Warsaw University

Faculty of Psychology

Małgorzata Zarzycka

Event-related potentials and false recognition

Tutor:

Prof. UW dr hab. Ewa Czerniawska

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Abstract

False recognition is one form of misattribution, where individuals mistakenly claim that a novel item or episode is familiar. It can be investigated with eeg which allow us to see time course of this kind of mistakes. This kind of examination investigate event-related potentials, which are potentials correlated with events such as perception of word or picture. The aim of this study was to investigate of false recognition of highly emotional picture stimuli. Investigators especially concentrated on one effect which is connected with false recognition: old/new effect. It shows that correct old responses to targets elicits significantly more pronounced positive waveforms in comparison to correct rejections of distractors (old/new effect) between 400 and 700ms after stimulus onset (Daum et al.2006), especially in frontal and parietal electrodes.

In experiment which was done effect was shown only for parietal electrodes.

Key words: false recognition, event-related potentials, old/new effect

Contents

1. Introduction

Memory plays an important role in everyday life, allowing us to recollect past facts, learn new abilities, and remember what we ought to do in the future. But memory can fail us very often and for instance disrupt past experiences. Schacter (Dodson et al.2001) has classified the misdeeds of memory into seven categories: transience, absent-mindeness, blocking, misattribution, suggestibility, bias and persistence. It is worth mentioning that all of them concern episodic memory, although they can also involve other forms of memory. Sometimes people create 'sins' of memory on their own – for example when they discuss situations which happened to them. It is called 'dispute memory' and mainly concerns twins (Kemp et. al 2001).

False recognition is one form of misattribution, where individuals mistakenly claim that a novel item or episode is familiar (Dodson et al.2001). It is important to distinguish between false recognition and deception. The first one is not accompanied by a subjective feeling that person is responding untruthfully whereas in second case people are responding mistakenly in purpose (Abe et al.2008). However, they must be somehow connected it the brain via neuronal circuits because both in FR and in deception fMRI studies showed anterior cingurate cortex activation (Ford et al.2003).

Several neuroimaging studies using positron emission tomography (PET), functional magnetic resonance imaging (fMRI) and event-related potentials were done to investigate false recognition phenomenon (Dodson et al.2001). Because of the fact that this paper involve ERP it is worth mentioning that this class of potentials display stable time relationships to a definable reference event. In this case it can be picture or word which is presents to the subject. ERPs make possible to determine which stage or stages of processing are affected by specific experimental manipulation (Luck, 2005). They have got very high temporal resolution which allow scientists to see brain response to the stimuli in time range of milliseconds. However, spatial resolution of ERP what makes extremely hard to predict that source of signal. It is called 'inverse problem – and simply means that particular voltage distribution on the scalp can be produced by many different sources configurations (Papanicolaou,1998).

The most popular paradigm which is used to study this effect on behavioral level was developed by Deese in 1995 and modified by Roedinger and McDermott and is called 'DRM paradigm' (Fan et al.2007). It involve presenting lists of words, each of which is highly related to a nonpresent critical item (lure). When subjects are asked to recall freely the lists or recognize the items on the lists among distracter items, they often mistakenly report that nonpresented lures had been experienced in the earlier study lists (Fan et al.2007).

Many factors have influence on formation of false recognition. One of them is retention delay. When scientists changed it from 40s to 80s it had no significant effect on true but just for false recognition creation (Mecklinger et al.2003). It is worth mentioning that there are not a lot of studies which use retention delays longer than several seconds.

Several studies suggest that emotional content of stimuli facilitated the formation of false recognition. What is more interesting, emotional charge of stimuli provide higher involvement of the right prefrontal cortex in false recognition generation (Brechmann et al.2008).

Brain activity connected with recognition changes across one's life. Comparatively with young people, elderly adults show less positive waveforms even if behavioral measures show no differences (Federmeier et al.2007).

