Demographic Variables and Selective, Sustained Attention and Planning through Cognitive Tasks among Healthy Adults

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ABSTRACT

Introduction: Cognitive tasks are considered to be applicable and appropriate in assessing cognitive domains. The purpose of our study is to determine the relationship existence between variables of age, sex and education with selective, sustained attention and planning abilities by means of computerized cognitive tasks among healthy adults.

Methods: A cross-sectional study was implemented during 6 months from June to November, 2010 on 84 healthy adults (42 male and 42 female). The whole participants performed computerized CPT, STROOP and TOL tests after being content and trained.

Results: The obtained data indicate that there is a significant correlation coefficient between age, sex and education variables ($p<0.05$).

Discussion: The above-mentioned tests can be used to assess selective, sustained attention and planning.

1. Introduction

Computerized neuro-cognitive tests are considered appropriate in new and developing fields of psychological testing. Relatively mild measures of neuro-cognitive impairments can be assessed by these tests where speed, efficiency and low cost are of great importance. In theory, computerized neuro-cognitive tests can enhance efficiency, productivity and knowledge. However, these tests are also confronted with some restrictions like any other technology (Gualtieri et al. 2006). In comparison to common psychological tests, computerized neuro-cognitive tests have few advantages including coordination in administration and scoring, probability of creating substituting suitable forms, the ability of tracking different components of participant's response and the ability of developing detailed and large databases (Gualtieri et al. 2006).

Cognitive functions can be measured through various domains such as executive functions, memory, language and visuo-spatial functions (Bosma et al. 2008), (Cynthia et al. 2002). Attention is a cognitive process which is defined based on one aspect of environment as selective concentration, while other aspects are ignored. Also, attention has been attributed to allocation of resources processing (Anderson 2004). Selective attention is defined as information processing capability during rejection of false and irrelevant one (MacLeod 1991). Selective attention is evaluated by STROOP test. This test provides a measure of cognitive inhibition or

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the ability to control something learned tightly before (the dominant response) in favor of an uncommon response (Stroop 1935). Sustained attention is needed to accomplish any cognitive planned, systematic activity and thoughts. Having disorder in this type of attention can be observed in diseases like ADHD, schizophrenia and brain tumors (Lin et al. 1999). Sustained attention is measured through Continuous Performance Test (CPT), which obtain quantitative information in regards to sustaining attention in a matter of specified time (Beck et al. 1956).

Executive function is a term referred to self-control behaviors, which are related to rules and regulations done through some selective and sustained behaviors. In order to perform a task which is not done habitually, executive functions need progress and performance of an approach. A distributed neural net conducts executive functions with cortical and sub-cortical parts including frontal cortex and basal ganglia–thalamic–cerebellar connections (Cynthia et al. 2002). Planning as a sub-category of problem solving ability consists of some parts which events anticipation and track keeping for goal achievement are among them (Shallice 1982). To assess planning ability in executive function domain Tower Of London (TOL) test has been used. TOL test has been developed as a mean to recognize unexpected planning processes disorders which allocate to dysfunction of frontal Lobe (Owen et al. 1990), (Lange et al. 1992). TOL is sensitive to dysfunction of brain anterior part, which has been confirmed in studies reviewed clinical samples (Krikorian et al. 1994).

The popularity of the cognitive tests in clinical and research settings (Lezak et al. 2004) means that it is important to characterize the influence of age factors on test performance. Previous studies have provided data about the effects of age, sex, and education on cognitive tests performance. Although most authors reported age-related decrements in these tests performance (Daigneault et al. 1992), (Feinstein et al. 1994), (Hameleers et al. 2000), (Houx et al. 1993), (Ivnik et al. 1996) (Klein et al. 1997), (Libon et al. 1994), (Moering et al. 2003),(Spreen & Strauss, 1998), (Swerdlow et al.1995), (Van Boxtel et al. 2001), some like Graf et al. (1995) did not find age to influence tests performance. Sex differences in Cognitive tests performance have been reported by some (Hameleers et al. 2000), (Martin & Franzen 1989), (Moering et al. 2003), (Van Boxtel et al. 2001) but not all (Houx et al. 1993), (Klein et al. 1997), (Swerdlow et al. 1995), (Trenerry et al. 1989) authors. Again, education was found to be positively related to Stroop test performance by some authors (Hameleers et al. 2000; Houx et al. 1993; Moering et al. 2003; Van Boxtel et al. 2001) but not by others (Trennery et al., 1989).

