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The Effect of Ramadan Fasting on Visual Spatial Attention Through Food Stimuli

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Abstract: During the ramadan fasting, the life style of Muslims is changed by the physiological and the mental effects of fasting which are associated to altering metabolic and circadian rhythm. The present experiment for the first time looked in to the visual spatial attention affection by Ramadan fasting via behavioral and Event Related Potential (ERP) measuring for 26 participants to reveal the temporal and spatial brain activities; before-during and after-fasting periods. Besides, two factors concerning hydration and glucose level had been evaluated.

Key words: Fasting, food, spatial attention, ERP, Ramadan

INTRODUCTION

Everyday, the neural system of the human receives a lot of data from the environment but within a limited capacity to process the data as it gives attention to the mechanism of filtering and managing information (Pessoa and Ungerleider, 2004). Stimuli that are essential for survival of the human, i.e., stimuli that indicate a threat or hazard as well as stimuli that signal the availability of nutrition and sex or reward are subject to automatically attract attention. This automatically-biased attention is called ‘motivated attention’ since, it is supposed to generate from the human’s motivation to be alive and appears under the influence of motivational factor (Littel *et al*., 2012).

In addition, some reasons like restricted resources or those multi-tasking have led to focus on significant information that is determined as a very important ability. Therefore, currentexperimenthad considered the visual stimuli as a salient motivation to focus the attention on the special source as well as area or space of food.

However, through different types of fasting condition, the visual spatial attention to food as motivational stimuli displayed some changes (Ahern *et al*., 2010; Nijs *et al*., 2010; Tapper *et al*., 2010; Di Pellegrino *et al*., 2010). Majority of the studies only used food deprivation in different time interval as a non-periodic nutrition regime intended for limited time in 1 day and did not checked the intermittent fasting pattern like Ramadan fasting.

In fact, during the lunar month of Ramadan, healthy muslims abstain from eating, drinking, smoking and sexual activity in the daytime which was defined as a Ramadan fasting (Roky *et al*., 2004).

The aim of this experiment was to evaluate the altered fascination of food stimuli by attentional system during the Ramadan fasting period.

Strap task had excellently explored the food motivation effect in attentional process (MacLeod, 1991; Williams *et al*., 1996; Mogg *et al*., 1998; Placanica *et al*., 2002). But the dot-probe task is generally preferred to alternative methods in assessing cases related to attention bias (e.g., Strap tasks) as it does not rely on interference effects (Sluis and Boschen, 2014).

Moreover, the dot-probe paradigm was suggested by MacLeod *et al*. (1986). In the original method, all subjects should focus on a screen and avoid any eye movement during the experiment. The cue displayed on the left (or right) side across the screen is an exogenous task. The target that comes after the cue is placed on the opposite side of the cue. When the triggered cue (food image in the current test) and the goal appear on the same side, it is known as a congruent (valid) condition and when they appear on opposite sides, it is named as an incongruent (invalid) condition. In the dot-probe paradigm, the prediction of subject which is related to cue value and position, offers ability in a varied level of reaction time with valid (congruent) or invalid (in congruent) condition. When the reaction time is faster for congruent trials, it could be interpreted as a more fascinated attention to motivate stimuli.

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Also, measuring the Event Related Potential (ERP), besides the reaction time, could provide more details about the brain activity and the visual attention mechanism. For the 1st time, we used ERP result during dot probe to evaluate the neural mechanism of the food biased attention.

Parallel with the concern of food stimuli effect through spatial attention task, the changing measured factors of hydration and glocuse during Ramadan had been controlled to identify a more accurate effect on visual spatial attentionduring Ramadan fasting.

MATERIALS AND METHODS

Twenty six postgraduate students from Universiti Teknologi Malaysia (UTM) participated in this experiment voluntarily but after the task was completed, all students received cash reward unexpectedly to prevent any bias attitude and to avoid inducement (Vere, 1991).

The 14 males and 12 females accomplished the task completely with the mean age of 25 years old and standard deviation at 3.7. Three periods of data collection; before, during and after fasting period of Ramadan. One of the participants after fasting did not attend the test. No participants were reported to have neurological and psychiatric illness during the interview prior to experiment. All participants were signed the written consent and agreement which has been approved by research ethics committee of Universiti Teknologi Malaysia in accordance to Helsinki protocol, prior to joining the experiment.

In order to analyze the effect of fasting on attention, the experiment was carried out for one and a half hour (17:00-18:30) after 11 h of abstaining in Ramadan.

Next in order to evaluate the level of dehydration among the subjects during the test period, VAS was used (Rolls *et al*., 1980; Pross *et al*., 2013). All the subjects were assessed for their level of dehydration by crossing the thirsty level on the line scale (Rolls *et al*., 1980). The score was rated between 0 and 10. Some of the questions included looked into the feeling of thirsty, the pleasantness of drinking and feeling dry inside the mouth. The average of the score was reported as thirsty score.

Next to evaluatethe dehydration level that was developed in the test fields, Specific Gravity (SG) was measured. The specific gravity is equivalent to the mass density as dehydration increases the mass density in the body. This is the result of change in the osmolalityrate in urine (Dorner *et al*., 1984). Besides, the blood glucose rate was measured by using a glucose meter.

