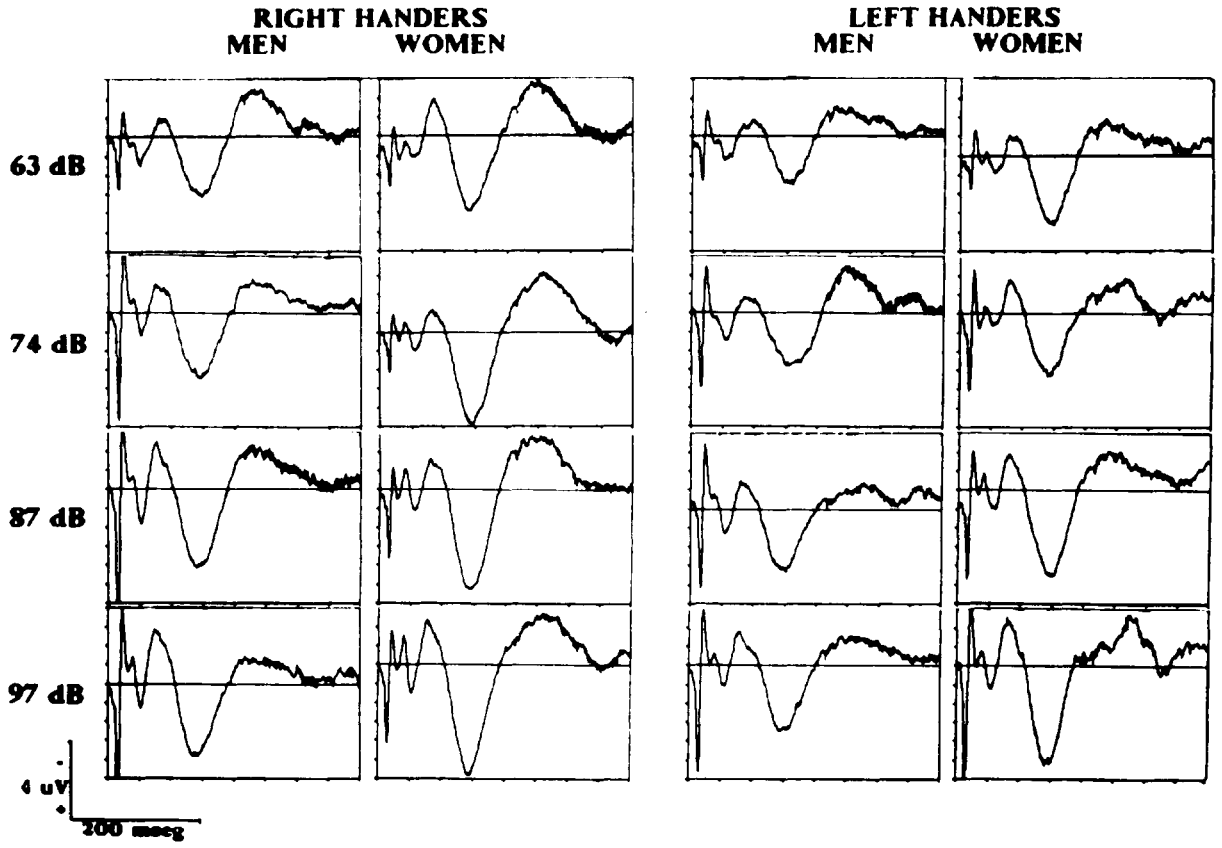

Fig. 1 — Grand averages at Cz according to sex and handedness at four intensities. N=14 for each average.

Analysis of variance for central lead P1N1, N1P2 and P2N2 peak-to-peak amplitudes shows different influence of the variables studied on the components (Table 3). Latency was less influenced by these factors (Table 4).

Right-left differences in amplitude were found for P1N1 in right handers, Wilcoxon: C4>C3 in right handed males at 74 and 87 dB ($p<0.05$); C4>C3 in right handed females at 63 dB ($p<0.02$). P1N1 amplitude at C3 and C4 is shown in Table 5.

Amplitude asymmetry as measured by LPAC is only influenced by handedness (Table 6). Values for LPAC of right and left handers are shown in Table 4. Differences can be appreciated in Figure 2. There is no latency asymmetry.

