Perceptual and Motor Skills, 1984, 59, 227-232. © Perceptual and Motor Skills 1984

EVOKED POTENTIALS BY LETTERS IN PRINTED AND SCRIPT FORMS

LUCIANO MECACCI AND DARIO SALMASO

Istituto di Psicologia del Consiglio Nazionale delle Ricerche[1]

Summary.—Visual evoked potentials were recorded for 6 adult male subjects in response to single vowels and consonants in printed and script forms. Analysis showed the vowels in the printed form to have evoked responses with shorter latency (component P_1 at about 133 msec.) and larger amplitude (component P_1-N_1) than the other letter-typeface combinations. No hemispheric asymmetries were found. The results partially agree with the behavioral data on the visual information-processing of letters.

The functional specialization of humans' left and right cerebral hemispheres has recently been submitted to a systematic electrophysiological investigation. Many studies converge in obtaining the same result: the evoked potentials by verbal stimuli are asymmetrical in the two hemispheres and have normally a larger amplitude in the left hemisphere (Desmedt, 1977; Donchin, Kutas, & McCarthy, 1977; Hillyard & Woods, 1979; Molfese, 1980). The processing of letters and syllables was investigated to verify the hemispheric lateralization found for behavioral tasks. Shankweiler and Studdert-Kennedy (1967), Darwin (1971), and Cutting (1974), using a dichotic listening technique, showed superiority of the left hemisphere in processing the phonemic information carried by stop consonants, whereas vowels did not show hemispheric asymmetries. Molfese (1978) and Molfese and Erwin (1981) confirmed this result recording the evoked potentials, respectively, in response to consonants and vowels. Other authors studied the visual processing of vowels and consonants and noted an interaction both with visual field and typeface. The well-known superiority of the left hemisphere for letters presented in the right visual field (Rizzolatti, Umiltà, & Berlucchi, 1971) may be reversed to superiority of the right hemisphere, using script instead of the traditional printed material (Bryden & Allard, 1976). However this latter effect is not present for all letters. In fact, in a same-different reaction-time task to pairs of letters, it was shown for vowels (Salmaso & Umiltà, 1982), but not for consonants (Umiltà, Sava, & Salmaso, 1980).

The aim of the present work was to study with the evoked potential technique the interaction of the visual features of a single letter (dependent on the printed or script typeface) and its linguistic features (dependent on being a consonant or vowel) and to ascertain if these features are lateralized in the cerebral hemispheres. The advantage of using the evoked potential technique

[1]The authors thank Elio Pasquali and Renzo Roveri for their assistance. Requests for reprints should be sent to Luciano Mecacci, Istituto di Psicologia del CNR, via dei Monti Tiburtini 509, 00157 Roma, Italia.

with behavioral tasks ties in the possibility of distinguishing different stages of information processing. A first stage of purely visual analysis would be correlated with the relatively short latency evoked potential components and a second stage of specifically cognitive analysis would be correlated with the late components. Since it is known that evoked potentials are affected by attention or other cognitive processes in tasks such as pattern or letter discrimination or in reaction time experiments, no active task was required of subjects to determine specifically the visual information processing involved in detection of letters.

Method

Subjects

Six male subjects (21 to 24 yr. old) of the University of Rome participated in the experiment. All were right-handed as determined by the Edinburgh Handedness Inventory (Oldfield, 1971) (the mean laterality quotient was 77.7) and showed right-eye preference for sighting.

Stimuli

Experimental materials were Italian letters, four vowels, (A, E, O, U) and four consonants (B, P, D, T). They were transferred from a letterpress sheet (RP and SK of R41 series) on plain white cards. Photographic negatives of each pattern were mounted in slide holders for tachistoscopic projection on a back-projection screen.

Procedure

Subjects were seated in front of a translucent screen at a distance of 60 cm in a dark sound-proof electrically shielded room. An acoustic signal (800 Hz for 1 sec.) prompted the subjects to fixate a clearly marked central point of the screen. One-half second after the warning signal, a slide was back-projected for 30 msec. on the center of the screen. The size of the single letters was approximately from 2 to 4° of visual angle. Stimulus intensity and the luminance of environmental light were kept constant at 22.3 and 6.1 ft-L, respectively. Each letter (e.g., script A) was presented 10 times in a random order together with the other letters of the same class (e.g., script vowels). Each class (script vowels, printed vowels, script consonants and printed consonants) was formed by 40 stimuli and was presented three times.

Electrophysiological Recordings

The recordings were taken from two electrodes in the left and right hemispheres. The points were on the temporal line between the locations T_5 (and T_6) and O_1 (and O_2), according to the 10-20 system (Jasper, 1958), with the electrode positioned 2 cm posterior to the temporal location on this line. The reference and the ground electrodes were, respectively, on the right and left earlobes. A computer (Laben Correlatron BU 1024) was used to average the response for 500 msec. after stimulus onset. For each stimulus class, the three averages, each based on 40 responses, were subsequently averaged to have four evoked potentials for each subject. The latency and amplitude (peak-to-peak) of the components P_1, N_1, and P_2 were measured (Fig. 1).

