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Comparison of attention in females before and after puberty and during menopause

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ABSTRACT

Objective: Due to the presence of estrogen and progesterone receptors in the brain this study is to evaluate the hypothesis that sexuality changes during the menstrual cycle and accompanied with aging in females have some effects on attention.
Materials and methods: 17 immature-girls, 15 young-adult women with regular menstrual cycles and 17 postmenopausal-women were studied here. Cognitive tests of Stroop and ANT performed three times for young-adults at early follicular, ovulation and mid-luteal phases respectively and for both the immature-girls and postmenopausal-women only in one session. Serum levels of sex-related hormones were measured after each session.
Results: Interference scores of postmenopausal-women and immature-girls in the Stroop test were significantly higher than the young-adults in different phases. Function of alerting-network was significantly weaker for immature-girls than the other groups, however, in orienting-network; there weren't significant difference between the groups. Function of executive control network was significantly poorer in immature-girls and it was significantly better in mid-luteal phase of young-adults than in the others. The serum levels of progesterone, LH and FSH were significantly higher in the postmenopausal-women than the other groups. Serum levels of estradiol were significantly less in the immature-girls than the other groups.
Conclusions: Low levels of estrogen in immature-girls maybe associated with reduced attention in the Stroop test and decreased performance of executive control network in the attentional network tests. Also, low levels of estrogen and high levels of LH and FSH in the post-menopausal women seems to have effects on the attention performance in the Stroop test.

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1. Introduction

Extensive studies on sexuality differences in cognitive abilities suggest that women perform consistently better than men on tasks of verbal-related ability such as memory recall and fluency, whereas men perform better than women on spatial ability related tasks (Hatta & Nagaya, 2009). The research has shown that there are differences in performance between male and female brains, which can lead to differences in the functions of Neuropsychology (Casey, 1996). In this regard, Kimura (1996) proposed a model that explains why there is a sex difference in cognitive abilities. Kimura's model is sometimes called the "sex-related hormone theory" and the main points are that most of the sexually differentiated functions are strongly influenced by the amount of hormonal secretion, while the role of estrogen is critical in verbal ability and perceptual speed (Hatta & Nagaya, 2009). Many researchers who are interested in cerebral functional asymmetry have reported findings that cognitive performance in women appears to be modulated by the fluctuation of sex related hormone levels over the menstrual cycle (Hausmann & Gunturkun, 2000; Heister, Landis, Regard, & Schroeder-Heister, 1989). In part from the studies on the relation between sex-related hormones and functional cerebral asymmetry, researchers examined sex-related developmental changes in cognitive abilities that relate to prefrontal cortex function in middle-aged and elderly people (Munro et al., 2012). The findings showed that the sex difference in cognitive abilities does not remain stable throughout human life, especially in women, and strongly suggest that biological factors, such as sex-related hormones that contribute to prefrontal cortex function, seem to be related to age-related sex differences (Taketani & Maehara, 2001). The findings also indicate that sex-related hormones might have different effects depending on the

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type of cognitive abilities such as attention, memory, and verbal fluency (Hatta & Nagaya, 2009). Physiological fluctuations in sex hormone levels during the menstrual cycle can serve as a valuable tool for non-invasive studies of the cognitive effects of sex hormones, particularly estrogen (Pompili, Arnone, & Gasbarri, 2012). According to the fluctuation of ovarian hormone at different phases of the menstrual cycle, and changes in the secretion of these hormones with aging, especially after menopause, it prompts us to present a hypothesis in which changes in sexual performance have effects on the attention throughout women life and aging, seems that it is possible to examine this hypothesis in which aging especially in the menopausal period has negative effects on the different levels of attention.

2. Methods

In this study, 42 people in three groups were participated. The first group consisted of 17 healthy immature girls ranging from 9 to 11 years old (9.4 ± 0.87) whose menstrual cycles are not observed, volunteered to participate in this experiment.

The second group consisted of 15 healthy women ranging from 20 to 25 years old (21.8 ± 1.6), with regular menstrual cycles (26–30 days), volunteered to participate in this experiment.

The third group consisted of 17 healthy postmenopausal women ranging from 45 to 55 years old (52.3 ± 1.6), volunteered to participate in this experiment. All persons were none used oral contraceptives, hormonal replacement, or any other medication that could influence the central nervous system.

2.1. Stroop test

The Stroop test is employed to evaluate the attention and information processing speed (Macleod, 1991; Macleod & Macdonald, 2000). In this test, participant are required to name the color of words (red, yellow, blue and green) that are shown in colors incongruent to the name of the color.