Table 1. The comparison of age groups with sex and education

Age Vs. Sex		Age Groups					TOTAL	Value	df	sig
		15-24	25-34	35-44	45-54	55-65				
Sex	Female	7	10	4	13	8	42	10.185	2	.006
	Male	7	10	4	13	8	42			
TOTAL		14	20	8	26	16	84			
Age Vs. Education		15-24	25-34	35-44	45-54	55-65	TOTAL			
Education	Illiterate	0	0	0	0	0	0	6.016	2	0.049
	Diploma	2	5	1	6	3	17			
	Associate of science	3	6	2	7	4	22			
	Bachelor of science	7	0	10	2	6	25			
	Master of science	1	8	6	4	1	20			
TOTAL		13	19	19	19	19	84			

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Table 1 has been analyzed by t-test method. Considering the equal number of healthy men and women participated in our study, table 1 shows a significant relationship is observed among all age groups ($p<0.05$). Despite the difference of education level in each age group, a significant relationship has also been shown between age and education variables ($p<0.05$).

Since people with different age groups and education levels can show different degrees of attention and planning, they need to get these domains enhanced for cognitive rehabilitation. Demographic variables of age, sex and education were the most important influencing factors on the basis of previous studies. Hence, current study aims to determine the relationship between age, sex and education variables with selective, sustained attention and planning through cognitive tasks among healthy adults.

2. Methods

This cross-sectional study was conducted during 6 months from June to November, 2010 at neuroscience department of Functional Neurosurgery Research Center (FNRC) of Shohada hospital in Tehran. The population study was selected through random sampling, 15-65 years old of 84 (42 male and 42 female) healthy adult subjects whose mean age was 46±3. Filling the informed consent letter before entering the study was necessary for the whole subjects. Afterwards, they were examined by neurosurgeons, neurologists and psychiatrists in order to be removed in case of noticing any disease. After being confirmed by the mentioned physicians, healthy participants were referred to perform the computerized STROOP, CPT and TOL tests. Being healthy and free from previous or current history of psychological and neurological disorders, having no history of head injury, lacking any learning disability, living in Tehran, being Farsi speaker and in age range of 15-65 years old were the inclusion criteria for participants whom were accepted for taking part in the study. Anyone did not qualify these criteria was excluded from the study. This study has been compromised in ethic committee and research faculty of Shahid Beheshti University of Medical Sciences. It has been also approved and implemented in Functional Neurosurgery Research Center (FNRC).

Statistical Analysis

After completing demographic questionnaire and performing the CPT, TOL and STROOP tests by participants, the data were entered the SPSS18 software. Statistical analysis of this study was done through descriptive statistical tests, Pearson correlation coefficient, stepwise regression and the t-test.

Computerized Tests

STROOP test: This test was first designed and introduced by Ridley Stroop in 1935 for the purpose of assessing selective attention and cognitive flexibility (Stroop 1935). Stroop test has been used for several cognitive evaluations (Stuss et al. 2001), (Ehlis et al. 2005), (Aman et al. 1998), (Stroop 1935). In our study, this test is based on the variables of computerized version of STROOP (Stroop 1935). Naming the colors is the first stage of the test in which the examinee is asked to click on the labeled key of the same colored circle shown frequently in red, blue, yellow and green on the screen. The goal of first stage is to train the test performance technique to the examinee. The score of this stage has no effect on the test's final result. The second stage is the main STROOP test performance. At this stage, 48 congruent colored and 48 incongruent colored words are revealed. Congruent words are those which their color and meaning is the same, for instance the written word blue which is shown also in blue. Incongruent is referred to the written words which are not similar in color and meaning, for example the word yellow which is displayed in green, blue or red. Totally, 96 congruent and incongruent colored words are shown randomly and consecutively on the screen and the examinee has to click on the relevant tagged keys just by considering the colors regardless of the meaning. Therefore, the examinees should be aware that the apparent words colors may look different from their meaning and the emphasis is on color. The presentation time of each stimulus on the screen is 2 seconds and the interval between each two presentation is 800 milliseconds. Researchers believe that color-word task (the second stage) can measure mental flexibility, interference and response inhibition (Wecker et al. 2000). The interference measure is obtained by subtracting the score of correct incongruent number from the score of correct congruent words. The