Dot-probe task as suggested by Loeber, 20 paired color image of food and neutral non-food were set (Nijs *et al*., 2010; Loeber *et al*., 2013). Both food and non-food stimuli were obtained from the internet data base and commercial source. All the images were formatted to similar resolution and size. In addition, around one third of trials in each block had been randomly used as a non-target (catch) trial which did not show the target. The catchtrial helped to vary the task and to decrease the monotony. Also it could be used to eliminate the effects of brain activity during the cue ERP processing (Busse and Woldorff, 2003). There solution of all images was constructed as 24-bit image. Food and non-food were displayed in both left and right sides at the same rate.

In every time period of data collection (before, during and after fasting), each participant performed the experiment in 4 runs where each trial was continued for almost 4.1 min. Each run included 92 trials which consisted of 16 repetitions of 4 target trials and 14 repetitions of 2 non-target trials (catch trials).

The experimental process was begun with 100 msec crosse logo in the center of the screen and it was continued by displaying two cue images in the right and the left sides of the center point. These pictures remained for 100 msec in short Stimulus Onset Asynchrony (SOA) or 500 msec in long SOA tomaintain spatial attention. The first and the second runs of the current test applied short SOA while the third and the fourth runs employed long SOA. After this section (displaying food and non-food images simultaneously), the target (food or non-food) was enclosed by a purple frame. For 1000 msec, the computer waited to receive the signal for left or right push-button which should be compatible with the target side. When the participants pushed the key or 1000 msec period ended, the next trial was begun until the end of the run.

Furthermore as suggested in previous studies, the images were displayed on the upper visual side (Sun *et al*., 2012).

Before the test started, all the subjects were reminded to join the test attentively and focused on the fixation point as well as to press the target side button ("D" for left and "F" for right) within the minimum time during each trial. Reaction time and EEG for all participants were recorded during the dot-probe test (Mogg *et al*., 1998; Castellanos *et al*., 2009). The acceptable interval reaction was between 200 and 900 msec and those exceeded that range were removed from the results. Besides, participants who committed 30% error were disqualified as experimental participants. The EEG acquisition was carried out with an EEG-9100 nihone kohden and the software was EEG-1000/9000 Acquisition Program.

This device had a 19-channel standard electrode cap with Ag/Ag Cl electrodes. The electroence phalogram for each electrode was recorded at 1 kHz sampling rate. The analysis was done with Eeglab version: 13.4.4b and Erplab version: 4.0.3.1. The target trials were categorized into 4 bins: (2 congruencies: food and non-food) x (2 target visual fields: left and right). Moreover, the catch trials were divided into 2 bins (2 congruencies: food and non-food).

The original brain waves were filtered by using band passed filter (0.01-45 Hz) and had an epoch in the range of 200-800 msec based on target onset where the data between 200 and 0 msec were set as baseline. Besides, manual eye inspection with automatic rejection for amplitude exceeding 50 μV was applied to the epoched data which rejected about 5.6% of the total data.

The epoched data, after artifact rejection were considered to be clean data for further analyses. Based on previous studies and the current results (Leland and Pineda, 2006; Nijs *et al*., 2010), two components of ERP; P1 (115-145 msec) and P3 (340-380 msec) had been looked into. Besides, data obtained from those two ERP components were then analyzed by repeated measures of ANOVAs with 3 factors (fasting, not-fasting) x (congruency: food, non-food) x (visual target field: left, right) through two short and long SOA categories.

RESULTS AND DISCUSSION

In order to elucidate the effects of fasting, two comparisons were made; before-fasting versus during fasting and after-fasting versus during-fasting. As explained above, before-fasting reflected the data taken before the month of Ramadan while during-fasting referred to those taken in the month of Ramadan and after fasting had been those taken after the month of Ramadan. From here on before-fasting versus during-fasting is designated as step 1 whereas after-fasting versus during fasting as step 2.

- Step 1: collected data from 26 participants to be evaluated and compared
- Step 2: retrieved data from 25 participants

The repeated measures of ANOVA showed that the measured glucose level decreased during Ramadan fasting compared to before and after Ramadan.

- Step 1: before = 86.90, during = 82.50, $F (1.25) = 3.128$, $p = 0.089$
- Step 2: during = 82.90, after = 87.50 , $F (1.24) = 4.197$, $p = 0.052$)

The urinary specific gravity test results of the subjects were analyzed by repeating the measuring ANOVAs. It showed that the level of urinary specific gravity for dehydration state increased significantly during the Ramadan fasting period in comparison to thatfor before and after the fasting period during Ramadan.

- Step 1: before = 1009, during = 1019, $F (1.25) = 21.966$, $p<0.01$
- Step 2: during = 1019, after = 1011, $F (1.24) = 15.474$, $p = 0.001$)

Behavior results: The reaction time was analyzed via repeated measures of ANOVA for 2 factors (fasting and non-fasting) x (congruencies: food and non-food) through two short SOA and long SOA categories in both steps respectively (Table 1).

