REVISTA ESPAÑOLA DE FISIOLOGIA, 50 (4), 205-210, 1994

Visual Evoked Potentials in Response to Pattern Reversal in the Cat Cortex*

J. C. Pérez-Cobo, M. López de Armentia, S. Sánchez-Suero** and M. Pérez-Arroyo***

Departamento de Fisiología, Facultad de Farmacia, Universidad del Pais Vasco, Vitoria (Spain)

(Received on April 6, 1994)

J. C. PÉREZ-COBO, M. LÓPEZ DE ARMENTIA, S. SÁNCHEZ-SUERO and M. PÉREZ- ARROYO. *Visual Evoked Potentials in Response to Pattern Reversal in the Cat Cortex.* Rev. esp. Fisiol. (J. Physiol. Biochem.), 50 (4), 205-210, 1994.

A model of the visually evoked potential (VEP) in the cerebral cortex of the cat after binocular stimulation by means of pattern reversal is presented. The VEP is defined by four components: P_1, N_1, P_2 and N_2, which appear during the 100 ms following the stimulus. This model is repeated for the majority of recording points although N_1 and P_2 do not appear to be homogeneous over the entire cortex. The variability of the VEPs recorded at the same point in different cats is lower than the one observed by means of stimulation with flashes. The possible origin of the four components in the primary visual area is presented as a hypothesis and a discussion is made of the differences which exist between the models proposed for flash and pattern reversal.

Key words: Visual evoked potentials, Cat, VEP to Pattern Reversal, Typology of VEP, Topography of VEP.

The advantages for the clinic of stimulation by means of geometrical shapes compared with flashes has been commented by several authors (2, 5, 6). In these papers, emphasis is given to the greater sensitivity of stimulation with models for the recognition of several types of disturbances and pathologies of visual paths and of the central nervous system. They allude to the lower level of contamination of the response due to environmental luminance and to the consistency which is found in VEPs obtained in this way, both with regard to the morphology of components and to their latencies (2). They also point

Correspondence to J. C. Pérez-Cobo: Departamento de Fisiología, Facultad de Farmacia, Apartado 450, 01080-Vitoria (Spain). (Tel.: 945/14.00.05. Fax: 945/13.07.56).

* Study financed by the University of the Basque Country (Research Project 89 cod. 081.123/0080/89).

** Basque Government scholarship.

*** Departamento de Fisiología, Facultad de Medicina, Alicante (Spain).

to the good correlation which exists between VEPs recorded after a reversal of the model with physiological parameters such as visual sharpness (3, 7). Due to these and other reasons the use of geometrical stimulation models is recommended for routine clinical diagnosis, instead of changes in luminosity.

Despite the fact that there is a great deal of literature on luminous stimulation methodology with regard to humans, a complete study has yet to be made for the entire cerebral cortex of the cat, for the VEPs caused by pattern reversal. This paper complements previous work (4) in which flashes were used as stimulus.

Materials and Methods

Seven cats (*Felis catus*, L.) of the common variety were studied and VEPs were recorded in accordance with the earlier description (4). The stimulation method used in this case was pattern reversal. A Digitimer Light Pattern Stimulator Type D112 was used for this purpose. Stimulation was binocular, with the eyes open and with a frequency of 1 Hz. The screen of the apparatus was placed 30 cm in front of the animal and the luminous intensity of the screen, at this distance, was 35 lux. The model used established that each square subtended an arc of approximately four degrees of the field of vision.

The signal was amplified in an Alvar, Minihuit Reega TR electroencephalograph and the experiment was recorded on magnetic tape without any kind of filtration. Potentials were averaged with a Hewlett Packard Spectrum Analyzer 3582A. During analysis, the signal was filtered, leaving a bandpass between 10 Hz and 1000 Hz (Digitimer filters, Neurolog System NL115 and NL 125).

