Recent Advances in Human Neurophysiology

Proceedings of the 6th International Evoked Potentials Symposium held in Okazaki, Japan on 21–25 March 1998

Editors:

Isao Hashimoto, MD, PhD
Department of Psychophysiology
Tokyo Institute of Psychiatry, Tokyo
and Department of Integrative Physiology
National Institute for Physiological Sciences, Okazaki

Recent Advances in Human Neurophysiology.
I. Hashimoto and R. Kakigi, editors.

Detection of deception with P300

Fang Fang and Zheng Shen
Department of Psychology and National Laboratory on Machine Perception, Peking University, Beijing, P.R. China

Abstract. Because event-related potentials (ERPs) could reflect dynamic changes in brain function during cognitive processes in human subjects, and the changes are independent of the activities of autonomic nervous system, they have been used as indicators of lie detection.

Twenty subjects imagined they had committed burglary of an apartment. Guilty knowledge test (GKT) taking question-answers format was constructed according to the crime. For each of 18 questions, the corresponding five answers consisting of one relevant item (RI) and four irrelevant items (II) were presented serially after its presentation.

Significant differences in P300 amplitude were found between RIs and IIs at F3, Fz and F4, but not at N400. We also compared the differences in P300 amplitude between RI and II among F3, Fz and F4. Only the difference between F3 and F4 reached significant level.

These results suggested that we could utilize the P300 amplitude to distinguish guilt from innocence. Meanwhile, in the views of actual applications, if the visual stimuli eliciting P300 component were semantic, for right-handed subjects, F3 was a better location to record ERPs for detecting deception than F4, Fz.

Keywords: ERPs, N400, P300, polygraph, voice-stress analyzer

nervous system related to information processing rather than emotion-dependent activities of autonomic nervous system, the methods used to escape the detection of traditional techniques will be null [6]. Rosenfeld et al. used P300 as an indicator to detect guilty knowledge [7]. In their experiment, a larger P300 was elicited by an "oddball" stimulus – the item supposed to be stolen by the subjects. N400 component was firstly described by Kutas and Hillyard [8]. They compared ERPs produced in response to words which completed sentences in a semanti-

Ages ranged from 21 to 35 years, and 11 of the subjects were men. All subjects were right-handed and reported having normal or corrected to normal vision. EEG data from two of these subjects were not included in the analysis because of excessive eye movement artifact.

Materials

A piece of diary describing a burglary of an apartment in detail was read by the subjects. Guilty knowledge test (GKT) taking question-answers format was constructed according to the crime. Each of 18 questions comprised five answers including one relevant item (RI) and four irrelevant items (II). Each of the total 90 items was a word with 2–3 Chinese characters. It was relevant items, but not irrelevant items, that were semantically congruous with the question according to the crime.

Recording system

Stimulus presentation and EEG data collection were controlled separately by PC586 and PC486. Stimuli appeared centered on the screen placed directly in front of the subject. The distance between subject and screen was 1 m.

EEG was recorded from location F3, F4 and Fz according to the international 10-20 system and was referenced to linked ear lobes. The forehead grounded and eye movement were monitored by an electrode placed supraorbitally. An elastic cap with silver/silver chloride electrodes (Neuroscan Comp.) was used in all cases. Electrode impedances did not exceed 5 kΩ. The EEG signals were amplified and filtered with a band pass of 0.5–30 Hz by Neuropack-8 (Nihon Kohden, Japan). The signals were digitized at 250 Hz/location and stored on disk for later analysis.

Procedure

Upon the subject's arrival, a general description of the experimental procedure was given, and the subject's informed consent to participate was obtained. An electrode cap was put on and impedances of electrodes were verified less than 5 kΩ. The subject then sat in front of the screen of the computer in an electrically shielded room and the experimenter taught him/her how to operate the keyboard. All subjects were instructed to read the diary depicting a burglary of an apartment and to remember some details which had been labeled by the experimenter and were relevant to the questions. The subjects were given the following

"j" or "h" on the keyboard. Try your best to appear innocent during this interrogation, even if you were the thief.

Every question was presented for 5,000 ms. Each of the five corresponding items was presented successfully for 300 ms, starting 1,000 ms after the offset of the question. There was an interval of [illegible]