Table 3 — Significant factors affecting components peak to peak amplitude at Cz and their interactions as determined by analysis of variance.

Anova	Amplitude at Cz		
	P1N1	N1P2	P2N2
sex	ns	$p<0.02$	ns
man pref	ns	$p<0.05$	$p<0.01$
intensity	$p<0.01$	$p<0.001$	ns
sex*man pref	ns	ns	ns
sex*int	$p<0.05$	$p<0.001$	ns
man pref*int	$p<0.03$	$p<0.000$	$p<0.03$
sex*man pref*int	ns	$p<0.002$	ns

Table 4 — Significant factors affecting components latency at Cz and their interactions as determined by analysis of variance.

Anova	Latency at Cz			
	P1	N1	P2	N2
sex	ns	ns	$p<0.03$	ns
man pref	ns	ns	ns	ns
intensity	ns	$p<0.05$	ns	ns
sex*man pref	$p<0.03$	ns	ns	ns
sex*int	ns	ns	ns	ns
man pref*int	ns	ns	ns	ns
sex*man pref*int	ns	ns	ns	ns

Table 5 — P1N1 amplitude at C3 and C4.

		C3				C4			
		63dB	74dB	87dB	97dB	63dB	74dB	87dB	97dB
Right handers									
Men	X	3.50	3.41	4.22	3.77	4.00	4.19	4.75	4.54
(N=14)	(SD)	(1.57)	(1.94)	(1.90)	(1.52)	(1.64)	(2.75)	(3.16)	(2.35)
Women	X	3.88	3.14	3.39	3.48	4.42	3.34	3.97	3.62
(N=14)	(SD)	(1.33)	(1.08)	(1.47)	(1.94)	(1.02)	(1.16)	(1.61)	(1.68)
Left handers									
Men	X	3.05	3.79	3.93	4.93	3.35	3.77	3.66	4.02
(N=14)	(SD)	(2.02)	(1.89)	(1.37)	(1.55)	(1.50)	(1.70)	(1.95)	(2.49)
Women	X	3.77	3.79	3.93	4.93	3.55	3.80	4.24	4.75
(N=14)	(SD)	(1.41)	(1.37)	(1.78)	(1.87)	(1.45)	(1.68)	(1.84)	(1.57)

Table 6 — Significant factors affecting asymmetry of components peak to peak amplitude, represented in the left proportional amplitude coefficient (LPAC), as determined by analysis of variances.

Anova of LPAC	P1N1	N1P2	P2N2
sex	ns	ns	ns
man pref	$p<0.004$	ns	$p<0.001$
intensity	ns	ns	ns
sex*man pref	ns	ns	ns
sex*int	ns	ns	ns
man pref*int	ns	ns	ns
sex*man pref*int	ns	ns	ns

