

Are there modulated Electromagnetic Field Effects on Human Conscious Perception during Attentional Blink Test?

Jaanus Lass, Anastassia Rodina, Jevgeni Riipulk, Hiie Hinrikus and Talis Bachmann

Abstract — The aim of this study was to experimentally examine the effects of low-level modulated electromagnetic fields on human central nervous system function utilizing the phenomenon of attentional blink. Twenty healthy volunteers were exposed to 450MHz electromagnetic field (EMF) modulated with 40Hz stimulation. During the exposure the subjects were presented rapid serial visual presentation (RSVP) sequence, which consisted of 8 letters (stimuli) and two numbers (targets - T1 and T2). The task was to detect two target stimuli out of the sequence. The experiment protocol consisted of two sessions – 100 trials each. One session was done under EMF exposure condition and another under sham condition. The attentional blink phenomenon can be described as impairment of the identification of the second of two targets if it is presented less than about 500ms after the first. Resulting data were statistically analyzed using a two-tailed Student's *t*-test. The results showed that EMF had no immediate effect on attentional blink characteristics of human perception.

Keywords: Microwave exposure, visual masking, psychological effects, cognitive functions, object recognition.

I. INTRODUCTION

The number of devices emitting electromagnetic fields (EMF) is growing rapidly and there is a concern about possible low-level electromagnetic field effects on human health, mind, and behavior. Various techniques for studying EMF exposure effects were applied by different authors. Several groups of scientist have investigated low-level electromagnetic field effects on human sleep and waking EEG [1-15]. Many have found that EMF exposure causes changes in EEG rhythms [1-3, 5-9]. Obtained results suggest that there can be an effect also on human processing performances, i.e. cognitive functions. The research group from Finland (Koivisto, Haarala, Krause et al.) has reported contradictory results in their different studies. In earlier reports they have found EMF effect on the mental activity and cognitive functions, especially attention and memory

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J. Lass, J. Riipulk, H. Hinrikus are with the Biomedical Engineering Centre, Tallinn University of Technology, Ehitajate tee 5, 19086 Tallinn, Estonia (phone: +3726202206; fax: +3726202201; e-mail: jaanus@cb.ttu.ee).

A. Rodina was with the Biomedical Engineering Centre, Tallinn University of Technology, Ehitajate tee 5, 19086 Tallinn, Estonia. She is now with the School of Medicine, University of Patras, 26500 Rio, Patras, Greece (email: stasia@cb.ttu.ee)

T. Bachmann is with the Institute of Law, University of Tartu, Kaarli pst. 3, 10119 Tallinn, Estonia (email: talis.bachmann@ut.ee)

[16-19]. In the experiments authors used pulse-modulated EMF emitted by the GSM mobile phones (902MHz, 217Hz). A study from the group of authors investigated the topic with the help of the reaction time task (n-back task). The results showed a speed-up of reaction time during the EMF exposure in case when three items had to be kept in memory. Based on the assumption of these results the authors concluded that the RF fields emitted by GSM phones ease cognitive task performance and this effect is possibly dependent on the complexity level of the cognitive functions involved [16]. In their later replication studies authors could not reiterate their previous results and assumed that inability to replicate previous findings might be produced by the lack of the EMF effects or the magnitude of effects is at the sensitivity threshold of the test used [20, 21]. Lee et al. reported mild-facilitating effect of EMF emitted by mobile phones on the attentional functions [22]. In our previous studies we demonstrated that EMF has an effect on the performance in neuropsychological tasks associated with the attention and short-term memory. We have reported results similar to Koivisto et al. that the effect of the modulated microwave field varies with the complexity level of the task performed [23]. In our last experimental series we studied the influence of low-level electromagnetic field (450MHz, 7Hz) on human visual perception by the method of face masking. The subjects were presented two male photos in fast succession and had to identify the faces and their order. The masking phenomenon is revealed as anamorphosis in subject's perception of two instantaneous visual stimuli presented within a short time interval. Despite of the fact that the statistically significant results were obtained when the dependent measure was correct perception of both stimuli, it was concluded that early stages of visual information processing are overwhelmingly robust and routine (and adaptively significant) activities, so that the physical field-effects exerted are extremely weak [24].

In the current study we investigate EMF effects on human conscious visual perception by the attentional blink phenomenon. The "attentional blink" can be described as a transient reduction of attention, which occurs if more than one targets has to be processed in a series of rapidly consecutive stimuli. The phenomenon was first observed in the mid-1980s [25-27]. In a typical attentional blink experiment, a series of up to about 20 stimuli is displayed at the same location with a frequency of about 10 per second. The series of stimuli contains two targets of a pre-defined category (T1, T2) occurring with variable temporal lag relative to each other. If both targets have to be attentively

processed, detection accuracy for the second target (T2) is strongly impaired when it follows the first by about 200–400ms and when T1 is correctly identified [28].