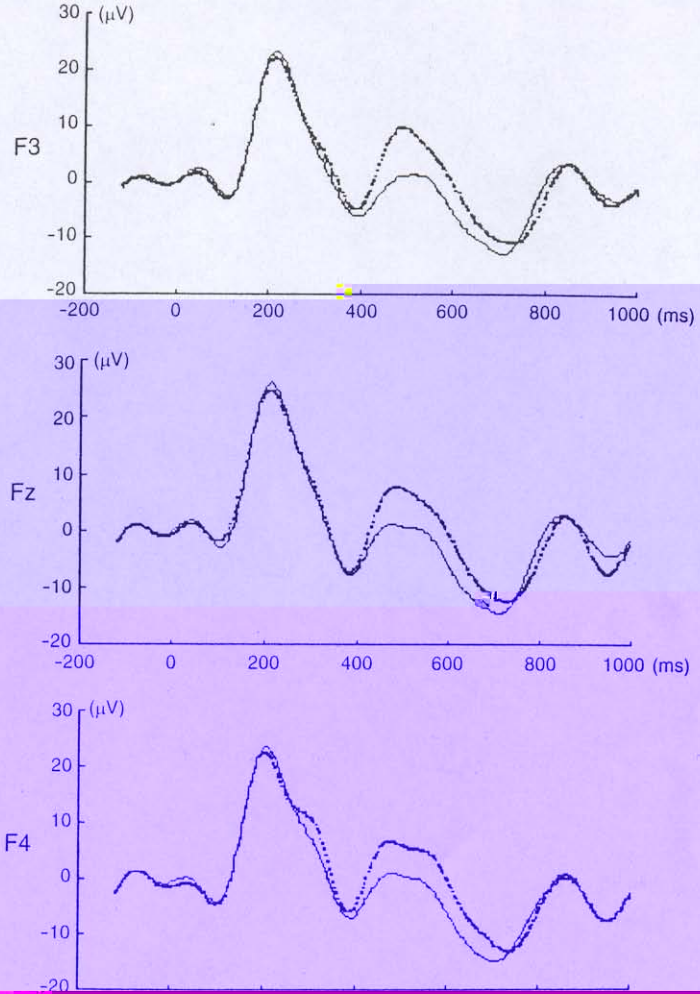
F3
30
(μV)
20
10
0
-10
-20
-200
0
200
400
600
800
1000 (ms)
Fz
30
(μV)
20
10
0
-10
-20
-200
0
200
400
600
800
1000 (ms)
F4
30
(μV)
20
10
0
-10
-20

Table 1. Amplitudes of the ERP peaks.

	F3	Fz	F4
P300			
RI	9.31 (7.52)[a]	7.59 (6.31)[a]	5.94 (6.80)[a]
II	1.66 (4.40)	1.49 (5.76)	1.46 (5.66)
N400			
RI	−5.09 (6.54)	−7.51 (5.33)	−6.60 (5.66)
II	−6.79 (3.97)	−8.02 (4.34)	−7.26 (4.04)

Note: mean (SD) (μV) peak-to-baseline amplitudes of P300 and N400 elicited by RI and II at F3, Fz and F4 (n = 18). [a]$p < 0.001$ (paired t test between RIs and IIs).

N400 reflects semantic processing of words in context. N400 component was also observed for false sentences pertaining to episodic information learned by subjects in the laboratory (e.g., "Diane is a lawyer") in which the sentence endings are not incongruous in any way [12]. In our experiment, irrelevant items were semantically incongruous with the question according to the information learned by subjects. According to Boaz et al.'s hypothesis, N400s ought to be elic-

founding variables and examiner bias. Thus ERPs show promise as a method for detecting the presence of guilty knowledge.

Acknowledgements

This research was supported by the National Academic Committee. The grant number is 96-919-08.

References

1. Saxe L, Dougherty D, Cross T. The validity of polygraph testing. Am Psychol 1985;40:355–366.
2. Lykken DT. The detection of deception. Psychol Bull 1979;86:47–53.
3. Waid WM, Orne EC, Cook MR, Orne MT. Meprobamate reduces accuracy of physiological detection of deception. Science 1981;212:71–73.
4. Honts CR, Hodes RL, Raskin DC. Effects of physical countermeasures on the detection of deception. J Appl Psychol 1985;70:177–187.
5. Leiphart J, Rosenfeld JP, Gabrieli JD. Event-related potential correlates of implicit priming and explicit memory tasks. Int J Psychophysiol 1993;15:197–206.
6. Farwell LA, Donchin E. Can the P300 be used in the detection of deception? Psychophysiol 1986;23:434 (Abstract).
7. Rosenfeld JP, Nasman VT, Whalen R, Cantwell B, Mazzeri L. Late vertex positivity in event-related potentials as a guilty knowledge indicator: a new method of lie detection. Polygraph 1987;4:258–263.
8. Kutas M, Hillyard SA. Reading senseless sentences: brain potentials reflect semantic incongruity. Science 1980;207:203–204.
9. Fischler I, Bloom PA, Childers DG, Roucos SE, Perry NW. Brain potentials related to stages of sentence verification. Psychophysiol 1983;20:400–409.
10. Boaz TL, Perry NW, Raney G, Fishler I, Shuman Dennis. Detection of guilty knowledge with event-related potentials. J Appl Psychol 1991; 6: 788-795.
11. Roberts K, Lawrence PD, Eisen A, Hoirch M. Enhancement and dynamic time warping of somatosensory evoked potential components applied to patients with multiple sclerosis. IEEE Trans Biomed Eng 1985:BME-34:397–405.
12. Fischler I, Childer DG, Achariyapaopan T, Perry NW. Brain potentials during sentence verification: automatic aspects of comprehension. Biol Psychol 1985;21:83–105.