When the short SOA category was considered, two significant effects in both steps were revealed. For more details, during step 1 (before-fasting vs. fasting), the results of dot-probe test indicated that the congruency factor was significantly faster to food image stimuli rather than non-food fasting. Congruency, short SOA:

- Step 1: $F (1.25) = 418.735$, $p<0.001$
- Step 2: $F (1.24) = 399.498$, $p<0.001$

In addition, the interaction between congruency and fasting factors was significant. In fact, the post hoc analyses by using the Bonferroni correction revealed slower reaction to non-food stimuli and faster reaction time to food stimuli as recorded during fasting period rather than before fasting period. Congruency x fasting, short SOA:

Table 1: Dot-probe reaction time

	Short SOA				Long SOA			
	Food		None food		Food		None food	
Parameters	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre-fasting	427.72	29.44	452.17	28.30	396.20	15.51	396.29	13.57
During fasting	424.17	31.11	458.44	29.74	398.79	14.02	403.26	16.82
Post-fasting	429.31	22.70	452.77	19.88	389.59	18.08	394.66	21.26

- Step 1: $F(1.25) = 8.012$, $p = 0.009$
- Step 2: $F(1.24) = 8.855$, $p = 0.007$

On the other hand when the reaction time was looked into during step 2 (the period of fasting and after-fasting), the variables acknowledged similar effects with those before the fasting period.

Moreover, the congruency factor displayed the main significant effect on reaction time with faster reaction time to the food stimuli rather than the non-food stimuli. Congruency, long SOA:

- Step 1: $F(1.25) = 1.384$, $p = 0.251$
- Step 2: $F(1.24) = 3.492$, $p = 0.074$

In addition, the interaction between fasting and congruency was found to be significant as the post hoc analyses via Bonferroni correction revealed faster Reaction time on food stimuli but slower reaction time towards non-food stimuli which was reported during Ramadan fasting in comparison to after fasting period. Congruency x fasting, long SOA:

- Step 1: $F(1.25) = 1.308$, $p = 0.264$
- Step 2: $F(1.24) = 0.137$, $p = 0.715$

When the repeated measures of ANOVA were applied on long SOA category, the significant effect of congruency and its interaction with fasting factor was removed in both step 1 and 2.

The bias favoring food picture effect which was evaluated by using (difference between reaction time for non-food and reaction time forfood) showed more fascinating attention to food stimuli (Brignell *et al*., 2009; Nijs *et al*., 2010).

Likewise, the significant correlation between glucose rate and bias favoring food reaction time with Pearson product-moment correlation coefficient ($r = -0.780$, $p<0.01$) as well as Spearman's rank correlation coefficient ($r = -0.773$, $p<0.01$) had been found in the short SOA category.

Moreover, this coefficient had been found to be significant between food liking rate and bias favoring food reaction time with Spearman's rank correlation coefficient ($r = 0.301$, $p = 0.004$). Besides, the Pearson product-moment correlation coefficient was reported to be significant with less value than that of glucose rate ($r = 0.304$, $p = 0.003$).

When the dot-probe was applied along SOA, the repeated measures of ANOVAs showed that all the correlation between bias favoring food reaction time and glucose rate as well as food liking rate had been evacuated.

ERP results: During the period of test through applying the dot-probe, the ERP was evaluated before, during and after Ramadan for three times which had been locked on the target onset.

By referring to the resultsobtained from previous researches (Leland and Pineda, 2006; Nijs *et al*., 2010). The researchers focused on two major and important ERP components which were P1 (115-145 msec) and P3 (340-380 msec). Based on the results, P1 was activated over the parieto-occipital electrodes (O1, O2, P3 and P4), whereas P3 was activated over the Centro-parietal electrodes (Cz, Pz, P3 and P4) (Fig. 1 and 2).

The ERP analysis on the factors of fasting (fasting and non-fasting), congruency (food and non-food), target (right and left visual fields), through two short SOA and long SOA categories had been conducted via the repeated measures of ANOVAs in step 1 (before fasting and after fasting) as well as step 2 (while fasting and after fasting). The ANOVA result is shown in Table 2.

Besides, utilizing the repeated ANOVAs over the interval time of 115-145 msec at the occipital area indicated a significant main effect of emotional facial stimuli through

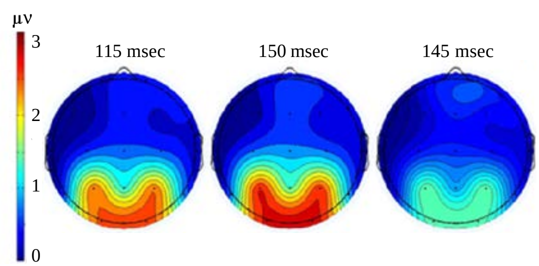

Fig. 1: The topography of scalp during first positive peak (P1) by target onset. It represented the P1 component (115 to 145 msec) which was activated more over parieto-occipital electrodes (O1, O2, P3, P4)

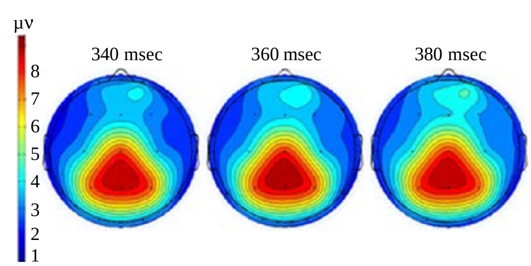

Fig. 2: The topography of scalp during second positive peak (P3) by target onset. It illustrated the P3 component (340-380 msec) which was activated more over centro-parietal electrodes (Cz and Pz electrodes)

