



INVESTIGATING THE EFFECT OF HEAT EXPOSURE ON DISTRACTION IN MALE AND FEMALE IN LABORATORY CONDITIONS

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ABSTRACT

Harmful physical agents such as heat can be affected on human cognitive performance. This study aimed to investigate the effect of heat on the distraction of male and female was conducted in a controlled environment. This empirical study was conducted in the heat stress chamber. The distraction was measured using the Toloz-Piron test, after exposure to different levels of heat (22°C and 37°C) for 90 minutes. The mean performance score of male in comparison to female in terms of distraction and double working conditions, was significantly lower ($p < 0.05$). The average speed and accuracy of female were significantly more than male ($p < 0.05$). At 22°C, female had better performance than male in terms of distraction, doing double work, speed and accuracy. The results showed, exposure to heat in the condition of distraction and work doubling, male's efficiency generally decreased more than female's and approximately to half. So it is recommended that male do not do two works at the same time, when exposed to heat. When people are doing cognitive performances strong, heat reduces their accuracy and speed.

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Introduction

The performance of individuals at the workplace is affected by a combination of physical factors such as noise, heat, and light and air quality [1] approximately % 51.4 of the small and medium-sized enterprise are exposed to heat in the workplace [2]. These physical parameters are considered as a threat to the health of employees, compatibility and dysfunction. Therefore, the main goal should be the compatibility with the physical environment in such a way that the employees can work without distraction or physical stress and have full use of their skills to do the work [3]. Physiological stress can engage with mental stress and reduce performing visual tasks.

Despite the increasing rise of experimental studies in the field of human body's physiologic responses to heat, less attention has been paid to the effects of thermal stress on human's cognitive abilities. The occupational heat stress standards are trying to basically adjust the limits of exposure to hot environments based on physiological and medical criteria Heat stress, in addition to physiological disorders and diseases caused by heat can impair cognitive responses and affect human performance [4]. Some studies have reported that the attempts of people to do mental works has declined at 27° c which reflects the effects of temperature on mental functions [7].

Leibowitz concluded that the effects of heat stress can defeat motivated and experienced individuals [8]. Bursill reported that when the perception load of a task is high, accuracy of detecting environmental stimuli in adverse heat conditions reduces [9]. Disruptions due to thermal stress such as heat shock, heat exhaustion and heat acne through creating a distraction, poor concentration and increased fatigue leads to a negative effect on workers' safety and productivity [10].

Among the human factors, attention and focus of attention as a cognitive component, is one of the major causes of accidents and based on the conducted studies, 20 to 50 percent of accidents occur due to inattention and distraction in various ways [11,

12] Wacky people confront problems in recognizing necessary information. A wacky and inattentive person is unable to respond appropriately to changing conditions, which eventually leads to an accident[13]. On the other hand, distractive factors lead to loss of conscious performance and distraction and increase the risk of accident[14].

Inability to focus attention is common in comparison to distraction and is often a frustrating experience. The consequence of such a failure is merely the reduced quality of life through affecting the ability to read or focus on the job that causes an accident[15]. Holahan concluded that distraction largely affects the reaction time of the subjects[16]. Kristie reported that distraction led to an increase in errors [17]. In a study by Mack Worth, they found that people have difficulty in maintaining consciousness for a long time, and the performance of the subjects was quickly disrupted in order to detect signs, which became apparent with real losses in consciousness [18]. Considering the materials mentioned above, despite various studies conducted on cognitive functions and the importance of considering these functions, few studies have been conducted so far on the effect of heat on distraction. This study aimed to investigate the effect of heat on distraction on men and women, in the controlled laboratory environment.

2. Method

2.1. Design

This experimental study aimed to determine the effect of heat on distraction of male and female students in 2015. All experiments were conducted in a room with controlled atmospheric conditions. In this study, the temperature of the environment was set to 22°C and 37°C by the heating device and the lighting intensity was supplied by fluorescent tubes (with a color temperature of 4500° C) in the work level of the subjects equal to 500lux. To determine the effect of heat on cognitive performance of the subjects, Toulouse-prion test was used to measure the performance of subjects in distraction and double work circumstances. Heat exposure of the subjects was about 1.5 hours[18].