2. Theoretical part

Dual-process theories of recognition memory state two independent processes. The first, which is called 'recollection', reflects intentional and controlled processing. The second, which is called 'familiarity', is an automatic process, occurring as a passive consequence of stimulation and requiring relatively little capacities. Recollection reflects more context, in which an item was last encountered, and familiarity is thought to reflect a feeling that an item has been encountered, but there is no information when and where. It is worth mentioning that familiarity is distinct from perceptual implicit memory but has many common features with conceptual implicit memory. Recollection depends mainly on hippocampus and the frontal lobe, and familiarity depends on temporal and frontal regions (Daum et al.2006). Thus left inferior frontal gyrus could be crucial in this issue, because it is a critical neural substrate for the resolution of proactive interference in working memory (Feredoes et al.2010).

To examine this issues Tulving introduced remember/know task which measures subject's awareness during recognition. Subjects are instructed to rate recognizes stimuli either as 'remembered' (when they are consciously aware of what happened when the stimulus was presented) or as a 'known' (when they recognize items but are unaware of any additional, item-specific information). 'Remember' and 'Know' responses not only reflect the strength of memory, but also are very sensitive to many variables which affect recollection and familiarity-based recognition in different ways, such as levels of processing, divided attention at study, or perceptual fluency (Daum et al.2006).

Many investigations have shown that familiarity and recollection can be dissociated at the neural level. They include: examinations of patients with lesions thought to be restricted to the hippocampus, differential patterns of neural activity revealed by functional magnetic resonance imaging (fMRI) and dissociations among retrieval-related event-related potential effects (Curran et al.2007). ERP studies on recognition memory has shown more positive deflection to old compared to new items, with a latency around 400ms and maximal amplitude at parietal sites. This is called parietal old/new effect and it has been demonstrated to be more pronounced at left-hemispheric electrodes for words (Daum et al.2006). It is modulated by successful or unsuccessful source judgments (Curran et al.2007) and reflects recollection (rather than familiarity).

More recent study has shown also later component (500ms - 800ms after stimuli presentation) of the old/new effect, which is often maximal over left parietal scalp sites and reflect effects of familiarity (Daum et al.2006). It is often referred to LPC (Late Positive Complex) (Budson et al.2006).

In study investigating old/new effect scientists often use three kinds of stimuli during recognition task: items previously presented (targets), somehow related to them distractors (lures) and unrelated new items (distractors). Correct old responses to targets elicits significantly more pronounced positive waveforms in comparison to correct rejections of distractors (old/new effect) between 400 and 700ms after stimulus onset, mainly at all left and central electrodes positions (Daum et al.2006). Study has shown also that significant old/new effect for false alarms to lures is observed only at the left parietal electrodes. ERPs associated with hits and false alarms to lures are similar at parietal but differed at frontal electrode positions. These results suggests existence different patterns of processing true and false recognition in frontal and posterior brain regions (Daum et al.2006).

Old/new effect exists also in intentional forgetting but in that case it’s pattern is completely different (Jednoróg et al.2009).

It is worth mentioning that recent research suggest a continuing maturation of the brain networks assessing novelty or familiarity (Czernochowski et al.2009).

3. Empirical part

3.1. Problem and research questions

The aim of the study was to investigate old/new effect, using picture material which contains emotional and neutral stimuli. Also examinators wanted to know whether people remember better items which they assess as more negative (than neutral) or not. This study is unique, because first of all allow people to assess emotionality of pictures and then examine recognition. This type of stimuli is hardly use in this kind of study
Does the old/new effect exist for neutral and negative pictures?
Is this effect different for those kinds of stimuli?
Do people remember better emotional items, comparatively to neutral?

3.2. Hypothesis

• There is more false recognition for negative than for neutral stimuli.

• There is more true recognition for negative stimuli that for neutral stimuli.

• Old/new effect for emotional stimuli exists (there is more pronounced amplitude for old than for new stimuli).

3.3. Methods

3.3.1. Tools

EEG activity was recorded during second part of experiment. An EEG cap was used to place a set of 64 EEG electrodes according to the international 10-20 system (Jaśkowski, 2004). References were placed on ears. Before electrode attachment, the positions were slightly scrubbed with a gel in order to provide a good measurement. Electrode impedance was kept below 5kΩ.

All data were digitized, displayed, and stored by a PC system. In order to reduce artifacts, subjects were instructed to sit as relaxed as possible and to avoid eye movements during recoding.