Table 2: The repeated measures ANOVA result for ERP components

				Step 1		Step 2	
Components	SOA	Effects	Electrode	F-test	p-values	F-test	p-values
P1	Short	Congruency	O1	35.880	<0.01	31.916	<0.01
			O2	35.508	<0.01	<0.010	<0.01
			P3	39.016	<0.01	34.238	<0.01
			P4	40.766	<0.01	38.905	<0.01
		Fasting×Congruency	O1	28.809	<0.01	28.343	<0.01
			O2	28.940	<0.01	21.376	<0.01
			P3	28.510	<0.01	30.102	<0.01
			P4	35.723	<0.01	30.545	<0.01
P3	Short	Congruency	Cz	46.606	<0.01	37.540	<0.01
			Pz	32.152	<0.01	28.459	<0.01
			P3	35.710	<0.01	31.989	<0.01
			P4	31.285	<0.01	29.844	<0.01
			Cz	35.147	<0.01	43.849	<0.01
			Pz	31.767	<0.01	7.932	<0.01
			P3	27.913	<0.01	27.099	<0.01
			P4	26.377	<0.01	21.852	<0.01
	Long	Congruency	Cz	43.534	<0.01	42.272	<0.01
			Pz	38.506	<0.01	34.171	<0.01
			P3	38.550	<0.01	34.449	<0.01
			P4	36.757	<0.01	34.933	<0.01
		Fasting x congruency	Cz	27.811	<0.01	27.540	<0.01
			Pz	31.723	<0.01	31.378	<0.01
			P3	32.141	<0.01	32.817	<0.01
			P4	34.055	<0.01	31.267	<0.01

P1 component. In conducting the analysis, the target visual field was divided into contralateral and ipsilateral based on the positions of the electrodes.

As for congruency effect, the P1-amplitude exposed greater significant value for food stimuli in brain activity when the short SOA was applied in both steps over P3, P4, O1 and O2 electrodes compared to those for non-food stimuli. Besides, for the congruency effect, the position of the target visual field was affected by the P1-amplitude contralateral where P1-amplitude was greater as the target appeared at the contralateral visual view. P1-amplitude at O1 and P3 had been greater when the target was on the right-visual view rather than the left-visual view whereas at O2 and P4, it happened reversely. On the other hand as for the short SOA, the interaction between fasting and congruency had been found to be significant. Hence, Post hoc analyses using Bonferroni correction revealed in regard to this interaction that bigger P1-apmlitude accompanied by food stimuli and smaller P1-apmlitude accompanied by non-food stimuli had been recorded during fasting (in oppose tonon-fasting period) in both steps over O1, O2, P3 and P4 electrodes (Fig. 3).

In addition when long SOA in the experiment was applied, the significant effect of contralateral food congruency and its interaction with fasting factor had been evacuated.

Furthermore, when the ERP data were analyzed via repeated measures of ANOVA, four electrodes; Cz, Pz, P3 and P4, exhibited repeated pattern over congruency factor and its interaction with fasting period.

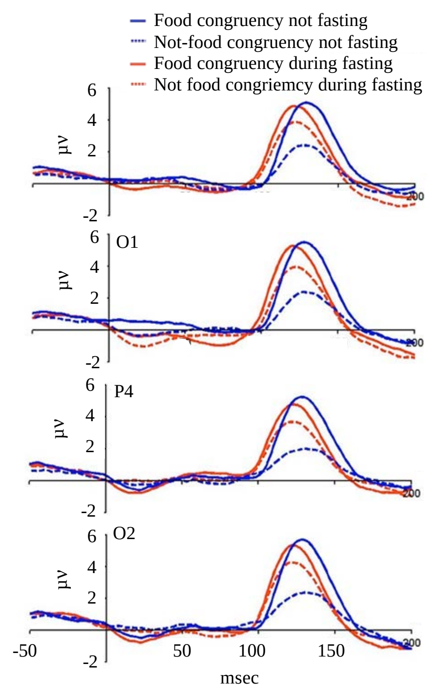

Fig. 3: The P1 component for both food and not food stimuli, fasting vs. not-fasting in short SOA. It was represented the ERP from occipital area electrodes (O1, P3, O2, P4). The maximum response to food stimuli and minimum response to not food stimuli for P1component amplitude was during Ramadan fasting period

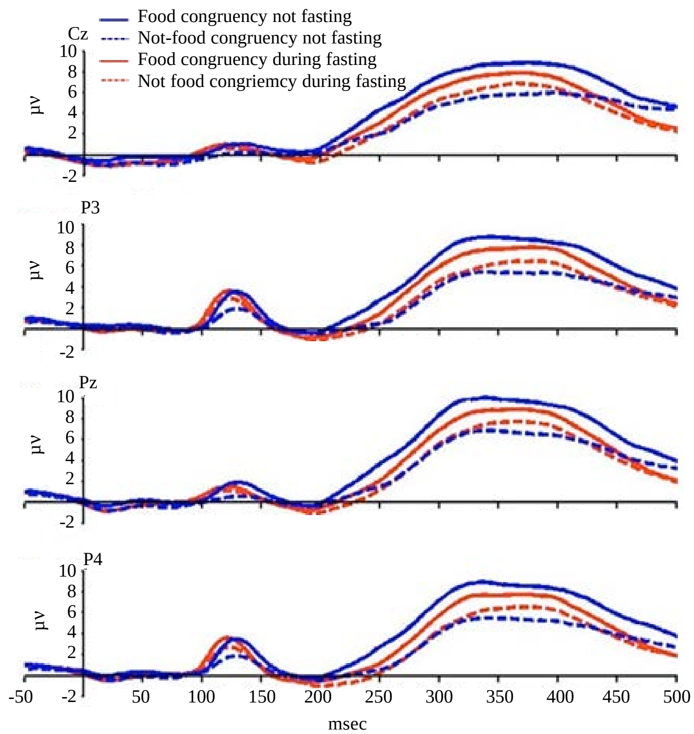

Fig. 4: The P3 component for both food and not food stimuli, fasting vs. not fasting in short SOA. It was represented the ERP from centro-parietal area electrodes (Cz, Pz, P3, P4). The maximum response to food stimuli and minimum response to not food stimuli for P3 component amplitude was during Ramadan fasting period