In this study, the computer classic Stroop test is presented by Salehi Fadardi and Ziaei (2010) for Persian users (Salehi Fadardi & Ziaei, 2010).

2.2. Attention network test

The original Attention Network Test (ANT) was presented by Fan et al. (2002) (Fan, Mccandliss, Sommer, Raz, & Posner, 2002; Ishigami & Klein, 2010). ANT is a suitable behavioural test in neuropsychology researches and it is designed to evaluate the different levels of attention network including alerting, orienting and executive control within a single 30-min testing session (Hahn et al., 2011). ANT is a combination of "Cued Reaction Time" and Flanker task (Fan et al., 2002). The ANT involves viewing a sequence of visual cues, arrows and responding to the direction of a central arrow (Brunye, Mahoney, Lieberman, & Taylor, 2010).

At the beginning of session 1, the participants were given the instructions for the two cognitive tests. The second group of participants (young adult women with regular menstrual cycles) were tested three times: the early follicular phase (cycle day 2–3), ovulatory phase (cycle day 14) and mid-luteal phase (cycle day 21–22). All three testing sessions were conducted at the same time between 10 am to 2 pm to possibly decrease the potential effects of circadian rhythm upon brain function. Directly after every session, 5 ml of blood from each participant was collected for hormonal testing. The first group of participants (immature girls) and third (postmenopausal women) were tested in a single session, and directly 5 ml of blood from each participant was collected for hormonal testing. Subsequently, the serum levels of estradiol, progesterone, follicle-stimulating hormone and luteinizing hormone were measured by ELISA test in blood samples.

2.3. Statistical analysis

The results are presented as mean ± SEM. One-way ANOVA was used and the post hoc Tukey test was used to compare means. $p < 0.05$ was considered as the minimum level of significance. All statistical analyses were performed using GraphPad Prism 5 software (GraphPad Software Inc., USA), and the graphs were drawn using Microsoft Excel 2010 software.

3. Results

3.1. Stroop test

The results of Stroop test showed that the interference score-was calculated by subtracting the mean reaction time (s) for incongruent stimuli from mean reaction time (s) for congruent stimuli shows significant changes according to different groups of females [$F(4,69) = 7.683$, $p < 0.001$]. These results indicated that the interference score is significantly higher in immature girls and menopausal women than in young adults in the different phases of the menstrual cycle ($p < 0.001$), (Fig. 1).

3.2. ANT results

3.2.1. Alerting network

The results revealed that the difference score in the alerting network – was calculated by subtracting mean RTs of the conditions with no cue from the mean RTs of the conditions with double cues- changes according to different groups of females [$F(4,78) = 4.789$, $p < 0.001$]. The Fig. 2 shows that, this index is significantly higher in immature girls than in the other groups ($p < 0.001$). In addition, difference score in the alerting network showed no significant difference in the different phases of the menstrual cycle (Fig. 2).

3.2.2. Orienting network

The comparison of orienting network between the different groups showed that the difference score in orienting network – was calculated by subtracting the mean RTs of the conditions with center cues from the mean RTs of the conditions with spatial cues-there was no significant change according to different groups of females [$F(4,78) = 0.7354$, $p < 0.57$], (Fig. 3).

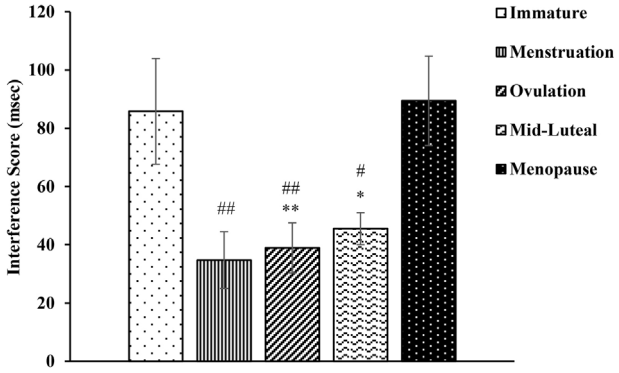

Fig. 1. The Comparison of the interference score in different stages of immature to menopause. Interference score was significantly increased in immature girls and postmenopausal women than in young adults in the different phases of the menstrual cycle. The results are presented as mean ± SEM. (*$p < 0.05$ and **$p < 0.01$ compared to immature and #$p < 0.05$ and ##$p < 0.01$ compared to postmenopausal women).

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