Coloured photographs were taken from IAPS picture set. This set has been widely used to demonstrate preferential allocation of attention to emotionally arousing stimuli, differential reflex modulation by emotional background stimuli and behavioral indices of free-recall and recognition memory (Hauswald et al.2008).

In the first part of the experiment subjects saw: 64 negative photos and 64 neutral photos. In the second part of the experiment subjects saw: 61 ‘old’ negative photos (from the first part – so called ‘old’), 66 ‘old’ neutral photos (from the first part – so called ‘old’), 98 ‘new’ negative photos and 94 ‘new’ neutral photos. All stimuli were coded in Presentation 14.4. software.

3.3.2. Participants

6 healthy females and 3 males between 20 and 30 years of age participated in the experiment. Two people (one male and one female) were excluded from analysis because of too small amount of ERPs which were required to make means. Subjects were students of Warsaw University and PhD students of The Nencki Institute of Experimental Biology Polish Academy of Science in Warsaw. Some of them were paid 10 euro as a recompense for participation in the experiment. Subjects could leave the study at any time for any reason if they wished to do so without any consequences. The investigators could decide to withdraw a subject from the study if he/she did not comply with the rules of the experiment.

3.3.3. Experimental design

All subjects were examined in April and May in 2010 in Psychophysiology Laboratory in The Nencki Institute of Experimental Biology Polish Academy of Science in Warsaw. Experiment consisted on two parts. Subjects were informed that experiment concerned emotions and involved electroencephalographical examination. In the first part subjects job was to classify photos which were presented into two categories: neutral or negative. They did it by pressing mouse’s button – right for negative stimuli and left for neutral stimuli. They were asked to decide as fast as it was possible. Before start they were able to took part in short training. Subjects saw photos for 500 ms and fixation points among all of stimuli.

Subsequently, participants were kindly asked to go for a walk or to cafeteria for 30 minutes and come back to laboratory after this time to perform second part of the experiment. After their coming back two experimentators put EEG cap on their scalps. It took about 30 minutes as well, so basically time delay was longer – about one hour. In the second subjects were asked to blink as less as it was possible and try not move. They were informed that they were going to see photos from first part of the experiment and several new pictures. Their task were to decide if the saw or not photos in the first part. They did it by pressing mouse's button – right for 'new' stimuli and left for 'old' stimuli. It was no training before that task. Subjects saw photos for 500 ms and fixation points among all of stimuli.

Afterwards subjects were informed about real aim of the experiment. Many of them wanted to know how good their memory was but this information was not provided. Many participants claimed that they had used strategy in second part of experiment – when they had not known if they saw photo before they classified it as 'new'.

Both parts of the experiment took part in insulated and dark room. Photos were presented on huge screen. It is worth mentioning that performance of bright, colourful photos in dark rook could have influence on results (for instance because of the fact that it enhanced possibility of blinking).

3.4. Analysis

3.4.1. Behavioral data

Analysis was performed for 9 participants. There was one dependent variable – amount of true recognition (also we can make an operation: 100 - true recognition=false recognition). Basically, there were four experimental conditions: old neutral (neutral stimuli which were presented in the first part of experiment), old negative (negative stimuli which were presented in the first part of experiment), new neutral (neutral stimuli which were presented in the second part of experiment), new negative (negative stimuli which were presented in the second part of experiment).

