

ERP Analysis of Episodic Memory Recall

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Abstract

Episodic memory is the explicit recollection of incidents occurred at a particular time and place in one's personal past. In this study, detection of episodic memory activity in Event Related Potentials (ERPs) was done. ERPs were recorded while the subjects made old/new recognition judgments on the new unstudied meaningless pictures and the old pictures which had been presented at the study phase. In order to extract the features correlated with the episodic memory activity, time and time-frequency features were extracted from ERPs. Wavelet method was implemented for feature extraction in time-frequency. Independent sample test has was for detection of the separable degree the between old/new ERPs. Furthermore, by using stepwise linear discriminate analysis, ERP signals were classified to old and new classes. Ultimately for better classification between old/new ERPs, Multi Layer Perceptron was implemented, and for best feature selection, genetic algorithm was used. In the best results, by using time domain features extracted from Pz channel, 100% accuracy in the training and test data was obtained.

Keywords: Episodic Memory; ERP; Time Domain Features; Quantification; Classification

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ERP

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(ERP)

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ERP

ERP

t

ERP

ERP

% Pz

ERP

ERP

ERP :

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ghoshuni@mshdiau.ac.ir :

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ERP []

N

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(N []

ERP

([])

ERP

ERP

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[]

ERP

ERP LPC ()

(ERP)

ms

ERP

ERP) N ERP []

(ms

ERP

ms

¹ Declarative
⁵ Semantic
⁹ Rugg
¹³ Besson
¹⁷ task

² Nondeclarative
⁶ Episodic
¹⁰ Late Positive Component
¹⁴ Frontal
¹⁸ Pattern recognition

³ Explicit
⁷ Event Related Potential
¹¹ Parietal
¹⁵ Finnigan

⁴ Implicit
⁸ Johnson
¹² Friedman
¹⁶ Dzulkipli

) ERP
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19 PET

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ERP

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¹⁹ Temporal lobe
²³ Positron Emission Tomography

²⁰ Hippocampus
²⁴ Medial temporal

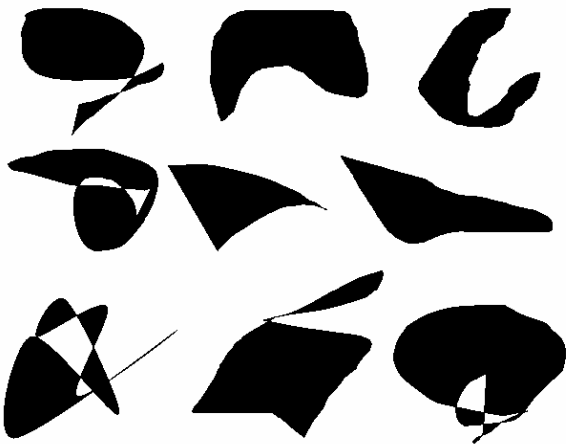
²¹ Prefrontal cortex

²² Source amnesia

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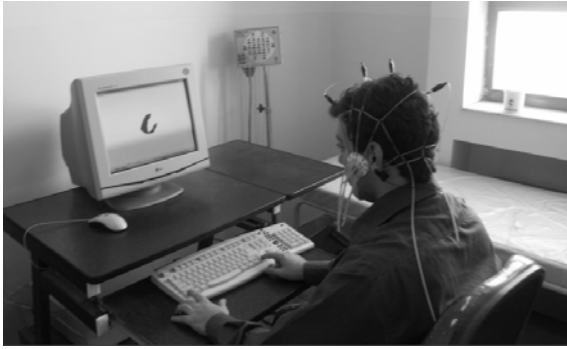
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²⁵ Blanchet

²⁶ Microsoft word



EEG

ms
s
ms
/ s

Cz Pz

Fz

ERP

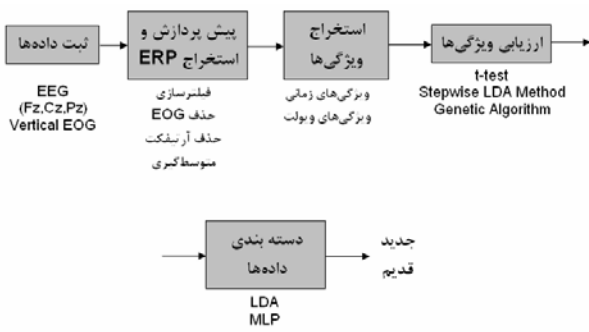
[]

