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Comparing executive cognitive functions of brain in blind and matched sighted

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Abstract

Aims: More than half of brain is involved in visual processing in sighted people. Blinds have different information processing method compared to sighted people. The purpose of present study was to compare executive cognitive functions of blind veterans and matched sighted people through behavioral test.

Methods: This cross-sectional comparative case-control study was performed on 93 blinds and 116 age and education matched sighted people in year 2008 in Mashhad. Executive functions were evaluated by Dysexecutive (DEX) questionnaire. Data were analyzed using inferential statistical tests including independent T-test, Kolmogorov-Smirnov test and Mann-Whitney U test by SPSS 17 software.

Results: Results didn't show significant difference between two groups in executive memory, awareness and restlessness subscales. Findings showed significant difference between two groups in inhibition and intentionality subscales and total scores. Significantly higher importance and necessity in all dimensions of executive cognitive functions was observed for sighted samples compared to the blind.

Conclusion: Blind individuals not only have no dysfunction in executive function compared to sighted people, but also have better performance in inhibition and intentionality subscales. This is related to paucity of basic information needed for executive cognitive functions.

Keywords: Blind, Executive Cognitive Functions, Dysexecutive Questionnaire (DEX)

Introduction

Brain can adapt with the environmental changes and this approved principle is called brain flexibility. Based on this principle, following the absence or defect of a limb (e.g. amputation) or the absence of a sensory system (such as peripheral blindness), different parts of the brain are able to compensate the disability by organizing the available communication. In this compensation process, the remaining parts take the assignments which are not typically responsible for that [1, 2]. The congenital blinds use the feature of the brain flexibility well, and the structures of different areas of their brains are formed based on remained sensory information [2, 3]. This is not evident about people with the acquired blindness. Many studies have reported the brain flexibility in the acquired blindness [4, 5, 6], but another group believes a critical period in childhood for brain flexibility [7, 8].

The main question is whether the cognitive functions of the brain can be affected from this absence of the visual sensory information? Our previous studies had shown that the general cognitive functions and the clinical memory are less in the acquired blindness than matched sighted [9, 10]. These studies had studied the general cognitive functions by a mini- mental state examination (MMSE) and the clinical memory by Wexler clinical memory test. The question of the present study was whether the cognitive impairment in the blindness is specifically true for the executive cognitive functions or not?

The executive cognitive functions include some cognitive processes which integrate and control other cognitive activities. Anatomical origin of the cognitive executive functions is the pre-frontal brain part which helps recent discoveries, programming, executive strategies, performance monitoring, using feedback for the response modulation, alertness and inhibition of the unrelated information with the task. The executive function is a comprehensive process which is used for assignments such as programming, work memory, emotional control, inhibition, transport and also the start and follow-up of the motion [11, 12]. There are various neurological tests to evaluate the executive functions and most of them are related to the visual stimuli. In this study, the behavioral test had been used for this purpose. Being inclusive and easy is one of the advantages of the cognitive behavioral assessment instruments over the nerve-mental instruments. Clark et al. [13] and Solanto et al. [14] showed a significant relationship between the nerve-mental tests and the related behavioral instruments.

The purpose of the present study was to compare the executive cognitive functions of the blind veterans and matched sighted people through behavioral tests.

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Methods

This cross-sectional comparative case-control study was performed on 93 veterans blinded in both eyes and 116 sighted people with the same age and education level. The population included all binocular blind veterans of Iran (600 patients). Among this population, people who had participated in the recreational- treatment camping of the foundation of martyrs and veterans affairs in Mashhad in the summer of 2008, participated in this study. The number of samples was to be 10% of the whole population (60 subjects) and 93 subjects participated in this study. The criterion of the complete binocular blindness was the profile of the veterans' medical commission. Sampling was done via available sampling method. A group of healthy people was also selected among the citizens of Mashhad by available sampling and with the condition of having the same age and education level as the matched group. All participants of both groups were men and had no history of addiction, nerve disease, head trauma, physical pain, and the use of any psychometric drugs. In order to observe the ethical considerations in the study, besides the explanation of the kind and the purpose of the study for the subjects, they were asked to accept to participate in the study. They could exclude from the study if they were not willing to cooperate at any stage of the study.