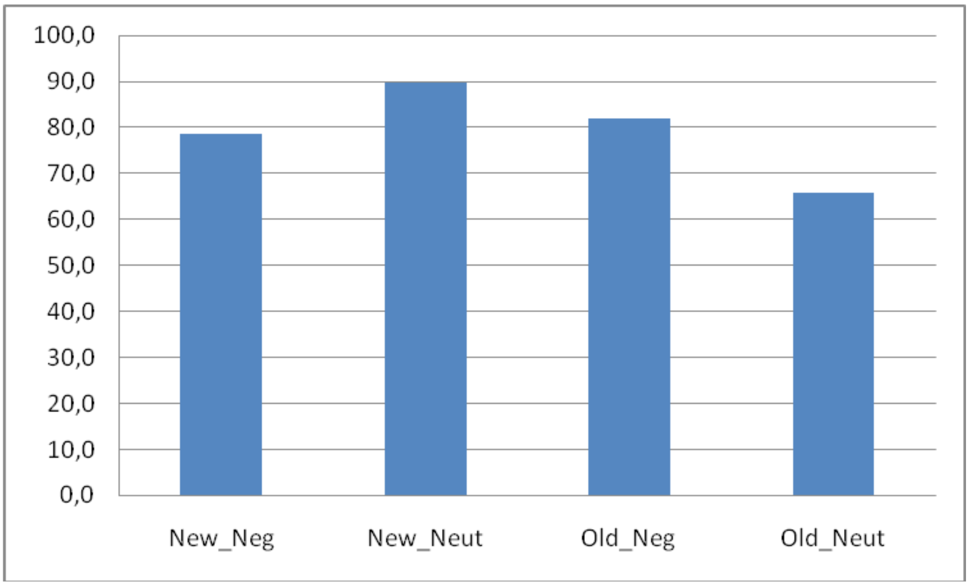

Fig.1. Amount of true recognition for all kinds of stimuli.

Type of stimuli	Percent of true recognition	Percent of false recognition
Old Neutral	65,8	34,2
Old Negative	81,9	18,1
New Neutral	89,8	10,2
New Negative	78,6	21,4

Fig.2. Percent of true and false recognition in all experimental conditions.

3.4.2. EEG data

EEG was registered continuously at 1000 Hz sampling rate and analog-filtered in the 0.01 – 70 Hz frequency band. Vision Recorder software was used in data acquisition. Data analysis was performed using BESA 5.18. software (MEGIS Software, Munich, Germany). Data from 7 people were analyzed (2 people had to be rejected because too big amount of artifacts in their data). Data were band-pass filtered from 0.1 to 30 Hz (zero phase) off-line. Eye-blink artifacts were identified with a template-based method and corrected using the adaptive artifact correction method.

Only frontal and parietal electrode were used in analysis.

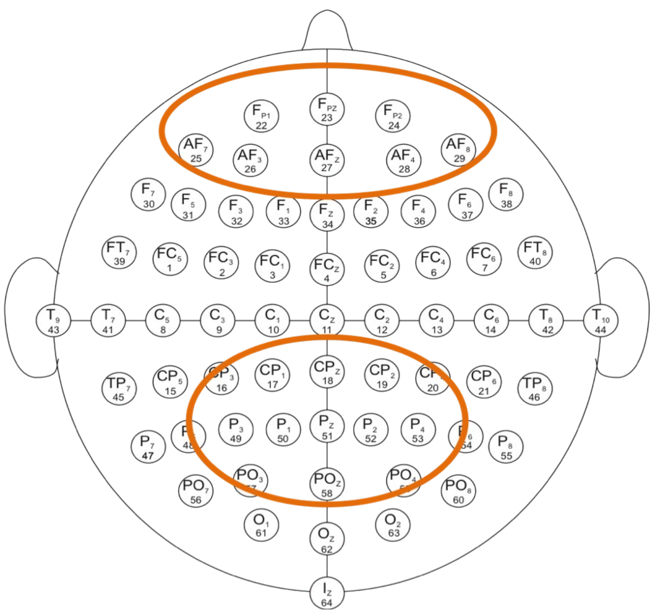

Fig.3. Scalp Site Array. Orange circles show scalp locations for electrodes used in analysis.

Trials containing artifacts other than eye-blinks, identified as having voltage amplitudes greater than ~90µV, were removed before averaging.

Two kinds of epochs were analyzed: from 350 to 450 ms after stimulus presentation (where one can observe old/new effect) and from 450 to 650 ms after stimulus presentation (where one can observe differences between true and false recognition in new stimuli).

What is crucial for all analysis, both neutral and natural stimuli were analyzed together, because of too small amount of samples (just 7 subjects data were used in analysis).

Posterior parietal central and lateral electrodes were analyzed separately.