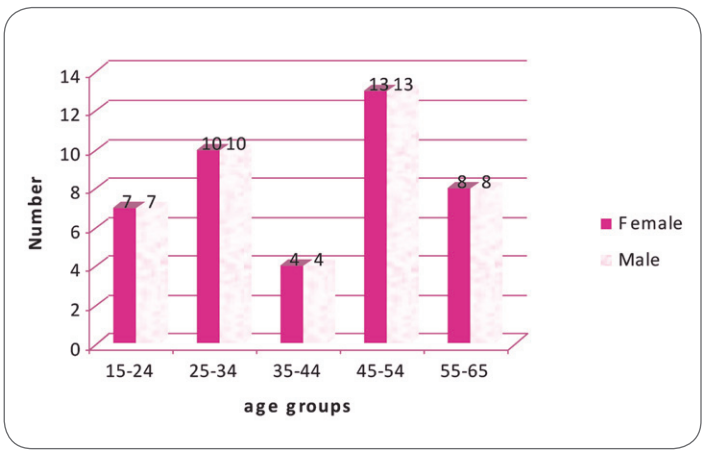

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Figure 1. Frequency of male and female in different age groups

investigating measures of computerized STROOP test include congruent and incongruent error, congruent and incongruent time reaction and result tests of the participants (Stuss et al. 2001), (Ehlis et al. 2005), (Aman et al. 1998).

CPT test: In order to measure sustained attention, CPT test has been used in many studies (Verbaten et al. 1994), (Losier et al. 1996). Due to its relevance with cognitive and mental disorders, it is considered a popular test (Epstein et al. 2001), (Lindsay et al. 2001), (Mirksy et al. 1956), (Riccio & Reynolds et al. 2001), (Vadhan et al. 2001), (Sykes et al. 1971), (McGee et al. 2000), (Wohlberg et al. 1973). This test has also been used to assess treatment and rehabilitation impacts on diseases (Barkley 1977), (Riccio et al. 2001). In all types of CPT test, the examinee should pay attention to the complex of visual or auditory stimuli for a while (only visual stimuli are presented in this test). This test should take place in a suitable time and place in which the performance conditions of the test should be observed psychologically. Of course, the test is computerized and the examinee should select and press the correct key at the appearance moment of any stimulus. The purpose of this test is that each examinee applies his/her maximum ability to present the best performance with a proper speed. In this test, 150 stimuli are presented from which 20% are target stimuli (the stimulus that the examinee has to answer is depicted as star, moon and circle on the screen). The presentation time of each stimulus is 200 milliseconds and the interval between each two presentation is 1 second. Before the main test, an experimental test (sample test) will be run. At the beginning of sample test, required explanations were presented to the examinee. By the time the sample test is performed and the examinee is ready the test will start. The test time including the time for experimental part is entirely 200 seconds. According to various forms and obtained analyses of test, designed computerized CPT test in this study investigates sustained attention on the basis of Time test, Error01 (error of response in first 50 stimuli), No01 (no response in first 50 stimuli), True01 (true response in first 50 stimuli), Time reaction01 (time reaction of first 50 stimuli), Error02 (error of response in second 50 stimuli), No02 (no response in second 50 stimuli), True02 (true response in second 50 stimuli), Time reaction02 (time reaction of second 50 stimuli), Error03 (error of response in third 50 stimuli), No03 (no response in third 50 stimuli), True03 (true response in third 50 stimuli) and Time reaction03 (time reaction of

Table 2. Determining selective attention scale among healthy subjects through computerized STROOP test based on age, sex and education

Table 2 indicates that a significant relationship ($p<0.05$) is observed between error02 (incongruent error) and no02 (incongruent no response) measures of STROOP test and all three variables of age, sex and education.