2.2. Participants

The sample is comprised of 33 individuals, including 17 men and 16 women (mean age = 22.1, SD = 2.3, age range of 19 to 26 years). The samples were selected through simple random sampling. The requirements (criteria) to enter the study were: being between 19-26 years old, having no eye defect, no suffering from color blindness, having no background of consuming heart drugs, blood sugar reducers, antidepressants and tranquilizers, antihistamines, Anti-Parkinson drugs and other drugs, having normal hearing, having no background of cardiovascular disease, breathing problems and sleep disorders. The requirement to withdraw was the subjects' reluctance to cooperate in the study. After the final selection of the qualified individuals, the test was explained to them completely. Before starting the test, according to the directive of the ethical committee of the university on the basis of Helsinki agreement, a letter of consent was taken from the volunteer participants in the study and documented.

2.3. Setting

Dimensions of the room intended for the experiment was 3 × 4 with a height of 2.8 meters, which was equipped with smart heating and cooling system.

2.4. Procedure

The volunteers were present in the room for 20 minutes in order to conduct Toulouse-prion distraction test, and they conducted the test twice in moments zero (before exposure to heat) and 90 minutes (after exposure to heat). This test is in the form of consecutive squares that three forms of consecutive squares have been determined as the pattern on top of each form[20]. Every individual must specify and determine the given patterns from among the squares of the form, at a specified time. So that squares which are similar to each of the three models at the top of the page, are specified with an X. The individual should start the work from the left and go line by line and specify the squares that are similar to the top three squares in each line. Each page has its own pattern, and the patterns of the pages are different from each other. Selecting the squares is conducted in several stages. At the end of each stage, the subject must specify the last square with a tick mark in order to start the next step. The duration of each stage is five minutes, including three minutes of marking and two minutes of break. At the end of three minutes, the number of correct responses are counted and a lower number of correct answers is a sign of distraction in the respondent. The whole work was carried out in seven stages.

2.5. Measures

2.5.1. Crossing in normal circumstances

In the first stage, which is the exercise and identification stage of work, each individual selects and marks the squares for three minutes according to the model above the page from the first page. At the end of the exercise stage and within two minutes of rest, the subjects turned test papers so that they cannot see the squares. The results of this stage will be calculated. In the second stage, the subject starts marking after the previous stage and stops at the end of three minutes of working, and the papers were turned again and the subjects rested for two minutes.

2.5.2. Crossing in double circumstances (crossing squares + counting the numbers)

In the third stage, crossing in double work conditions began, so that it was provided to the subjects, and they were asked to add a few units to the desired number through crossing. The subjects were explained that both works are of equal importance. That is, as they should cross a large number of squares, they should not cross incorrect, do not miss the marks, counting the numbers is of an equal importance, that is they should count a lot, should not miss and should not count incorrectly. After

making sure that the subjects are well aware of the procedure, the command was given to start the work and number 25 was determined, and they were asked to add to this number three by three. At the end of 3 minutes, they were asked to write the last number on the margin and turn the papers in addition to specifying the last square.

2.5.3. Crossing in normal circumstances

In the fourth stage, the subjects were asked again to check the boxes intermittently for 3 minutes.

2.5.4. Crossing in distraction circumstances

In the fifth stage, Crossing began in distraction circumstances. So that as the subjects were checking the squares, the research team began to talk to each other and raise different issues in a loud voice to make nuisance and cause distraction for the subjects who were busy checking.

2.5.5. Crossing in normal circumstances

In the sixth stage, the subjects were again busy checking the squares in normal conditions.

2.5.6. Mental counting

At the seventh/ the last stage, the participants were asked to count the number they had given, three by three, without marking the squares, and then to record the final number at the end of this stage (they counted up to 151).

2.5.7 Total performance rating

The papers were scored at the end of the experiment, after collecting the forms. All the correctly and wrongly marked squares and the forgotten ones in each stage and final performance were calculated. One positive point was given to each correctly marked square and for each wrongly marked or forgotten square, half a negative point was allotted. Determining the performance of participants included counting the utilized forms in the test, and calculating the total positive and negative points.

2.5.8. Calculation of precision and speed

The two main criteria of Toulouse linearity Piron Test include number of the correctly marked signs that show participants' speed or in other words. The more the number of the correctly marked signs, the higher the speed of the participants. The percentage of the wrongly marked or forgotten signs shows participants' precision. In other words, it can be said that the more the number of the wrongly marked or forgotten signs, the lower the participants' precision.

