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Sex-related differences in attention and memory

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ABSTRACT

Background and objectives: The sex differences and similarities in cognitive abilities is a continuing topic of major interest. Besides, the influences of trends over time and possible effects of sex steroid and assessment time on cognition have expanded the necessity to re-evaluate differences between men and women. Therefore, the aim of this study was to compare cognitive performance between men and women in a strongly controlled experiment.

Materials and methods: In total, 28 men and 25 women were investigated. Variables of body temperature and heart rate were assessed. A cognitive test battery was used to assess attention (visual search, unpredictable task switching as well as complex visual search and predictable task switching tests) and memory (forced visual memory, forward digit span and free recall test).

Results: The differences in heart rate and body temperatures between men and women were not significant. There were no differences in the mean values of attention and memory abilities between men and women. Coefficients of variation of unpredictable task switching response and forward digit span were lower ($P < 0.05$) in men. Coefficients of variation positively correlated ($P < 0.05$) with attention task incorrect response and negatively correlated ($P < 0.05$) with correct answers in the memory task.

Conclusions: Current study showed no sex differences in the mean values of cognition, whereas higher intra-individual variability of short-term memory and attention switching was identified in women, indicating that their performance was lower on these cognitive abilities.

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1. Introduction

Sex differences in cognitive ability have been studied extensively in recent decades [1]. Important issue is if there are any sex-based differences in human cognition [2]. New findings, especially about trends over time (education, new technologies, gender equity, etc.), sex hormones, brain differences, and culture, indicate that earlier conclusions about sex differences and similarities in cognitive abilities need to be re-examined [3].

The different sex brain anatomy is a continuing topic of major interest. Among the observed sex differences, there are larger overall brain dimensions in men, relative increases of global and regional gray matter in women and higher percentage of white matter in men [4,5]. Kanai and Rees [6] highlighted the importance of gray matter in attention. Cognitive function has most commonly been associated with the prefrontal cortex. Recently the crucial role of the basal ganglia has been highlighted, as it interacts with the prefrontal cortex and thalamus via anatomical fronto-striato-thalamic circuits to implement cognitive flexibility. Attention switching performance could be predicted on the basis of individual differences in white matter microstructure in/around the basal ganglia [7]. Rijpkema et al. [8] indicated no differences in basal ganglia morphology between men and women. With reference to the studies mentioned above [5,8], it can be expected that there would be no sex differences in cognitive performance, which includes task switching, whereas attention test without task switching will be different between women and men.

Aging studies have shown that working memory is associated with white and gray matters [9]. Moreover, people with high visual short-term memory capacity have increased gray matter volume [10]. According to sex differences in brain gray and white matter, observed by Luders et al. [5] and Gur et al. [4], it can be expected that women might have advantage in short-term memory task performance, whereas no difference will be observed in working memory tests.

It is noteworthy that sex-related cognitive performance differences observed in previous studies [11–16] do not correspond to previously discussed gray matter and white matter differences in men and women [4,5]. Observed disagreements could be partly attributed to non-controllable experiments. Studies show that both sexes are sensitive to variation in hormonal state, as evidenced in the fluctuations in cognitive performance across diurnal and circadian rhythms, and menstrual cycle in women [3,17,18]. Most neuropsychological studies do not control natural biological rhythms and/or women's menstrual cycles. Measurement of rectal temperature (T_{RE}) is a reliable way of measuring core temperature to study the circadian rhythm [19]. Scheer et al. [20] showed that heart rate (HR) depended on the phase of the day-night cycle and on the intensity of light. The data suggests that circadian rhythm modulates HR. Therefore, the study was performed in the morning and rectal temperate as well as HR were assessed then. Furthermore, it is known that sex hormones can affect neurotransmitter levels responsible for cognition [2,18,21], thus women were tested during the early follicular phase when estradiol and progesterone levels are low. Besides, educational level should be taken into account [3]. Thus, the aim of this study was to compare cognitive performance between men and women in a strongly controlled (assessment timing, women's menstrual cycle and educational level matched groups) experiment.

2. Materials and methods

2.1. Participants

The criteria for participants' inclusion were: (1) the age of 18–25 years; (2) no excessive sport activities, i.e. <3 times per week; (3) non-smoking; (4) no medications that could affect cognitive function; (5) no diseases or disorders that could affect cognitive performance. Seventy-nine participants were assessed for eligibility. In total, 53 volunteers (28 men and 25 women matched by educational level) met the inclusion criteria and agreed to participate in this study. Their physical characteristics are presented in Table 1. Written informed consent was obtained from all subjects after the explanation of all details of the experimental procedures. All procedures were approved by the Human Research Ethics Committee and conducted according to the guidelines of the Declaration of Helsinki. Subjects were in self-reported good health, which was confirmed by medical history and physical examination.

2.2. Familiarization and experimental trials

The study comprised a familiarization trial and an experimental trial. To attain a stable level of performance, one week before the experimental trial, participants attended a familiarization session during which they were introduced to the experimental procedures for cognitive testing. To control for circadian and diurnal rhythm, the experiment began at 8.00 AM. Women were studied during the early follicular phase (days 3–5) of the menstrual cycle. The subjects refrained from consuming any food for at least 12 h, alcohol, heavy exercise and caffeine for at least 24 h before the experiment, and were instructed to sleep at least 8 h the night before the experiment. The experiments were performed at 22 °C and relative humidity of 60%.

On arrival at the laboratory, the subject dressed in a T-shirt, short shorts and socks and self-inserted the rectal probe, and then the strap for recording HR was attached to the chest. The subject was asked to rest in a semi-recumbent posture for 30 min, their HR were recorded during the last 20 min. After the stabilization of the body temperatures, control measurements of T_{RE} and skin temperatures were made. The subject

Table 1 – Physical characteristics of subjects.

Variable	Men (n = 28)	Women (n = 25)
Age, years	20.9 ± 0.8	21.6 ± 2.1
Height, cm	182.5 ± 5.5	169.8 ± 6.5
Mass, kg	78.5 ± 8.4	62.2 ± 9.8
Body mass index, kg/m^2	23.6 ± 2.4	21.7 ± 3.4

Data are presented as mean ± standard deviation.