II. MATERIALS AND METHODS

A. Subjects

Twenty volunteers participated in the current single-blind study. The group of subjects consisted of 9 male and 11 female, aged between 22-34 years with a mean age 23.4. All subjects were healthy, without any known medical disorder or brain damages and had normal or correct-to-normal vision. They were asked to abstain from the caffeine and alcohol on the day before the experiment.

All participants were familiarized with the experiment conditions and gave their written confirmation prior to the experiment. The local ethics committee of research on human beings approved the study protocol.

B. Method

During the experiment the rapid serial visual presentation (RSVP) sequence was presented and participants were asked to search for two target numbers. The subjects were requested to respond as accurately as they could. In case they had not seen any of the targets they had a right not to respond or if the second target was not seen the participants were giving only one answer (T1).

The experiment for a subject took place during one day. The participants were provided with the task of the test prior to the study. All the subjects performed the same experiment under the same conditions and instructions given. Subjects participated in two tests (EMF and sham conditions) and training sessions. Each test session consisted of 100 trials (RSVP sequences), training session consisted of 20 trials. There was a 15-minute break between two tests and the training session. The order of exposure conditions was counterbalanced across the subjects so that if the first session was under EMF condition, the second was sham and vice versa.

The experiment was carried out in a dimly lit sound isolated room. To avoid social stress subjects were left alone in the room during the experiment.

C. Apparatus and stimuli

Special software in the LabVIEW environment was developed for the RSVP sequence presentation on the PC monitor. All stimulus items were depicted as white letters on a dark background. The RSVP sequence consisted of eight capital letters and two target numbers (T1 and T2) presented on a black background. Letters and numbers were presented in Courier font type of 24p size. The vertical dimensions of all the stream items amounted to about 0.4° of the visual angle, observed from the subject's point of view. The fixation point was set in the middle of the computer monitor, where the stimuli appeared. T1 position varied inside the RSVP and could appear on the 3-6 serial positions (Fig. 1).

Regardless of T1 position T2 appeared always on the third serial position after the first target presentation – lag 3. On each trial, two mutually independent targets were chosen randomly from the pool of alternative numbers: 2, 3, 4, 5, 6, 7, 8, 9. The stimuli letters were randomly chosen from the following set: A, B, C, D, E, F, G, H, J, K, L, M, N, P, R, T, U, V. Numbers and letters were chosen based on the principle that if superimposed spatially with each other, the numbers could be easily discriminated and not to be confounded.

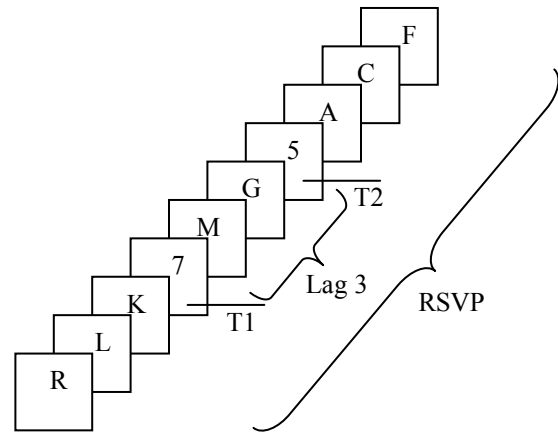


Fig. 1. Schematic diagram of the stimulus presentation

Stimulus and targets were presented for 40ms with 60ms inter stimulus interval. Participants were asked to give the answer in the window that appeared after the RSVP presentation. The responses were given by clicking two appropriate numbers on the computer keyboard and the button Enter. Thereafter, the fixation point appeared on the monitor and by clicking Enter once again the participant started the RSVP presentation. In this way the participants were free to run RSVP sequence by themselves when they were ready to follow it. Response time was not limited.

D. Microwave Exposure

The EMF exposure conditions were the same for all subjects. During each test session, the experimenter knew the exposure condition for each subject. The generator was switched on at the moment the test started and endured until the end of the session. One test session lasted about 15-20 minutes, depending on the speed of the subject's performance.

The 450MHz microwave radiation was 100% amplitude modulated by the pulse modulator at 40Hz frequency (duty cycle 50%). The 1W output power was guided by a coaxial cable to the 13cm quarter wave antenna, located 10cm from the right side of the head. Estimated by the measured calibration curves, the field power density at the skin was 0.16mW/cm², SAR was about 0.35W/kg [24].