Cz Pz

Fz

Fz Cz Pz

EEG



EOG

Hz

++

EEG

ERP

²⁷ Ag_AgCl
³¹ Artifact

²⁸ ElectroEncephaloGram

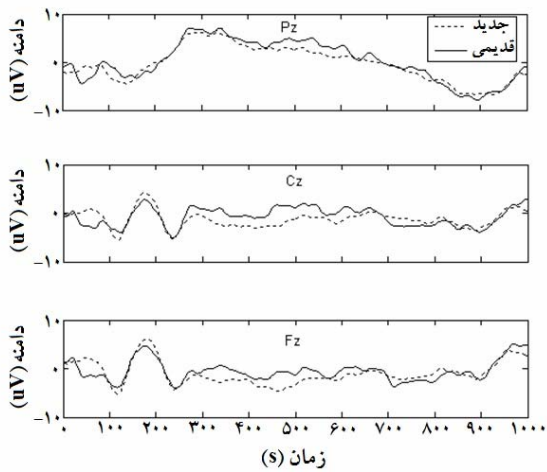
²⁹ ElectroOculoGram

³⁰ Visual C++

EEG ERP EOG EOG
 Fz Cz Pz ()
 EEG
 μv

ERP EOG DC
 EEG
 DC
 ERP [] / Hz

()



ERP
 (/)

EEG
 Hz
 ERP
 Hz
 []
 EOG
 [] EEG
 EOG
 EOG
 EEG
 EOG
 EOG
 EOG
 EOG
 f(.)

³¹ Wavelet
³⁵ Elliptic
³⁹ Grand Average

³² T-test
³⁶ Adaptive Neuro Fuzzy Inference System in ANFIS

³³ Noise

³⁴ Direct Current offset
³⁷ Synchron

$$A_p = \sum_{t=t_{start}}^{t_{stop}} 0.5(s(t) + |s(t)|) \quad ()$$

:(NAR A_n) ERP

$$A_n = \sum_{t=t_{start}}^{t_{stop}} 0.5(s(t) - |s(t)|) \quad ()$$

[] ERP

:(ANAR) ERP

$$|A_n| \quad ()$$

ERP

:(TAR A_{pn}) ()

$$A_{pn} = A_p + A_n \quad ()$$

:(ATAR) ERP $s(t)$ ()

$$|A_{pn}| \quad ()$$

[tstart tstop]

:(LAT t_{Smax})

$$A_{p|n|} = A_p + |A_n| \quad ()$$

$$t_{Smax} = \{t | s(t) = s_{max}\} \quad ()$$

(AMP S_{max})

:(AASS $|\bar{s}|$) :

$$|\bar{s}| = \frac{1}{n} \sum_{t=t_{start}}^{t_{stop}-\tau} \frac{1}{\tau} |s(t+\tau) - s(t)| \quad ()$$

$$s_{max} = \max\{s(t)\} \quad ()$$

n τ

:(LAR)

$$t_{smax} / s_{max} \quad ()$$

:(PP pp)

$$PP = s_{max} - s_{min} \quad ()$$

:(AAMP)

$$s_{min} = \min\{s(t)\} \quad |s_{max}| \quad ()$$

:(PPT t_{pp})

$$t_{pp} = t_{smax} - t_{smin} \quad ()$$

:(ALAR)

:(PPS \dot{s}_{pp}) $|t_{smax} / s_{max}| \quad ()$

$$\dot{s}_{pp} = \frac{PP}{t_{pp}} \quad ()$$

:(PAR A_p)

⁴⁰ Latency ⁴¹ Amplitude ⁴² Latency/Amplitude Ratio ⁴³ Absolute Amplitude
⁴⁴ Absolute Latency/Amplitude Ratio ⁴⁵ Positive Area ⁴⁶ Negative Area ⁴⁷ Absolute Negative Area
⁴⁸ Total Area ⁴⁹ Absolute Total Area ⁵⁰ Total Absolute Area ⁵¹ Average Absolute Signal Slope
⁵² Peak to Peak ⁵³ Peak to Peak Time window ⁵⁴ Peak to Peak Slope