Based on STROOP test, the highest correlation has been observed between No02 (incongruent no response) and age and education variables. Sex variable is highly correlated with Error02 (incongruent error) measure. Conversely, the lowest correlations of age and education variables have been observed with Error02 and No02 has lowest correlation with sex variable.

	time01	error01	no01	true01	timerec01	time02	error02	no02	true02	timerec02	Result Test
Age	r=.037 p-value=.061	r=.036 p-value=.071	r=.042 p-value=.070	r=.034 p-value=.061	r =.042 p-value=.027	r=.045 p-value=.065	r=-.071 p-value=.009	r=.084 p-value=.021	r=.064 p-value=.054	r=.045 p-value=.051	r=.021 p-value=.71
Sex	r=.024 p-value=.051	r-.031 p-value=.061	r=.022 p-value=.060	r=.032 p-value=.060	r=.045 p-value=.065	r=.064 p-value=.054	r=.072 p-value=.009	r=-.083 p-value=.021	r=-.034 p-value=.061	r=-.036 p-value=.061	r=.045 p-value=.065
Education	r=.047 p-value=.051	r=-.036 p-value=.061	r=.012 p-value=.060	r=.014 p-value=.061	r=.022 p-value=.064	r=.015 p-value=.065	r=-.061 p-value=.009	r=.074 p-value=.021	r=.063 p-value=.054	r=.052 p-value=.051	r=.022 p-value=.71

third 50 stimuli) measures comparison (Rosvold et al. 1956), (warm 1984).

TOL test: Planning ability that can be measured through TOL test was first introduced by Shallice in 1982 (Shallice 1982). TOL is a reliable tool designed to evaluate at least two aspects of executive actions including planning and problem solving (Lezak 1995), (Mazzocco et al. 1992), (Morris et al. 1988), (Owen et al. 1990), (Lange et al. 1992). In various diseases such as brain injuries, Parkinson, Hanitington corea disease, hydrocephalus, depression, attention and hyperactivity disorder and autism, TOL test has been used to assess these executive actions (Lange et al 1992), (Owen et al. 1990). The performance method of this computerized test similar to all other types of TOL test consists of an experimental stage in which the examinee tries to learn the correct way of doing the test. An example is shown on the left side of the monitor screen according to which the examinee has to put colored loops upon designed bars on the right side of the screen. During the test, by moving the colored loops (green, blue and red) to a proper place as the sample, the score of this problem is received. There are only three opportunities for the examinee in each turn. Accomplishing the example on the first try has 3 points; the second has 2, and last has only 1. If the problem is solved correctly for the first time 3 points, for the second time 2 points and for the third time 1 point will be received. In case the problem is still not resolved after three attempts, the score of this level won't be considered. The number of movements in each level is counted and after three attempts, the scoring will be stopped. Otherwise, presenting a repeated test would violate the test's central dimension (its novelty or nonroutine nature of problem solving ability) which is required for applying executive planning (Shallice 1991b). As we have mentioned before, measures of computerized TOL test include Time Test, Time Late, Time Total, Result and Error. (Morgan 1998).

3. Results

The demographic and statistical data, which has been summarized within 5 age groups of 15-24, 25-34, 35-44, 45-54 and 55-65 are presented in four tables, two charts and three scattered plot diagrams.

The CPT test diagram shows that age and sex variables have the highest correlation with Error03 (error of response in third 50 stimuli) measure while education is highly correlated with True02 (correct responses to second 50 stimuli). In contrast, Timereco2 (time reaction of second 50 stimuli) and age, Timerec03 (time reaction of third 50 stimuli) and sex and error03 (error of response in third 50 stimuli) and education variable have the lowest correlations.