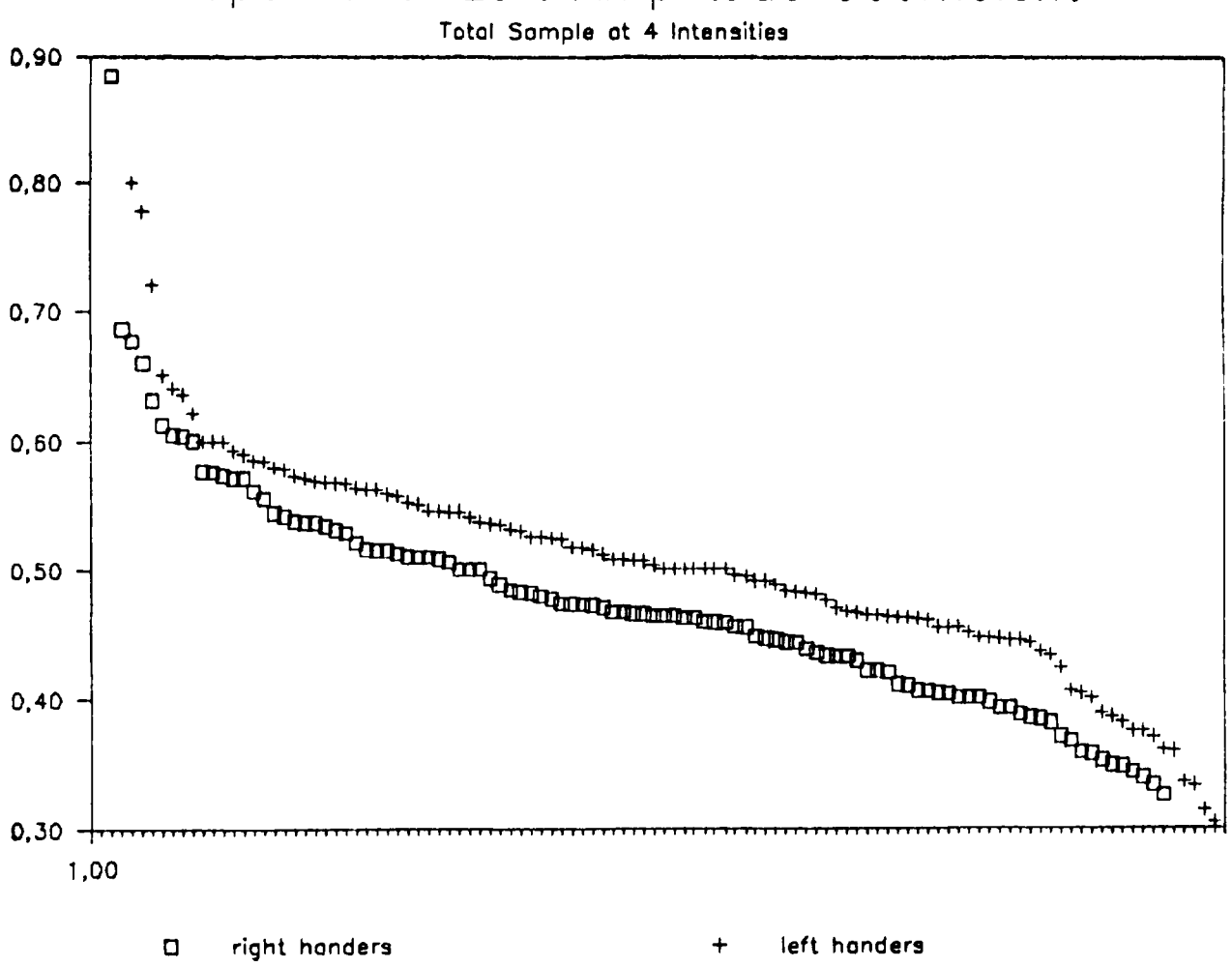

Fig. 2 — Left proportional amplitude coefficient (LPAC=C3 ampl./C3+C4 ampl.) for P1N1 in right and left handers at four intensities. N=56.

COMMENTS

Stimulus intensity and gender influence early sensory components of AEP at central leads but exert no influence on hemispheric asymmetry of electrocortical signals. Asymmetry is influenced only by handedness, with right handers showing larger amplitudes over the right hemisphere.

Amplitude at central lead is influenced by the three factors studied: P1N1 by intensity; N1P2 by intensity, gender and handedness; and P2N2 only by handedness. The influence of intensity on early cortical components is well known, therefore they are called «stimulus dependent» [14]. Sexual differences are also known, women tend to have larger amplitudes [3].

The influence of handedness on central lead amplitude is a new finding and could be explained if left handers had more bilateral activation of supratemporal regions. Only right handed subjects show greater C4 amplitudes, in left handers no significant asymmetry could be demonstrated. Amplitude depends on previous activation of generator sites, the greater the previous activation, the lower is the evoked amplitude [15]. This view would be concordant with greater left side activation in right handers (thus showing lower amplitudes at C3) and with bilateral activation in left handers (thus showing less asymmetry and lower amplitudes at Cz). This bilateral activation can be related to the thicker central part of corpus callosum, which includes auditory cortex callosal fibers 1. Anova shows asymmetry as measured by LPAC of P1N1 and P2N2 to be influenced only by handedness.

This kind of AEP study is complementary with behavioral asymmetry studies and contributes data on early and basic aspects of hemispheric processing, which can be used for prediction of behavioral outcomes.

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