() : (ZC n_{zc})

$$s(t) = \sum_{t=t_s \min}^{t_s \max} \delta_s \quad ()$$

s(t) = δ_s =

(ZCD d_{zc})

SPSS ERP

$$d_{zc} = \frac{n_{zc}}{t_{pp}} \quad ()$$

(LDA) ERP

$$n_{sa} = \sum_{t=t_{start}+\tau}^{t_{stop}-\tau} 0.5 \times \left[\frac{s(t-\tau) - s(t)}{|s(t-\tau) - s(t)|} + \frac{s(t+\tau) - s(t)}{|s(t+\tau) - s(t)|} \right] \quad ()$$

MATLAB

t

[]

t

t

ms

[]

Hz

Hz

C Pz P)

(Fz F Cz

G B A T D)

()

()

⁵⁵ Zero Crossings ⁵⁶ Zero Crossing Density ⁵⁷ Slope Sign Alterations ⁵⁸ MATrix Laboratory
⁵⁹ Quadratic B-Splines ⁶⁰ SPSS ⁶¹ Linear Discriminant Analysis ⁶² Stepwise linear discriminant analysis
⁶³ Independent sample t test ⁶⁴ Fitness

MATLAB

ERP)
ERP (

$$fitness = \frac{overall\ accuracy(\%)}{100 + number\ of\ features} \quad ()$$

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ERP

ERP /

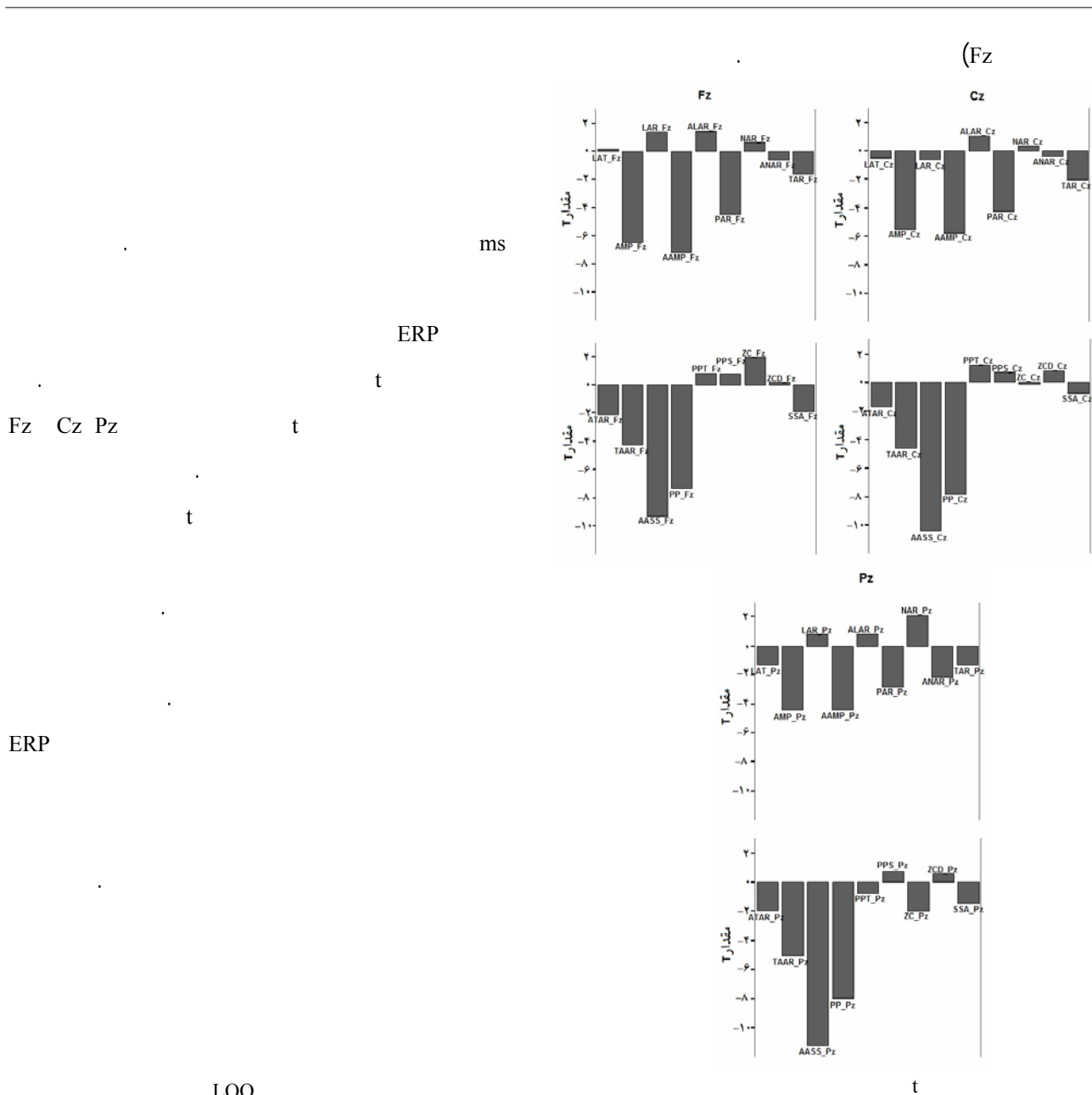
ERP ms

⁶⁵ Crossover Rate
⁶⁹ Backpropagation
⁷³ Variance

⁶⁶ Mutation Rate
⁷⁰ Batch mode

⁶⁷ Generation
⁷¹ Epoch

⁶⁸ tansig
⁷² Learning rate



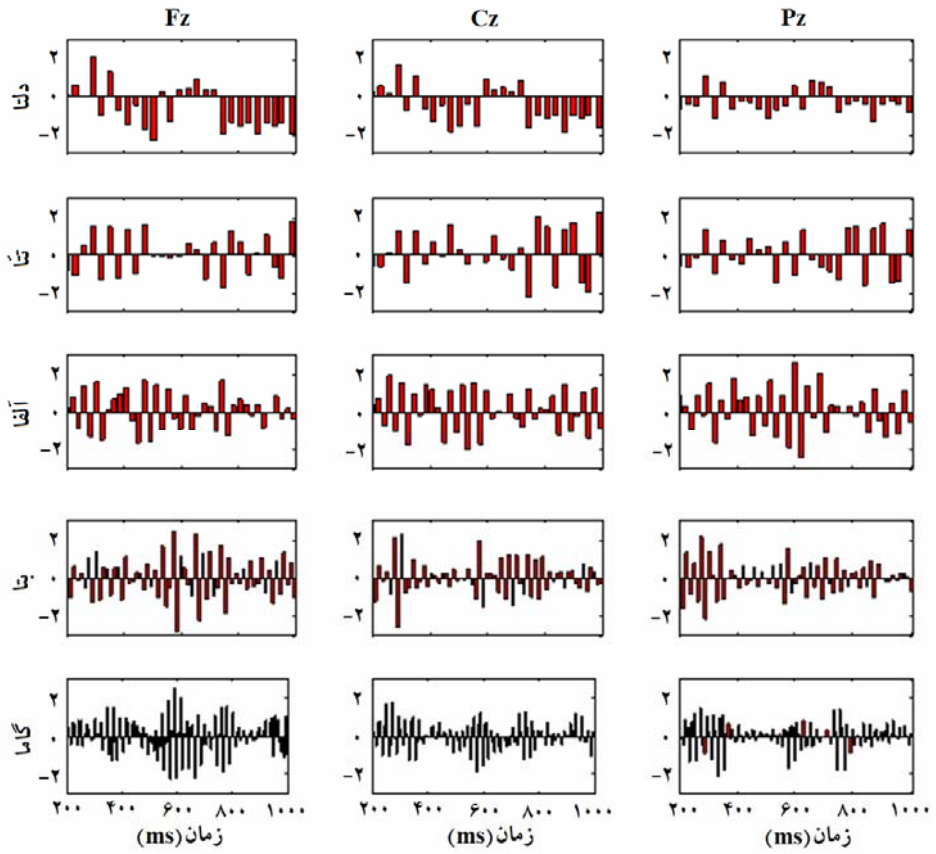
LOO

LOO					(%)	(%)	
					/	/	Fz
					/		Cz
					/	/	Pz
					/		Fz, Cz, Pz

AMP

PP PAR TAAR AAMP

ERP



Fz Cz Pz

t

Fz