2.5.9. Validity and reliability

The validity and reliability of this test were reported satisfactory in Pearson's study. For example, the simultaneous validity of this test with that of Burdon's distraction test was reported 0.74 Irvani (2008). In Narimani and his colleagues study, the reliability of this test was reported 0.7, using Cronbach alpha.

2.6. Statistical analysis:

The One-Way ANOVA method was used to analyze the data. The data collected were fed in the computer and then analyzed, using SPSS software, version 16.

3. Results

3.1 Comparison of mean score of performance level of male and female in distracting conditions and double work after 90 minutes of exposure to 37°C temperature

According to the [Chart 1], exposure to heat led to drop in men and women's performance in distracting situation, whereas during the exposure to heat, the drop in men's performance in distracting situation was significantly higher than that of women's ($p < 0.05$). The average total performance score in distracting situation was 37.4 and 29 for women and men respectively. On the other hand, the performance of men and women in double work situation was dropped significantly while exposure to 37 C, in comparison to exposure to 22 C ($p < 0.05$). The effect of heat on men's performance was lower than that on women, in double work situation and the average acquired scores were 31 and 23.3 for women and men, respectively. Regarding being exposed to heat, women's performance was estimated to be higher compared to men in double work and distracting situation.

3.2 Comparison of average performance level of men and women in distracting and double work situation after 90 minutes of exposure to 22°C temperature

According to the results, women's abilities were estimated to be higher than men's and while being exposed to 22 degrees Celsius in double work situation, women and men scored 38 and 35 respectively. The calculated scores for women and men in the distracting situation were 59 and 55, respectively [Chart 2].

3.3 Comparison of average mental counting of male and female

The drop of performance in double work, under the influence of heat can also be shown in other ways, which is, comparing the counted number in third stage and the counted number in last stage. In the third stage, which the participants had to recognize and mark the squares and count the numbers three by three mentally, the final number of the participants were summed up, and then a mean was estimated for men and women; the obtained number was 82.1 for women and 68.1 for men. In the last stage, that the participants were only busy counting the numbers, the announced numbers of the participants were summed up, and the average was 122.4 for women and 110.5 for men. The difference between these two indicated the effect of heat on people's performance in double work situation.

3.4 Comparing speed and precision in male and female

Being exposed to 37 degrees Celsius, the number of correctly marked signs (speed) in women was higher than men in distracting and double work situation [Chart 3] and statistically these differences were meaningful ($p < 0.05$). According to [Chart 4], the average wrongly marked or forgotten signs in double work and distracting situations were lower in women than men. In other words, women demonstrated higher precision than men and the statistically these differences were meaningful ($P < 0.05$). On the other hand, 90 minutes after exposure to 22 degrees Celsius heat, women were faster than men [Chart 5] and in distracting situation, men and women had equal precision [Chart 6] however, in double work situation women had meaningfully higher precision than men ($P < 0.05$).

4. Discussion

In human brain anatomy, there are differences in each gender that can explain some of the documented differences in behavior. Some studies have concluded that women are better than men in verbal tasks and memory, whereas men are better than women in spatial tasks[21]. These differences are attributed to specifications of functions in brain hemispheres. However, generally, verbal tasks are dominated by left hemisphere and spatial tasks in the right hemisphere[26]. Some neuropsychological studies suggested that brain hemisphere specialization is less in women than men([22, 23] . Temperature is one of the important factors which influences cognitive function of people because of heat stress[24]. Numerous studies have indicated that heat stress can have a negative impact on people's mental functioning[6, 27].

The results of this study showed that total performance of both groups (men and women) in distracting and double work situations (mental counting and simultaneous marking) decreased in heat exposure. It seems that heat stress has a more unpleasant effect on men's performance than women's performance. Heat decreased men's ability in double work and distracting situation (compared to women). This finding is in line with Wyon and his colleagues' study that declared men's performance in 28 degrees Celsius in double work situation decreased meaningfully, whereas women's performance was not influenced by heat stress, in the same task[28]. The results of the a recent study showed that the increase in heat and light intensity through increase the reaction time and the reaction time error of individuals when performing cognitive activities can be reduced cognitive function of individuals[29]. Comparison of people's performance in double work stage before and after the normal situation manifests that people's performance decreases after one and a half hours of exposure to heat. Therefore, it will be effective that people get involved with one task in one specific time, while being exposed to heat.