The behavior assessment test of the executive cognitive function was used as the research instrument which included 5 sub-tests: inhibition, intentionality, cognition and executive memory, awareness and hyper activity. In this instrument based on some questions, the executive cognitive functions were investigated in the daily activities. In the second section of the questionnaire, the items related to the executive cognitive functions were raised again and the subjects were asked that to what extent this point was important in their daily life and how much they were involved with it. In the third section of the questionnaire, the questions related to the executive cognitive functions and the subjects were asked that to what extent they tried to compensate the defects or prevent this problem. Chan conducted a study on the Chinese healthy people and showed that all five factors had a high correlation with the tracking nerve-cognitive test, and the sub-test of the inhibition showed a significant relationship with the Stroop test as a nerve-cognitive test of the selective attention and inhibition [15].

Independent T test was used to evaluate the differences between two groups of the blind veterans and matched sighted groups considering age and education level. Kolmogorov-Smirnov test was used to investigate the normality of the data distribution. Due to the ranking of variables related to the executive cognitive functions, Mann-Whitney U test was used to compare the efficiency of the sub-tests and the complete test of the impairment in the executive function. The level of significance was considered to be less than 0.05.

Results

The mean age for both sighted and blind groups was 46.71±12.40 and 43.86±8.46 years old respectively, T-test statistics was 1.889 and significant level was 0.06. The mean of the education time for both blind and sighted groups was 10.17±4.72 and 11.23±2.95, T-test statistics was 1.984 and significant level was 0.061. So, there was no significant difference in age and education between these two groups (Table 1).

Table 1- Demographic profile of the studied samples

Group→ Profile ↓		Blind (93)		Sighted (116 subjects)	
		Number	Percent	Number	Percent
Age group	29-20	5	5.3	2	1.7
	39-30	20	21.5	30	25.9
	49- 40	49	52.7	37	31.9
	59-50	14	15	21	18.1
	69-60	5	5.4	19	16.3
Education level	Illiterate	5	5.3	2	1.7
	Elementary	19	20.4	5	4.3
	Middle school	14	15	25	21.5
	High school	28	30.1	49	42.5
	University	25	26.9	29	25

Table 2- The sub-tests' efficacy of the executive functional impairment test based on the Mann-Whitney U test

Group → Sub-tests of the executive functions↓	Blind	Sighted	Z statistic	Significant level
	Mean Score			
Inhibitory functions	86.12	102.68	2.03	0.042*
Intentionality	82.72	101.73	2.23	0.018*
Executive Recognition and Memory	90.87	92.79	0.25	0.802
Awareness	99.62	100.09	1.41	0.156
Restlessness and Hyper activity	87.40	100.00	1.56	0.117
Whole test	74.73	95.50	2.64	0.008**

*Significant p<0.05, **Significant p<0.1

There was a significant difference between blind and sighted counterparts in the sub-tests of inhibition and intentionality (CI 0.05). Efficiency of the blind subjects was higher in the sub-tests, but there was no significant difference in the sub-tests of executive cognition and memory, awareness and hyper activity. There was a significant difference in the whole test in both two groups with CI 0.05 for the blind (Table 2).

Table 3- The need for the executive functions in the daily life based on Mann-Whitney U test

Group → Sub-tests of the executive functions↓	Blind Mean score	Sighted Mean score	Z statistic	Significant level
Inhibitory Functions	0.45	99	3.54	0.001**
Intentionality	67.93	98.07	3.77	0.001**
Executive recognition and memory	71.61	89.55	2.28	0.022*
Awareness	70.86	103.81	4.09	0.001**
Restlessness and hyper activity	75.31	96.75	2.70	0.007**
The whole test	61.94	89.69	3.56	0.001**

*Significant p<0.05, **Significant p<0.1

The importance of cognitive executive functions in the daily life for the whole test and sub-tests was significantly lower than the matched sighted (Table 3). In the section of attempt to compensate the defects or prevention of the cognitive impairment in the executive functions, there was a significant difference for sub-tests of inhibition, intentionality and executive cognitive and memory. The attempt of the blind subjects to compensate and prevent in these executive cognitive indicators was significantly higher than matched sighted. There was no significant difference between the sub-tests of awareness and hyper activity. The whole test showed a significant difference in both groups to the advantage of the blinds (Table 4).