% /

%

Cz

ERP

%

Cz

Pz

Fz

ERP

Fz

Cz

Pz

%

%

ERP ERP ERP

%

Pz

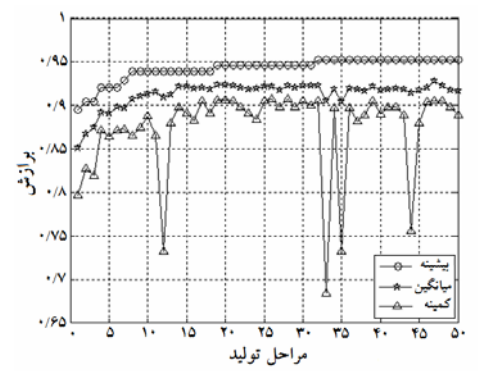
/ ERP ms
()

ERP ERP

[]

	(%)	(%)	
	/	/	Fz
	/	/	Cz
			Pz

ERP ERP
t AASS t



Pz

ms

ERP

t

ERP

Pz

Fz Cz

t

Cz

Pz

(Fz)

/

t

[]

AMP

PP PAR TAAR AAMP

(Fz)

ERP

t

ms

ERP

ERP

/

ERP

ms

ms

[]

ms

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(ERP)

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t

% /

LOO % /

Fz Pz

%

LOO % /

Fz Cz Pz

Pz

% / % /

(Pz)

(Fz) (Cz)

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ERP

Pz

ERP %

ERP Pz

⁷⁵ Howard

<p>EEG</p> <p>EOG</p> <p>ANFIS</p> <p>ERP</p>	<p>[]</p> <p>[]</p>	<p>[6] Finnigan S., Humphreys M.S., Dennis S, Geffen G., ERP ‘old/new’ effects: memory strength and decisional factor(s); <i>Neuropsychologia</i>; 2002; 40:2288-2304.</p> <p>[7] Dzulkifli M.A., Herron J.E., Wilding E.L., Memory retrieval processing: Neural indices of processes supporting episodic retrieval; <i>Neuropsychologia</i>; 2006; 44:1120-1130.</p> <p>[8] Milner B., Corsi P., Leonard G., Frontal lobe contribution to recently judgments; <i>Neuropsychologia</i>; 1991; 29:601-618.