On the other hand, men's precision and speed decreased in marking stage in double work and distracting situation (compared to women's). While exposed to heat, the number of wrongly marked and forgotten signs was higher in men than women. Or in other words, men's precision in double work and distracting situation decreased. This finding is in line with the study by Habibi et al. who obtained similar findings[25]. Witterseh found that exposure to heat leads to flaws in attention and concentration and loss of self-estimated performance in people and the increase in error rate and heat had more unpleasant effect on male than female[30]. It can be said human's precision has a scope and limit. No one can think about a problem all day, get involved in specific work and yield a pleasant output. Human's precision is always fluctuating; that is, human cannot focus on one problem for a long time. Resting between tasks and reducing working hours can minimize the lack of concentration and fluctuation of precision[31]. Therefore, it can be concluded that the decrease in human precision because of heat not only affects performance, but can also be a risk to their health. In addition, according to findings of Ramsey et al., the probability of accidents and dangerous behavior in work environments increase by the increase in temperature up to 24 degrees Celsius, and he also declared that there is a meaningful relationship between increase in workload and unsafe behavior of people. These two factors emphasize the importance of speed and precise decision making in crowded and warm work places[32]

In double work situation and exposure to heat, women worked faster than men. While performing a rather short experiment, people may have conscious effort to confront distraction, which will lead to more exhaustion and decrease in their speed [30].

5. Conclusion

The results of this research manifested that exposure to heat in distracting and double work situation has an effect on people's performance. Definitely, heat in distracting and double work situation decreased men's performance more than women's and almost decreased men's performance to half. Therefore, it is suggested that men do not get involved in two works in one session while being exposed to heat. In addition, men must not work in warm environments that cause distractions for different reasons. Besides, the results of the current study showed that heat lowers people's precision and speed in doing higher cognitive tasks. To increase the security of warm working environments, people must avoid doing tasks that need higher cognitive function, or else they must find suitable solutions to control environmental heat.

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Conflict of interest

We have no conflicts of interest.