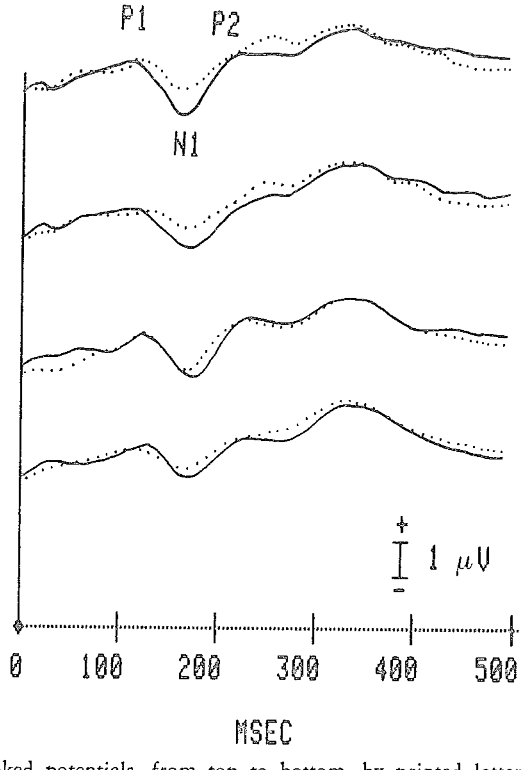

FIG. 1. Evoked potentials, from top to bottom, by printed letters in the left and right hemispheres and by script letters in the left and right hemispheres. Solid lines: vowels. Dotted lines: consonants.

RESULTS

The means and standard deviations across six subjects for the latencies and amplitudes are given in the Table 1. Two analyses of variance were performed for the latency and amplitude, considering the factors letter (vowel or consonant), the typeface (script and printed typeface), cerebral hemisphere (left and right), and their interactions (Kirk, 1968; Keppel, 1982). Only the interaction between the letter and typeface turned out to be significant for the P_1 latency ($F = 24$, $df = 1/5$, $p < .01$) and the P_1-N_1 amplitude ($F = 15.66$, $df = 1/5$, $p < .025$). According to the Tukey's *HSD* test (Kirk,

TABLE 1

MEANS AND STANDARD DEVIATIONS OF LATENCIES AND AMPLITUDES FOR EVOKED POTENTIALS BY SCRIPT VOWELS, PRINTED VOWELS, SCRIPT CONSONANTS, AND PRINTED CONSONANTS

Stimuli		Latency (msec.)			Amplitude (μV)	
		P_1	N_2	P_2	P_1-N_1	N_1-P_2
Script vowels						
Left hemisphere	*M*	135.7	159.7	228.3	0.8	2.4
	SD	6.6	14.4	14.5	0.5	0.8
Right hemisphere	*M*	135.9	160.3	229.4	0.9	2.6
	SD	8.0	15.3	14.4	0.7	1.1
Printed vowels						
Left hemisphere	*M*	127.5	167.0	229.0	1.2	2.3
	SD	13.0	16.0	23.0	0.9	1.0
Right hemisphere	*M*	132.5	165.2	242.6	1.1	2.9
	SD	11.0	14.3	21.4	0.6	1.4
Script consonants						
Left hemisphere	*M*	130.7	165.0	228.0	1.0	2.3
	SD	4.4	14.3	16.8	0.4	0.1
Right hemisphere	*M*	134.8	160.0	229.0	1.0	2.5
	SD	7.6	9.6	13.4	0.6	1.1
Printed consonants						
Left hemisphere	*M*	135.5	169.2	235.5	1.0	2.3
	SD	11.3	14.8	23.0	0.6	0.9
Right hemisphere	*M*	137.0	167.4	244.0	0.8	2.9
	SD	8.8	16.0	21.2	0.6	1.4

1968), only the difference between the printed vowels and each other class was significant ($p < .05$), both for the P_1 latency and the P_1-N_1 amplitude (Fig. 2).

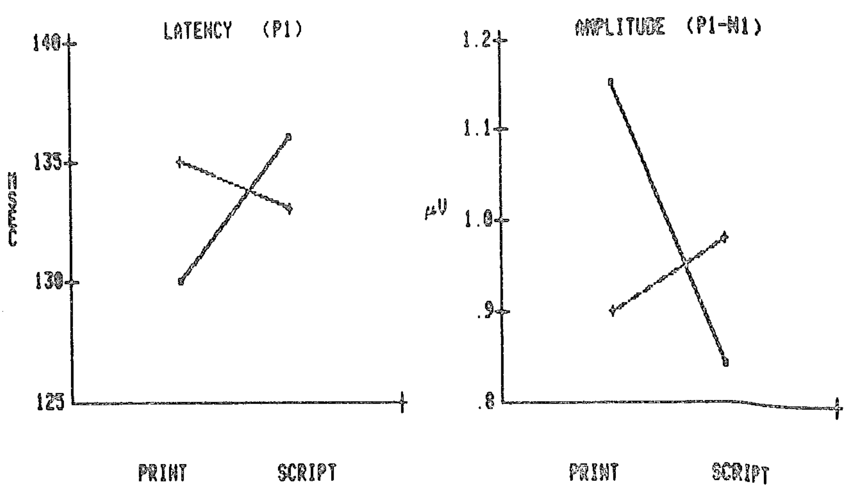

FIG. 2. Mean latency (P_1) and mean amplitude (P_1-N_1) of the evoked potentials by vowels (solid line) and consonants (dotted line) in printed and script forms