III. RESULTS

Obtained data were statistically analyzed with a two-tailed

Student's t-test ($p < 0.05$ considered significantly different). The results were grouped into three categories regarding correct identification with regard to the order of the targets. The obtained data is presented in the Table 1. The results show that 450MHz electromagnetic field modulated at 40Hz has no clear effect on conscious perception.

TABLE 1.
THE RESULTS OF THE ATTENTIONAL BLINK TEST.
PERCENT CORRECT RECOGNITION OF TARGETS T1 AND T2
DURING ELECTROMAGNETIC FIELD ON AND OFF
CONDITIONS.

SUBJ.	FIRST TARGET DETECTED		SECOND TARGET DETECTED		BOTH TARGETS DETECTED	
	ON	OFF	ON	OFF	ON	OFF
1	83	83	48	50	46	47
2	84	86	68	67	61	65
3	88	86	75	73	74	73
4	94	86	81	74	80	73
5	98	98	85	71	85	71
6	78	81	32	29	27	27
7	100	99	90	98	90	97
8	71	72	38	41	35	38
9	85	86	73	72	71	68
10	84	98	53	75	53	74
11	94	95	93	90	91	89
12	95	97	91	82	89	80
13	83	88	46	69	45	68
14	100	98	97	96	97	96
15	88	94	81	94	81	93
16	94	99	76	92	73	91
17	100	98	97	97	97	97
18	96	99	78	79	78	79
19	93	92	90	90	89	90
20	71	73	28	39	25	31
Mean	88.95	90.4	71.0	73.9	69.35	72.35
SD	8.97	8.59	22.24	20.41	23.19	21.68
P	0.15		0.2		0.17	

IV. DISCUSSION

There are various psychophysical techniques for manipulating visual awareness, i.e. degradation of the conscious perception [29]. In our experiments we have studied the influence of EMF on two of this techniques, visual masking and attentional blink. Visual masking is a phenomenon that results in strong T2 domination over T1 during two-target recognition presented on the blank background one after another with a short inter-stimulus interval. The results of a previous study showed that EMF has an influence on the correct detection of the both stimuli [24]. In the current study we examined EMF effect on attentional blink, which showed no influence of EMF on human visual conscious perception.

The absence of the effect can be conditioned by several reasons. Attentional blink and visual masking are different techniques in design and stimulus size, but they have more similarities in the produced effect and stimulus application than any other method of the same kind. Both methods: a) imply using big variety of the stimuli; b) equally utilize central and peripheral vision; c) have weak constraints on

the exposure duration or the stimulus timing; d) result in the effect where stimuli become absent from perceptual experience; e) allow the prediction of the duration of the stimuli remaining in unawareness. Despite the prevision of the probability of the second target appearance, the repeated testing is feasible [29]. The last argument makes attentional blink method suitable for EMF effect investigation of the human visual perception as it eludes the learning effect. But despite similarities in the produced effect and advantages of attentional blink, the underlying processing mechanisms of those two methods are partly different and involve different stages of visual information processing [30-38].

In previous and present studies different exposure parameters were used, 450MHz electromagnetic field modulated at 7 Hz in the study involved masking effect and 450MHz EMF field modulated at 40Hz in the current study. The exposure conditions of the given experiment were chosen based on the previous findings of our studies. We showed that EMF effect depends on the modulation frequency and probably is stronger at higher modulation frequencies [1,5,23,24,39]. We demonstrated that EMF exposure at 7, 14 and 21Hz modulation frequencies have an effect on human EEG alpha waves and cognitive functions, but this effect is likely to be too small or on the threshold level if detection is measured. We have also found that EMF, modulated at 217Hz, causes changes in EEG signal variability and intensity for 10-20% of subjects [39]. Based on these investigations we proposed that there might exist a possible optimum modulation frequency between 7-217Hz that has more remarkable effect on human cognitive functions. Another good reason for choosing particularly 40Hz modulation frequency is proposed by Fell et al. and Kranczoch et al. who reported that gamma activity is responsible for the attentional blink [28, 40].

Differences in the methodology of two of our cognitive studies can also predetermine the absence of the effect. Font as a stimulus is simpler than face stimulus, which is reputed to be one of the most complex stimuli. This fact on the one hand lightened the task, but on the other hand the task became more complicated by the way of stimuli presentation: masking in a RSVP string is stronger than on a blank background [41].

Summing up the results of our studies it is clear that the detection of EMF effects on human cognitive functions is difficult and depends greatly on the method used [23, 24].

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