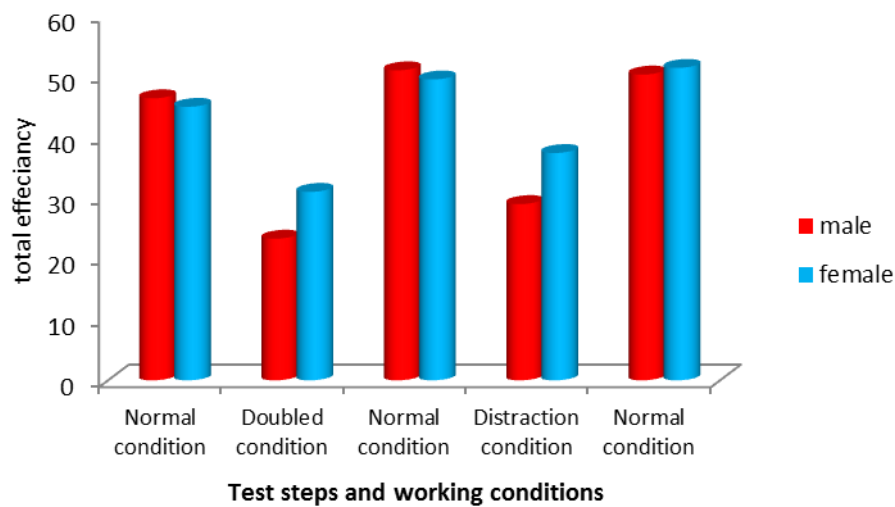
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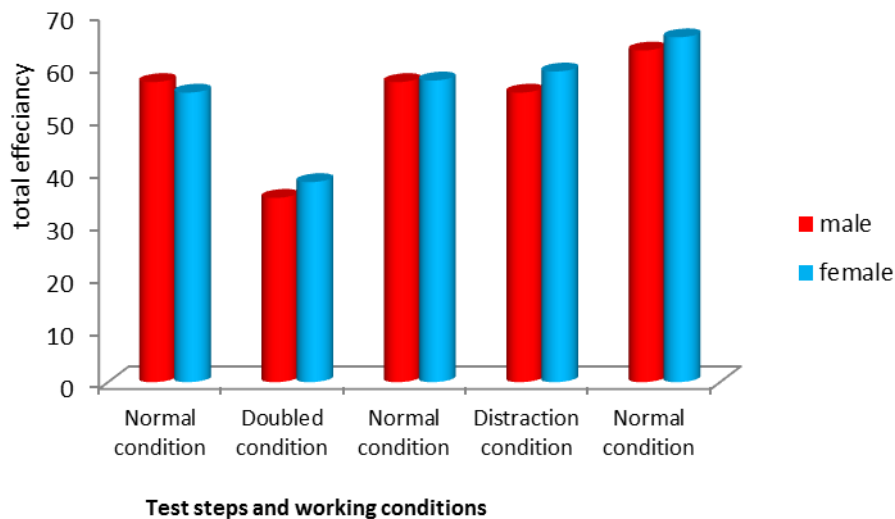
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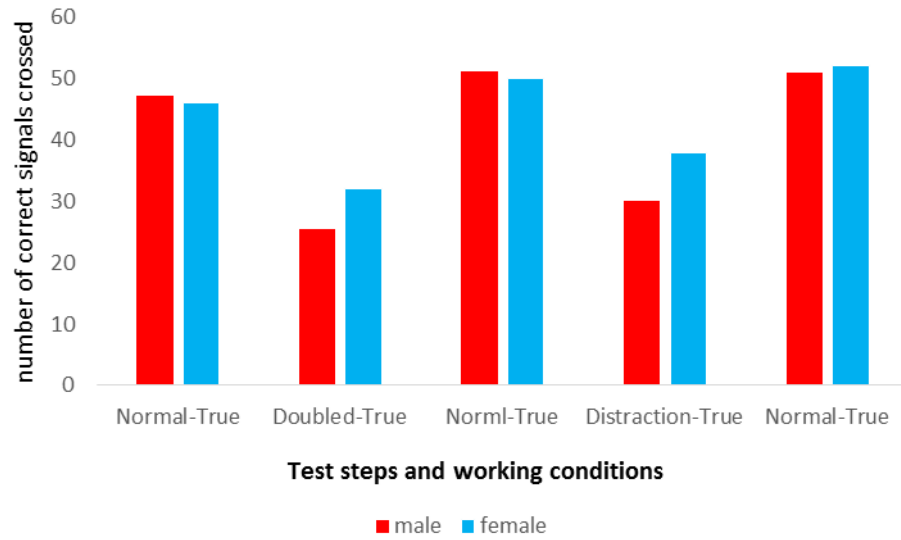
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34. **Chart 1:** Comparison of mean score of performance level of male and female in distracting conditions and double work after 90 minutes of exposure to 37°C temperature