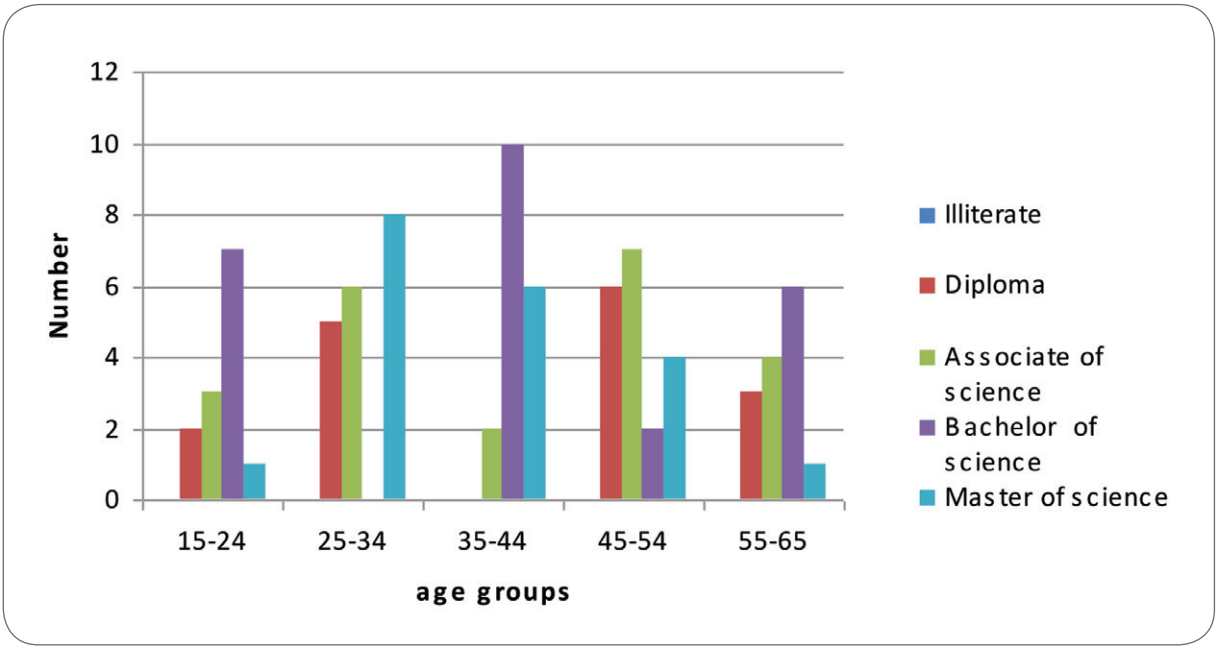

Figure 2. Frequency of education levels in different age groups

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The total numbers of participants with different educational levels which are equal in both sexes are presented in Figure 1 and 2.

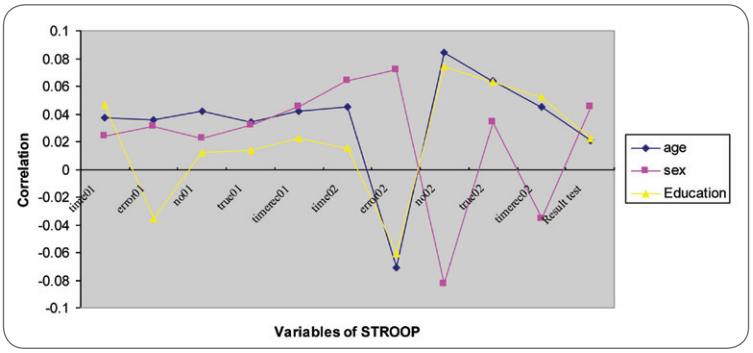

Figure 3. Correlation of age, sex and education variables with STROOP measures

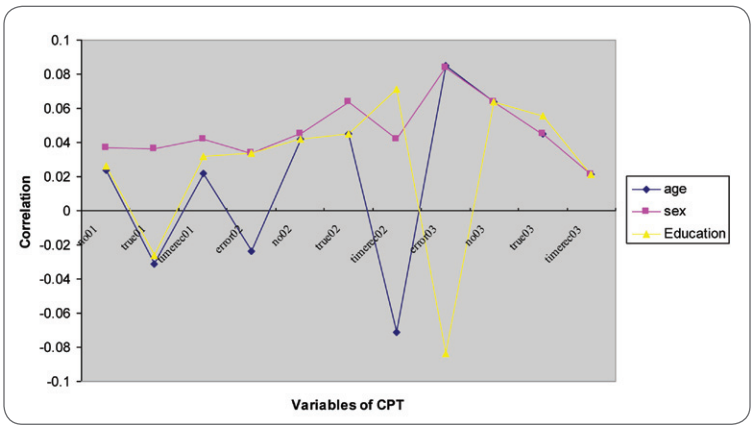

Figure 4. Correlation of age, sex and education variables with CPT measures

Figure 5 indicates that Time Late measure has the maximum correlation with age and sex variables while the highest correlation of education variable is with Time Total measure. Age and education variables have the lowest correlations with Error. Sex variable is also slightly correlated with Time Total measure.