Discussion

In reaction-time tasks the processing is faster for vowels than for consonants (Salmaso, Sava, & Umiltà, 1978) and for printed than for script typefaces both in vowels (Salmaso & Umiltà, 1982) and in consonants (Umiltà, Sava, & Salmaso, 1980). Our electrophysiological results partially agree with these behavioral data in showing a shorter latency for printed vowels and a significant interaction between letter and typeface. Since this effect has been observed in the short components of evoked potentials, we may speculate that a primary stage of information processing has been involved in our task. Both hemispheres may perform this basic processing as was suggested by some authors (Moscovitch, 1979) and confirmed by our data which showed no hemispheric asymmetry of evoked potentials. However, the interaction of letter and typeface indicates that even in this relatively simple task where no linguistic attention is required, differential stages of analysis are implicated and a processing is performed for the cognitive properties of the stimulus.

REFERENCES

BRYDEN, M. P., & ALLARD, F. Visual hemifield differences depend on typeface. *Brain and Language*, 1976, 3, 191-200.

CUTTING, J. E. Two left-hemisphere mechanisms in speech perception. *Perception & Psychophysics*, 1974, 16, 601-612.

DARWIN, C. Ear differences in the recall of fricatives and vowels. *Quarterly Journal of Experimental Psychology*, 1971, 23, 46-62.

DESMEDT, J. E. (Ed.) *Language and hemispheric specialization in man: cerebral event-related potentials*. Basel: Karger, 1977.

DONCHIN, E., KUTAS, M., & MCCARTHY, G. Electrocortical indices of hemisphere utilization. In S. Harnad, R. W. Doty, L. Goldstein, J. Jaynes, & G. Krauthamer (Eds.), *Lateralization in the nervous system*. New York: Academic Press, 1977. Pp. 339-384.

HILLYARD, S. A., & WOODS, D. L. Electrophysiological analysis of human brain function. In M. S. Gazzaniga (Ed.), *Handbook of behavioral neurobiology*. Vol. 2. *Neuropsychology*. New York: Plenum, 1979. Pp. 345-378.

JASPER, H. H. The ten-twenty electrode system of the International Federation. *Electroencephalography and Clinical Neurophysiology*, 1958, 10, 371-375.

KEPPEL, G. *Design and analysis: a researcher's handbook*. (2nd ed.) Englewood Cliffs, NJ: Prentice-Hall, 1982.

KIRK, P. E. *Experimental design: procedures for the behavioral sciences*. Belmont, CA: Brooks/Cole, 1968.

MOLFESE, D. L. Left and right hemisphere involvement in speech perception: electrophysiological correlates. *Perception & Psychophysics*, 1978, 23, 237-243.

MOLFESE, D. L. (Ed.) Neuroelectrical correlates of language processes: evidence from scalp recorded evoked potential research. *Brain & Language*, 1980, 11, 233-397.

MOLFESE, D. L., & ERWIN, R. J. Intrahemispheric differentiation of vowels: principal component analysis of auditory evoked responses to computer-synthesized vowel sounds. *Brain & Language*, 1981, 13, 333-344.

MOSCOVITCH, M. Information processing and the cerebral hemispheres. In M. S. Gazzaniga (Ed.), *Handbook of behavioral neurobiology*. Vol. 2. *Neuropsychology*. New York: Plenum, 1979. Pp. 379-446.

OLDFIELD, R. C. The assessment and analysis of handedness: the Edinburgh Inventory. *Neuropsychologia*, 1971, 9, 97-113.

RIZZOLATTI, G., UMILTÀ, C., & BERLUCCHI, G. Opposite superiorities for the right and left cerebral hemispheres in discrimination reaction time to physiognomical and alphabetical material. *Brain*, 1971, 94, 431-442.

SALMASO, D., SAVA, D., & UMILTÀ, C. Differenze funzionali tra gli emisferi cerebrali nel riconoscimento di vocali e consonanti. *Giornale Italiano di Psicologia*, 1978, 6, 393-406.

SALMASO, D., & UMILTÀ, C. Vowel processing in the left and right visual fields. *Brain and Language*, 1982, 16, 147-157.

SHANKWEILER, D., & STUDDERT-KENNEDY, M. Identification of consonants and vowels presented to left and right ears. *Quarterly Journal of Experimental Psychology*, 1967, 19, 59-63.

UMILTÀ, C., SAVA, D., & SALMASO, D. Hemispheric asymmetries in a letter classification task with different typefaces. *Brain and Language*, 1980, 9, 171-181.

Accepted June 20, 1984.