ANOVA for posterior parietal lateral electrodes was done for time window between 350 and 450 ms. Repeated measures ANOVA was performed with the following factors: 'condition' (2 levels: old stimuli, new stimuli), response (2 levels: true , false), hemisphere (2 levels: right, left) and kind of electrode (5 levels: CP3/CP4, CP1/CP2, P3/P4, P1/P2, PO3/PO4). Kind of response had statistically significant effect on amplitude (F(1,6) = 8,52, p=0,027). Statistically significant 'condition'*response*'hemisphere'*kind of electrode interaction was also found (F(4,3) = 4,01, p=0,038).

Paired comparison showed that in old stimuli there is statistically significant difference between true and false responses in two kind of electrodes: PO3 (p=0.047) and PO4 (p =0.073).

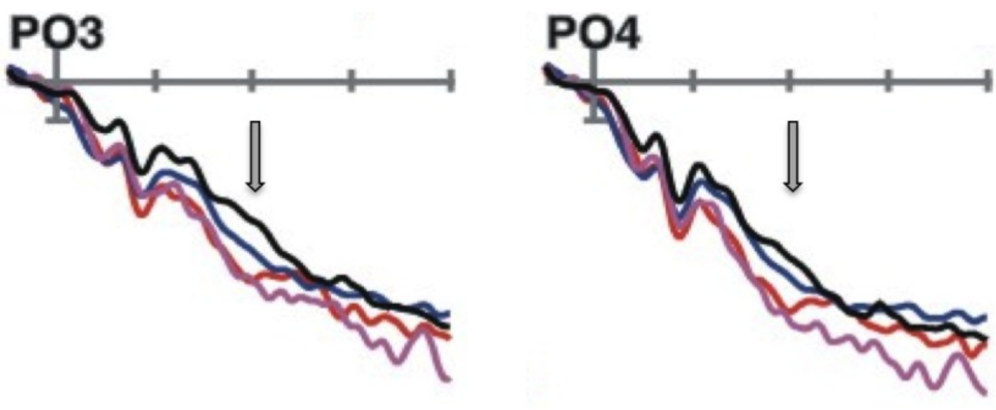

Fig.4. Old/new effect in PO3 and PO4 electrodes. Black line – old true recognition, red line – old false recognition, blue line – new true recognition, purple line – new false recognition. Higher amplitude for stimuli which were truly recognized (old true recognition), comparatively to these which were not properly recognized (old false recognition).

Further ANOVA was done for posterior parietal central electrodes for time window between 350 and 450 ms. Repeated measures ANOVA was performed with the following factors: ‘condition’ (2 levels: old stimuli, new stimuli), response (2 levels: true , false) and kind of electrode (3 levels: CPz, Pz, POz). Effect of ‘condition’ was not found. Effect of kind of response was found ($F(1,6) = 9,11$, $p=0,023$).

ANOVA was done for frontal central electrodes for time window between 450 and 650 ms. It showed no statistically significant effects.

ANOVA for frontal lateral electrodes was done for time window between 450 and 650 ms. Repeated measures ANOVA was performed with the following factors: ‘condition’ (2 levels: old stimuli, new stimuli), response (2 levels: true , false), hemisphere (2 levels: right, left) and kind of electrode (3 levels: Fp1/Fp2, AF3/AF4, AF7/AF8). Kind of response (true vs false) had statistically significant effect only in ‘new’ condition for Fp1 electrode ($p=0.05$) and trend was observed in both AF7 and Fp2 electrodes ($p=0.064$ and $p=0.068$). In ‘old’ condition there is only trend in Fp2 electrode ($p=0.067$). Statistically significant ‘condition’*response*’hemisphere’*kind of electrode interaction was also found ($F(2,5) = 7,62$, $p=0,03$).

Statistically significant ‘response’*’kind of electrode’ interaction was found ($F(2,5) = 5,63$, $p=0,033$).

All in all, statistically significant difference in amplitude between kind of response was observed only for Fp1/Fp2 and AF7/AF8 electrodes.