4. Discussion

Assessment of cognitive domains of selective, sustained attention and planning through computerized STROOP, CPT and TOL tests is possible in appropriate circumstances. In situations where error reduction, speed and efficiency are considered, these tests can be well used (Culberston et al. 1995). It is significant to note that these tests are applicable as a sensitive tool in vast range of clinical conditions relevant to cognitive defects (Gualtieri et al. 2006). In studies in which common neuro-cognitive tests have been stated, moderate correlation coefficient has been observed among STROOP, CPT and TOL tests' measures (Baker et al. 1985). The influence of individual and environmental factors on

Table 3. Determining sustained attention measure among healthy subjects through computerized CPT test based on age, sex, and education

According to Table 3, there is a significant relationship ($p<0.05$) between two measures of CPT test, Timerec02, Error03 and age, sex and education variables.

	no01	true01	timerec01	error02	no02	true02	timerec02	error03	no03	true03	timerec03
Age	r=.024 p-value=.051	r-.031 p-value=.06	r=.022 p-value=.060	r=-.024 p-value=.061	r=.042 p-value=.064	r=.045 p-value=.065	r=-.071 p-value=.009	r=.084 p-value=.021	r=.064 p-value=.054	r=.045 p-value=.051	r=.021 p-value=.71
Sex	r=.037 p-value=.061	r=.036 P-value=.071	r=.042 p-value=.070	r=.034 p-value=.061	r=.045 p-value=.065	r=.064 p-value=.054	r =.042 p- value=.027	r=.084 p-value=.021	r=.064 p-value=.054	r=.045 p-value=.051	r=.021 p- value=.71
Education	r=.026 p-value=.051	r=-.026 p-value=.06	r=.032 p-value=.060	r=.034 p-value=.061	r=.042 p-value=.064	r=.045 p-value=.065	r=.071 p-value=.009	r=-.084 p-value=.021	r=.064 p-value=.054	r=.055 p-value=.051	r=.021 p-value=.71

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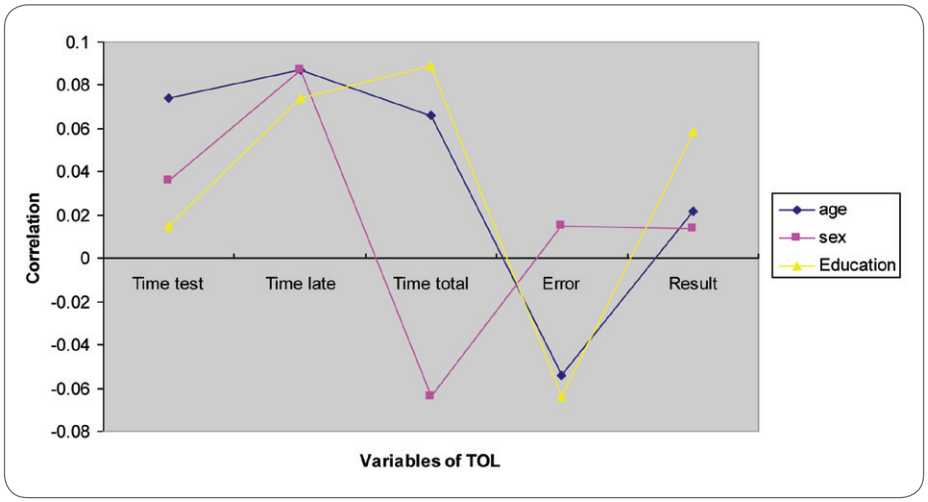

Figure 5. Correlation of age, sex and education variables with TOL measures NEUROSCIENCE

the computerized neuro-cognitive tests' performance is important which refers to the popularity of these tests in research (Lezak et al. 2004). In current study, measures of the mentioned tests are assessed by age, sex and education variables. Many researchers have reported some factors such as age related to the changes of attention and planning in these tests (Jerger et al. 1993), in some other studies age had no effect on the interference measure of these patterns (Moering et al. 2003), (Wright et al. 2003), (Van Boxtel et al. 2001), (Hameleers et al. 2000). In this study, the impact of age groups is shown on the error02 (incongruent error) and no02 (incongruent no response) measures of STROOP test. The obtained results are in line with some previous studies which showed the age effects on interference scores of the test. This is a classic case that has been confirmed in several studies (Hameleers et al. 2000), (Daigneault et al. 1992), (Feinstein et al. 1994). Sex is another variable which has been referred by McLeod in all age groups with minimum correlation with STROOP test measures (McLeod 1991). However, in our study, two measures of STROOP test, error02 (incongruent error) and no02 (incongruent no response) have been influenced by sex variable. The education levels of participants ranged from illiterate to Master of Science, were correlated with error02 (incongruent error) and no02 (incongruent no response) measures of STROOP test. Nevertheless some exceptions exist in the average performance of timerec02 (incongruent time reaction) of any age groups with different education levels which is an indicator of significant influence. Also, a significant correlation is observed between education and the performance of error01 (congruent error) and the average of timerec01 (congruent time reaction). In conclusion, the influence of age on interference score may be due to the attention improvement that occurs by age increasing not just by the automatic response reading (Wright et al. 2003), (Gestardt et al. 1994), (Welsh et al. 1991), (Diamond et al. 1996).