Table 4- The amount of compensate or prevent defects of executive functions in daily life test based on Mann-Whitney U

Group → Sub-tests of the executive functions↓	Blind Mean score	Sighted Mean score	Z statistic	Significant level
Inhibitory Functions	96.57	80.96	1.96	0.049*
Intentionality	98.29	80.96	2.22	0.026*
Executive recognition and memory	100.81	79.95	2.63	0.008**
Awareness	96.75	82.95	1.74	0.082
Restlessness and hyper activity	98.79	84.99	1.73	0.084
The Whole Test	89.28	73.26	2.07	0.038*

*Significant p<0.05, **Significant p<0.1

Discussion

The findings of this study showed that the inhibitory functions in the blind were better than the sighted subjects. It seems that the inhibitory functions are strengthened in the blind due to being cautious in their daily activities. Visual information is required for many activities of daily life and this rapid and accurate information accelerate human behaviors. Absence of this information in the blind affects their immediate response system and strengthens their ability to inhibit responses. There are evidences that many brain neuronal connections are disappeared or turned off during the growth. One of these evidences is the record of the evoked potential on the temporal cortex and occipital in children. In adults, this potential can be recorded in the temporal cortex [15]. In fact, many cortical connections are disappeared after the childhood. Since the visual inputs are more rapid, potent and simultaneous than auditory information and the sense of body, these inputs devoted the occipital cortex to themselves and other communications are disappeared. Actually, the type of the input information to the cortex determines what directions remain and what directions disappear [3]. Therefore, it can be concluded that the visual information is very precise and quick compared to other senses. Although these studies have shown that the occipital cortex receives inputs from the auditory system and body sense at the birth time, but the rapid and accurate visual information possesses this brain part. There are several evidences that the occipital piece does the tactile and auditory processing in the congenital blind people. That is, the occipital cortex belongs to the other senses in the absence of the visual information [16, 17].

Regarding the findings of this study, the superiority of the inhibitory functions in the blind could be justified as this: the visual input is very quick and provides a lot of information for the subjects, so subjects could have quick responses. The blind subjects who have been deprived of this sensory input are more cautious towards other inputs and this causes strength of their ability to inhibit behavior. For example, imagine the condition that you are walking into a dark room. In this condition, all behaviors are done slowly. A group of researchers have shown that the walking speed is slower in blinds than normal people [18].

One of the inhibitory processes is the inhibitory process in motion. The test which is presented to measure this type of inhibition is the case that a person moves his finger with the lowest speed on a circle which is given to him. In this condition, the ability of motion and slower motions are indicators of the inhibitory efficiency of the individual [19]. Thus, the slow motion caused by caution enhances the inhibitory functions and the related behaviors in the blind.

One of the other important issues in the inhibition is the disturbed stimulations. In other words, the disturbed control is one of the components of inhibitory functions [20, 21]. It seems that the extensive visual information in the sighted people which was not necessarily related to the requested task provided a kind of disturbance. This disturbance did

not exist in the blind people. Therefore, the inhibitory processes was associated with less cognitive load in the blinds, and seemed more successful; although the importance of this indicator (inhibitory function) was shown less in the blinds than the matched sighted in the second section of this test.

The lifestyle of the blinds is completely different and this should be considered in every judgment and behavioral comparison. Thus, in the second section of the questionnaire, the items related to the executive cognitive functions were raised again and the subjects were asked to what extent this was relevant in their daily life. For example, one of the items related to the intentionality indicators was "To what extent do you have problem in decision-making?" The subjects were asked in the second section "to what extent does this factor interact in your daily life?" The results of the Mann-Whitney U test for all indicators showed that the interference of these indicators was less in the daily life of blinds than the sighted people. In other words, the blinds needed less executive cognitive brain functions for their daily life.

In the other section, the attempt to deal with problems related to the indicators of the executive functions was introduced and it was determined that the blinds show higher attempt in fighting inhibition, intentionality and the executive memory than sighted people. This finding demonstrated the importance of the visual information for the executive functions. In other words, blinds required more attempts to perform the cognitive executive tasks due to the absence of fast and accurate visual information.

One limitation of the present study was the use of the behavioral test to assess the executive cognitive functions. Although the available tests of measuring the executive functions are based on the visual stimuli, the researchers recommend future studies on the nerve tests of measuring the executive functions, especially the inhibitory functions based on the auditory stimuli.