</p> <p>[9] Moscovitch M., <i>Confabulation In Memory Distortion: How minds, Brains and Societies Reconstruct the past</i>; Harvard University Press, Cambridge, MA; 1995:226-254.</p> <p>[10] Buckner R.L., Tulving E., Neuroimaging studies of memory: Theory and recent PET results; <i>Handbook of Neuropsychology</i>, Elsevier, Amsterdam; 1995:439-466.</p> <p>[11] Ungerleider L.G., Functional brain imaging studies of cortical mechanisms for memory; <i>Science</i>; 1995; 270:760-775.</p> <p>[12] Martin A., Wiggs C.L., Weisberg J.A., Modulation of human temporal lobe activity by form, meaning, and experience; <i>Hippocampus</i>; 1997; 7:587-593.</p> <p>[13] Schacter D.L., Alpert N.M., Savage C.R, Rauch S. L., Albert M.S., Conscious recollection and the human hippocampal formation: Evidence from position emission tomography; <i>Proc. Natl. Acad. Sci. U.S.A.</i>; 1996; 93:321-325.</p> <p>[14] Blanchet S., Belleville S., Lavoie M.E., Item-related versus task-related activity during encoding and retrieval in verbal and non-verbal episodic memory: an event-related potential study; <i>Cognitive Brain Research</i>; 2003; 17:462-474.</p>
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