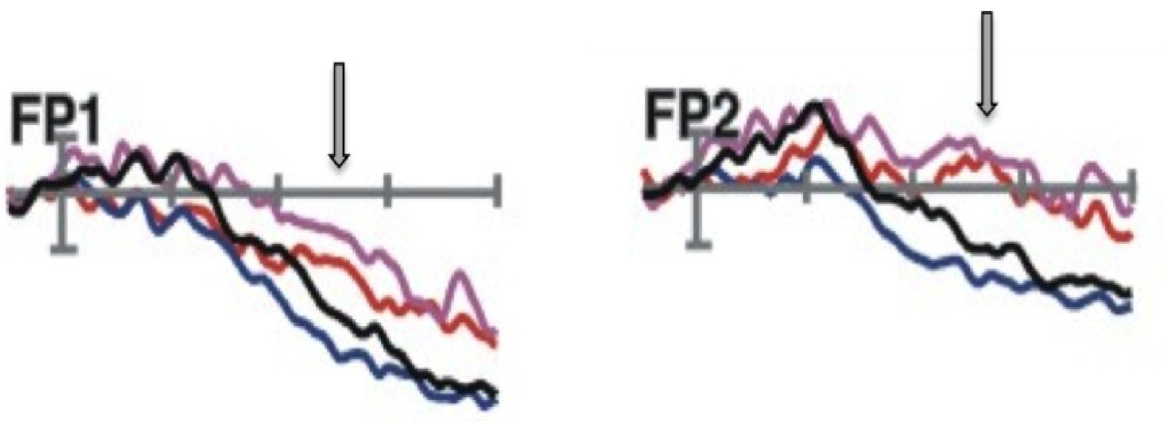

Fig.5. Old/new effect in FP1 and FP2 electrodes. Black line – old true recognition, red line – old false recognition, blue line – new true recognition, purple line – new false recognition.