Furthermore, the P3 component amplitude exposed significantly bigger amplitude value for food stimuli when the short SOA was applied in both steps over the Centro-parietal area (Cz, Pz, P3, P4 electrodes) compared to that for non-food stimuli.

Moreover, the interaction between fasting and congruency had been significant through short SOA. Post hoc analyses using Bonferroni correction showed in regard to between fasting and congruency that greater P3 component amplitude accompanied by food stimuli and smaller P3 component amplitude accompanied by non-food stimuli had been recorded during the fasting period in comparison to that for non-fasting period over Cz, Pz, P3 and P4 electrodes in both step 1 and 2 (Fig. 4).

Meanwhile, for long SOA, the common main effect of congruency and its interaction with fasting factor displayed similar trend to that of short SOA between Cz, Pz, P3 and p4 electrodes as the steps were repeated significantly in both steps. Please refer to Fig. 5 for more details.

Finally, for short SOA, the decreased urinary specific gravity level during the fasting period in comparison to that of non-fasting period, revealed a significant correlation by reducing the averaged P1 amplitude among P3, P4, O1 and O2 which was accompanied by non-food stimuli during fasting period in comparison to non-fasting period in both steps.

- Step 1: Spearman's rho: ($r = -0.708$, $p<0.01$); Pearson's r: ($r = -0.633$, $p = 0.01$)
- Step 2: Spearman's rho ($r = -0.508$, $p = 0.01$); Pearson's r: ($r = -0.671$, $p = p<0.01$)

This research was carried out to evaluate the effects of intermittent Ramadan fasting on spatial attention. Generally, the metabolism of carbohydrate within a limited time (around 8-16 h) of fasting isexplained below (D 2001).

Inthe initial stage of fasting, some hours after fasting, the glucose level of blood decreases.To maintain the glucose rate, after sending chemical signal with rising of glucagon, falling of the insulin and sympathetic nervous activity, the regulation process takes place. In long term fasting, after 13-21 h of food intake there is another source of energy production the gluconeogenesis process (D 2001).

Thus, a published research suggested that the adaptation to repeat fasting/re-feedingcould develop a greater capacity to store, spare and perhaps, manufacture carbohydrate in the liver (Stannard, 2011). The researches

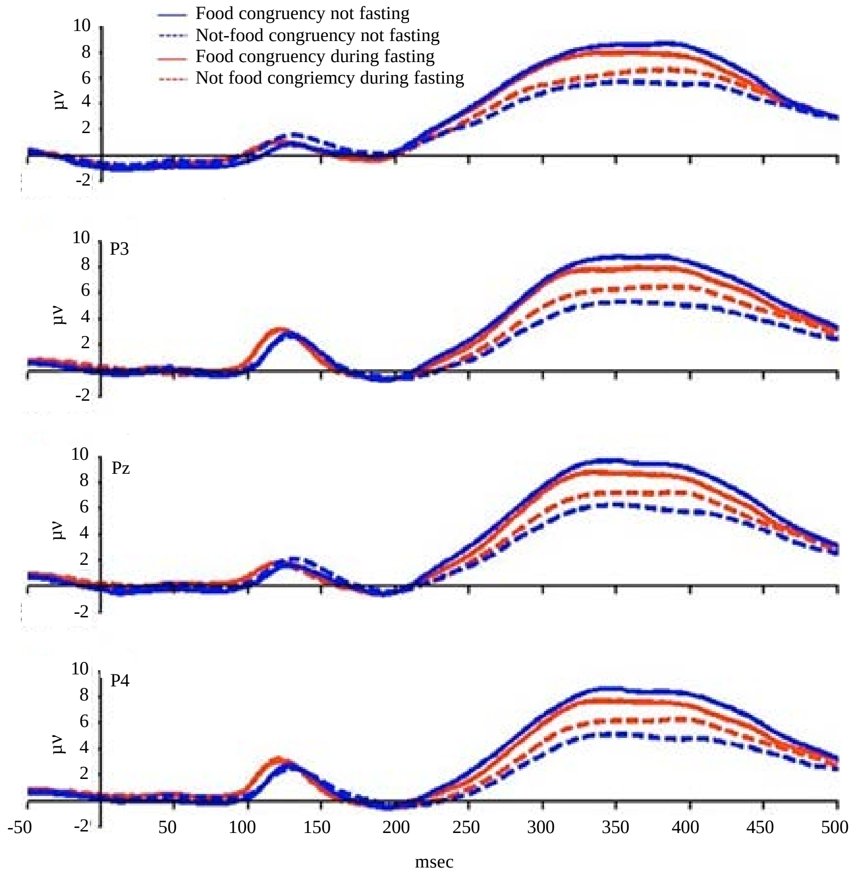

Fig. 5: The P3 component for both food and not food stimuli, fasting vs. not-fasting in long SOA. It was represented the ERP from centro-parietal area electrodes (Cz, Pz, P3, P4). The maximum response to food stimuli and minimum response to not food stimuli for P3 component amplitude was during Ramadan fasting period

in this area have illustrated that the glucose level, however, moderately decreases in the first few days during intermittent fasting but it maintains and does not change significantly in the rest of the fasting period or altered negligibly (Azizi and Rasouli, 1987; Temizhan *et al*., 2000; Gillian, 2006; Boroujeni *et al*., 2011). In this experiment, the glucose levelwas not reduced tremendously. This was indicted in the same adaptation process.