Results

The VEP model proposed for stimulation by means of pattern reversal consists of the same number of components as are obtained by means of flash stimulation. It may be assumed, however, that as the amplitudes and latencies are dissimilar,

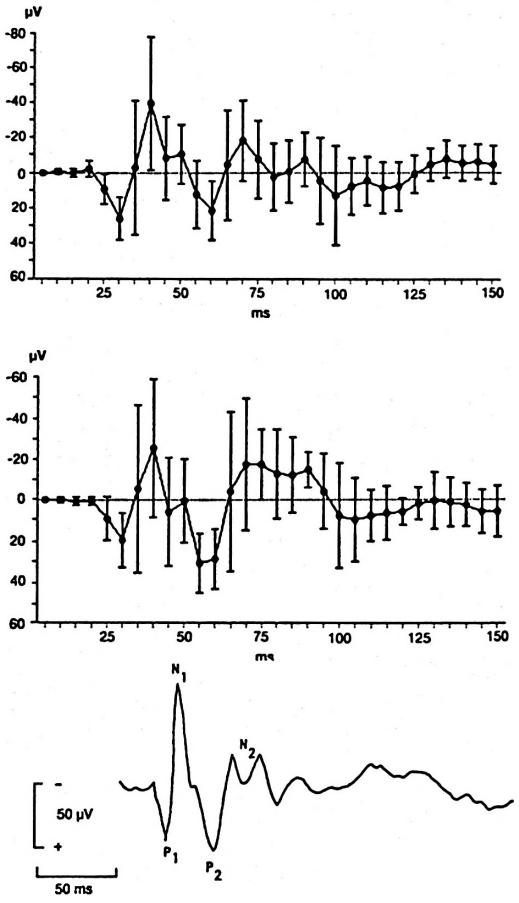

Fig. 1. *Average VEPs and VEP in the cerebral cortex of the cat by meas of binocular stimulation with pattern reversal.*
The graphs at the top show the averages and standard deviations of 14 VEPs (two for each cat used) obtained in electrodes 11 and 16. The four tendencies which are observed in both cases during the first 100 ms correspond with the larger components indicated in the VEP model obtained in the model VEP (lower graph).

the different components do not correspond exactly to the same cerebral occurrences, despite their being given the same name. This is due to the fact that the criteria followed refer exclusively to polarity and the order in which they appear.

The model is based on the averages of the VEPs obtained on the primary visual area, as this is where the components are defined with greater amplitude. Fig. 1 shows the averages and the corresponding standard deviations of 14 VEPs, two for each cat used, recorded at electrodes 11 and 16, respectively. During the 100 ms following the stimulus, four different tendencies can be seen: two positive tendencies and two negative, which alternate. An experimental VEP is shown on the lower part, obtained during the recordings, the largest components of which, P_1, N_1, P_2 and N_2, correspond to the four tendencies observed in the averages of the electrodes located on area 17 of Brodman. The first wave which appears after pattern reversal is P_1 and this takes place between 29 and 38 ms (table I), depending on the recording point. With a positive polarity and high amplitude, this is the most character-

Table I. *Average latencies and standard deviations (ms) of the four components defined in the VEP at different recording points.*
The data obtained at recording points 1, 2 and 3 is not significant as it was determined only from clearly-defined VEPs.