Conclusion

There was no significant difference between the blind and the sighted peers in the executive cognitive memory, awareness, and restlessness. But the efficacy of blinds was significantly higher than the sighted subjects in terms of inhibition, intentionality subscales, and the whole test. The necessity and importance of the cognitive executive functions in sighted people were significantly higher than the blinds in all dimensions.

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References

1- Pascual-Leone A, Amedi A, Fregni F, Merabet LB. The plastic human brain cortex. Ann Rev Neurosci. 2005;28:377-401.

2- Cattaneo Z, Vecchi T, Cornoldi C, Mammarella I, Bonino D, Ricciardi E, et al. Imagery and spatial processes in blindness and visual impairment. Neurosci Biobehav Rev. 2008;32:1346-60.

3- Bavelier D, Neville H. Cross-modal plasticity: Where and how? Nat Rev Neurosci. 2002;3:443-52.

4- Buchel C, Price C, Frackowiak RS, Friston K. Different activation patterns in the visual cortex of late and congenitally blind subjects. Brain. 1998;121:409-19.

5- Kujala T, Alho K, Huotilainen M, Ilmoniemi RJ, Lehtokoki A, Leinonen A. Electrophysiological evidence for cross-modal plasticity in humans with early- and late-onset blindness. Psychophysiology. 1997;34:213-6.

6- Voss P, Lassonde M, Gougoux F, Fortin M, Guillemot JP, Lepore F. Early and late-onset blind individuals show supra-normal auditory abilities in far-space. Curr Biol. 2004;14:1734-8.

7- Cohen LG, Weeks RA, Sadato N, Celnik P, Ishii K, Hallett M. Period of susceptibility for cross-modal plasticity in the blind. Ann Neurol. 1999;45:451-60.

8- Sadato N, Okada T, Honda M, Yonekura Y. Critical period for cross-modal plasticity in blind humans: A functional MRI study. Neuro Image. 2002;16:389-400.

9- Nejati V. Comparison of clinical memory of blinds veteran with normal sighted. Tebe Janbaz. 2010;4(1):1-11. [Persian]

10- Nejati V. Comparison of cognitive status of blinds veteran with normal sighted. Mil Med. 2008;10(1):21-8. [Persian]

11- Stuss DT, Knight RT. Principles of frontal lobe function. Oxford: Oxford University Press; 2002.

12- Chudasama Y, Robbins TW. Functions of frontostriatal systems in cognition: Comparative neuropsychopharmacological studies in rats, monkeys and humans. Biol Psychol. 2006;73:19-38.

13- Clark C, Prior M, Kinsella G. Do executive function deficits differentiate between adolescents with ADHD and oppositional defiant/conduct disorder? A neuropsychological study using the six elements test and hayling sentence completion test. J Abnorm Child Psychol. 2000;28(5):403-14.

14- Solanto MV, Abikoff H, Sonuga-Barke E, Schachar R, Logan GD, Wigal T, et al. The ecological validity of delay aversion and response inhibition as measures of impulsivity in AD/HD: A supplement to the NIMH multimodal treatment study of AD/HD. J Abnorm Child Psychol. 2001;29(3):215-28.

15- Neville H. Variability in human brain plasticity. In: Munakata Y, Johnson MH, editors. Attention and performance: Processes of change in brain and cognitive development. Eur J Neurol. 2006;7:249-74.

16- Burton H. Visual cortex activity in early and late blind people. J Neurosci. 2003;23:4005-11.

17- Rauschecker JP. Cortical map plasticity in animals and humans. Prog Brain Res. 2002;138:73-88.

18- Bolach E, Skolimowski T. Influence of the sport team game on the posture of body of blinds and people with dimness of vision. Gymnica. 2000;30:2-12.

19- Scheres A, Oosterlaan J, Geurts H, Morein-Zamir S, Meiran N, Schut H, et al. Executive functioning in boys with ADHD: Primarily an inhibition deficit? Arch Clin Neuropsychol. 2004;19:569-94.
20- Li K, Dupuis K. Attentional switching in the sequential flanker task: Age, location and time course effects. Acta Psychol. 2008;127:416-27.
21- Treccani B, Cubelli R, Sala SD, Umilta CQ. Flanker and Simon effects interact at the response selection stage. J Exp Psychol. 2009;23:1-21.