Consequently, measuring the urine concentration can be employed for measuring dehydration. By considering the effect of fasting on hydration during the fasting period, the rate of osmolality during fasting period rose and the amount of output urine decreased (Mustafa *et al*., 1978; Cheah *et al*., 1990; Shirreffs, 2003).

From the results obtained, the level of urine specific gravity was increased specifically. This is confirmed from the view of previous researches (Leiper and Molla, 2003). In accordance with the aim of this research it evaluated if the normal subjects for intermittent fasting during Ramadan could modulate the attention towards food stimuli.

By measuring the reaction time, the interaction between "fasting" and "food congruency" through to maximum delayed reaction time for non-food visual stimuli and minimum delayed reaction time for food visual stimuli during Ramadan fasting period in comparison to non-fasting period was significant.

Dehydration displayed a direct effect on brain activity. The correlation between reduced P1 ERP and increased dehydration during Ramadan illustrated the critical rule of dehydration level on visual brain processing during the experiment and the cognitive neural performance.

Some previous studies which considered the effect of dehydration, confirmed the current result. Patel *et al*. (2007) reported that mild dehydration influenced the self-reported of concussion problem and self-reported fatigue rate (Patel *et al*., 2007).

In addition, the current research supports the hypothesis that visual food stimuli biased the attention of normal fasting participants during Ramadan. The bias interaction between "fasting" and "food congruency" was significant when the food stimuli produced larger P1 during the fasting period.

Hence, the P1 alterationcan be interpreted by two approaches. First, the significantly higher p1 amplitude and faster RT inshort SOA for food stimuli than that for neutral and evacuating this effect during long SOA could be explained through the inhibition of return "IOR" during the visual process. IOR is defined as the orientation mechanism that briefly enhances (SOA 100-300 msec) the speed and the accuracy with which an object is detected after the object is attended but then impairs detection speed and accuracy (for SOA 500-3000 msec). This determines the automatic nature of spatial food biased stimuli during the test. Previously, 3 studies provided some evidence about this automatic process just with behavior data and nil ERP analysis (Castellanos *et al*., 2009; Nijs *et al*., 2010; Loeber *et al*., 2013). So in the first approach, the automatic mechanism of motivation was assessed. Accordingly, P1 as an early positive evoked ERP signal that maximized close to 100 msec is supposed to signify the automatic attention process (Brosch *et al*., 2008) for fearful stimuli.

Second, the effect of motivational system was illustrated during the visual spatial attention task. It is in agreement with this fact that P1 peak was modulated duringthe motivational task. By definition which considered that the motivation is the mechanism to detect the valuable threats (e.g., dangerous and fear full stimuli) and resources (e.g., nutrition or drug addicted motivation), the test output indexed that the P1 modulation was generated by motivational stimuli. Consequently, another study showed that the P1 on the locations Pz and Oz, enhanced amplitude and also illustrated the IOR for smoking (addicted) stimuli. Thus, the lexical nutrition stimuli modulated the P1 and offered evidence of IOR for foodword stimuli (Leland and Pineda, 2006). Also, visual fearful stimuli triggered P1 and showed that the early modulation of spatial attention had been related to fear-relevant stimuli (Compton, 2003).

During the current visual experiment, the next component that was influenced by the congruency factor effect was the third positive peak (P3). The P3 showed that the interaction between "food congruency" and "fasting" factors was evidenced at around 340-400 msec after the target was on set.

The previous reports which confirmed the results obtained concerning this component, displayed positive peak at around 300-360 msec in the centro-parietal area for food stimuli during non-spatial task (Stockburger *et al*., 2009). Furthermore, this study reported a delayed time interval (450-600 msec) for enlarged amplitudes of the Late Positive Potential (LPP) by nutrition images.

Simultaneously, our experiment and the results obtained by Little *et al*. (2012) showed that P3 and LPP were influenced by motivation. The P3 and LPP had been more related to cognitive and voluntary processes. Besides, long latency of ERP with more delayed time than 300 msec indicated maintained attention, memory feature storage and meaning extraction (Schupp *et al*., 2006; Hajcak *et al*., 2010). Those are signs of voluntary and cognitive functions as a top-down mechanism (Olofsson *et al*., 2008). This declared that even though the motivation is an evolutionary relevant mechanism that follows the automatic manner, it could be related to cognitive and involuntary processes.

Moreover in our spatial task, most of the ERP activation had been recorded over the posterior side of the scalp. This is in agreement with a recent FMRI research.