	POINT 1	POINT 2	POINT 3		
P_1:	39.25 ± 4.13	44.60 ± 8.35	39.83 ± 4.11		
N_1:	54.00 ± 7.19	53.80 ± 9.17	53.00 ± 8.98		
P_2:	—	—	—		
N_2:	95.87 ± 22.80	112.60 ± 8.29	99.00 ± 27.90		
	POINT 4	POINT 5	POINT 6	POINT 7	POINT 8
P_1:	37.33 ± 2.57	38.91 ± 2.93	33.66 ± 3.33	38.66 ± 4.43	37.75 ± 3.36
N_1:	56.16 ± 4.26	49.25 ± 5.67	43.41 ± 5.53	51.50 ± 11.27	55.33 ± 5.97
P_2:	72.09 ± 8.13	62.50 ± 14.05	60.00 ± 6.68	58.10 ± 14.31	75.27 ± 8.24
N_2:	90.83 ± 10.19	77.16 ± 14.12	87.25 ± 20.60	79.00 ± 15.00	98.75 ± 8.67
	POINT 9	POINT 10	POINT 11	POINT 12	POINT 13
P_1:	37.60 ± 4.96	36.00 ± 3.07	31.83 ± 3.21	37.66 ± 7.34	37.41 ± 6.08
N_1:	56.25 ± 4.20	49.00 ± 5.52	41.00 ± 3.88	47.00 ± 7.28	53.80 ± 4.38
P_2:	64.66 ± 8.24	52.00 ± 15.94	59.41 ± 3.57	55.72 ± 8.40	64.09 ± 8.64
N_2:	91.50 ± 9.83	82.75 ± 14.83	78.66 ± 12.23	80.83 ± 12.31	82.83 ± 13.71
	POINT 14	POINT 15	POINT 16	POINT 17	POINT 18
P_1:	36.66 ± 3.49	33.50 ± 3.17	32.50 ± 4.54	33.75 ± 2.52	38.58 ± 7.11
N_1:	48.16 ± 6.05	43.91 ± 5.28	42.16 ± 5.44	42.00 ± 4.39	50.66 ± 8.28
P_2:	57.50 ± 12.21	52.83 ± 8.48	56.58 ± 7.89	53.83 ± 7.69	59.75 ± 10.12
N_2:	79.00 ± 16.14	80.16 ± 11.15	78.83 ± 10.07	76.50 ± 9.09	98.75 ± 8.47
	POINT 19	POINT 20	POINT 21		
P_1:	33.41 ± 3.72	28.25 ± 5.95	34.08 ± 2.93		
N_1:	41.25 ± 3.72	42.75 ± 3.72	41.33 ± 4.18		
P_2:	50.05 ± 8.94	54.66 ± 7.32	51.36 ± 9.04		
N_2:	79.33 ± 10.88	78.16 ± 7.77	85.75 ± 12.11		