Table 4. Correlation of age, sex and education variables with CPT measures

Table 4 indicates that Time Test and Time Late measures of TOL test have a significant relationship ($p<0.05$) with age variable. There is also, a significant relationship ($p<0.05$) between Time Late and Time Total measures and education variable.

	Time test	Time late	Time total	Error	Result
Age	r=.074 p-value=.009	r=.087 p-value=.021	r=.065 p-value=.054	r=-.054 p-value=.051	r=.022 p-value=.71
Sex	r=.036 p-value=.061	r=.087 p-value=.021	r=-.064 p-value=.010	r=.015 p-value=.065	r=.014 p-value=.061
Education	r=.015 p-value=.065	r=.074 p-value=.009	r=.089 p-value=.021	r=-.064 p-value=.054	r=.059 p-value=.051

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The CPT test has been constantly reviewed among healthy subjects whom had the same age, sex and race point of view (Advokat et al. 2007). The analysis of scores difference through non-parametric methods was statistically significant (Advokat et al. 2007). In some studies, the correlation of time reaction and response error (commission) measures was significant with the demographic variables of healthy subjects. Another study has shown more significant errors in commission and omission measures. In CPT test, no difference such as variability of standard error measure has been observed among healthy subjects (Epstein et al. 1998).

According to the CPT test in our study, a significant correlation coefficient has been observed between timerec02 (time reaction of second 50 stimuli) and error03 (error of response in third 50 stimuli) measures and age, sex and education variables.

Based on previous studies, scores of Time test and Time late measures of TOL test have indicated a significant difference among healthy subjects by increase of executive planning and problem solving efficiency in aging. This mentioned paradigm is consistent with previous studies in same field (Welsh et al. 1991), (Levin et al. 1991). Age-related differences (score tests difference) were not visible regarding to Time test measure. This difference indicates that both young people and elder ones have the ability of planning even in the presence of few limitations dominated on tests. In fact by age increasing, healthy subjects show much less speed in duration of Time test which is due to the failure in detecting a significant age-related change (Grodzinsky et al. 1992), (Pennington et al. 1996).

In some studies, time-related variables present age-based changes in younger healthy subjects according to which test performance speed and total time test have been slower among younger ones. Although test performance and ultimately total time test are affected by dexterity, the number of movements used in TOL test performance was considerably more among younger people. This requires more executive function as a primary determinant factor in improving test performance speed of people. Findings regards to the comparison of test performance at different age groups reveal that planning speed is similar for everyone but in case of high total score and low error scores, planning efficiency would be higher. Therefore, executive planning performance in some ages is associated with more accuracy and speed (Welsh et al. 1991), (krikorian et al. 1994). Findings related to the performance of TOL test between men and women are consistent with previous studies. Demographic variables such as socio-economic status, race and geographic locations were not controlled among healthy subjects. In some other studies, initial results of validity and reliability as a measure of executive planning and problem solving support TOL test (Culberston et al. 1995).

Other studies have reported noticeable reduction of total time mean and number of errors due to aging and also significant correlation of participants' performance with age variable (Levin et al. 1991), (Welsh et al. 1991), (Culberston et al. 1995). Similarly, variables relevant to time test have shown age-based changes which means people in all age groups plan identically as a matter of time but efficiency of this planning is more among adults (Gualtieri et al. 2006). However, current study shows that time test and time late measures of TOL test have significant correlation coefficient with age variable and there is also a significant correlation coefficient between time late and time total measures and education variable.

Eventually, this test is conducted in order to determine the existing relationship between demographic variables of age, sex and education with selective, sustained attention and planning through cognitive tasks among healthy adults.

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