Furthermore, Posterior Cingulated showed involvement in the procedure of visuospatial attention to cues when predicting the target position (Hopfinger *et al*., 2000; Small *et al*., 2003). It was reported that there was a positive correlation between Posterior Cingulated activation and anticipatory spatial attention shifting which was elicited by monetary incentives (Small *et al*., 2003, 2005).

In comparison with the prediction of a previous study by Loeber *et al*. (2013) which claimed that the food-biased attention could be affected by energy-based mechanism this experiment revealed a surprising result. The balancing energy seems to be adapted by religious fasting condition. Moreover, the level of glucose did not change sharply significant between the fasting and the non-fasting periods. It found that however the energy-based system with marginally significant alteration during Ramadan had been adapted to the fasting condition. Nonetheless, bias to food images responses through RT significantly changed during the Ramadan fasting period. This was confirmed by ERP results where P1 and P3 components showed bias to food images during Ramadan.

Food liking which increased significantly during the Ramadan fasting period could provide the answer. The correlation between the food liking scales as a food reward component and bias-favoring food as well as reaction time as a biased food attention factor, could interpret that the rewarding mechanism plays a critical rule in significantly faster responses to food images during the fasting period. So both food liking and biased food attention showed significant alteration level during Ramadan.

In addition, the simultaneous correlation of food liking rate and glucose level with bias-favoring food showed a close link between these two different systems (energy system and rewarding system). Accordingly to Loeber hunger and palatability rates might be related to two different processes with regard to the control of food intake. These are homeostatic energy regulation and food rewarding mechanism. However, in agreement with previous research, more correlation (due to stronger correlation coefficient) between glucose rate and biased-favoring food reaction time in comparison to food liking scale and biased-favoring food reaction had been reported. Thus, one could declare a more effective rule of energy regulation system to induce the food attention for the dot-probe paradigm.

CONCLUSION

The results proved that hydration rate were changed significantly during the Ramadan ($p<0.05$). Also, the findings illustrated that the Ramadan fasting biased the visual food attention which were supported by P1 and P3 as an ERP evidence and RT as a behavioral result through both automatically and involuntary mechanisms. However, the correlation between glucose rate and biased visual food attention declared the more effective rule of energy regulation system in the dot-probe paradigm. Nevertheless, the results revealed that the highly significant increase in visual food attention during Ramadan had been more related to food reward than energy regulation system.

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REFERENCES

Ahern, A.L., M. Field, S. Yokum, C. Bohon and E. Stice, 2010. Relation of dietary restraint scores to cognitive biases and reward sensitivity. Appetite, 55: 61-68.

Azizi, F. and H.A. Rasouli, 1987. Erum glucose, bilirubin, calcium, phosphorus, protein and albumin concentrations during Ramadan. Med. J. IR. Iran, 1: 38-41.

Boroujeni, J., M.S. Behradmanesh, S. Kheiri, J. Nasiri and M. Fayazi, 2011. Effect of ramadan fasting on blood glucose levels and continues performance test (CPT). J. Shahrekord Univ. Med. Sci., 12: 41-48.

Brignell, C., T. Griffiths, B.P. Bradley and K. Mogg, 2009. Attentional and approach biases for pictorial food cues. Influence External Eating Appetite, 52: 299-306.

Brosch, T., D. Sander, G. Pourtois and K.R. Scherer, 2008. Beyond fear rapid spatial orienting toward positive emotional stimuli. Psychol. sci., 19: 362-370.

Busse, L. and M.G. Woldorff, 2003. The ERP omitted stimulus response to no-stim events and its implications for fast-rate event-related fMRI designs. Neuroimage, 18: 856-864.

Castellanos, E.H., E. Charboneau, M.S. Dietrich, S. Park, B.P. Bradley, K. Mogg and R.L. Cowan, 2009. Obese adults have visual attention bias for food cue images: evidence for altered reward system function. Int. J. Obesity, 33: 1063-1073.

Cheah, S.H., S.L. Change, R. Hussein and M.T. Ducan, 1990. Effects of fasting during Ramadan on urinary excretion in Malaysian Muslims. Br. J. Nutr., 63: 329-337.

Compton, R.J., 2003. The interface between emotion and attention: A review of evidence from psychology and neuroscience. Behav. Cogn. Neurosci. Rev., 2: 115-129.

Di Pellegrino, G., S. Magarelli and F. Mengarelli, 2010. Food pleasantness affects visual selective attention. Q. J. Exp. Psychol, 64: 560-571.

Dorner, K., R. Campos and S. Bornsen, 1984. Further evaluation of the SG test strip for estimation of urinary osmolality. Clin. Chem. Lab. Med., 22: 419-426.

Gillian P.C.D., 2006. The Regulation of Plasma Glucose: Human Physiology. Oxford University Press, NewYork, USA., 545.

Hajcak, G., A. MacNamara, D.M. Olvet, 2010. Event-related potentials, emotion and emotion regulation: an integrative review. Dev. Neuropsychol., 35: 129-155.

Hopfinger, J. B., M.H. Buonocore, and G.R. Mangun, 2000. The neural mechanisms of top-down attentional control. Nat. neurosci., 3: 284-291.

Leiper, J.B. and A.M. Molla, 2003. Effects on health of fluid restriction during fasting in ramadan. Eur. J. clin. Nutr., 57: 30-38.

Leland, D.S. and J.A. Pineda, 2006. Effects of food-related stimuli on visual spatial attention in fasting and nonfasting normal subjects. Behave. electrophysiol. Clin. Neurophysiology, 117: 67-84.