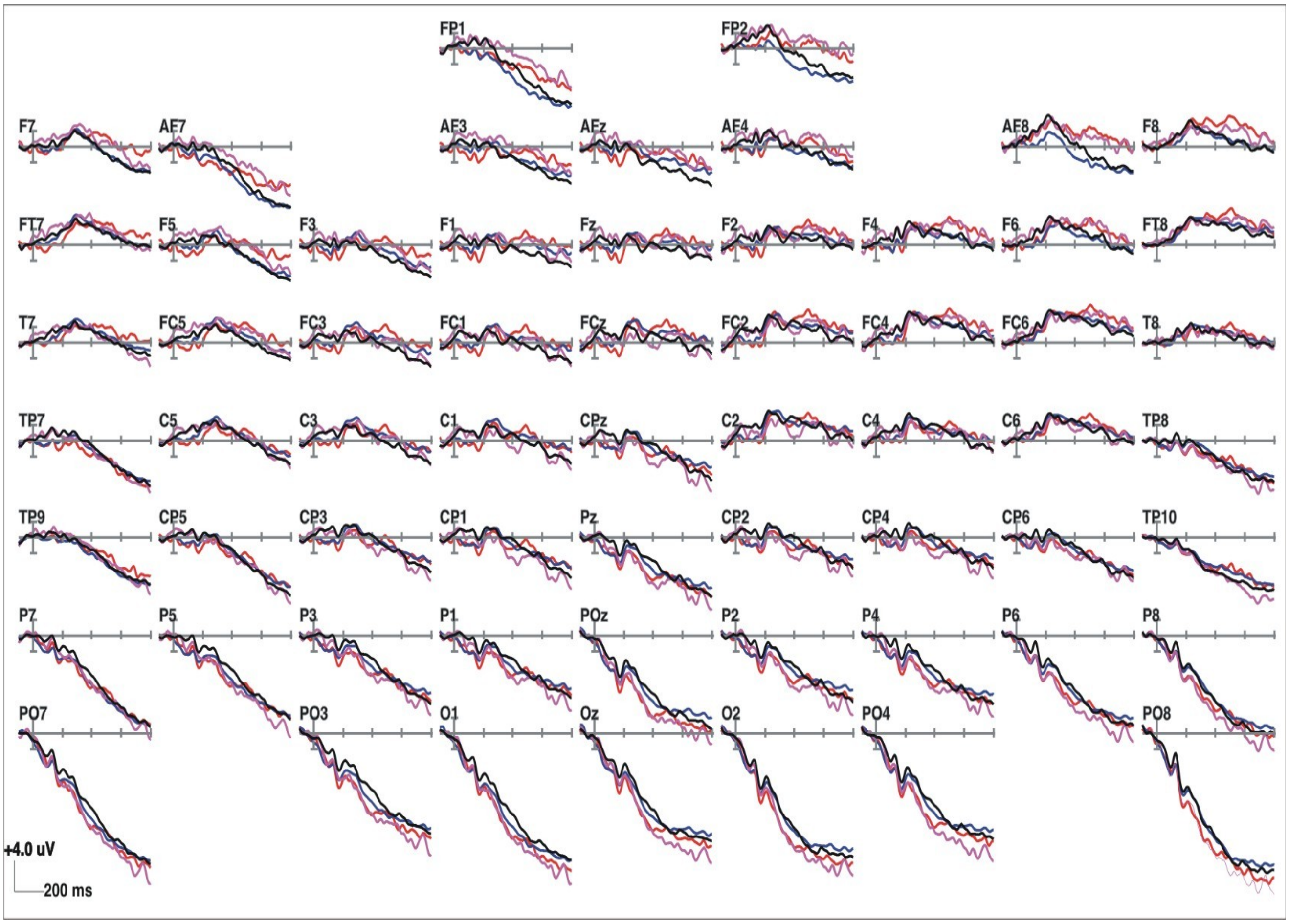

Fig.5. Event-related potentials from all electrodes which were analyzed (64). Black line – old true recognition, red line – old false recognition, blue line – new true recognition, purple line – new false recognition.

4. Discussion

The aim of the study was to investigate existence old/new effect for negative and neutral picture stimuli. Investigators were especially curious if it is more pronounced for negative than for neutral stimuli. It was impossible to verify second hypothesis with eeg data – amount of subjects who were examined was too small to make analysis which could proof that or not. Also, amount of artifacts in 2 subjects was very high and examinators have decided to exclude their data from further analysis. It is always striking problem in research which use eeg – it is very hard to collect enough amount of data.

In that case experimental design could have had big influence on artifacts – subjects had to sit without movements about half of hour. It was obvious that some of them would not be able to deal with that.

It is worth mentioning that kind of stimuli and whole experimental situation had influence in subjects and their results. Firstly, differences in reaction for emotional stimuli between people exists. Differences could concern especially physiological reactions and they have influence on eeg results (for instance even slow heart rating disturb eeg signal). Among stimuli there were picture with people whose heads another parts of their bodies were shot away. Second of all, temperature in room was very low. All those factors could disturb results.

Moreover, intelligence of subjects can have influence not only on reaction times but also on brain waves. Participants who were examinated mostly were definitely more intelligent than another part of society.

Behavioral data support hypothesis which states that emotional pictures are remembered better. There is bigger percent of true recognition of negative stimuli (81.9%) than for neutral (65.8%). What is interesting, there is more false recognition for negative (21.4%) than for neutral stimuli (10.2%). It shows that people are more likely to remember negative stimuli which are probably more important in everyday life, even from evolutionary point of view.

Clear old/new effect (higher amplitude for old than for new stimuli) was observed only for frontal lateral electrodes. In another electrodes which were analyzed there was no effect or it was just trend.

According to the literature which shows that there is more pronounced old/new effect for stimuli which are properly remembered than which are not remembered properly we can see that effect in two electrodes: P03 and P03 (parietal lateral electrodes).

The same differences was observed in frontal parietal electrodes.

On the basis of those results we can not say that old/new effect for emotional stimuli is not as pronounced as for another kinds of stimuli (for instance for words), because amount of data which was analyzed was too small. The best way to examine this problem would be to perform this experiment one more time with bigger sample. There were no separate effects of hemisphere – and according to the literature old/new effect ought to be more pronounced on left hemisphere.

There are many problems concerning false recognition experiments which should be solved. One of them is using of strategy by participants – for instance in second part of experiments many of subjects press ‘new’ button when they are not certainly sure is they saw stimulus before. This one and another strategies can have huge influence on results. Scientists who explore false recognition should put a lot of attention to eliminate this kind of ‘artifacts’. We should be aware of the fact that results of this experiments can have practical implications in juridical psychology and examining of bystanders and because of that methodology of experiments is very important issue to make results as plausible as it is possible.

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