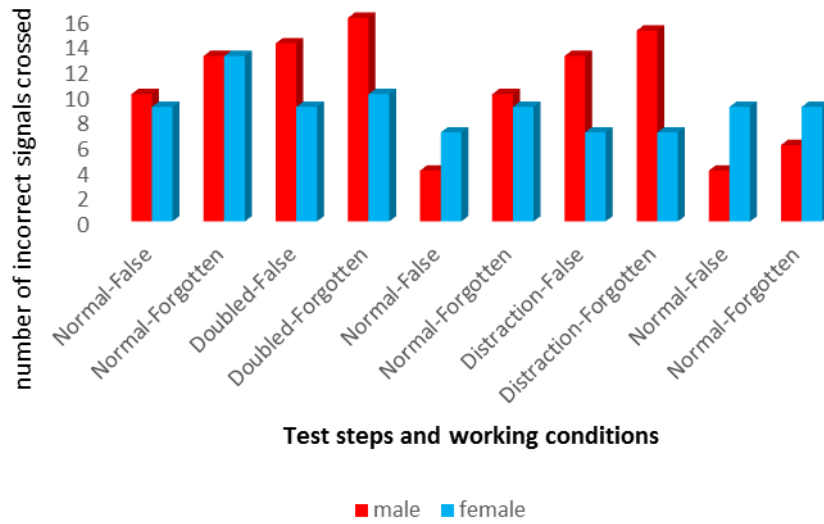


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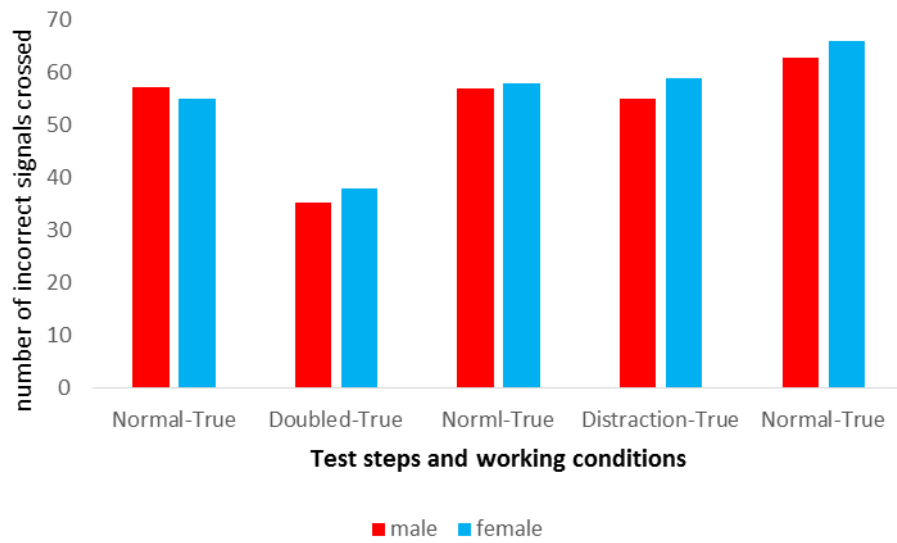
36. **Chart 2:** Comparison of average performance level of male and female in distracting and double work situation after 90 minutes of exposure to 22°C temperature



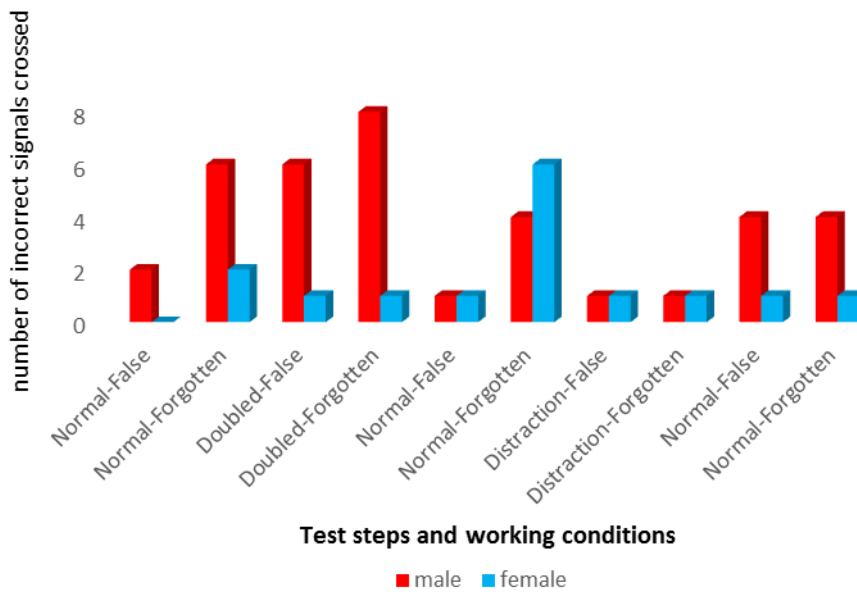
37.
 38. **Chart 3:** compare the number of squares crossed (speed) in male and female after exposure to temperature 37°C



39.
 40. **Chart 4:** Compare wrong number of squares crossed out and forgotten (accuracy) in male and female after exposure to temperature 37°C



41.
 42. **Chart 5:** compare the number of squares crossed (speed) in male and female after exposure to temperature 22°C



43.
 44. **Chart 6:** Compare wrong number of squares crossed out and forgotten (accuracy) in male and female after exposure to temperature 22°C

Table 1: Mean and standard deviation total performance score, after exposure to 22 °C temperature

Test steps	mean		SD	
	male	female	male	female
normal circumstances	57.1	55	8.1	5

double circumstances	35	38	3.3	3.2
normal circumstances	57	57.3	5.2	4
distraction circumstances	55	59	4	5
normal circumstances	63	65.4	4	65.4

Table 2: Mean and standard deviation total performance score, after exposure to 37 °c temperature

Test steps	Mean		SD	
	male	female	male	female
normal circumstances	46.4	44.5	4	3.2
double circumstances	23.3	31	2.2	2
normal circumstances	51	49.5	4	4
distraction circumstances	29	37.4	2.4	2.3
normal circumstances	50.3	51.4	3.2	6