Littel, M., A.S. Euser, M.R. Munafo and I.H. Franken, 2012. Electrophysiological indices of biased cognitive processing of substance-related cues: A meta-analysis. Neurosci. Biobehav. Rev., 36: 1803-1816.

Loeber, S.M. Grosshans, S. Herpertz, F. Kiefer and S.C. Herpertz, 2013. Hunger modulates behavioral disinhibition and attention allocation to food-associated cues in normal-weight controls. Appetite, 71: 32-39.

MacLeod, C., A. Mathews and P. Tata, 1986. Attentional bias in emotional disorders. J. Abnormal Psychol., 95: 15-20.

MacLeod, C.M., 1991. Half a century of research on the stroop effect: an integrative review. Psychological bull., 109: 163-203.

Mogg, K., B.P. Bradley, H. Hyare and S. Lee, 1998. Selective attention to food-related stimuli in hunger: are attentional biases specific to emotional and psychopathological states or are they also found in normal drive states?. Behav. Res. Ther., 36: 227-237.

Mustafa, K.Y., N.A. Mahmoud, K.A. Gumaa and A.M. Gader, 1978. The effects of fasting in Ramadan. 2: Fluid and electrolyte balance. Br. J. Nutr., 40: 583-589.

Nijs, I.M.T., P. Muris, A.S. Euser and I.H.A. Franken, 2010. Differences in attention to food and food intake between overweight/obese and normal-weight females under conditions of hunger and satiety Appetite, 54: 243-254.

Olofsson, J.K., S. Nordin, H. Sequeira and J. Polich, 2008. Affective picture processing: an integrative review of ERP findings. Biol. Psychol., 77: 247-265.

Patel, A.V., J.P. Mihalik, A.J. Notebaert, K.M. Guskiewicz and W.E. Prentice, 2007. Neuropsychological performance, postural stability, and symptoms after dehydration. J. Athl. Train., 42: 66-75.

Pessoa, L. and L.G. Ungerleider, 2004. Neuroimaging studies of attention and the processing of emotion-laden stimuli. Prog. Brain Res., 144: 171-182.

Placanica, J.L., G.J. Faunce and R.F.S. Job, 2002. The effect of fasting on attentional biases for food and body shape/weight words in high and low eating disorder inventory scorers. Int. J. Eating Disorders, 32 : 79-90.

Pross, N., A. Demazieres, N. Girard, R. Barnouin and F. Santoro *et al*., 2013. Influence of progressive fluid restriction on mood and physiological markers of dehydration in women. Br. J. Nutr., 109: 313-321.

Roky, R., I. Houti, S. Moussamih, S. Qotbi and N. Aadil, 2004. Physiological and chronobiological changes during ramadan intermittent fasting. Ann. Nutr. Metab., 48: 296-303.

Rolls, B.J., R.J. Wood, E.T. Rolls, H. Lind and W. Lind *et al*., 1980. Thirst following water deprivation in humans. Am. J. Physiol. Regul. Integr. Comp. Physiol., 239: R476-R482.

Schupp, H.T., T. Flaisch, J. Stockburger and M. Junghofer, 2006. Emotion and attention: Event-related brain potential studies. Prog. Brain Res., 156: 31-51.

Shirreffs, S.M., 2003. Markers of hydration status. Eur. J. Clin. Nutr., 57: S6-S9.

Sluis, R.A. and M.J. Boschen, 2014. Fear of evaluation in social anxiety: Mediation of attentional bias to human faces. J. Behav. Ther. Exp. Psychiatry, 45: 475-483.

Small, D.M., D. Gitelman, K. Simmons, S.M. Bloise and T. Parrish *et al*., 2005. Monetary incentives enhance processing in brain regions mediating top-down control of attention. Cereb. Cortex, 15: 1855-1865.

Small, D.M., D.R. Gitelman, M.D. Gregory, A.C. Nobre and T.B. Parrish *et al*., 2003. The posterior cingulate and medial prefrontal cortex mediate the anticipatory allocation of spatial attention. Neuroimage, 18: 633-641.

Stannard, S.R., 2011. Ramadan and its effect on fuel selection during exercise and following exercise training. Asian J. Sports Med., 2: 127-133.

Stockburger, J., R. Schmalzle, T. Flaisch, F. Bublatzky and H.T. Schupp, 2009. The impact of hunger on food cue processing: An event-related brain potential study. Neuroimage, 47: 1819-1829.

Sun, J., B. Sun, B. Wang and H. Gong, 2012. The processing bias for threatening cues revealed by event-related potential and event-related oscillation analyses. Neurosci., 203: 91-98.

Tapper, K., E.M. Pothos and A.D. Lawrence, 2010. Feast your eyes: Hunger and trait reward drive predict attentional bias for food cues. Emotion, 10: 949-954.

Temizhan, A., I. Tandogan, O. Donderici and B. Demirbas, 2000. The effects of Ramadan fasting on blood lipid levels. Am. J. Med., 109: 341-342.

Vere, D.W., 1991. Payments to healthy volunteers-ethical problems. Br. J. Clin. Pharmacol., 32: 141-142.

Williams, J.M.G., A. Mathews and C. MacLeod, 1996. The emotional stroop task and psychopathology. Psychol. Bull., 120: 3-24.