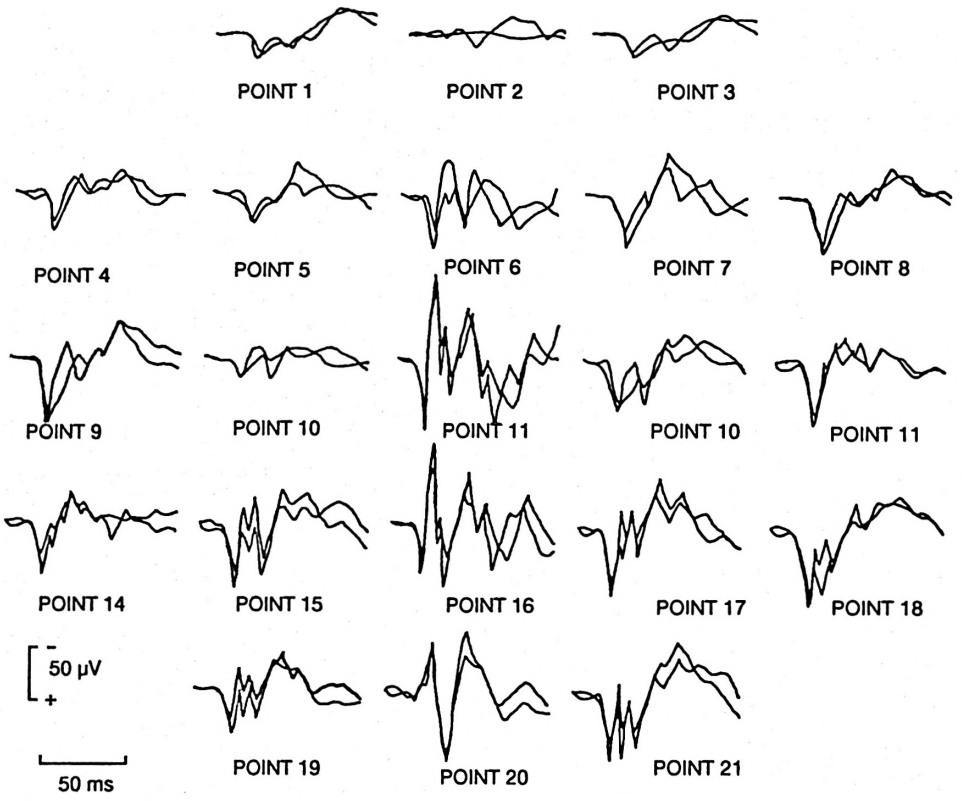

Fig. 2. *General topography of cortical VEPs in the cat obtained with binocular pattern reversal.*

istic wave of the VEP. It is seen at all recording points as a sharp peak, clearly differentiated from the rest, except at point 20 which normally shows a lower amplitude than the one observed at the other recording points.

It is followed by a negative wave, N_1. Its amplitude varies in accordance with the recording point, and can be seen to be more intense in the primary visual area than in the rest of the cortex (fig. 2). As occurs with flash stimulation, in some cases it appears to consist of two peaks. The latency of the first or only peak ranges between 42 ms in the primary visual area and 55 ms in the more distant areas.

There follows immediately a positive component, P_2, with a latency of 56-70 ms. Its latency varies considerably depending on the recording point, it being almost negligible in the more peripheral areas. In the primary visual area, it was seen to have a medium amplitude except at electrode 20 where a higher amplitude than the rest of the recording points was detected.

The last wave to be generated was N_2, at around 78 ms. This is the most complex of the waves and has a longer duration than the rest. At electrodes 11, 16 and 20, the peaks which compose it, appear to be more defined than the rest of the electrodes and, moreover, the total duration of the wave is shorter.

The latencies of the components defined as constants in the VEP after a pattern reversal are lower in the primary

visual area and increase the further the recording point is away from this area (table I). Besides, the amplitude of components P_1 and N_2 remains more or less constant throughout the cerebral surface, while a high stability and uniformity can be observed in the appearance of these waves between different cats: the standard deviations of the appearance latencies are small (fig. 2 and table I). In other words, at each point and for all the cats, the moment when waves P_1 and N_2 appear does not vary significantly. On the other hand, N_1 and P_2 are only uniform interindividually, with respect to amplitude and latency, on visual areas.

With this kind of stimulation, significant VEPs are obtained only behind the coronal suture: the components which characterize the VEP as a model are not well defined above this.

The topographical description of cortical VEPs after stimulation with pattern reversal is shown graphically in fig. 2 and statistically in table I.

P_1 appears 30 ms after the stimulus in the primary visual area and after 7 ms reaches the most peripheral areas of the cortex. It is at this moment when N_1 begins to be generated, also above the primary visual area, where it can be seen intensely. But, as it propagates itself, N_1 loses intensity and is detected weakly at the point furthest from the primary visual area. P_2 begins to be generated to the rear of area 17 of Brodman, 54 ms after the stimulus. Its propagation is accompanied by a fall in amplitude, as occurs with N_1 and, in several cases, and cannot be seen in areas near the coronal suture. Twenty ms after the appearance of P_2, wave N_2 began to be formed on area 17 of Brodman which took 15 ms to spread throughout the cortex. This component shows a similar amplitude at all recording points, although it duration is lower in the primary visual area.

Discussion

The focal point for the appearance of the four waves can be considered to be in the primary visual area, where these can be recorded with greater amplitude and lower latency. As to this area, they propagate symmetrically throughout the cortical surface, although not all the waves show themselves to be uniform.

The responses generated by means of stimulation by pattern reversal exhibit less variability inter- and intra-individually than those obtained with flashes. This fact is pointed out in all studies which have used pattern reversal for recording VEP (2, 6) and with respect to cats, it can be seen by comparing the data presented here with the equivalent data in the previous work (4). The reason for the greater stability of the response is due to the fact that, in the case of pattern reversal, the animal recognizes a figure within a visual field the luminosity of which does not vary, while with flashes, it detects a sharp change in the luminosity of the environment. In other words, in the first case a foveal activation is produced, especially of those channels the functioning of which is based on "on-off" mechanisms (1, 7), and in the second case a nonspecific activation is produced of the entire retina. Pattern reversal, despite its limitations, produces a stimulus which is more similar to reality than a flash.

This implies that the processing of information received is different in each case and, therefore, the contribution of visual cortical areas and of association to the origin of the VEP varies a great deal, depending on the type of stimulation. The idea that they are different occurrences is corroborated by the following facts: a) The components, despite their having been given the same name, show different latencies and amplitudes for each type of stimulation; b) Its propagation does not

follow the same distribution pattern for all the types of stimulation, in spite of the fact that all the components appear in the primary visual area; and c) Should both responses correspond to the same phenomenon, a response of lesser amplitude might be expected for pattern reversal, as the intensity of the stimulus is several times lower than that produced by flashes. The amplitude which is obtained, however, is very similar in both cases (5).

Acknowledgements

The authors wish to thank J. M. Rodríguez-Robledo for his collaboration in the extraction and subsequent analysis of the data.

J. C. PÉREZ-COBO, M. LÓPEZ DE ARMENTIA, S. SÁNCHEZ-SUERO y M. PÉREZ-ARROYO. *Potenciales evocados visuales de respuesta a la inversión de modelos en la corteza cerebral de gato.* Rev. esp. Fisiol. (J. Physiol. Biochem.), 50 (4), 205-210, 1994.

Se presenta un modelo de los potenciales evocados visuales (PEV) en la corteza cerebral del gato tras la estimulación mediante un sistema de inversión de patrón geométrico. El PEV se define por cuatro componentes, P_1, N_1, P_2 y N_2, que aparecen durante los cien milisegundos posteriores al estímulo. Este modelo se repite para la mayoría de los puntos de registro, aunque N_1 y P_2 no parecen ser homogéneos en la totalidad de la corteza registrada. La variabilidad de los PEV registrados en el mismo punto en diferentes gatos es menor que la observada mediante la estimulación con destellos. Se presenta como hipótesis el posible origen de los cuatro componentes en el área visual primaria y se discute sobre las diferencias que existen entre los modelos propuestos para destellos y para la inversión de patrón geométrico.

Palabras clave: Potenciales evocados visuales, Gato, PEV por inversión de patrón, Tipología de los PEV, Topografía de los PEV.

References

1. Bodis-Wollner, I., Ghilardi, M. F. and Mylin L. H. (1986): In "Evoked potentials" (R.Q. Cracco, and I. Bodis-Wollner, eds.). Alan R. Liss, New York. pp 15-27.
2. Halliday, A. M. (1982): Evoked potentials in clinical testing. Churchill Livigstone, Edinburgh.
3. Maffei, L., Fiorentini, A. and Bisti, S. (1990): *Vision Res.*, 30, 527-528.
4. Pérez-Cobo, J. C., López de Armentia, M., Sánchez-Suero, S. and Pérez-Arroyo, M. (1994): *Rev. esp. Fisiol.*, 50, 183-190.
5. Regan, D. (1972): Evoked potentials in psychology, sensory physiology and clinical medicine. Chapman Hall. London.
6. Regan, D. (1989): Human Brain Electrophysiology. Evoked potentials and evoked magnetic fields in science and medicine. Elsevier. New York.
7. Stone, J., Freeman, R. B. and Konstanz, J. R. (1973): In "Central visual information" (R. Jung, ed.) "Handbook of sensory physiology". Springer-Verlag, Berlin. VII/3A, pp 153-207.